LEABHARLANN CHOLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH | TRINITY COLLEGE LIBRARY DUBLIN
Ollscoil Átha Cliath | The University of Dublin

**Terms and Conditions of Use of Digitised Theses from Trinity College Library Dublin**

**Copyright statement**

All material supplied by Trinity College Library is protected by copyright (under the Copyright and Related Rights Act, 2000 as amended) and other relevant Intellectual Property Rights. By accessing and using a Digitised Thesis from Trinity College Library you acknowledge that all Intellectual Property Rights in any Works supplied are the sole and exclusive property of the copyright and/or other IPR holder. Specific copyright holders may not be explicitly identified. Use of materials from other sources within a thesis should not be construed as a claim over them.

A non-exclusive, non-transferable licence is hereby granted to those using or reproducing, in whole or in part, the material for valid purposes, providing the copyright owners are acknowledged using the normal conventions. Where specific permission to use material is required, this is identified and such permission must be sought from the copyright holder or agency cited.

**Liability statement**

By using a Digitised Thesis, I accept that Trinity College Dublin bears no legal responsibility for the accuracy, legality or comprehensiveness of materials contained within the thesis, and that Trinity College Dublin accepts no liability for indirect, consequential, or incidental, damages or losses arising from use of the thesis for whatever reason. Information located in a thesis may be subject to specific use constraints, details of which may not be explicitly described. It is the responsibility of potential and actual users to be aware of such constraints and to abide by them. By making use of material from a digitised thesis, you accept these copyright and disclaimer provisions. Where it is brought to the attention of Trinity College Library that there may be a breach of copyright or other restraint, it is the policy to withdraw or take down access to a thesis while the issue is being resolved.

**Access Agreement**

By using a Digitised Thesis from Trinity College Library you are bound by the following Terms & Conditions. Please read them carefully.

I have read and I understand the following statement: All material supplied via a Digitised Thesis from Trinity College Library is protected by copyright and other intellectual property rights, and duplication or sale of all or part of any of a thesis is not permitted, except that material may be duplicated by you for your research use or for educational purposes in electronic or print form providing the copyright owners are acknowledged using the normal conventions. You must obtain permission for any other use. Electronic or print copies may not be offered, whether for sale or otherwise to anyone. This copy has been supplied on the understanding that it is copyright material and that no quotation from the thesis may be published without proper acknowledgement.

# THE
# STUDY OF PERIODICITY OF EATING & PUBLIC HEALTH NUTRITION ISSUES

**A Thesis for the Degree of Doctor of Philosophy (Ph.D.)**

**by**

**Karen E. Harrington**

**Submitted to the University of Dublin,**
**Trinity College**

**Department of Clinical Medicine,**
**University of Dublin,**
**Trinity College.**

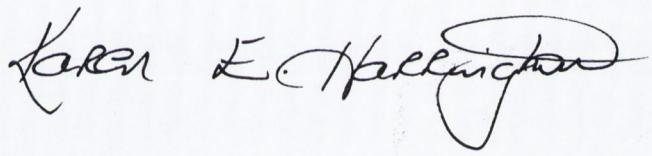
**April, 2001**

TRINITY COLLEGE
2 4 NOV 2015
LIBRARY DUBLIN

Thesis 6478

## DECLARATION

**This thesis is submitted by the undersigned to Trinity College, University of Dublin for examination for the degree of Ph.D. The work herein is entirely my own except where acknowledged and has not been submitted for a degree to any other University. The thesis may be made available from the library for consultation or copying.**



**Karen E. Harrington**

# SUMMARY

This thesis set out to provide an objective understanding of periodicity of eating in a group of free-living adults, by determining the temporal pattern of nutrient intake during eating occasions throughout the day. A dietary assessment study was carried out using a 7-day estimated food diary in a sample of 133 adults recruited from a city local authority. During the survey period, respondents were met on at least three occasions to encourage and motivate them to follow their usual dietary habits and to record their intakes in as detailed a manner as possible. A combination of quantification methods was used to obtain best estimates for the weights of all food and drink consumed, including a photographic food atlas, manufacturers' information, the weighing of specific food and drinks, household measures and standard portion sizes. The food and drink information was coded to allow analysis of the data in terms of individual eating occasions. An eating occasion was coded to the nearest hour and included every item of food and drink consumed within an hourly period. Nutrient analysis was carried out using the FOODBASE© program on each eating occasion of each of the seven days for each respondent. This program was specifically chosen as it allowed specification of the amount and type of fat used in preparing and cooking foods. The nutrient intake data was entered into SPSS® to create a database, which contained every hour of each of the seven days for each respondent, together with the nutrient analysis data of every eating occasion, at the specific hour of consumption. This database was then used to determine the temporal pattern of nutrient intake during eating occasions throughout the day to address a number of questions. Eating occasions of non-nutritive value were not included in the analysis.

Four data analysis approaches were explored in order to determine temporal patterns of eating. Only two of these approaches, *the eating occasion method* and the *eating occasion by individual method,* were considered appropriate to represent the temporal pattern of mean nutrient intakes during eating occasions throughout the day in free-living individuals.

The *eating occasion method* was used to determine the amounts of fat consumed during eating occasions of free-living adults on self-selected diets and this information was used to address, for the first time, whether test meals used in postprandial lipeamia studies represent the macronutrient content of eating occasions of free-living adults. Most test meals used in postprandial lipaemia studies contain between 20g and 140g of fat whereas most (89%) eating occasions of the free-living adults in this study contained less than 40g of fat. As much as 76% of the 5391 eating occasions (> 0MJ) observed contained less than 20g of fat. The temporal pattern of fat intake revealed a low-fat high-carbohydrate eating pattern in the early morning hours, the time at which postprandial studies usually administer a

single high-fat test meal. Overall, this study showed that the usual postprandial study protocol does not represent the free-living situation.

The temporal pattern of eating was also determined to provide baseline data for the development of evidence based dietary guidelines that may involve specific eating occasions of the day and thus set out to make consumer messages more relevant. Three issues were addressed. Firstly, a comparison was made of the temporal pattern of macronutrient intake during eating occasions between high-fat and low-fat consumers. Similar temporal patterns of macronutrient intake were observed although high-fat consumers had greater fat intakes (g) and as a result greater energy intakes (MJ) during almost every eating occasion than the low-fat consumers. Secondly, the effect of differences in periodicity of eating on mean daily macronutrient intakes and the temporal pattern of macronutrient intake during eating occasions was determined. The high eating frequency group had higher mean daily energy intakes (P=0.015) and higher proportions of energy from carbohydrate (P=0.006) and sugars (P=0.001) than the low eating frequency group, who had higher proportions of energy from protein (P=0.002). No difference in fat intakes (% energy) was observed between the groups. Similar temporal patterns of macronutrient intake were observed between groups. Thirdly, the day-of-the-week effect on macronutrient intakes and the temporal pattern of eating between weekdays and weekend days was investigated. The main finding was a higher total energy intake (P=0.017) but not food energy intake on weekend vs. weekdays. Similar temporal patterns of macronutrient intake were observed between weekdays and weekend days. These investigations demonstrated the importance and value of studying data at the level of eating occasions. This study, however, is limited because of its small sample size. Food and nutrient intake findings of a small non-random population in a country must be also be observed in a random and representative sample of the population before recommendations can be formulated. As part of the North/South Ireland Food Consumption Survey a methodology was developed to ensure the data analysis could be conducted at the level of individual eating occasions. A description of the methodology used is presented in this thesis and the macronutrient intakes and food sources of this representative sample of Irish adults are described. Fat intakes (37% food energy) were higher than recommendations (35% food energy), carbohydrate intakes (46%) were lower than recommendations (50%+ food energy). Protein intakes were adequate with 93% of men and 86% of women with protein intakes above the PRI (0.7g of protein/kg body weight/day).

*To Mam & Dad, with thanks*

# ACKNOWLEDGEMENTS

I would like to thank sincerely all the following people / organisations for their help and support during this research:

Professor Mike Gibney, my supervisor, for all his support, guidance, patience, kindness and friendship throughout my Ph.D.

Dr. Tommy Cooke, my DIT supervisor, for all his encouragement and help with this work.

Unilever for providing me with the Flora Award under which my research was initially funded.

The Irish Universities Nutrition Alliance (IUNA), Nutriscan Ltd. and the Dublin Institute of Technology Strategic Research Development Programme for sponsoring various aspects of the research carried out. Special thanks to Mr. Bob Kavanagh of the SRD Programme.

All the members of the IUNA, both North and South, for providing a wonderful and stimulating work environment for carrying out this research. My special thanks to Mairéad for her support, patience and friendship and to Maureen and Sinéad for all their help and friendship.

All the team in the Institute of European Food Studies for their input and suggestions for my work and for lots of good company along the way.

Dr. Adrian Dunne, UCD, for his valuable assistance with the statistical analysis.

Dr. Helen Roche and the other members of the Nutrition Laboratory in the Dept. of Clinical Medicine for all their technical and moral support and friendship.

The employees of Dublin Corporation and all the respondents in the IUNA survey.

My friends who have all helped in different ways to keep me going and encouraged me to complete my thesis. A special thanks to Margaret and John.

Joyce, thanks for a very special friendship and Paul, thanks for your encouragement and friendship. I look forward to helping you both with the plans for your 'Big Day'.

Mam, Dad, Dermot, Pauline, and Susan for all their support throughout the years – I'm looking forward to spending a lot more time with you all now.

# TABLE OF CONTENTS


| | | |
|---|---|---|
| **Chapter 1** | **INTRODUCTION** | **1** |
| **1.1** | **Current Prevalence of Periodicity of Eating** | **3** |
| **1.2** | **Methodological aspects of the Study of Periodicity of Eating** | **7** |
| 1.2.1 | The definition of an eating occasion | 7 |
| | 1.2.1.1 Time periods | 8 |
| | 1.2.1.2 Colloquial terms of breakfast, lunch, dinner & snack | 8 |
| | 1.2.1.3 Energy content & time difference between eating occasions | 9 |
| | 1.2.1.4 Consideration to non-nutritive eating occasions | 10 |
| | 1.2.1.5 Researcher-defined or subject-defined eating occasions | 11 |
| 1.2.2 | Dietary assessment methodology & the study of periodicity of eating | 15 |
| 1.2.3 | Validity of reported food intakes & the study of periodicity of eating | 18 |
| | 1.2.3.1 Evaluation of the validity of food intake data | 18 |
| | 1.2.3.2 Validity of reported eating patterns | 20 |
| | 1.2.3.3 Dieters and the validity of reported food intake data | 20 |
| | 1.2.3.4 Other factors & validity of reported food intake data | 21 |
| **1.3** | **The Dietary Implications of an increased periodicity of eating** | **23** |
| 1.3.1 | The contribution of 'snacks' to total daily nutrient intake | 24 |
| | 1.3.1.1 The contribution of 'snacks' to total daily energy intake | 24 |
| | 1.3.1.2 The contribution of 'snacks' to total daily macronutrient intake | 25 |
| | 1.3.1.3 The contribution of 'snacks' to total daily sugar, fibre & micronutrient intake | 26 |
| 1.3.2 | The contribution of the individual eating occasions of the day to total daily nutrient intake | 27 |
| | 1.3.2.1 The contribution of the individual eating occasions of the day to total daily energy intake | 28 |
| | 1.3.2.2 The contribution of the individual eating occasions of the day to total daily macronutrient intake | 29 |
| | 1.3.2.3 The contribution of the individual eating occasions of the day to total daily micronutrient intake | 30 |

1.3.3 The effect of different periodicities of eating on mean daily nutrient intakes 32
1.3.4 The nutrient composition of 'snacks' and 'meals' 36
1.3.4.1 Energy and macronutrient content of 'meals' & 'snacks' 36
1.3.4.2 Micronutrient content of 'meals' & 'snacks' 38
1.3.5 The nutrient composition of the individual eating occasions of the day 40
**1.4 The Health Implications of an increased periodicity of eating 42**
1.4.1 An increased periodicity of eating & reduced risk of CHD 42
1.4.1.1 Studies of an increased periodicity of eating on blood lipids in normolipidaemic individuals 43
1.4.1.2 Studies of an increased periodicity of eating on blood lipids in hyperlipidaemic individuals 49
1.4.2 Increased periodicity of eating & carbohydrate tolerance & diabetes mellitus 52
1.4.3 An increased periodicity of eating & body weight balance & regulation 53
1.4.3.1 Methodological factors to consider in interpreting studies 54
1.4.3.2 Main findings of studies of an increased eating frequency & body weight status 54
1.4.3.3 Four possible advantages of frequent eating & body weight control 55
1.4.4 An increased frequency of eating & effect on dental caries 58
**1.5 The potential value of research on periodicity of eating to other areas of nutrition research 59**
1.5.1 The development of food-based dietary guidelines (FBDG) 60
1.5.2 Nutrition research studies that use test meals 62
1.5.2.1 Postprandial lipaemia 62
**1.6 Objective & specific aims of this thesis 65**
**1.7 References 68**

**Chapter 2 A STUDY OF THE TEMPORAL PATTERN OF NUTRIENT INTAKE THROUGHOUT THE DAY IN FREE-LIVING HEALTHY IRISH ADULTS: METHODOLOGY & BASELINE RESULTS 95**

**2.1 Introduction 96**

**2.2 Methods 98**

2.2.1 Subject Recruitment 98

2.2.2 Dietary Assessment Procedure: 7-day food diary 98

2.2.3 Anthropometry 101

2.2.4 Health & Lifestyle Questionnaire Data 101

2.2.5 Quality & Validity of Dietary Data 102

2.2.6 Data analysis & Statistical Analysis 103

**2.3 Baseline Results 104**

2.3.1 Response rate 104

2.3.2 Validity of reported energy intakes 104

2.3.3 Mean daily nutrient intakes & anthropometric measurements 104

2.3.4 Comparison of mean daily nutrient intakes with other Irish food intake studies 105

2.3.5 Socio-demographic and lifestyle characteristics 105

2.3.6 Mean daily eating frequency data 106

**2.4 Discussion 106**

**2.5 References 122**

**Chapter 3 THE TEMPORAL PATTERN OF MACRONUTRIENT INTAKE DURING EATING OCCASIONS THROUGHOUT THE DAY: EXPLORATION OF DATA ANALYSIS METHODS 135**

**3.1 Introduction 136**

**3.2 Methods 137**

3.2.1 Data analysis methods 138

**3.3 Results 142**

**3.4 Discussion 143**

**3.5 References 149**

**Chapter 4 THE TEMPORAL PATTERN OF THE INTAKE OF DIETARY FAT AND OTHER ENERGY SOURCES, DURING EATING OCCASIONS THROUGHOUT THE DAY: IMPLICATIONS TO STUDIES OF POSTPRANDIAL LIPAEMIA** **151**

**4.1 Introduction** **152**

**4.2 Methods** **153**

4.2.1 Subject Recruitment 153

4.2.2 Dietary Assessment Procedure 154

4.2.3 Anthropometry 154

4.2.4 Quality & Validity of Dietary Data 154

4.2.4 Data analysis 155

4.2.5 Statistical analysis 158

**4.3 Results** **159**

4.3.1 Response rate 159

4.3.2 Validity of reported energy intakes 159

4.3.3 Mean daily nutrient intakes and anthropometric measurements 159

4.3.4 Fat intake (g) per eating occasions (>0MJ & > 0g fat) 160

4.3.5 Temporal pattern of mean macronutrient content of eating occasions per hour 160

4.3.6 Mean fat content (g) of eating occasions per kg body weight of subject at time points 162

**4.4 Discussion** **162**

**4.5 References** **193**

**Chapter 5 CHARACTERISATION OF THE TEMPORAL PATTERN OF MACRONUTRIENT INTAKE DURING EATING OCCASIONS THROUGHOUT THE DAY OF HABITUAL FREE-LIVING HIGH-FAT AND LOW-FAT COMSUMERS: APPLICATION TO THE FORMULATION OF EATING –OCCASION BASED DIETARY GUIDELINES** **206**

**5.1 Introduction** **207**

**5.2 Methods** **208**

5.2.1 Subject recruitment 208

5.2.2 Dietary Assessment Procedure 208

5.2.3 Anthropometry 209

5.2.4 Quality & Validity of Dietary Data 209

5.2.5 Data analysis 210

5.2.6 Statistical analysis 211

**5.3 Results** **212**

5.3.1 Response rate 212

5.3.2 Validity of reported energy intakes 212

5.3.3 Mean daily nutrient intakes & subject characteristics 213

5.3.4 Temporal pattern of macronutrient intake during eating occasions 214

**5.4 Discussion** **216**

**5.5 References** **233**

**Chapter 6 THE EFFECT OF DIFFERENCES IN PERIODICITY OF EATING ON MEAN DAILY MACRONUTRIENT INTAKES & THE TEMPORAL PATTERN OF MACRONUTRIENT INTAKE DURING EATING OCCASIONS THROUGHOUT THE DAY** **242**

**6.1 Introduction** **243**

**6.2 Methods** **245**

6.2.1 Subject Recruitment 245

6.2.2 Dietary Assessment Procedure 245

6.2.3 Anthropometry 245

6.2.4 Quality & Validity of Dietary Data 245

6.2.5 Data analysis 246

6.2.6 Statistical analysis 248

**6.3 Results** **248**

6.3.1 Response rate 248

6.3.2 Validity of reported energy intakes 249

6.3.3 Mean daily nutrient intakes & subject characteristics 249

6.3.4 Temporal pattern of macronutrient intake during eating occasions 256
**6.4 Discussion 252**
**6.5 References 269**

**Chapter 7 DIFFERENCES IN DAILY MACRONUTRIENT INTAKES BETWEEN WEEKDAYS AND WEEKEND DAYS & THE TEMPORAL PATTERN OF MACRONUTRIENT INTAKE DURING EATING OCCASIONS THROUGHOUT THE DAY 277**
**7.1 Introduction 278**
**7.2 Methods 280**
7.2.1 Subject Recruitment 280
7.2.2 Dietary Assessment Procedure 280
7.2.3 Anthropometry 281
7.2.4 Quality & Validity of Dietary Data 281
7.2.5 Data analysis & Statistical analysis 281
**7.3 Results 283**
7.3.1 Response Rate 283
7.3.2 Validity of reported energy intakes 283
7.3.3 Mean daily nutrient intakes 284
7.3.4 Temporal pattern of macronutrient intakes during eating occasions 285
**7.4 Discussion 286**
**7.5 References 302**

**Chapter 8 THE NORTH/SOUTH IRELAND FOOD CONSUMPTION SURVEY: SURVEY DESIGN AND METHODOLOGY 306**
**8.1 Introduction 307**
**8.2 Sampling 308**
**8.3 Respondent Recruitment 308**
**8.4 Survey Procedures 308**
8.4.1 Food Intake Data Collection 308
8.4.2 Quantification of Food Diaries 309

8.4.3 Coding, Data Entry and Analysis of Food Diaries 312
8.4.4 Quality Control of Food Diary Data 313
8.4.5 Food Composition Database 314
8.4.6. Anthropometric measurements 315
8.4.7 Questionnaire Design 315
8.4.8 Questionnaire Data Management 317
**8.5 References 319**

**Chapter 9 MACRONUTRIENT INTAKES AND FOOD SOURCES IN IRISH ADULTS: FINDINGS OF THE NORTH/SOUTH IRELAND FOOD CONSUMPTION SURVEY 323**
**9.1 Introduction 324**
**9.2 Methods 325**
9.2.1 Dietary Assessment 326
9.2.2 Nutrient analysis 326
9.2.3 Comparison with Dietary Recommendations 327
9.2.4 Statistical Analysis 327
**9.3 Results 328**
9.3.1 Mean daily energy and macronutrient intakes 328
9.3.2 Mean daily macronutrient intakes compared to dietary recommendations 329
9.3.3 % contribution of foods to mean daily macronutrient intakes 330
**9.4 Discussion 332**
**9.5 References 346**

**Chapter 10 GENERAL DISCUSSION 356**

**APPENDICES 361**

## LIST OF TABLES


| | | |
|---|---|---|
| Table 1.1a | The prevalence of periodicity of eating in adult populations | 5 |
| Table 1.1b | The prevalence of periodicity of eating in children & adolescent populations | 6 |
| Table 1.2 | The criteria used to define eating occasions by different researchers in studies of eating patterns | 12 |
| Table 1.3 | Dietary assessment methods used to study periodicity of eating in different population groups | 17 |
| Table 1.4 | The contribution of 'snacks' to total daily macronutrient intake | 25 |
| Table 1.5 | The distribution of daily nutrient intake across the individual eating occasions of the day (%) | 30 |
| Table 1.6 | The nutritional composition of 'meals' and 'snacks' | 39 |
| Table 1.7 | Studies of altered periodicity of eating on fasting blood lipids and lipoproteins in normolipidaemic individuals | 47 |
| Table 1.8 | Studies of altered periodicity of eating on fasting blood lipids and lipoproteins in hyperlipidaemic individuals | 51 |
| Table 2.1 | Response rate of the study sample | 116 |
| Table 2.2 | Mean and standard deviation (SD) values for EI/$BMR_{est}$ values, anthropometric measurements and daily nutrient intake data of men, women and the total sample | 117 |
| Table 2.3 | Comparison of the mean daily nutrient intakes of the men of this study with those of men in other Irish food intake studies | 118 |
| Table 2.4 | Comparison of the mean daily nutrient intakes of the women of this study with those of women in other Irish food intake studies | 119 |
| Table 2.5 | Socio-demographic & lifestyle characteristics of men, women and the total sample | 120 |
| Table 2.6 | Descriptive data on daily eating frequency for men, women and the total sample | 121 |
| Table 3.1 | Mean fat (g) intake during eating occasions at each hour throughout the day, calculated by 4 different methods | 147 |

| | | |
|---|---|---|
| Table 4.1 | Mean and standard deviation (SD) values of EI/$BMR_{est}$, anthropometric measurements and mean daily nutrient intakes of men, women and the total sample | 173 |
| Table: 4.2 | Mean, standard deviation (SD) and percentiles of fat (g) intake per eating occasions (> 0 MJ) and per fat-containing eating occasions (> 0g fat) during 7 days of food diary recording, for the total sample and men and women | 174 |
| Table 4.3 | Percentages (%) of all eating occasions (> 0 MJ) and fat containing eating occasions (> 0g fat) that are within defined ranges of fat intake (g) during 7 days of food diary recording in 133 subjects | 175 |
| Table 4.4 | Descriptive data for energy & macronutrient intake (g) per eating occasions per hour for each hour of the day in 133 free-living adults | 176 |
| Table 4.5.1 | Temporal pattern of mean energy & proportions of total energy (TE) from protein, carbohydrate, fat and alcohol during eating occasions/hour in Males | 177 |
| Table 4.5.2 | Temporal pattern of mean energy & proportions of total energy (TE) from protein, carbohydrate, fat and alcohol during eating occasions/hour in Females | 178 |
| Table 4.6 | Postprandial Studies: description of the amounts of fat, nutrient composition and nature of test meals (TM) used, subject details and study aims | 179 |
| Table 4.7 | Postprandial Studies that used amounts of fat per test meal (TM) comparable to the fat content of eating occasions observed in this study | 187 |
| Table 5.1 | Mean and standard deviation (SD) values of anthropometric measurements, EI/$BMR_{est}$ values, daily eating frequency, energy and macronutrient intakes of high-fat (HF) and low-fat (LF) consumers by sex | 225 |
| Table 5.2 | The number (*n*) of values per hour | 226 |

| | | |
|---|---|---|
| Table 5.3 | Mean daily energy and macronutrient intakes (% total energy) in High-fat and Low-fat groups in previous studies | 227 |
| Table 6.1 | Mean and standard deviation (SD) values of anthropometric measurements, EI/$BMR_{est}$ values, daily eating frequency, energy and macronutrient intakes of high eating frequency (HEF) and low eating frequency (LEF) groups by sex | 260 |
| Table 6.2 | The number (*n*) of values per hour | 261 |
| Table 6.3 | Periodicity of Eating and mean daily macronutrient intakes in adult populations | 262 |
| Table 7.1 | The day-of-the-week effect on energy and macronutrient intakes : mean and standard deviation (SD) values | 294 |
| Table 7.2 | Mean and standard deviation (SD) values of total daily energy and macronutrient intakes of Irish adults on weekdays and weekend days | 295 |
| Table 7.3 | The number (*n*) of values per hour | 296 |
| Table 9.1 | Mean daily energy and macro-nutrient intakes and standard deviations (SD) in Irish adults according to sex and age group | 340 |
| Table 9.2 | Percentage (%) of Irish adults adhering to current dietary recommendations for total fat and carbohydrate intakes according to sex and age group | 341 |
| Table 9.3 | Percentage (%) contribution of food groups to mean daily protein intake of Irish adults according to sex and age group | 342 |
| Table 9.4 | Percentage (%) contribution of food groups to mean daily fat intake of Irish adults according to sex and age group | 343 |
| Table 9.5 | Percentage (%) contribution of food groups to mean daily carbohydrate intake of Irish adults according to sex and age group | 344 |
| Table 9.6 | Comparison of mean daily macronutrient intakes of men and women in the present study (NSIFCS) with other large scale food and nutrition surveys in Ireland (INNS) and the UK (DLHNI & DNSBA) | 345 |

## LIST OF FIGURES


| | | |
|---|---|---|
| Figure 2.1 | Distribution of individual EI/$BMR_{est}$ values derived from self-reported energy intake and estimated BMR in 133 subjects studied for 7 days | 121 |
| Figure 3.1 | Temporal pattern of the mean fat intake (g) during eating occasions per hour | 148 |
| Figure 4.1 | Temporal pattern of mean macronutrient intake (g) during eating occasions/hour | 189 |
| Figure 4.2 | Temporal pattern of mean proportion of total energy from macronutients during eating occasions/hour | 190 |
| Figure 4.3 | Temporal pattern of mean proportion of food energy from macronutients during eating occasions/hour | 191 |
| Figure 4.4 | Temporal pattern of mean macronutrient intake (g) during eating occasions/hour for males (M) and females (F) | 192 |
| Figure 5.1 | Temporal pattern of mean energy (MJ) intake during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers | 228 |
| Figure 5.2a | Temporal pattern of mean carbohydrate & fat intake (g) during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers | 229 |
| Figure 5.2b | Temporal pattern of mean protein & alcohol intake (g) during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers | 230 |
| Figure 5.3 | Temporal pattern of mean proportion of total energy from macronutrients during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers | 231 |
| Figure 5.4 | Temporal pattern of mean proportion of food energy from macronutrients during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers | 232 |
| Figure 6.1 | Temporal pattern of mean energy intake (MJ) during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups | 264 |
| Figure 6.2a | Temporal pattern of mean carbohydrate and fat intake (g) during eating occasions/hour for High Eating Frequency (HEF) | |

| | | |
|---|---|---|
| | and Low Eating Frequency (LEF) Groups | 265 |
| Figure 6.2b | Temporal pattern of mean protein and alcohol intake (g) during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups | 266 |
| Figure 6.3 | Temporal pattern of mean proportion of total energy from macronutrients during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups | 267 |
| Figure 6.4 | Temporal pattern of mean proportion of food energy from macronutrients during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups | 268 |
| Figure 7.1 | Temporal pattern of mean energy intake (MJ) during eating occasions/hour on weekdays (WD) and weekend days (WE) | 297 |
| Figure 7.2a | Temporal pattern of mean carbohydrate and fat intake (g) during eating occasions/hour on weekdays (WD) and weekend days (WE) | 298 |
| Figure 7.2b | Temporal pattern of mean protein and alcohol intake (g) during eating occasions/hour on weekdays (WD) and weekend days (WE) | 299 |
| Figure 7.3 | Temporal pattern of mean proportions of total energy from macronutrients during eating occasions/hour on weekdays (WD) and weekend days (WE) | 300 |
| Figure 7.4 | Temporal pattern of mean proportions of food energy from macronutrients during eating occasions/hour on weekdays (WD) and weekend days (WE) | 301 |

# ABBREVIATIONS

| | |
|---|---|
| ANOVA | analysis of variance |
| BDA | British Dietetic Association |
| BMI | body mass index |
| BMR | basal metabolic rate |
| $BMR_{est}$ | estimated basal metabolic rate |
| BW | body weight |
| CE | cholesterol ester |
| CETP | cholesterol ester transfer protein |
| CHD | coronary heart disease |
| CHO | carbohydrate |
| CM | chylomicron |
| cm | centimetre |
| DLHNI | Diet, Lifestyle & Health in Northern Ireland |
| DNSBA | Diet and Nutrition Survey of British adults |
| DRV | dietary reference values |
| EC | European Commission |
| EHN | European Heart Network |
| $EI/BMR_{est}$ | ratio of energy intake to estimated basal metabolic rate |
| EU | European Union |
| FAO | Food and Agriculture Organisation of the United Nations |
| FBDG | food based dietary guidelines |
| FSAI | Food Safety Authority of Ireland |
| g | gram |
| GIP | gastric inhibitory peptide |
| Hb | haemoglobin |
| $Hb_{A1}C$ | glycosylated haemoglobin |
| HDL | high density lipoprotein |
| HEA | Health Education Authority |

| | |
|---|---|
| HEF | high eating frequency |
| HF | high fat |
| HMG-CoA | β-hydroxy-β-methylglutaryl-coenzyme A |
| HMSO | Her Majesty's Stationery Office |
| IEFS | Institute of European Food Studies |
| INNS | Irish National Nutrition Survey (1990) |
| IUNA | Irish Universities Nutrition Alliance |
| IUNS | International Union of Nutritional Sciences |
| kcal | kilocalorie |
| kg | kilogramme |
| LCAT | lecithin cholesterol acyltransferase |
| LDL | low density lipoprotein |
| LEF | low eating frequency |
| LF | low fat |
| LPL | lipoprotein lipase |
| LTI | lower threshold intake |
| l | litre |
| MAFF | Ministry of Agriculture Fisheries & Food |
| m | metre |
| mg | milligramme |
| mmol | millimole |
| Min | minute |
| MJ | megajoule |
| n | number |
| NDC | National Dairy Council |
| NHANES | National Health and Nutrition Examination Survey |
| NSIFCS | North/South Ireland Food Consumption Survey |
| NR | not reported |
| ns | non-significant |
| NSP | non-starch polysaccharide |
| p | probability |

| | |
|---|---|
| PAL | physical activity level |
| PRI | population reference intake |
| prot | protein |
| RCT | reverse cholesterol transport |
| RDA | recommended dietary allowance |
| ROH | alcohol |
| RNI | reference nutrient intake |
| SC | social class |
| SD | standard deviation |
| SPSS | statistical package for the social sciences |
| TAG | triacylglycerol |
| TC | total cholesterol |
| TDEI | total daily energy intake |
| TE | total energy |
| TM | test meal |
| TRL | triacylglycerol rich lipoproteins |
| UK | United Kingdom |
| USA | United States of America |
| VLDL | very low density lipoprotein |
| Vs. | versus |
| wd | weekday |
| we | weekend |
| WHO | World Health Organisation |

# CHAPTER 1

## Introduction

The number of times an individual eats or drinks during the day has been described by the terms 'frequency of eating', 'meal frequency', 'snacking frequency' and more recently 'periodicity of eating'. The terms 'periodicity of eating' or 'eating frequency' are objective terms as they avoid the use of value laden terms such as 'meal frequency' or 'snacking', terms, which mean many different things to different individuals and groups. The term 'periodicity of eating' in this thesis refers not only to variation in the nutrient content of eating occasions during the day, but it also refers to variation in the size, food content and timing of the different eating occasions of the day. In nutrition research, the study of periodicity of eating falls under the domain of the study of eating patterns. 'Eating patterns' has recently been described as the spatio-temporal structure of food and drink intake, meals, snacks and drinks (Oltersdorf, 1996).

Interest in studying periodicity of eating stems from the metabolic and behavioural effects of the frequency of food intake. Research undertaken in the 1960s suggested potential health benefits of eating more frequently, including reducing the risk of coronary heart disease (CHD) and aiding the treatment of diabetes mellitus and obesity. Following a lull period, in the 1980s, research into the health benefits of periodicity of eating recommenced. Simultaneously, an increased frequency of eating 'snacks' was recognized, particularly in adolescent populations. The traditional pattern of eating three meals a day and not between meals, declined in many population groups and the dietary implications of an increased frequency of eating was of concern. Snacks were considered to be high in fat and thus to have a negative impact on the nutrient quality of the diet. More recently in the 1990s, attention has been paid to the methodologies used to identify and analyse eating patterns. It is acknowledged that there is little agreement in the methods used to identify and assess eating patterns and methodology needs standardisation to allow comparisons between studies and to allow the growth and advancement of this area, which has such potential health benefits. Dietary surveys of populations present nutrient intakes almost exclusively as average nutrient intakes per day and the nutrient intake of the different eating occasions of the day are only rarely investigated or presented. An increased frequency of eating has been described by the terms 'high eating frequency', 'snacking', 'nibbling' and 'grazing'. The terms 'gorging', 'infrequent feeding' and 'meal-eating' have described a low eating frequency.

This chapter reviews the area of periodicity of eating in terms of the current prevalence of periodicity of eating, methodological aspects of the study of this area, the dietary and health implications and the potential value of undertaking research in this area to other areas of nutrition science.

## 1.1 CURRENT PREVALENCE OF PERIODICITY OF EATING

In recent years it has become increasingly evident, through market research and nutrition research, that the traditional eating pattern of three meals a day has been replaced by a more frequent pattern of eating. Most people are now eating 5 to 6 times a day (Gibney & Wolever, 1997), as snacks are forming an increasingly important part of the modern diet. This more frequent pattern of eating is often referred to as a 'grazing' or 'nibbling' pattern of eating. In 1999, a nationwide survey of 420 women revealed that 98% of the women ate between meals and 84% admitted to having at least five snacks per day (Ursell, 1999). In 1997, the National Snack Survey, commissioned by the UK Slimmers Magazine, found that 71% of people had at least one or two snacks every day and a further 13% had five or more a day (UK Slimmers Magazine, 1997). A survey of the eating habits of 11 – 16 year old British children, in 1995, found that 95% of children ate snacks at some point during the day (NDC, 1995). In 1992, the UK Snack-foods Report also reported a growing trend towards snacking or grazing among consumers (Leatherhead Food Research Association, 1992).

The prevalence of a more frequent pattern of eating in children and adolescents has been known for some time. Concerns over the nutrient adequacy of the diets of children and adolescents, lead to studies, which specifically investigated their eating patterns and a grazing pattern of eating was observed to be predominant (Truswell & Darton-Hill, 1981; Gillespie, 1983; Skinner *et al.*, 1985; Dugdale *et al.*, 1988; Anderson *et al.*, 1993; Bartkiw, 1993). It is only in recent years that an increased frequency of eating has been observed in adult populations. Indeed, studies of eating frequency in adult populations remain limited today, as observed by Gatenby in 1997. Two studies addressed mean daily eating frequency in the Irish population (McGrath & Gibney, 1994; Bellisle *et al.*, 1995). The first demonstrated a mean daily eating frequency of 3.8 – 6.3 eating occasions per day in a group of 23 office workers (McGrath & Gibney, 1994). Bellisle *et al.*, (1995) studied 762 Irish University students as

part of a European study of eating patterns. The men had a mean daily eating frequency of 5 eating occasions per day and the women had a mean daily eating frequency of 4.8 eating occasions per day.

Tables 1.1a & 1.1b list the nutrition studies that have reported the mean daily eating frequency of adult populations and younger populations, respectively. A mean daily eating frequency of 5 – 6 eating occasions per day was largely observed. Gender did not influence daily eating frequency (Gatenby *et al.*, 1995; St. Jeor *et al*, 1995; Crawley & Summerbell, 1997; Drummond *et al.*, (unpublished); Haveman-nies *et al.*, 1998). Conversely, age was been shown to have an effect, an increasing age was associated with a lower mean daily eating frequency in a British population (Gatenby, 1997). This finding was not consistent however. An assessment of the eating patterns of elderly populations in 13 small towns, in the SENACA follow-up survey of 1993, revealed differences in the number of eating occasions per day between the elderly populations of the different towns (Schlettwein-Gsell & Barclay, 1996). The elderly populations of Denmark, the Netherlands and Switzerland had at least 4 eating occasions per day, whereas the elderly populations of France and Poland generally had less than 4 eating occasions per day. This finding illustrates cultural differences in eating patterns.

In addition to measuring mean daily eating frequency, an increased frequency of eating in populations has also become evident through an examination of the percentage of total daily energy intake (TDEI) derived from snacks. The percentage of TDEI derived from snacks is also presented in Tables 1.1a and 1.1b. Snacks provided 20% to 25% of TDEI in adult populations (Gatenby *et al.*, 1995; Summerbell *et al.*, 1995; Drummond *et al.*, 1996) and 16% to 33% of TDEI in children and adolescent populations (Livingstone, 1991; Robson & Strain, 1991; Summerbell *et al.*, 1995; Samuelson *et al.*, 1996). This figure varied in elderly populations, depending on the nationality of the population. Danish and Dutch populations obtained as much as 20-32% of TDEI from snacks, whereas French, Italian, Swiss, Polish and British elderly populations obtained between 7% and 18% of TDEI from snacks (Summerbell *et al.*, 1995; Schlettwein-Gsell & Barclay, 1996).

Overall, it is clear that eating 5-6 times a day, is a most common eating frequency in free-living populations, whether assessed by determining mean daily eating frequency or the percentage of TDEI derived from snacks. However, it is important to realise that determination of the number of times an individual eats or drinks during the day is currently challenged by the fact that there is no standard in the methodology to study eating patterns (Olstersdorf, 1996; Olstersdorf *et al.*, 1999). This makes comparisons between studies extremely difficult.

**Table 1.1a: The Prevalence of Periodicity of Eating in Adult populations**

| Author | Subjects | Dietary Assessment Method | Mean daily eating frequency | % Energy (TDEI) from Snacks & Additional Info |
|---|---|---|---|---|
| Mäkelä *et al.*, 1999 | 1200 subjects 15y+, from Denmark(D), Finland(F), Norway(N), Sweden(S) | 24 hour recall Telephone interviews | 4.15 (D)<br>4.3 (F)<br>3.73 (N)<br>4.11 (S) | NR |
| Winkler *et al.*, 1999 | 899 German men 45-64 y | 7d food record | 4 – 5 | 21% TDEI as snacks |
| Haveman-nies *et al.*, 1998 | 807 EU subjects 74 – 79y | 3d estimated record | 4.6 (1.5) M<br>4.7 (1.7) F | 11-12% for all<br>6-29% between countries |
| Drummond *et al.*, unpublished | 96 Scottish adults | | 4.11 M<br>4.31 F | NR |
| Gatenby, 1997 | Adults<br>Elderly<br>Very Elderly | 7d record | 6.5<br>6.02<br>5.6 | NR |
| Longnecker *et al.*, 1997 | 3182 American subjects, 19y+ | 1d 24hr recall & 2 day diet record | 3.47 ( > 0 MJ)<br>3.12 (> 0.29MJ)<br>2.80 (> 0.63MJ) | NR |
| Whybrow & Kirk, 1997 | 44 Scottish female students<br>17 – 30 y | 7d weighed record | 5.5 ( > 0 MJ)<br>4.8 ( ≥ 0.21MJ)<br>Range: 3.43 – 6.86 | 27-41% TDEI<br>2.38 meals<br>2.46 snacks/d |
| Kirk & Crombie, 1996 | British subjects | NR | 5 – 7 | |
| Schlettwein-Gsell & Barclay, 1996 | 1435 elderly Europeans, 74-79y | 3d food record | varied between countries, 3-7 | 7-32%, varied between countries |
| Bellisle *et al.*, 1995 | 16486 European students, 17-25y | Questionnaire | 4.4M<br>4.4F | 2.8 (0.9) meals/d<br>1.6 (1.2) snacks/d |
| Gatenby *et al.*, 1995 | 75 British adults | 7d weighed & unweighed record | 4.9 (0.12) eating<br>2.55 drinking<br>Range: 3 – 8.2 | 25% TDEI snacks<br>2.7-2.8 meals/d<br>1.6-1.7 snacks/d |
| Kant *et al.*, 1995 | 7147 US NHANES 1 (1971-75) & 7101 NHEFS (1982 –84), 25 – 74y | 24 hour recall (NHANES) & questionnaire (NHEFS) | 5.3 M; 4.9 F (NHANES)<br>3.6 M; 3.6F (NHEFS) | NR |
| Kirk *et al.*, 1995 | | | 4.9 (0.1) | NR |
| St Jeor *et al.*, 1995 | 484 American adults | NR | 5.9 M<br>6.1 F | NR |

| Author | Subjects | Dietary Assessment Method | Mean daily eating frequency | % Energy (TDEI) from Snacks & Additional Info |
|---|---|---|---|---|
| Summerbell *et al.*, 1995 | 59 British adults<br>40 middle-aged<br>88 elderly | 7d weighed diary | NR | 19% M, 19% F<br>26% M, 21% F<br>17% M, 18% F |
| Cross *et al.*, 1994 | 1422 American adults, 18y+ | Telephone interviews | NR | Modal snacking frequency of 2-3 times/d |
| McGrath & Gibney, 1994 | 92 Irish adult men | Food diary, unweighed | 4.0 – 4.6 | NR |
| Lennernäs *et al.*, 1993 | 16 Dutch male shiftworkers | 24 hour recall | 6.5 | NR |
| McBride *et al.*, 1990 | 36 men, 18-47y | 7d weighed record | 4.5 (> 0 MJ)<br>4.0 (> 0.5MJ) | NR |
| Dreon *et al.*, 1988 | 155 American obese men, 30-59y | 7d diet record | 4.5 | 18% TDEI as snacks |
| B.N.F. 1985 | 1000 British subjects | 24 hour recall | 6.5 | 1.68 meals/d<br>4.76 snacks/d |
| Baecke *et al.*, 1983 | 262 Dutch adults, 20-32y | 2 d diet record | NR | 34% M; 35% F TDEI as snacks |
| Khan & Lipke., 1982 | 250 American university students ≤ 24y | 24 hour recall | 4.34 & 4.96 for nutrition or non-nutrition student | NR |

NR = not reported; M = men; F = women; TDEI = total daily energy intake

**Table 1.1b: The Prevalence of Periodicity of Eating in Children & Adolescent Populations**

| Author | Subjects | Dietary Assessment Method | Mean daily eating frequency | % Total Daily Energy (TDEI) from Snacks |
|---|---|---|---|---|
| Crawley & Summerbell, 1997 | 731 British subjects<br>16 – 17y | 4d diet diary | 6.3 M<br>6.4 F | NR |
| Ruxton *et al.*, 1996 | Scottish children<br>7-8y | 7d weighed diary | NR | 26% |
| Samuelson *et al.*, 1996 | 411 Swedish adolescents, 15y | FFQ & 7d diet record | NR | 16% city<br>28% town |
| Summerbell *et al.*, 1995 | 33 British adolescents<br>13y | 7d weighed diary | NR | 29% M<br>24% F |
| Cross *et al.*, 1994 | 369 children, 12-13y | Telephone interviews | Modal snacking frequency of 2-3 times/d | NR |
| Anderson *et al.*, 1993 | 1009 Scottish adolescents, 15y | FFQ & Questionnaire | 5.5 (1.8)<br>2.7 (0.4) meals/d<br>2.8 (1.8) snacks/d | NR |
| H. P. Wales 1993 | 11 – 16y Welsh school children | Questionnaire | ↑ in 3+ snacks/d | NR |
| Robson & Strain, 1991 | 1015 N.I. adolescents<br>12-15y | Dietary History | NR | 30%: 12y<br>31 – 33%: 15y |
| Eastwood Garcia *et al.*, 1990 | Mexican pre-school children | | 13 | 45% |
| Livingstone, 1991 | 48 children<br>5 – 12y | Diet History | 6+ | 33% |

| Author | Subjects | Dietary Assessment Method | Mean daily eating frequency | % Total Daily Energy (TDEI) from Snacks |
|---|---|---|---|---|
| Magarey *et al.*, 1987 | 141 children 8y | NR | NR | 22-24% |
| Farris *et al.*, 1986 | 871 children, 10y | 24hour recall | NR | Approx. 33% |
| Skinner *et al*, 1985 | 225 American adolescents | 24 hour record | NR | 33% |

NR = not reported; M = men; F = women; H.P. = Health Promotion

## 1.2 METHODOLOGICAL ASPECTS OF THE STUDY OF PERIODICITY OF EATING

### 1.2.1 THE DEFINITION OF AN EATING OCCASION

The way in which an eating occasion or an eating event is defined is an important methodological challenge, which faces those interested in studying periodicity of eating. There is currently a lack of criteria available for defining an eating occasion and there is no agreement in the scientific literature on the criteria to be used (Gatenby, 1997; Gibney & Wolever, 1997; Lennernäs & Andersson, 1999). Terms such as 'meal' or 'snack' vary in their meaning between individuals and between cultures and the difference between a 'snack' and 'meal' lacks clarity. A comprehensive review on methodologies to study eating frequency recently highlighted this issue (Gatenby, 1997). This fact has also been realised by the Nutrition and Food Habits committee, which was set up by the International Union of Nutritional Sciences (IUNS) in 1994, to review the impact of changing food choice on nutritional status (Oltersdorf, 1996; Olstersdorf *et al.*, 1999). Because the methodology to study eating patterns lacked standardisation, the IUNS committee set up a research group to review the methodology to identify and assess eating patterns. The proceedings from this group's workshop, which was held in 1997, were published recently (Oltersdorf *et al.*, 1999). Table 1.2 lists the approaches used to define eating occasions in studies of eating patterns and the relative merits of each approach are considered below.

The term 'meal' is generally understood to represent one of the main eating occasions of the day, (breakfast, lunch and dinner) (Gatenby, 1997). The term 'snack' refers to other eating events, which are generally smaller and less structured (Gatenby, 1997). Indeed, most

researchers refer to eating occasions using the traditional and colloquial terms of breakfast, lunch, dinner (or evening meal) and snacks. The actual meaning of these terms is not consistent between studies however, depending on the criteria used to define an eating occasion. Researchers have defined eating occasions according to time, food type, food quantity, energy content or a combination of these criteria (Table 1.2).

#### 1.2.1.1 Time periods

Many researchers have divided the day into a number of defined time periods, which were then assigned one of the colloquial eating occasion terms (breakfast, lunch, dinner, snacks). Six feeding periods have been used to take account of breakfast, lunch, dinner and morning, afternoon and evening snacks (Magarey *et al.*, 1987; Summerbell *et al.*, 1995; 1996; Prättälä & Roos, 1999; Winkler *et al.*, 1999). Seven and eight feeding periods were also used (Dreon *et al.*, 1988; Haveman-nies *et al.*, 1998). The additional feeding periods used by Dreon *et al.*, (1988) and Haveman-nies *et al.*, (1998), were used to account for eating during the night or before breakfast. By imposing time constraints, the use of time periods to define eating occasions can have limitations in estimating mean daily eating frequency. This approach can underestimate the actual number of eating occasions that occur during the day, by combining several eating occasions that fall within a defined time period, into one eating occasion. It can also mask irregular eating patterns and suggest a more regular eating pattern of 3 meals a day, as 'snacks' may be classified as 'meals' if they fall within the defined time period for 'meals'.

#### 1.2.1.2 Colloquial terms of breakfast, lunch, dinner & snack

Other researchers have more loosely defined eating occasions as breakfast, lunch, dinner and snacks, according to the type of food consumed and the time of consumption (Skinner *et al.*, 1985; Viglietti & Skinner, 1987; Anderson *et al.*, 1993; Basdevant *et al.*, 1993; Ballard-Barbash *et al.*, 1994; Drummond *et al.*, 1996; Samuelson *et al.*, 1996; Siega-Riz *et al.*, 1998). Skinner *et al.*, (1985) and Viglietti & Skinner, (1987) considered breakfast, lunch and the evening meal as the eating occasions with the greatest variety of foods and consumed between 6am and 10am, between 11am and 2.50pm, and between 3.30pm and 10pm respectively. Other eating events that occurred within these defined times and all other eating events were classified as snacks. Drummond *et al.*, (1996) defined a meal as one of the main eating

occasions of the day, occurring in the morning (breakfast), midday (lunch) and evening (dinner) and snacks were considered to represent any food taken outside these eating times. Drummond *et al.*, (1996) considered food type in defining an eating occasion as follows. If a subject habitually consumed a breakfast food (e.g. cereal, toast, bacon, egg) 1 hour after rising, this was still considered a 'breakfast' eating event. Similarly, if a 'snack' type food (e.g. crisps, chocolate bar, fruit) was eaten at a time usually considered to be a 'meal' time, the eating occasion was considered a 'snack'. Samuelson *et al.*, (1996) used a similar approach to Skinner *et al.*, (1985) in classifying eating occasions as breakfast, lunch (before 3pm) and dinner (after 3pm). In this study however, only specific food items (i.e. ice-cream, buns, cakes, biscuits, sweets, soft drinks) were considered to represent 'snacks' and foods such as fruit, sandwiches, milk and cereal were classified as 'light meals' and not 'snacks'. The different approaches used to define an eating occasion with this particular approach (i.e. using the terms breakfast, lunch, dinner and snack), highlights the difficulties encountered when comparing and interpreting the results of these studies.

#### 1.2.1.3 Energy content & time difference between eating occasions

Eating occasions have also been defined according to the energy content of an eating occasion and a minimal time difference between eating occasions. Eating occasions of 0.2MJ, 0.42MJ, 0.63MJ and 0.84MJ have been used by De Castro for many years (De Castro, 1987; 1997) and more recently by Bellisle *et al.*, (1999). Energy intakes of 0.2MJ (Medaugh-Abernethy *et al.*, 1994; Whybrow & Kirk, 1997; King & Gibney, 1999), 0.29MJ (Longnecker *et al.*, 1997), 0.5 MJ (McBride *et al.*, 1990) and 0.84MJ (Redondo *et al.*, 1997) have also been used to define eating occasions. Time spans between eating occasions have varied from 15 minutes to 90 minutes (De Castro, 1987; Bellisle *et al.*, 1999; King & Gibney, 1999). A limitation of defining eating occasions according to their energy content is that the actual number of eating occasions that an individual has during the day may not be accurately determined. Different mean daily eating frequency results were obtained for populations when different energy intake definitions were used (McBride *et al.*, 1990; Longnecker *et al.*, 1997; Whybrow & Kirk, 1997, Table 1.2). A mean daily eating frequency of 4.84 was observed in Scottish women when eating occasions were defined as $\geq$ 0.2MJ of energy but this increased to 5.5 when all energy containing (>0MJ) eating occasions were included (Whybrow & Kirk, 1997).

Excluding eating occasions of < 0.2MJ excluded white tea and coffee with sugar, diet drinks and some servings of fruit. Longnecker *et al.*, (1997) observed a mean daily eating frequency of 3.12 in American adults of the 1987-1988 Nationwide Food Consumption Survey, when eating occasions of ≤ 0.29MJ were excluded. This value increased to 3.47 eating occasions per day when eating occasions of > 0MJ were included. The eating occasions of ≤ 0.29MJ were identified as tea, coffee and low calorie beverages. Defining eating occasions using the energy content of an eating occasion can influence the outcome and interpretation of the study in which it is used. McBride *et al.*, (1990) found the correlation between energy intake and eating frequency to be significant only, when an eating occasion provided more than 0.5MJ of energy.

#### 1.2.1.4 Consideration to non-nutritive eating occasions

A more accurate estimate of periodicity of eating may be obtained by ensuring that all eating occasions have an energy value of > 0MJ. This approach was used by some researchers (McBride *et al.*, 1990; Kant *et al.*, 1995, Wahlqvist *et al.*, 1999). This approach however excludes water, black tea or coffee and low calorie beverages. Indeed, whether eating occasions should refer to only eating occasions which involve eating something or should also include beverages or 'drinking' occasions, is another issue to be considered when defining eating occasions (Gatenby, 1997).

Some researchers consider beverages consumed without food, but which have an energy value, as an eating occasion (McBride *et al.*, 1990; Wahlqvist *et al.*, 1999) but others do not (Cross *et al.*, 1994; Drummond *et al.*, 1998; Mäkelä *et al.*, 1999). Gatenby *et al.*, (1995) observed a mean daily number of drinks of 2.55 taken without food and a mean daily number of eating events of 4.9, in a study which asked adult subjects to self-define eating occasions as 'meals', 'snacks' or 'drinks'. The types of beverages, which were considered under the term 'drinks', were not reported however. Whether water, black tea or coffee and low calorie beverages should be included as eating occasions remains unclear but their inclusion may be important in addressing some research questions.

### 1.2.1.5 Researcher-defined or subject-defined eating occasions

In general, researchers take responsibility to define eating occasions although some researchers have asked subjects to name eating occasions during dietary assessment (Ballard-Barbash *et al.*, 1994; Bellisle *et al.*, 1995; Roos & Prättälä, 1997; Pfau *et al.*, 1999; Prättälä & Roos, 1999; Winkler *et al.*, 1999). Recently, Gatenby *et al.*, (1995) asked the subjects to define their individual eating occasions as 'meals' or 'snacks'. Whilst knowledge of individuals perceptions of different eating occasions is invaluable to understanding free-living eating patterns and may be invaluable to formulating dietary advice in relation to eating occasions, unfortunately clear views were not observed. Gatenby *et al.*, (1995) observed that conflicting views were held by the general public, regarding what constitutes a 'meal' or 'snack'. For example, a biscuit at 12.30pm may be classified as a 'meal' or a 'snack', depending on whether the time of day or food type was used as a means of classification. Roos & Prättälä, (1997) and Prättälä & Roos, (1999) have also observed subjects to have difficulty in defining some eating occasions. When subjects were asked to classify eating occasions as either a 'meal' or a 'snack', many eating occasions were not defined by subjects. These uncoded eating occasions provided more than 10% of total daily energy intake. The authors suggested allowing subjects to also use the term 'drinks', in addition to 'meal' or 'snack', as a means of decreasing the frequency of uncoded eating occasions (Roos & Prättälä, 1997).

At this time consensus needs to be reached on criteria for defining eating occasions in nutrition research. A level of objective standardisation is also needed to ensure the results of future studies can be compared and interpreted. It may be that specific approaches can be identified which are best suited to specific study objectives. Indeed, the specific objectives of the study will largely determine the approach to be used to define an eating occasion.

**Table 1.2: The criteria used to define eating occasions by different researchers in studies of eating patterns**

| Authors | Eating occasion definition | Meal | Snack | Energy content of eating occasion | Minimum time between eating occ. |
|---|---|---|---|---|---|
| Johnstone *et al.*, 2000 | | | Small inter-meal ingestive event | | |
| Bellisle *et al.*, 1999 | energy content & time | | | 0.2MJ<br>0.42MJ<br>0.63MJ | 15min<br>45min<br>90min |
| King & Gibney, 1999 | energy content & time | | | 0.2MJ | 1 hour |
| Mäkelä *et al.*, 1999 | eating events only | an eating event was every occasion of eating something, just a drink or only chewing gum or sweets were excluded. | | | |
| Pfau *et al.*, 1999 | self-defined eating occasion | breakfast, lunch, dinner | snacks | | |
| Prättälä & Roos, 1999 | 6 time-based periods | breakfast, lunch, dinner | morning, afternoon, evening | | |
| Wahlqvist *et al.*, 1999 | Eating episode* | breakfast, lunch, dinner | morning tea, afternoon tea, supper | | |
| Winkler *et al.*, 1999 | 6 feeding periods | breakfast, lunch, dinner | mid-morning, afternoon, late event | | |
| Drummond *et al.*, 1998 | time | An eating occasion was any occasion when food was taken & excluded drinks consumed in the absence of food | | | 15min. |
| Haveman-nies *et al.*, 1998 | 8 feeding periods | breakfast, lunch, evening meal | before breakfast, during morning, during afternoon, evening snack, during night | | |
| Siega-Riz *et al.*, 1998 | food type & time | breakfast, lunch, dinner, supper | snack | | |
| Crawley & Summerbell, 1997 | energy content & time | eating occasions were numbered sequentially through the day | | > 0 MJ | 30min. |
| De Castro, 1997 | energy content & time | | | 0.2MJ<br>0.42MJ<br>0.84MJ | 15min.<br>45min.<br>90min. |
| Longnecker *et al.*, 1997 | energy content & time | | | >0.29MJ<br>>0MJ | 15 min. |
| Redondo *et al.*, 1997 | energy content | breakfast, midmorning, main, light + main evening meal | | 0.84MJ | |
| Whybrow & Kirk, 1997 | 'normal' British eating patterns | breakfast, lunch, dinner | snack | ≥ 0.21MJ | 30 min. |
| Drummond *et al.*, 1996 | food type & time | breakfast, lunch, dinner | any food taken outside of meals | | |
| Ruxton *et al.*, 1996 | meal or snack | meal | food not eaten at a recognised meal time | | |

| Authors | Eating occasion definition based on: | Meal | Snack | Energy content of eating occasion | Minimum time between eating occ. |
|---|---|---|---|---|---|
| Samuelson *et al.*, 1996 | time & food type | breakfast, lunch, dinner, light meal | snack | | |
| Schlettwein & Barclay, 1996 | pre-defined | breakfast, midday meal, evening meal | Before breakfast during morning & afternoon, after dinner, during night | | |
| Bellisle *et al.*, 1995 | self-defined | meal | snack | | |
| Gatenby *et al.*, 1995 | self-defined meal or snack | meal | snack | | 30 min. |
| Kant *et al.*, 1995 | time & energy content | foods consumed as part of a meal were considered an eating occasion | | > 0 MJ | |
| St. Jeor *et al.*, 1995 | different location & time | | | | 30 min. |
| Summerbell *et al.*, 1995; 1996 | 6 feeding periods | breakfast, lunch, evening meal | mid-morning, mid-afternoon, evening snacks | > 0 MJ | ≥ 1 hour |
| Ballard-Barbash *et al.*, 1994 | time & subject definition | morning, mid-day, evening meal | Snack or beverage or something else, regardless of when consumed | | |
| Cross *et al.*, 1994 | time & food type | | any foods, excluding beverages, eaten at a time other than a meal | | |
| Medaugh-Abernethy *et al.*, 1994 | time & energy content | | | 0.2MJ | 1 hour |
| Anderson *et al.*, 1993 | pre-defined | breakfast, lunch, dinner | morning, afternoon, evening | | |
| Basdevant *et al.*, 1993 | pre-defined | colloquial times | between meals | | |
| Lennernäs *et al.*, 1993; Lennernäs & Andersson, 1999 | nutrient density | reflects nutrient profile compared to dietary recommendations, 4 types | reflects nutrient density of snacks, 4 types | | |
| Robson & Strain, 1991 | usual eating pattern | breakfast, lunch, dinner | food or drink consumed between meals | | |
| Fricker *et al.*, 1990 | 4 defined eating occasions | breakfast lunch, dinner | extra-prandial consumption | | |
| McBride *et al.*, 1990 | time of British eating patterns or energy content | any food or drink other than black tea, coffee or water | | 0.5MJ | |
| Bellisle *et al.*, 1988 | usual eating pattern of 4 eating occasions | breakfast, lunch, dinner | afternoon snack | | |

| Authors | Eating occasion definition based on: | Meal | Snack | Energy content of eating occasion | Minimum time between eating occ. |
|---|---|---|---|---|---|
| Dreon *et al.*, 1988 | 7 defined time periods | breakfast, lunch, dinner | Postbreakfast postlunch, postdinner, m/n to breakfast | | |
| Dugdale *et al.*, 1988 | colloquial eating occasions | breakfast, lunch, dinner | morning, afternoon, before dinner, after dinner | | |
| De Castro, 1987 | energy content & time | | | 0.2MJ<br>0.63MJ<br>1 MJ | 15 min.<br>30 min.<br>60min. |
| Magarey *et al.*, 1987 | 6 feeding periods | breakfast, lunch, evening meal | morning tea, afternoon tea, supper | | |
| Viglietti & Skinner, 1987 | type & quantity of food & time | breakfast, lunch, evening meal | snack | | |
| McCoy *et al.*, 1986 | not stated | not stated | not stated | | |
| Rugg-Gunn *et al.*, 1986 | | | - made a minor contribution to daily intake.<br>- not eaten at recognized meal-time / place<br>- eaten when engaged in other activity | | |
| Skinner *et al.*, 1985 | type & quantity of food & time | breakfast, lunch, evening meal | snack | > 0 MJ | |
| Farris *et al.*, 1986 | macronutrient composition | a meal involved a mixture of food or a food that yields the macronutrient value of one serving of milk | snack = failure to meet the meal criterion, regardless of time or frequency of eating | | |
| Bernstein *et al.*, 1981 | energy content | | | > 0.37MJ | |
| Rotenburg, 1981 | presence or absence of fellow diners, social definition | planned social interaction centred on food | eating event conducted individually | | |
| Truswell & Darton-Hill, 1981 | usual eating pattern | breakfast, lunch, dinner | snacks | | |

* whenever a food/snack/meal/beverage was consumed it was considered an eating episode

**Energy definitions of eating occasions:**

50kcal = 0.21MJ
70kcal = 0.29MJ
100kcal = 0.42MJ
120kcal = 0.5MJ
150kcal = 0.63MJ
200kcal = 0.84MJ
250kcal = 1MJ

### 1.2.2 DIETARY ASSESSMENT METHODOLOGY & THE STUDY OF PERIODICITY OF EATING

There is currently no consensus on the dietary assessment method that yields the most precise or accurate information on the food intake of groups or individuals (Black *et al.*, 1991; Bingham, 1994; Livingstone, 1995). One or more of five basic methods are generally used to assess dietary intake. Two of these methods are records of actual consumption made at the time of eating, with the items of food and drink being weighed (weighed method) or estimated (estimated method), by the subjects. The other three methods assess food intake in the immediate, recent or distant past. Subjects are asked about their food intake in the past 24 hours (24 hour recall), over the past few weeks or months (diet history) or are asked how frequently certain foods are eaten during a specified period of time (food frequency questionnaire) (Bingham *et al.*, 1988; Thomas & B.D.A., 1994). Advantages and disadvantages are associated with all methods and have been comprehensively discussed by Marr, (1971) and Bingham, (1987). The purpose of the study will largely determine the most appropriate dietary assessment method to be used (Livingstone, 1995).

In studies of periodicity of eating, a dietary assessment method needs to be chosen which allows determination of the mean daily eating frequency in addition to usual food intake. The weighed and unweighed methods of dietary assessment being prospective methods reduce reliance on memory and recall errors and allow information on individual eating occasions to be recorded as eaten (Bone, 1992). On the other hand, the 24-hour recall and diet history method both rely on memory recall and an ability to describe food intake. Recording information at the time of food/drink consumption may increase the accuracy of information on individual eating occasions, which is the main focus of studies of periodicity of eating. Although a weighed record has potential to be a most accurate method, it may not capture detail on eating occasions if the subjects finds it too burdensome to complete and avoids eating or recording of eating occasions. Livingstone *et al.*, (1990) reported that a weighed intake had interfered with normal eating behaviour. The weighing of snack foods was reported to be onerous and irritating, which could result in under-reporting of such eating occasions (Livingstone *et al.*, 1990). More recently, Macdiarmid & Blundell, (1997) reported that 18% of subjects in the Leeds High Fat Study considered weighing of all foods to be of too

much inconvenience. Under-recording of snack foods was specifically mentioned. An unweighed method is simpler and less demanding for subjects than the weighed method (Bingham *et al.*, 1988) and may be more suited to studies of periodicity of eating. Although Rebro *et al.*, (1998) reported that healthy motivated women reduced the number of foods and snacks consumed during the completion of a 4-day unweighed food record. These results may have been influenced by the fact that this dietary assessment was undertaken to collect baseline data, at the beginning of a dietary intervention study to reduce dietary fat intake. It is important to note that although studies have compared food and nutrient intakes obtained using weighed and unweighed methods with approximate results (Edington *et al.*, 1989; Bingham *et al.*, 1994), no studies have yet compared data on mean daily eating frequencies assessed using different methods of dietary assessment. There is currently no consensus on the most suitable methodology to identify and assess eating patterns in free-living individuals (Gatenby, 1997; Oltersdorf *et al.*, 1999).

Diet records (weighed and unweighed), diet histories and 24 hour recalls have all been used in studies of eating frequency to date. The dietary assessment methods used to study periodicity of eating are presented in Table 1.3, according to different population groups. No one dietary assessment method has been used to specifically study periodicity of eating in any age group. Weighed records of 7 days, 5 days and 4 days duration and unweighed records of 7 days, 5 days, 4 days and 3 days duration have been used. A 3-day food record plus questionnaire (Prättälä & Roos, 1999), a 7-day food diary plus 7-day diet history (King & Gibney, 1999), a diet history (Basdevant *et al.*, 1993; Robson & Strain, 1991) and a 24 hour recall (Lennernäs *et al.*, 1993) have also been used in the study of eating frequency and nutrient intakes. Some studies, which were interested in establishing frequency of eating without knowledge of food and nutrient intakes, have used questionnaires to determine this information (Dugdale *et al.*, 1988; Anderson *et al.*, 1993; Bellisle *et al.*, 1995).

Given the potential benefits of an increased periodicity of eating, to not only the quality of the diet but also to health (see Section 1.3 and 1.4 respectively), determination of the most appropriate methods to study periodicity of eating is of great urgency in nutrition research.

**Table 1.3: Dietary assessment methods used to study periodicity of eating according to different population groups**

| Population | Dietary Assessment Method | Author |
|---|---|---|
| **Children** | | |
| 5-12y children | Diet History | Bellisle *et al.*, (1988); Livingstone, (1991) |
| 7-8y children | Weighed record | **4d:** Magarey *et al.*, (1987); **7d:** Ruxton *et al.*, (1996) |
| 10y children | 24 hour recall | Farris *et al.*, (1986) |
| **Teenagers** | Weighed record (7d) | Summerbell *et al.*, (1995;1996) |
| | Semi-weighed record (7d) | Samuelson *et al.*, (1996) |
| | Unweighed record (4d) | Crawley & Summerbell, (1997) |
| | Diet History | Robson *et al.*, (1991) |
| | 24 hour record | Skinner *et al.*, (1985) |
| | 24 hour recall & 2 day record | Siega-Riz *et al.*, (1998) |
| **Adults** | Weighed record (7d) | McBride *et al.*, (1990); Gatenby *et al.*, (1995); Summerbell *et al.*, (1995;1996); Whybrow & Kirk, (1997) |
| | Unweighed record (7d) | De Castro, (1987); Dreon *et al.*, (1988); Gatenby *et al.*, (1995); Drummond *et al.*, (1998); Bellisle *et al.*, (1999); Winkler *et al.*, (1999) |
| | Unweighed record (3d) | Arnold *et al.*, (1993); Prättälä & Roos, (1999) + questionnaire |
| | Diet History | Basdevant *et al.*, (1993) |
| | 24 hour recall | Metzner *et al.*, (1977); Lennernäs *et al.*, (1993); Kant *et al.*, (1995); Mäkelä *et al.*, (1999) |
| **Elderly** | Weighed record (7d) | Summerbell *et al.*, (1995;1996) |
| Institutionalised elderly | Weighed record (5d) | Redondo *et al.*, (1997) |
| Independent elderly | Unweighed record | **5d:** Redondo *et al.*, (1997), **3d:** Haveman-nies *et al.*, (1998) |

### 1.2.3 VALIDITY OF REPORTED FOOD INTAKES & THE STUDY OF PERIODICITY OF EATING

One of the greatest challenges in nutrition research is the collection of accurate food intake data. It is now well recognised that the majority of self-reported dietary intakes however are biased towards under-reporting of usual energy intakes (Schoeller, 1990; Livingstone, 1995; Black, 2000a). The prevalence of energy under-reporting in the majority of published studies is greater than 12%, with reports of up to 52% of individuals under-reporting energy intake in some studies (Heywood *et al.*, 1993; Ballard-Barbash *et al.*, 1996; Briefel *et al.*, 1997; Hirvonen *et al.*, 1997; Lafay *et al.*, 1997; Pryer *et al.*, 1997; Price *et al.*, 1997; Gnardellis *et al.*, 1998; Johansson *et al.*, 1998). It is not inevitable that mis-reporting of usual food intake will occur during dietary assessment. Highly motivated subjects have provided valid estimates of usual food intake (Prentice *et al.*, 1986; Goldberg *et al.*, 1991a; Black *et al.*, 1993). The skill and care of the researcher can also greatly improve the accuracy of the results (Thomas & B.D.A., 1994). Black, (2000a) has recently considered mis-reporting to be more accurately described by the phrase 'providing diet reports of poor validity' as under-eating, dieting, over-reporting and over-eating are all associated with mis-reporting of energy intake. Regardless of the terminology used to describe mis-reporting of energy intake, the accuracy of the food intake data collected in any dietary intake study is critical to the interpretation of the results. Therefore the validity of food intake data must be evaluated.

#### 1.2.3.1 Evaluation of the validity of food intake data

Ideally all dietary studies should incorporate independent measures of validity (Black *et al.*, 1993). A number of external independent markers of intake have been used (Black *et al.*, 1993; Bingham, 1994) to validate habitual food intake. Urine collections have been undertaken for 24-hour periods to validate protein intake using urinary nitrogen excretion, but this method is not suitable as a routine technique (Bingham, 1994). The doubly labelled water technique for measuring total energy expenditure has also been used to validate dietary assessment of energy intake (Prentice *et al.*, 1986). As this method requires that a subject takes a drink of isotope-labelled water and collects a single urine sample each day throughout the measurement period, it is an ideal field technique. However, as it is expensive and requires sophisticated laboratory backup, it is unsuitable for routine use (Black *et al.*, 1993;

Bingham, 1994, Livingstone, 1995). An alternative cost-effective technique proposed by Goldberg *et al.*, (1991b) and Black *et al.*, (1991) is to compare reported energy intakes, expressed as a ratio of energy intake to basal metabolic rate, to estimated energy expenditure to assess the validity of the reported food intake data. This technique simply requires that height and weight are measured as part of the study.

This technique firstly requires an estimation of basal metabolic rate ($BMR_{est}$) for each subject using age and measured weight (kg), according to the equations of Schofield *et al.*, (1985). The ratio of energy intakes to estimated basal metabolic rate ($EI/BMR_{est}$) is next calculated for each subject, before calculating the group mean $EI/BMR_{est}$ for the study group. The reported energy intakes of a study group can then be evaluated by comparing the mean $EI/BMR_{est}$ with a specific cut-off value derived by Goldberg equations (Goldberg *et al.*, 1991b; Black, 2000a). The cut-off value represents the lowest expected mean $EI/BMR_{est}$ for a study and takes into account the number of days surveyed and the population sample size.

The proportion of individuals in the study sample that are under-reporting can also be calculated using the Goldberg equations (Goldberg *et al.*, 1991b; Black, 2000a). The cut-off value that represents the lowest expected $EI/BMR_{est}$ value for one individual and considers the number of days of dietary assessment, can be used to identify individuals with reported energy intakes that do not reflect minimum expected estimates of energy intake during the dietary assessment period.

The validation of reported energy intakes using the Goldberg *et al.*, (1991b) cut-offs, which are based on a physical activity level (PAL) of 1.55, however does not necessarily identify all under-reporting which has been reported to occur across the full range of energy intakes and expenditures. This is because this PAL value of 1.55 is low and higher PAL values have been seen in many populations. Black, (2000b) recently reported only that 50% of under-reporters were identified using the Goldberg *et al.*, (1991b) criteria compared to actual energy expenditure data. Information on an individuals physical activity ideally needs to be collected, to calculate a study-specific PAL or to categorise individuals into low, medium or high activity, in order to increase the sensitivity of the cut-offs (Black *et al.*, 1996; Black *et al.*, 2000b).

### 1.2.3.2 Validity of reported eating patterns

In eating frequency research, evaluation of not only the validity of the reported energy intakes but also evaluation of the validity of the reported eating pattern or eating frequency is imperative. Such concern comes from the evidence of under-reporting of meals and snacks (Livingstone *et al.*, 1990; Summerbell *et al.*, 1996; Heitmann & Lissner, 1995; Briefel *et al.*, 1997; Poppitt *et al.*, 1998). In studies of eating frequency, mean daily eating frequency was lower in under-reporters than in those with valid records (Summerbell *et al.*, 1996; Drummond *et al.*, 1998). This finding highlights the importance of evaluating the validity of reported energy intakes in studies of periodicity of eating. Determination of whether differences exist in the mean daily eating frequencies of under-reporters compared to those with valid records also needs to be undertaken as if this is the case it may be necessary to exclude the under-reporters from any analysis. Evaluation of reported energy intakes and the proportion of under-reporters in a study group has generally not been undertaken in such studies until recently. Four studies addressed this issue during investigations of the relationship of periodicity of eating to body weight (Summerbell *et al.*, 1996; Crawley & Summerbell, 1997; Whybrow & Kirk, 1997; Drummond *et al.*, 1998). Two of these studies reported an inverse relationship between eating frequency and body weight status (Whybrow & Kirk, 1997; Drummond *et al.*, 1998) and two did not (Summerbell *et al.*, 1996; Crawley & Summerbell, 1997). Such an evaluation was recently stressed as an important requisite of eating frequency research to avoid the interpretation of spurious relationships (Summerbell *et al.*, 1996; Bellisle *et al.*, 1997; Gatenby, 1997; Kirk, 2000). Kirk, (2000) advised identification of under-reporters and their exclusion from analysis to study the relationship of body weight status with eating frequency.

### 1.2.3.3 Dieters and the validity of reported food intake data

Dieting affects not only reports of usual energy intake (Heitmann, 1993; Briefel *et al.*, 1997; French *et al.*, 1999) but also snack and meal patterns (Blair *et al.*, 1989; Bellisle *et al.*, 1995; Rossner, 1995; Booth, 1996; Crawley & Summerbell, 1997; French *et al.*, 1999). Reducing calorie intake between meals was found to be strongly associated with weight loss maintenance (Blair *et al.*, 1989; Booth, 1996). In a study of 16,486 university students in 21 European countries, Bellisle *et al.*, (1995) observed that dieters reported fewer snacks and that

female dieters also reported fewer meals than non-dieters. In a 4 year weight gain prevention study, participants mentioned reducing energy intake, eliminating snacks and skipping meals among the weight control behaviours used (French *et al.*, 1999).

As dieters will be a significant part of free-living populations, a decision will need to be made about whether dieting subjects should be excluded or included from nutrition research analysis. Bellisle *et al.*, (1995) observed 18% of women and 2.3% of men to be dieting in Ireland in the International Health and Behaviour Survey. There have been suggestions that even higher proportions (25-43%) of a free-living population may be dieting (Klesges *et al.*, 1987; Williamson *et al.*, 1992; Price *et al.*, 1997; Blokstra *et al.*, 1999). The prevalence of dieting is difficult to determine as the most appropriate questions to ask to identify dieters is unclear (French *et al.*, 1999). Particular attention however needs to be given to this issue in studies of periodicity of eating to allow results to be correctly interpreted.

#### 1.2.3.4 Other factors & validity of reported food intake data

Underestimation of reported energy intakes has been observed is some subgroups of the population. Women underreported their energy intakes more than men (Briefel *et al.*, 1995; Klesges *et al.*, 1995) and lower than expected energy intakes were reported in overweight and obese individuals (Prentice *et al.*, 1986; Schoeller, 1990; Lichtman *et al.*, 1992; Heitmann, 1993; Ballard-Barbash *et al.*, 1996; Briefel *et al.*, 1997; Lafay *et al.*, 1997). Under-reporting of energy intakes has also been identified in post-obese subjects (Black *et al.*, 1995), restrained eaters (Prentice *et al.*, 1986; Bingham *et al.*, 1995) and some authors have suggested that subjects from lower socio-economic groups have an increased tendancy to report low energy intakes (Livingstone *et al.*, 1990; Rutishauser *et al.*, 1994). Attempts can be made to address the influence or effect of some of these factors in dietary intake studies.

*Body Weight status*

As the overweight or obese are likely to under-report energy intake body weight can be measured during the study or subjects who are overweight or obese may be excluded from the study depending on the specific research question to be addressed. Such an assessment is particularly important in eating frequency research in light of suggestions of specific eating

occasions being under-reported by the obese (Heitmann & Lissner, 1995). It has been suggested that obese subjects under-report snacks, which would effect the validity of the reported eating frequency data of free-living populations. The under-eating of snacks by the overweight or obese as a method to lose weight following weight gain, has also been suggested as a reason for the lower than expected energy intakes obtained during dietary assessment in these groups. Such alterations of eating frequency have been referred to as the issue of reverse causality or post hoc alterations in diet pattern (Bellisle *et al.*, 1997; Kirk, 2000). Indeed there have been reports that the overweight are more likely to be dieting at any point in time than are individuals who are not overweight (Ballard-Barbash *et al.*, 1996; Blokstra *et al.*, 1999). This has particular relevance to addressing the relationship between body weight status and periodicity of eating (see Section 1.4.3). More recent evidence however, which associated under-reporting with failure to record snack foods in between meals, reported no difference between lean and obese females in the under-reporting of snacks in a metabolic study (Poppitt *et al.*, 1998). Whether these results can be extrapolated to free-living adults is as yet unknown. Nonetheless the weight status of populations must be determined in studies of periodicity of eating to allow for a clear interpretation of the results.

*Restrained eating*

Questionnaire methods have been developed to measure dietary restraint (Stunkard & Messick, 1985; Van Strien *et al.*, 1986), a distorted attitude to eating. Restrained eaters are often, but not necessarily, overweight and have an amplified consciousness of food, body weight and body image which tends to result in an eating pattern fluctuating between periods of successful restraint and disinhibition (binges). Restrained subjects may not be detected through questions on weight reduction but may nevertheless report energy intakes comparable to dieters and may in fact use the dietary assessment period as a period of dietary restriction (Price *et al.*, 1997). Restrained eaters use basic foods and snacks with the same frequency as unrestrained eaters though the quantities eaten may be different between groups (Tuschl *et al.*, 1990). Restrained eaters may make different food choices in an attempt to 'save' calories and the use of high-fat foods may be kept to periods of over-eating (Tuschl *et al.*, 1990). Poppitt *et al.*, (1998) observed great differences in accuracy of dietary reporting between restrained and unrestrained eaters in a metabolic study in which food intake was measured for 24h,

followed by a 24h recall. Energy intake from meals was poorly reported by restrained eaters and well reported by unrestrained eaters but snacks were badly reported by both groups. These results have implications for studies of periodicity of eating, though it is not clear to what extent these findings occur in free-living populations. The inclusion of dietary restraint questionnaires as part of a study can help the interpretation of the study results.

In summary, it is critical that attention is paid to these methodological issues when studying periodicity of eating and its relationship to diet and health.

## 1.3 THE DIETARY IMPLICATIONS OF AN INCREASED PERIODICITY OF EATING

As discussed in section 1.1, the current prevalence of periodicity of eating, knowledge of a 'grazing' pattern of eating among children and adolescents has contributed to interest in determining how snack consumption affects the nutrient quality of the diet. The consumption of snacks is generally considered negatively and snacks are perceived to be high in fat and composed of 'empty calories' (Thomas & Call, 1973; Chapman & Maclean, 1993; Roos *et al.*, 1993; Drummond *et al.*, 1996; Whybrow & Kirk, 1997). Indeed, the traditional pattern of eating three meals a day and avoiding eating between meals, is deeply ingrained in the publics mind, as the ideal eating pattern (British Nutrition Foundation, 1985; Kearney, 1994). The elimination of snacks is common practice in dieting individuals (Bellisle *et al.*, 1995; Booth, 1996; French *et al.*, 1999). To clarify the accuracy of these widely held notions, different types of investigations have been undertaken in nutrition research to determine the dietary implications of consuming snacks. Work in this area is limited to date however and studies have addressed this issue in many different ways. Most studies have involved children and adolescent populations and little research has been done in adult populations. The types of investigations, which have been undertaken to date, include the following which are next discussed in turn.

1. Determination of the contribution that 'snacks' make to total daily nutrient intake.
2. Determination of the contribution that the individual eating occasions of the day make to total daily nutrient intake.

3. Determination of the effect of different periodicities of eating on mean daily nutrient intakes.
4. Comparison of the nutrient composition of 'meals' and 'snacks'.
5. Comparison of the nutrient composition of the individual eating occasions of the day.

## 1.3.1 THE CONTRIBUTION OF 'SNACKS' TO TOTAL DAILY NUTRIENT INTAKE

### 1.3.1.1 The contribution of 'snacks' to total daily energy intake

As discussed in section 1.1 and detailed in Tables 1.1a and 1.1b (the current prevalence of periodicity of eating), examination of the percentage of total daily energy intake coming from snacks showed that snacks make a significant contribution to daily energy intake. In summary, adults derived 20-25% (Gatenby *et al.*, 1995; Summerbell *et al.*, 1995; Drummond *et al.*, 1996; Winkler *et al.*, 1999) and children and adolescents derived 16-33% of daily energy intake from snacks (Baecke *et al.*, 1983; Livingstone, 1991; Robson & Strain, 1991; Bartkiw, 1993; Ruxton *et al.*, 1996; Summerbell *et al.*, 1995; Samuelson *et al.*, 1996). The contribution that snacks made to daily energy intake in elderly populations however, varied from country to country, 7 - 32% (Summerbell *et al.*, 1995; Schlettwein-Gsell & Barclay, 1996; Haveman-nies *et al.*, 1998).

Some studies addressed the contribution of 'snacks' to the daily intake of other nutrients (Farris *et al.*, 1986; McCoy *et al.*, 1986; Magarey *et al.*, 1987; Robson & Strain, 1991; Ruxton *et al.*, 1996). These studies were undertaken in children and adolescent populations. Studies in adult populations could not be found. These studies demonstrated that, contrary to popular opinion, snacks made an important contribution to mean daily nutrient intake, particularly to fat, carbohydrate, total sugar and dietary fibre intake. Snacks also made a valuable contribution to daily micronutrient intake. Therefore it is incorrect to assume that 'snacks' are a source of 'empty calories'. Nevertheless it is important to note that contribution that 'snacks' made to daily micronutrient intake differed between studies. The findings of these studies are discussed below.

### 1.3.1.2 The contribution of 'snacks' to total daily macronutrient intake

Table 1.4 shows that snacks provided 20-33% of total daily fat intake, 13-40% of carbohydrate intake and 14-22% of protein intake in children and adolescent populations (Farris *et al.*, 1986; McCoy *et al.*, 1986; Magarey *et al.*, 1987; Robson & Strain, 1991; Ruxton *et al.*, 1996). Farris *et al.*, (1986) examined the diets of 871 10y old American children from the Bogulasa Heart Study using a 24hr recall and showed that snacks provided 33% of daily fat intake, 40% of carbohydrate intake and 20% of protein intake. In a study of 8y old Australian children, Magarey *et al.*, (1987) observed that snacks provided 20% of daily fat intake and 13% of daily protein intake. Carbohydrate intake from snacks was not reported in this study. Ruxton *et al.*, (1996) surveyed 136 7-8y old Scottish children with a 7d weighed record. Snacks accounted for almost one third of daily fat intake, as per Farris *et al.*, (1986), 26% of carbohydrate intake and 14% of protein intake. The contribution of 'snacks' to adolescent populations was studied by McCoy *et al.*, (1986) and Robson & Strain, (1991). Robson & Strain, (1991) surveyed 1015 adolescent children in Northern Ireland using a diet history and snacks provided 29-32% of total fat intake, 33-35% of total carbohydrate intake and 20-22% of total protein intake. In a study of 1224 adolescents, McCoy *et al.*, (1986) found that snacks provided 22% of daily fat intake, 27% of carbohydrate intake and 14% of protein intake.

**Table 1.4: The contribution of 'snacks' to total daily macronutrient intake**

| Author | Subjects | Contribution of 'snacks' to daily macronutrient intake | | | |
|---|---|---|---|---|---|
| *Children* | | **Fat (%)** | **CHO (%)** | **Protein (%)** | **Total Sugars (%)** |
| Farris *et al.*, 1986 | 871 10y Americans | 33% | 40% | 20% | NR |
| Magarey *et al.*,1987 | 141 8y Australians | 20% | 13% | NR | 39% |
| Ruxton *et al.*, 1996 | 136 7-8y Scottish children | 29% | 26% | 14% | 27% |
| *Adolescents* | | | | | |
| McCoy *et al.*, 1986 | 1224 girls | 22% | 27% | 14% | NR |
| Robson & Strain, 1991 | 1015 12y & 15y Northern Ireland adolescents | 29-32% | 33-35% | 20-22% | 44-46% |

NR=not reported

### 1.3.1.3 The contribution of 'snacks' to total daily sugar, fibre and micronutrient intake

Magarey *et al.*, (1987), Robson & Strain, (1991) and Ruxton *et al.*, (1996) also examined the contribution of 'snacks' to total daily sugar and micronutrient intake. 'Snacks' provided 39%, 44-46% and 27% of total daily sugar intake for the different study groups, respectively (Table 1.4), (Magarey *et al.*, 1987; Robson & Strain, 1991; Ruxton *et al.*, 1996). Magarey *et al.*, (1987) observed 21-23% of fibre, 17% of iron, 22% of calcium, 27% of vitamin C and 16% of thiamin intake to be derived from 'snacks' in the 8y olds. 'Snacks' provided 27% of total NSP, 20% of iron, 15% of calcium, 21% of vitamin C and 6-15% of the intake of other micronutrients in the 7-8y olds studied by Ruxton *et al.*, (1996). In adolescents, 'snacks' provided 25-28% of daily iron, 32-34% of calcium, 28% of vitamin C and 21-26% of daily thiamin and riboflavin (Robson & Strain, 1991). McCoy *et al.*, (1986) observed snacks to provide 15-20% of the daily mineral intake and 13-17% of the vitamin intake in adolescents.

The differences observed between these studies, in the contribution that 'snacks' made to daily nutrient intake, may be valid differences occurring between the different age groups studied. When comparing the results however, methodological differences between the studies must also be considered. The dietary assessment method used varied between studies and the criteria used to define an eating occasion also varied between the studies (see Table 1.2), which makes it extremely difficult to compare the results. Farris *et al.*, (1986) considered snacks to be all eating occasions whose macronutrient composition did not equal that of one serving of milk. McCoy *et al.*, (1986) however, defined snacks as all foods not identified as part of a meal. Magarey *et al.*, (1987) divided the day into 6 feeding periods with snacks occurring in three defined time periods (morning tea, afternoon tea and supper), which means that 'snacks' eaten during the defined periods for meal-times were incorrectly considered as 'meals'. On the other hand, Robson & Strain, (1991) and Ruxton *et al.*, (1996) considered snacks to be foods and drinks not consumed at usual 'meal-times'. Furthermore, these studies were undertaken with different objectives. Farris *et al.*, (1986) and Magarey *et al.*, (1987) investigated the distribution of total daily nutrient intake between all the eating occasions of the day whereas McCoy *et al.*, (1986), Robson & Strain, (1991) and Ruxton *et al.*, (1996) were only interested in 'snack' eating occasions.

In addition to examining the percentage contribution of 'snacks' to daily nutrient intake, other approaches were also used to examine the contribution that 'snacks' made to daily nutrient intake. The absolute average daily nutrient intake value provided by all 'snacks' in comparison to all meals was examined (McCoy *et al.*, 1986; Ruxton *et al.*, 1996). In addition, nutrient intake from 'snacks' was also expressed as a percentage of recommended intakes (Cala *et al.*, 1980; Khan & Lipke, 1982; Skinner *et al.*, 1985; McCoy *et al.*, 1986; Ruxton *et al.*, 1996). Ruxton *et al.*, (1996) found energy intake from 'snacks' was 25% of estimated average requirements and protein intake from 'snacks' was 25% of reference nutrient intakes (RNI). Intakes of vitamin C and nicotinic acid from 'snacks' were one third of the RNI. Intakes of iron and calcium from 'snacks' were just over a fifth of the RNI. 'Snacks' provided between 9% and 20% of the RNI for other vitamins. McCoy *et al.*, (1986) showed that 'snacks' contributed greatly to the intake of riboflavin, vitamin C and thiamin, providing 52%, 43% and 39% of the recommended daily allowance (RDA) respectively (McCoy *et al.*, 1986). The nutrients that 'snacks' contributed to in the lowest amounts relative to recommended amounts were folate, vitamin D, zinc and iron providing 8%, 9%, 10% and 11% of the RDA respectively. An earlier study of 250 American college students, also found almost one quarter of the RDA for energy to come from 'snacks' (Khan & Lipke, 1982). 'Snacks' provided from 3.5-34.8% of the RDAs for different nutrients. 'Snacks' provided 13.4-24.1% of the RDA for protein, 13.5-29% of the RDA for vitamin C, 14-30% of the RDA for calcium and 11-35% of the RDA for iron in this study. Had it not been for an intake of 'snacks', the authors concluded that the desired energy level for all subjects, iron and calcium level for women and vitamin A and thiamin level for some men, would have been below the RDA level (Khan & Lipke, 1982).

### 1.3.2 THE CONTRIBUTION OF THE INDIVIDUAL EATING OCCASIONS OF THE DAY TO TOTAL DAILY NUTRIENT INTAKE

Rather than simply examining the contribution of 'snacks' to daily nutrient intake, the contribution that each of the individual eating occasions of the day make to average daily nutrient intake or the distribution of daily nutrient intake between the different eating occasions of the day was also examined. This investigation of eating patterns provides insight into how the different eating occasions of the day contribute to daily nutrient intake, in the

context of each other. It allows a more appropriate and realistic assessment of the contribution that 'snacks' make to daily nutrient intake. The contribution that 'snacks' make to daily nutrient intake is compared to the contribution that each of the individual eating occasions of the day make to daily nutrient intake, rather than being considered in isolation or simply compared to the nutrient contribution of all 'meals' to daily nutrient intake. This means that a specific eating occasion can be more correctly identified as being a major contributor to the intake of a particular nutrient. For example, some studies which examined the percentage contribution of snacks to daily nutrient intake found 'snacks' to make a significant contribution (almost 33%) to daily fat intake (Robson & Strain, 1991; Ruxton *et al.*, 1996). Ruxton *et al.*, (1996) suggested that the consumption of lower fat 'snacks' may help to decrease overall percentage energy from fat in 7-8y old children. Before specifically targeting 'snacks' however, it is more appropriate to also examine the contribution that the other eating occasions of the day make to daily nutrient intake. This type of investigation improves our understanding of free-living eating patterns and contributes to more informed planning in the formulation and implementation of practical dietary guidelines. As observed before, much of this work has been carried out in children and adolescents and data on adults is scarce at this time.

#### 1.3.2.1 The contribution of the individual eating occasions of the day to total daily energy intake

Regarding energy intake, the evening meal (dinner) generally provided as much as one third of daily energy intake in children and adolescents. Breakfast and lunch provided 10-20% and 20-25% of energy intake respectively and 'snacks' provided 20-33% (Samuelson, 1971; 1996; Truswell & Darton-Hill, 1981; Skinner *et al.* 1985; Farris *et al.*, 1986; Magarey *et al.*, 1987). The distribution of daily energy intake through the day was also examined in 262 Dutch young adults aged 20-32y (Baecke *et al.*, 1983). Dinner again provided the greatest amount of daily energy intake (almost one third), with breakfast, lunch and 'snacks' providing 11%, 20-23% and 16-18% respectively, as observed in the younger populations. Samuelson *et al.*, (1996) investigated the distribution of daily energy intake across daily eating occasions on weekdays and weekend days in Swedish adolescents. Differences were found with energy intakes from breakfast, dinner and 'snacks' increasing at the weekend and intakes from lunch and light

meals decreasing at the weekend. This observation is important to improving our understanding of free-living eating patterns. The distribution of energy between the individual eating occasions of the day was also examined according to weight status (Bellisle *et al.*, 1988). The evening meal contributed to one third of daily energy intake in the obese French children, as observed in the other studies, but it provided closer to a quarter of daily energy intake in normal weight children. Conversely, breakfast and the afternoon snack contributed more to daily energy intake in normal weight children (18-19% and 13-14% respectively) than in overweight and obese children (15-18% and 10% respectively). Such an investigation may have implications for weight reduction strategies and dietary advice regarding the distribution of energy intake between the eating occasions of the day.

More recently the distribution of energy intake through the day was examined in elderly Europeans as part of the 1993 SENACA survey (Schlettwein-Gsell & Barclay, 1996). The main meals of the day, the mid-day meal and dinner, contributed to most of the daily energy intake (54-82%). Though whether the midday meal or dinner provided the most energy tended to vary from country to country. Breakfast provided 11-28% of energy intake and 'snacks' provided 7-32%, depending on the country. Clearly, an examination of the distribution of daily nutrient intake between the eating occasions of the day, allows the impact of 'snack'-type eating occasions on daily nutrient intake to be more appropriately judged.

#### 1.3.2.2 The contribution of the individual eating occasions of the day to total daily macronutrient intake

The distribution of the total daily intake of other nutrients through the day, besides energy, was examined in some studies (Truswell & Darton-Hill, 1981; Magarey *et al.*, 1987). The evening meal was also found to be a major source of daily protein intake (approx. 40%) and daily fat intake (approx. 36%) in Australian children and adolescents, see Table 1.5 (Truswell & Darton-Hill, 1981; Magarey *et al.*, 1987). Breakfast, lunch and snacks provided 16-20%, 25% and 13-18% of daily protein intake respectively and 15-17%, 25-28% and 20-23% of daily fat intake respectively (Truswell & Darton-Hill, 1981; Magarey *et al.*, 1987). Sugar, starch and fibre intake were examined by Magarey *et al.*, (1987). Snacks contributed greatly to daily sugar intake (39%), as observed by others (Farris *et al.*, 1996; Robson & Strain,

1991), with breakfast and the evening meal providing about 21% each and lunch providing 19% (Magarey *et al.*, 1987). Lunch provided the most of daily starch intake (over 30%), with almost a quarter of daily intake from each of breakfast and dinner and 16% from snacks. The intake of daily fibre was fairly evenly distributed between the three main meals and snacks, with just over a quarter coming from the evening meal and slightly less than a quarter from snacks. The range of individual values for the proportion of daily nutrient intake coming from the different eating occasions was rather wide however.

**Table 1.5: The distribution of daily nutrient intake across the individual eating occasions of the day (%)**

| Nutrient | Author | Breakfast | Lunch | Dinner | Snacks |
|---|---|---|---|---|---|
| **Total Fat** | Truswell & Darton-Hill, 1981 | 15 | 25 | 37 | 23 |
| | Magarey *et al.*, 1987 | 17 | 28 | 36 | 20 |
| **Total Protein** | Truswell & Darton-Hill, 1981 | 16 | 25 | 41 | 18 |
| | Magarey *et al.*, 1987 | 20 | 25 | 43 | 13 |
| **Total Sugar** | Magarey *et al.*, 1987 | 21 | 19 | 21 | 39 |
| **Total Starch** | Magarey *et al.*, 1987 | 25 | 32 | 27 | 16 |
| **Fibre** | Magarey *et al.*, 1987 | 24 | 25 | 28 | 23 |
| **Calcium** | Truswell & Darton-Hill, 1981 | 26 | 19 | 26 | 28 |
| | Magarey *et al.*, 1987 | 30 | 23 | 26 | 21 |
| **Iron** | Truswell & Darton-Hill, 1981 | 23 | 23 | 37 | 9 |
| | Magarey *et al.*, 1987 | 24 | 26 | 33 | 17 |
| **Vitamin C** | Truswell & Darton-Hill, 1981 | 14 | 19 | 27 | 27 |
| | Magarey *et al.*, 1987 | 20 | 20 | 33 | 27 |
| **Thiamin** | Truswell & Darton-Hill, 1981 | 28 | 22 | 28 | 20 |
| | Magarey *et al.*, 1987 | 35 | 24 | 25 | 16 |

### 1.3.2.3 The contribution of the individual eating occasions of the day to total daily micronutrient intake

Few studies have examined the distribution of daily micronutrient intake between the eating occasions of the day (Truswell & Darton-Hill, 1981; Magarey *et al.*, 1987). Breakfast provided almost one third of daily calcium intake, the evening meal provided just over one quarter and lunch and snacks each provided just under one quarter in 8y old Australian children (Magarey *et al.*, 1987). Truswell & Darton-Hill, (1981) demonstrated that snacks

provided 28% of the daily calcium intake of Australian adolescents, breakfast and dinner provided 26% and lunch provided 19% (Table 1.5). All main meals made important contributions to daily iron intake and the evening meal contributed the greatest amount (33%-37%) (Truswell & Darton-Hill, 1981; Magarey *et al.*, 1987). Snacks provided 17% of the daily iron intake of the 8y olds (Magarey *et al.*, (1987) but only 9% of the iron intake of the adolescents (Truswell & Darton-Hill, 1981). In both studies, the evening meal was also the most significant contributor to daily vitamin C intake (27-33%), snacks provided 27%, lunch provided approximately 20% and breakfast provided 14-20% of daily intake. Breakfast was a major source of thiamin intake (28-35%), lunch and the evening meal provided 22-24% and 25-28% respectively and snacks provided 16-20% of daily thiamin intake (Magarey *et al.*, 1987; Truswell & Darton-Hill, 1981).

This approach allows the contribution of 'snacks' to mean daily nutrient intake to be assessed in the context of the other eating occasions of the day. In studies which examined the percentage contribution of 'snacks' to daily nutrient intake (Farris *et al.*, 1986; McCoy *et al.*, 1986; Robson & Strain, 1991; Ruxton *et al.*, 1996), 'snacks' provided a significant proportion of mean daily fat intake, (20-33%, see Table 1.4). The studies of Truswell & Darton-Hill, (1981) and Magarey *et al.*, (1987) however, demonstrated that although 'snacks' made a significant contribution to mean daily fat intakes, 20-23% (Truswell & Darton-Hill, 1981; Magarey *et al.*, 1987), lunch and dinner were actually the main sources of total dietary fat intake, 25-28% and 36-37% respectively. This approach also demonstrates the significant contribution that 'snacks' made to daily micronutrient intakes in comparison to other daily eating occasions, in children and adolescent populations. Truswell & Darton-Hill, (1981) found that 'snacks' provided more calcium than the other eating events in Australian adolescents and Magarey *et al.*, (1987) observed 'snacks' to provide almost comparable amounts of calcium as lunch in Australian children. 'Snacks' also contributed more to daily vitamin C intake than lunch or breakfast (Truswell & Darton-Hill, 1981; Magarey *et al.*, 1987).

When using this approach to obtain insight into the contribution that individual eating occasions of the day make to average daily nutrient intakes, the method chosen to define an

eating occasion is critical to the results that will be obtained. Truswell & Darton-Hill, (1981) provide no information on the criteria used to define eating occasions as 'breakfast', 'lunch', 'dinner' or 'snacks'. Margarey *et al.*, (1987) divided the day into six feeding periods, corresponding to breakfast, morning tea, lunch, afternoon tea, evening meal and supper, but collapsed data from morning tea, afternoon tea and supper into one category called 'snacks'. By collapsing the nutrient intake from 'snacks' consumed at different times of the day into one value, information as to whether there is an association between the time of the day of snack consumption and the contribution that 'snacks' make to daily nutrient intake is lost. Truswell & Darton-Hill, (1981) reported that mid-afternoon 'snacks' provided 12% of daily energy intake with morning and evening 'snacks' providing 6% and 8% respectively. This type of information is invaluable to provide a thorough understanding of the impact of 'snacks' on the nutrient quality of the diet and the formulation of targeted and evidence-based dietary guidelines that involve 'snack' consumption.

### 1.3.3 THE EFFECT OF DIFFERENT PERIODICITIES OF EATING ON MEAN DAILY NUTRIENT INTAKES

Another approach to examining the effect of eating frequency on the diet, is to examine the nutrient intakes of those subjects with different periodicities of eating. In recent years, some researchers have used this approach (Basdevant *et al.*, 1993; Redondo *et al.*, 1997; Roos & Prättälä, 1997; Whybrow & Kirk, 1997; Drummond *et al.*, 1998).

Basdevant *et al.*, (1993) examined the average nutrient intakes of 273 obese French women by dividing the group into snackers (those who ate between usual meal times and had at least 15% of total daily energy intake from 'snacks') and non-snackers (the others). Redondo *et al.*, (1997) divided 150 Spanish elderly subjects into 3 groups, those who took two meals a day, three meals a day and four meals a day. Roos & Prättälä, (1997) compared the average daily nutrient intakes of 1689 Finnish men and women, when divided into those with at least 3 meals a day or 2 or less meals a day. Whybrow & Kirk, (1997) divided a group of 44 Scottish women into tertiles of eating frequency and compared their nutrient intakes. Drummond *et al.*, (1998) studied a group of 79 Scottish men and women and correlated mean daily eating frequency with mean daily nutrient intake.

Mean daily energy intakes were greater in those who ate more frequently (Basdevant *et al.*, 1993; Redondo *et al.*, 1997; Roos & Prättälä, 1997; Whybrow & Kirk, 1997). Drummond *et al.*, (1998) found eating frequency to be positively correlated with daily energy intake in women only however. Anderson *et al.*, (1997) also found the number of eating occasions to be significantly correlated with energy intake in women only.

With regard to macronutrient intakes, Basdevant *et al.*, (1993) found higher fat and lower protein intakes in snackers, when intakes were expressed as percentages of total energy. No differences were observed in carbohydrate intakes (% energy). In a study which investigated eating frequency and blood cholesterol concentrations, a higher fat intake (absolute intake) was also observed in those who ate more frequently (≥ 4 meals/d or 3 meals/d vs. 1-2meals/d), (Edelstein *et al.*, 1992). Conversely, a lower fat intake (% total energy) was observed in subjects with a high meal-eating frequency compared to when these subjects lowered their meal-eating frequency, which was associated with a significant increase in fat intake (McGrath & Gibney, 1994). Carbohydrate intake (% total energy) was found to be greater in those with a high eating frequency in two studies (Redondo *et al.*, 1997; Drummond *et al.*, 1998). Redondo *et al.*, (1997) observed a difference in carbohydrate intake only, with an increase in the proportion of total energy from carbohydrate with the number of meals taken. Drummond *et al.*, (1998) found a positive correlation between mean daily eating frequency and carbohydrate intake (% total energy). Roos & Prättälä, (1997) observed differences in alcohol intake only. Those with at least 3 meals a day had a small but significantly lower percentage of total energy from alcohol than those with 2 or less meals a day (1.2 vs. 1.9% respectively). In contrast to the above findings, Whybrow & Kirk, (1997) observed no difference in macronutrient intakes between those who ate more and less frequently.

Data on differences in total sugar intake in those with different periodicities of eating was presented in two studies (Roos & Prättälä, 1997; Drummond *et al.*, 1998). There was no difference in percentages of total energy from sugar in those who ate 3 or more meals a day and those who ate 2 or less meals per day (Roos & Prättälä, 1997). There was a significantly positive correlation observed however between eating frequency and total daily sugar intake,

in women only, when sugar was expressed in absolute intakes (Drummond *et al.*, 1998). No correlation was found between eating frequency and daily sugar intake when sugar was expressed as a percentage of total energy (Drummond *et al.*, 1998).

Regarding micronutrient intakes, Whybrow & Kirk, (1997) found a tendancy of higher mean daily micronutrient intakes in the highest tertile of eating frequency although this was only significant for vitamin A. Roos & Prättälä, (1997) examined vitamin C and carotenoids (mg/10MJ) only and observed daily vitamin C intake to be lower in those with a higher eating frequency (3 or more meals a day). Redondo *et al.*, (1997) also examined the contribution of nutrient intake to meeting nutrient recommendations with variation in the number of meals taken however (2, 3 or 4 meals/d). As the number of meals taken per day increased, the diet improved, as observed by the greater approximation to recommended intakes, for protein, fibre, vitamin C, thiamin, riboflavin, calcium, magnesium and iodine. The intake of the micronutrients seems to be conditioned by energy intake as no differences were observed in nutrient intake/1000kcal between the groups studied.

These authors made the following conclusions regarding the effect of periodicity of eating on the nutrient quality of the diet. Whybrow & Kirk, (1997) concluded, that snacking did not compromise the diet quality of the group studied by diluting the vitamin and mineral content of the diet. This study suggested that those with a high snacking frequency were not choosing an unbalanced diet, but were compensating partly by eating more food and partly by choosing a wider variety of snack foods which overall tend to be more micronutrient dense. Roos & Prättälä, (1997) concluded that meal pattern did not influence the healthfulness of the diet and that it was impossible to state whether a particular meal pattern was associated with attaining a more healthy diet. Redondo *et al.*, (1997) concluded however that as the number of meals taken increased, so too did the covering of theoretical energy expenditure. The intake of a range of nutrients also came closer to recommendations. This study favoured an increased periodicity of eating as a method of improving nutritional status in the elderly. Drummond *et al.*, (1998) suggested that a higher eating frequency may lead to a higher carbohydrate:fat ratio and that such a change in macronutrient profile is considered to favour weight control and the maintenance of a lower BMI.

It must be concluded that the effect of periodicity of eating on the nutrient quality of the diet is not clear at this time. There have been too few studies conducted from which to draw conclusions. Furthermore, as discussed previously, the lack of standardisation regarding the most appropriate methodology to be used to study eating frequency and the criteria used to define an eating occasion, make it difficult to interpret existing data and may explain the different results obtained. Studies varied in the dietary assessment methods used. A 7 day weighed record (Redondo *et al.*, 1997; Whybrow & Kirk, 1997), 7 day unweighed record (Redondo *et al.*, 1997; Drummond *et al.*, 1998), 3 day record plus questionnaire (Roos & Prättälä, 1997) and diet history (Basdevant *et al.*, 1993) were used. As discussed in section 1.2.2, there is evidence that weighed records may result in the under-reporting of eating occasions such as snack type eating occasions (Livingstone *et al.*, 1990; Macdiarmid & Blundell, 1997). This may explain the finding of Whybrow & Kirk, (1997) of no difference in macronutrient intakes (% energy) in those with high and low periodicities of eating.

The studies discussed above lack consistency in the criteria used to define an eating occasion and the method used to compare those with different periodicities of eating. Whybrow & Kirk, (1997) defined eating occasions according to 'normal' British eating patterns of breakfast, lunch, dinner and snack but also defined an eating occasion as having ≥ 0.21MJ of energy. This approach however, did not identify all the eating occasions of the day of this group, the mean daily eating frequency increased from 4.84 to 5.5 eating occasions/day, when eating occasions of > 0MJ of energy were included. Different results may have been obtained had this group been divided into tertiles using the latter mean daily eating frequency value. Redondo *et al.*, (1997) defined eating occasions as ≥ 0.84MJ, which may mask an even greater number of eating occasions. Roos & Prättälä, (1997) did not specifically investigate differences in nutrient intake according to the mean daily number of eating occasions/day per se but rather differences in meal patterns. A 3 or more meal per day pattern, which involved the consumption of a breakfast, warm lunch and warm dinner was compared to a meal pattern of 2 meals or less per day. On the other hand, Drummond *et al.*, (1998) defined eating occasions as any occasion when food was taken with a time difference of 15min. between eating occasions. This definition provides a greater opportunity of identifying all the eating occasions of the day and thus would result in a greater number of daily eating occasions being

identified than the definitions used in the other studies. It is noteworthy however that Drummond *et al.*, (1998) excluded drinks which were consumed in the absence of food, unless the drink was milk in excess of 0.5 of a pint, when the nutrient contribution was considered to be equivalent to a food. Different results may have been obtained if all eating occasions of > 0MJ were considered, irrespective of whether the eating occasion was a food or a drink.

### 1.3.4 THE NUTRIENT COMPOSITION OF 'SNACKS' AND 'MEALS'

With the realisation that the consumption of snacks was becoming popular, especially with adolescents and children, concerns grew about the nutrient content of snacks (Thomas & Call, 1973). There were fears that the consumption of snacks would increase the fat content of the diet. Indeed snacks are popularly perceived to be high in fat (Drummond *et al.*, 1996). Studies were thus undertaken which examined the nutrient composition of 'snacks' compared to 'meal' eating occasions. Table 1.6 summarises the limited number of studies, that investigated the macronutrient composition of 'meals' and 'snacks' consumed by adults, children and adolescents to date.

#### 1.3.4.1 Energy and macronutrient content of 'meals' & 'snacks'

'Meals' were generally larger (MJ of energy) than 'snacks' (Ruxton *et al.*, 1996; Whybrow & Kirk, 1997). Contrary to popular opinion, 'snacks' were generally of lower fat density than 'meals', with 'snacks' deriving 26-38% of total energy from fat and 'meals' deriving 36-43% of total energy from fat. There were exceptions however. Ruxton *et al.*, (1996) found that 7-8y old British children ate 'snacks' with a higher percentage of total energy from fat (43%) than 'meals' (36%) and Gatenby *et al.*, (1995) and Drummond *et al.*, (1998) found no difference in the fat content of 'meals' and 'snacks'. The percentage of total energy from protein was generally found to be lower in 'snacks' than 'meals', 6-12% vs. 12-19% respectively.

Results varied between studies in the carbohydrate content of 'meals' and 'snacks'. There was no difference between 'meals' and 'snacks' in the percentage of total energy derived from

carbohydrate in some adult, children and adolescent populations (Summerbell *et al.*, 1995; Ruxton *et al.*, 1996; Samuelson *et al.*, 1996; Whybrow & Kirk, 1997). 'Snacks' were found to be higher in carbohydrate compared to 'meals' however, in other adolescent and adult groups, 50-55% vs. 39-46% for 'snacks' and 'meals' respectively (McCoy *et al.*, 1986; Basdevant *et al.*, 1993; Gatenby *et al.*, 1995; Summerbell *et al.*, 1995; Drummond *et al.*, 1998). It is important to be aware however, that results can vary depending on whether the energy from alcohol is included in the calculations or not. Whybrow & Kirk, (1997) found no difference in the percentage of total energy from carbohydrate between 'meals' and 'snacks', but when energy from alcohol was excluded, 'snacks' provided a significantly greater percentage of energy from carbohydrate than 'meals'. 'Snacks' were also found to have a larger sugar content than 'meals', (% total energy) 25-36% vs. 14-22% respectively (Summerbell *et al.*, 1995), though Ruxton *et al.*, (1996) observed similar sugar densities between 'meals' and 'snacks'. Previous researchers have also found snack foods to be higher in sugar and lower in protein compared with meals (Truswell & Darton-Hill, 1981; Rugg-Gunn *et al.*, 1986; Morgan *et al.*, 1988). Summerbell *et al.*, (1995) have suggested that the lower fat content of 'snacks' may be due to the fact that items such as soft drinks, tea and coffee with sugar and alcoholic drinks are eaten 'between meals', in addition to eating higher fat foods such as crisps and chocolate. Thus, when these food and drink items were analysed together, 'snacks' were thus not found to be higher in fat compared to 'meals'. The higher fat content of 'snacks' observed by Ruxton *et al.*, (1996) may be due to the high consumption of crisps in this group of 7-8y olds.

The nutrient composition of 'snacks' compared to 'meals' was generally examined in terms of the macronutrient composition of the eating occasions expressed as a proportion of total energy, as just described. The nutrient density of 'snacks' compared to 'meals' was examined by presenting nutrient intake per 100kcal or per MJ to determine differences in micronutrient intake between 'snacks' and 'meals' (Thomas & Call, 1973; Bigler-Doughten *et al.*, 1987; Ruxton *et al.*, 1996; Redondo *et al.*, 1997; Whybrow & Kirk, 1997).

### 1.3.4.2 Micronutrient content of 'meals' & 'snacks'

Ruxton *et al.*, (1996) found the 'snacks' of 7-8y old children had a lower density of protein, vitamin A, $B_1$, $B_2$, folate, nicotinic acid equivalent, vitamin C and iron compared with 'meals'. Redondo *et al.*, (1997) examined the energy density of the 'meals' of an elderly population who ate two, three and four times a day and found no difference between groups in the energy density of the 'meals'. Whybrow & Kirk, (1997) showed that 'snacks' had a lower protein and fat density than 'meals' but no difference in total carbohydrate density. 'Snacks' were significantly more sugar dense and less starch dense than meals. 'Snacks' were significantly less nutrient dense for NSP, minerals and vitamins, except vitamin C. When alcohol energy was removed there was a trend towards increased micro-nutrient density for snacks, except folate and iron (Whybrow & Kirk, 1997). These studies used different criteria to define eating occasions however, which makes the results difficult to compare. Ruxton *et al.*, (1996) defined eating occasions as a 'meal' (food eaten at a recognised meal time) or 'snack' (food not eaten at a recognised meal time), whereas Redondo *et al.*, (1997) only examined eating occasions with an energy content of at least 0.84 MJ. Whybrow & Kirk, (1997) defined eating occasions according to 'normal' British eating patterns of breakfast, lunch, dinner and snacks but also defined an eating occasion as having $\geq$ 0.21MJ.

It is noteworthy that determination of the nutrient content of 'meals' and 'snacks' by considering all the 'meals' of the day as one mean value and all the 'snacks' of the day as one mean value, masks details of possible variation in the nutrient composition of eating occasions at different times of the day. For example, Ballard-Barbash *et al.*, (1994) have observed that the percentage of total energy from fat in snacks was lower than that in midday and evening meals but similar to that in morning meals. Clearly the data currently available on the nutrient composition of 'meals' and 'snacks' cannot be considered conclusive. Details of the actual foods being consumed during eating occasions is also important to understand the impact of individual eating occasions to the food and nutrient intakes of the diet.

**Table 1.6: The nutrient composition of 'meals' and 'snacks'**

| Author | Subjects | Meal definition | Meal (% energy) | | | | Snack definition | Snack (% energy) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | n & age (y) | | Fat | CHO | Protein | Total Sugars | | Fat | CHO | Protein | Total sugars |
| **Adults** | | | | | | | | | | | |
| Drummond *et al.*, 1998 | n=79 20-55y | regular meal-time | 42 | 41 | 17 | - | outside regular meal-time & in place of meal | 40 | 50 | 10 | - |
| Whybrow & Kirk, 1997 | n=44 17-30y | 50 kcal & meal-times | 37.3 37.7* | 45.8 46.2* | 15.5 15.7* | NR | 50kcal and between meals | 30.7 35.2* | 47 54.5* | 7.2 8.2* | NR |
| Gatenby *et al.*, 1995 | n=75 18-60y | self-defined | 37 | 45 | 16 | NR | self-defined | 38 | 50 | 10 | NR |
| Summerbell *et al.*, 1995 | n=59 17-60y | time periods | 39.0 | 43.9 | 14.5 | 16.3 | time periods | 31.5 | 47.8 | 8.9 | 32.3 |
| Summerbell *et al.*, 1995 | n=40 39 –59y | time periods | 42.6 | 41.7 | 15.1 | 13.9 | time periods | 37.7 | 44.2 | 11.5 | 25.8 |
| Summerbell *et al.*, 1995 | n=88 65-91y | time periods | 39.8 | 46.3 | 13.7 | 21.5 | time periods | 34.4 | 48.8 | 10.6 | 34.4 |
| Ballard-Barbash *et al.*, 1994 | n=1032 19-50y | name & time | 27/38/ 40** | NR | NR | NR | self-defined | 26.3 | NR | NR | NR |
| Basdevant *et al.*, 1993 | n=273 18-65y | usual times | 41 | 39 | 19 | NR | between meals | 34 | 54 | 11 | NR |
| **Children & adolescents** | | | | | | | | | | | |
| Ruxton *et al.*, 1996 | n=136 7-8y | meal-time | 36.0 | 50.1 | 13.6 | NR | not at meal-time | 42.6 | 51.4 | 6.0 | NR |
| Samuelson *et al.*, 1996 | n=411 15y | time & food type | 36 | 45-60 | 12-16 | NR | time & food type | 34 | 60 | 6 | NR |
| Summerbell *et al.*, 1995 | n=33 13-14y | time periods | 40.7 | 46.1 | 13.1 | 15.5 | time periods | 37.7 | 55.0 | 8.1 | 35.5 |
| McCoy *et al.*, 1986 | n=1224 12-16y | NR | 39.6 | 43.1 | 15 | NR | NR | 32.2 | 55.1 | 7.0 | NR |

NR= not reported; * percentage of food energy from each macronutrient; ** refers to % of energy from fat in the morning, midday and evening meal respectively; CHO=carbohydrate

### 1.3.5 THE NUTRIENT COMPOSITION OF THE INDIVIDUAL EATING OCCASIONS OF THE DAY

Another approach to obtain an understanding of the nutrient content of 'snacks' compared to the other eating occasions of the day is to investigate the nutrient composition of the individual eating occasions of the day also referred to as the temporal pattern of nutrient intake during the day. This information allows the nutrient quality of individual eating occasions to be evaluated in the context of each other and provides greater insight rather than simply comparing the nutrient composition of 'meals' and 'snacks'. Despite its potential value, this approach however, has received little attention to date.

Only 7 studies were found in the literature that investigated the temporal pattern of nutrient intake throughout the day. Meal patterns were analysed and presented as nutrient intake on an hourly basis by De Castro, (1987) in a study of 38 American students and by Roos & Prättälä, (1997) in a dietary survey of 1689 adult Finns. De Castro, (1987) also presented nutrient intake during 6 three-hour time periods, and per meal during 18 hourly time periods. Clear 24-hour rhythms for energy and macronutrient intakes were observed. The amount eaten per meal and the meals content of carbohydrate or fat but not protein varied over the day with peaks at lunch and dinner periods (De Castro, 1987). Roos & Prättälä, (1997) considered the pattern of energy intake through the day to correspond to the conventional three-meal pattern of one energy peak at breakfast time, one at lunch time and one at dinner time. Little detail was provided in both studies however, as to the exact calculations that were used in determining the mean nutrient content of eating occasions and a meal was defined by De Castro, (1987) as having an energy content of at least 50kcal (0.2MJ), 150kcal (0.63MJ) or 250kcal (1MJ).

Analysis of the average food and nutrient content of traditional Dutch eating occasions throughout the day (i.e. breakfast, lunch, dinner, snacks) was presented in reports of the Dutch national food consumption survey of 1987-1988 (vd Es *et al.*, 1989; Kistemaker & Aarnick, 1989; Kistemaker & Löwik, 1991. Four different methods were presented to calculate the average intakes (food or nutrients) per eating occasion and particular attention was given to a number of issues to be considered during these calculations, including the number of subjects

and the consumers of a meal, food or nutrient. The need to publish details of definitions and calculations used was stressed by these authors. Lennernäs *et al.*, (1993) used a qualitative food based approach of nutritionally 'complete' and 'incomplete' meals to present the nutrient content of eating occasions of 16 Swedish male adult shift-workers. The nutrient content of four types of eating occasions (morning, midday, evening, snacks), defined by time and name of the meal, were presented by Ballard-Barbash *et al.*, (1994), using dietary intakes of 1032 American adult women, with full details of the calculations used. The mean percentage of total energy derived from fat was lower in snacks than at the midday and evening meals, but similar to that of morning meals.

The nutrient composition of six eating occasions defined roughly by time were calculated by Westerterp-Plantenga *et al.*, (1996) in a study of energy intake adaptation in 68 Dutch women. A clear pattern of energy and macronutrient intake during the day was observed, with energy intake as well as fat intake increasing during the day and carbohydrate intake decreasing during the day. Differences were found between obese and non-obese women in this study group however. The temporal switch in the carbohydrate and fat content (% energy) of eating occasions occurred earlier in the day in the obese and more gradually in the non-obese subjects. Also, the obese ate more at their evening meal than the non-obese. Little information was provided on the calculations used.

The nutrient content of three eating occasions defined according to time periods (morning, afternoon, evening) was recently presented by Bellisle *et al.*, (1999) from a group of 16 French students. Lunch and dinner were equal in energy content with dinner richer in alcohol energy and breakfast was almost half the energy content of lunch and dinner. As before, little information was provided on the calculations used in this study.

Interpretation of the results of these few studies of the temporal pattern of nutrient intake throughout the day and comparisons between studies is challenged however by a number of factors. The definition of an eating occasion varied between studies, the exact details of the calculations used were not always reported, the dietary assessment methods differed, the study samples varied by age and gender and the samples were from different populations with

different cultural aspects to eating behaviour. More research in this area is required with a particular need for attention to the methodological aspects of undertaking these studies.

## 1.4 THE HEALTH IMPLICATIONS OF AN INCREASED PERIODICITY OF EATING

An increased periodicity of eating has been found to have implications for human health. It may be associated with reduced risk of coronary heart disease (CHD) and has been considered beneficial in the treatment of diabetes mellitus and obesity. The first group to study the implications of eating frequency on human health was led by Pavel Fabry in Prague in the mid 1950s. Little work was undertaken subsequently, until the 1980s, when interest was renewed in studying this area. The current consensus on the relationship of an increased periodicity of eating with CHD, diabetes mellitus and obesity are described later in this section. The possible negative relationship of an increased periodicity of eating on dental caries is also described. In this section, the term 'meal' is used in place of the objective term 'eating occasion', as authors have generally used the term 'meal' in their studies to describe the number of eating occasions that were taken by subjects each day (e.g. three meals/d vs. nine meals/d).

### 1.4.1 AN INCREASED PERIODICITY OF EATING & REDUCED RISK OF CHD

Suggestions that an increased frequency of eating is associated with a reduced risk of CHD began in the 1960s. The effect of 'nibbling' and 'gorging' on serum lipids was examined and it was demonstrated that plasma lipid levels were higher on the 'gorging' diet. Accordingly the authors proposed that a reduced eating frequency was associated with an increased risk of CHD (Gwinup *et al.*, 1963a; Fabry *et al.*, 1968). Epidemiological studies also indicated that frequency of eating was inversely related to hypercholesterolaemia (Fabry *et al.*, 1964; Edelstein *et al.*, 1992). Edelstein *et al.*, (1992) examined plasma cholesterol concentrations in 2034 American men and women aged 50-89y consuming 1-2 meals/d, 3 meals/d or 4 or more meals/d. Plasma total cholesterol concentrations and low density lipoprotein (LDL) cholesterol concentrations were lower, in those with the greatest number of eating occasions

per day (-0.23mmol/L and -0.16mmol/L, respectively). These associations persisted after adjustment for smoking, alcohol, waist-hip ratio, systolic blood pressure, body mass index and dietary nutrients. Redondo *et al.*, (1997) found the number of meals taken per day in a group of elderly Spanish subjects to be negatively correlated with serum total cholesterol, very low density lipoprotein (VLDL) cholesterol and triacylglycerol (TAG) levels. More recently, Powell *et al.*, (1999) observed that a 'nibbling' eating pattern was associated with significantly lower plasma cholesterol levels in smokers, with or without peripheral arterial disease. Hence it was concluded that smokers with a 'grazing' eating pattern had a reduced risk of developing symptomatic peripheral atherosclerosis. As these findings were derived from cross-sectional data therefore these results should be interpreted with caution.

#### 1.4.1.1 Studies of an increased periodicity of eating on blood lipids in normolipidaemic individuals

Intervention studies were also undertaken which directly compared the effects of diets with different eating frequencies on fasting blood lipids, in healthy normolipidaemic subjects and in hyperlipidaemic subjects. Different results were observed and the findings observed to date are described in the next two sections.

Studies of normolipidaemic subjects in which the experimental diets were followed for a minimum of 2 weeks or more are presented in Table 1.7. In summary, total and LDL-cholesterol were lower when subjects had a diet with six or more eating occasions daily, compared to diets with three or less eating occasions daily. Nevertheless it is important to note that the study designs were different between studies. The studies varied in the cohort size, the macronutrient composition of the background diet, the range of eating frequencies used, energy intakes and the presentation of the diet (e.g. formula diets, self-preparation of foods). Jenkins *et al.*, (1989) and Arnold *et al.*, (1993) used a randomised crossover design and careful dietary supervision to ensure total energy intake and macronutrient distribution were comparable on the experimental diets. While the results of these two studies showed very favourable reductions in total and LDL-cholesterol, both have limitations with regard to the formulation of practical recommendations from their findings. Jenkins *et al.*, (1989) compared the consumption of daily nutrient intake as 3 meals/d vs. 17 meals/d and Arnold *et*

*al.*, (1993) compared the consumption of 3 meals/d vs. 9 meals/d. The consumption of 17 and 9 eating occasions per day is clearly impractical as a recommendation for the public at large, given the prevalence of periodicity of eating of 5-6 times a day (Section 1.1). Both studies were also of limited duration (2 and 4 weeks respectively). Adaptation to dietary change is a well-recognised phenomenon and there is no clear evidence of whether adaptation might occur in this context. One early study (Cohn, 1964) suggested this might be the case. More recently, McGrath & Gibney, (1994) investigated the effect of increasing and decreasing habitual eating frequency on lipid metabolism. Two cohorts with a 'high meal-eating frequency' (6 meals/d) and a 'low meal-eating frequency' (3 meals/d) adopted the opposite eating pattern, after a stabilisation period of 3 weeks. Increased eating frequency caused a significant reduction in total and LDL-cholesterol. The nutrient content of the diet was not altered when eating frequency was increased whereas protein, fat and saturated fatty acids intakes (% energy) increased and alcohol (% energy) intakes decreased when habitual 'snackers' reduced their eating frequency (McGrath & Gibney, 1994).

The alterations in plasma total and LDL-cholesterol with an increased eating frequency may explain the observation of a lower incidence of CHD when eating frequency is high (Fabry *et al.*, 1968). It is estimated that every 1% change in total cholesterol is associated with a 2% change in CHD risk (Lipid Research Clinic Program, 1984). Accordingly, the 6.5% reduction in plasma cholesterol levels which occurred when eating frequency was increased from three to nine meals per day could be associated with a mean 13% decrease in CHD risk (Arnold *et al.*, 1993). Furthermore according to McGrath & Gibney, (1994) if eating frequency is increased from three to six meals per day there could theoretically be a mean 16% reduction in the risk of CHD. Clearly such findings encourage further research to establish whether altered frequency of eating could be an effective means of reducing risk of CHD.

*Proposed mechanisms by which periodicity of eating influences CHD risk*

With regard to possible mechanisms by which an increased frequency of eating can bring about the favourable reductions in total and LDL-cholesterol, two possible mechanisms have been proposed. One mechanism maintains that an increased eating frequency reduces insulin activation of β-hydroxy-β-methylglutaryl-coenzyme A (HMG-CoA) reductase, a key enzyme

of hepatic cholesterol synthesis. The reduction in serum cholesterol levels may thus result from the reduction in hepatic cholesterol synthesis, secondary to the maintenance of euglycaemia at lower serum insulin levels (Jenkins *et al.*, 1989). A reduction in cholesterol synthesis may also result in an increase in LDL receptors, further lowering serum cholesterol levels. Jenkins *et al.*, (1989) clearly demonstrated decreased mean diurnal insulin levels and reduced 24 hour urinary C-peptide output on the nibbling (17meals/d) as compared with the three meal/d diet. Arnold *et al.*, (1993) also observed a pattern of lower 24h insulin levels on the nibbling (9meals/d) diet compared to the three meal/d diet, though statistically significant differences were not observed. Furthermore, Jones *et al.*, (1993) found reduced cholesterol synthesis as well as reduced insulin and gastric inhibitory polypeptide (GIP) concentrations on the six meals/d diet, although this study was of short duration (3d on each diet comparing six and three meals daily).

The other proposed mechanism, by which an increased eating frequency may reduce serum total and LDL-cholesterol, suggests that increased eating frequency is associated with a more frequent and effective activation of reverse cholesterol transport (RCT), a key step in promoting hepatic oxidation of cholesterol. Removal of cholesterol via this route is greatly increased during the postprandial phase (Fielding, 1987), even after only small amounts of fat are ingested and therefore may be facilitated when eating frequency is increased (O Flaherty & Gibney, 1994).

*The effect of eating frequency on other indicators of lipid metabolism*

There is much less evidence available on the effect of eating frequency on the other indicators of lipid metabolism and cardiovascular risk. Existing data suggests inconsistent results. Arnold *et al.*, (1993) found a very small and marginally significant reduction in high density lipoprotein (HDL) cholesterol on three vs. nine meals daily, a finding not confirmed by Jenkins *et al.*, (1989). There is no consistent evidence for differences in fasting TAG or free fatty acid levels with varying eating frequency. Some investigators (Bortz *et al.*, 1969; Wadhwa *et al.*, 1973; Jenkins *et al.*, 1992) have suggested differences in TAG and free fatty acid levels during the day with altered eating frequency, but in well conducted studies it appears that eating occasion-related fluctuations, even with extreme variation in eating

frequency, are modest or negligible (Schlierf & Dorrow, 1973; van Gent *et al.*, 1979; Jenkins *et al.*, 1989; Wolever *et al.*, 1990). A very recent study of eleven young women has compared the effects of twelve and three meals daily on postprandial TAG, non-esterified fatty acids, glucose, insulin, GIP, glucagon-like peptide-1 levels as well as fasting lipids and lipoproteins and lipoprotein lipase activity after 2 weeks on each diet. The only significant difference between the two diets was a small but significant increase in HDL-cholesterol in subjects following the 'gorging' diet compared to the 'nibbling' diet (Murphy *et al.*, 1996). A recent animal study has investigated the effect of a 'nibbling' and 'gorging' eating pattern on postprandial lipaemia and atheroma deposition (Juhel *et al.*, 2000). Atheroma deposition was significantly increased with a 'gorging' eating pattern. The authors concluded that a 'gorging' eating pattern favoured atheroma deposition by reducing the rate of TAG- and cholesterol-rich lipoproteins clearance (Juhel *et al.*, 2000).

**Table 1.7: Studies of altered periodicity of eating on fasting blood lipids and lipoproteins in normolipidaemic individuals**

| Authors | Subjects | Background diet* | Meal frequency & Duration of study | Results |
|---|---|---|---|---|
| **Gwinup *et al.*, (1963a)** | 2 pts with slightly raised lipids, 3 pts with normal lipids | Usual foods, 44% fat, 38% CHO | 1 vs. 3 vs. 10 meals/d 14d or longer on each diet | Decrease in lipid levels when changing from 3 to 10 meals/d |
| **Nunes & Canham, (1963)** | 11M, baseline TC NR | NR | 2 vs. 9 meals/d 6weeks on each, crossover design | Significant change in cholesterol from control period, but not sustained |
| **Cohn, (1964)** | 5M, 1F. Baseline TC 5.7mmol/L | Usual diet, macronutrient content NR | 3 meals/d x 2 weeks & 6 meals/d for 4 weeks | Lower serum cholesterol on 6 meals/d after 2 weeks but reversion to initial levels after 4 weeks |
| **Bortz *et al.*, (1966)** | 6F, obese, 19-56y, baseline TC 5.3mmol | Restricted energy liquid formula diet (2500kJ/d) 38% fat, 53% CHO, 6% fat, 45% CHO | 1 vs. 3 vs. 9 meals/d, approx. 20 d on each diet | Reduction in cholesterol & TAG associated with weight loss, independent of meal frequency |
| **Irwin & Feeley, (1967)** | 15F, 17-21y, baseline TC 4.4mmol/L | 38% fat, 55% CHO | 3 equal meals/d or 2 small & 1 large meal/d vs. 6 equal meals/d, 20d on each | Lower cholesterol on 3 equal meals/d, but general increase in cholesterol over study period |
| **Young *et al.*, (1972)** | 10M, 21-27y, baseline TC 5.5mmol/L | 38% fat, 44% CHO, cholesterol 855mg | 1 vs. 6 meals/d, 5 weeks on each diet, randomised crossover | Cholesterol 8.7% higher on one meal/d compared to 6 meals/d |

| Authors | Subjects | Background diet* | Meal frequency & Duration of study | Results |
|---|---|---|---|---|
| **Wadhwa *et al.*, (1973)** | 13M, 20-30y, baseline TC 5.1-5.4mmol/L | 40% fat, 47% CHO | 2 vs. 8 meals/d, 4 weeks on each diet, randomised sequence | No significant differences on the 2 diets |
| **Peters *et al.*, (1979)** | 8M, 20-30y, baseline TC 5.4-5.5mmol/L | Usual fat & CHO | 3 vs. 8 meals/d, 2 weeks on each diet, randomised crossover | No significant differences on the 2 diets |
| **Jenkins *et al.*, (1989)** | 7M, 31-51y, baseline TC 5.1-5.3mmol/L | 33% fat, 52% CHO | 3 vs. 17 meals/d, 2 weeks on each, crossover design | Reduction of TC (8.5%), LDL-cholesterol (13.5%) & apo-B (15.1%) on 17 meals/d |
| **Arnold *et al.*, (1993)** | 9M, 10F, mean age 32y, baseline TC 4.49mmol/L | 30% fat, 54% CHO | 3 vs. 9 meals/d, 2 weeks on each, randomised crossover design | Reduction of TC (6.5%), LDL-cholesterol (8.1%) & HDL-cholesterol (4.1%) on 9 meals/d vs. 3 meals/d. |
| **McGrath & Gibney, (1994)** | 12M with 6meals/d & 11M with 3.1meals/d, mean age 29-30y, mean baseline TC 4.8 & 5.0mmol/L | 39% fat, 41-44% CHO | Those eating 6 times/d changed to 3 & those eating 3 times/d increased to 6 | Increasing from 3 to 6 meals/d, associated with significant reduction in TC (8%) and LDL-cholesterol (12%) |

* % values are % of total energy; Pts=patients; CHO=carbohydrate; M=men; F=women; TC=total cholesterol; NR=not reported; TAG=triacylglycerol; LDL=low density lipoprotein

### 1.4.1.2 Studies of an increased periodicity of eating on blood lipids in hyperlipidaemic individuals

It is of great health significance to determine whether the beneficial effects of an increased eating frequency on fasting blood lipid levels in normolipidaemic individuals would also be observed in those with hyperlipidaemia. Few studies have been conducted to date. Only five studies were found to study the effects of altered eating frequency on fasting blood lipids in hyperlipidaemic subjects. Table 1.8 summarises details of these studies. The overall finding was that of no change in fasting total or LDL-cholesterol with an increased eating frequency in hyperlipidaemic subjects. More recently King & Gibney, (1999) examined the role of alterations in eating frequency as part of therapeutic lipid lowering dietary advice in free-living hyperlipidaemic men. The effect of dietary advice, which lowered dietary fat intake in combination with a decrease or maintenance of usual eating frequency, or the effect of dietary advice, which decreased or increased eating frequency with no change in dietary fat intake, was examined. An increased eating frequency did not alter plasma total or LDL-cholesterol. Although the reduction in fat intake was associated with a significantly lower plasma total and LDL-cholesterol. A most interesting finding was the fact that an alteration of eating frequency posed the greatest difficulty for subjects, even greater than the reduction in dietary fat intake. The authors concluded that lipid-lowering dietary advice should be incorporated into the existing eating frequency pattern of each person rather than altering one's usual eating frequency pattern.

Mann, (1997) in a recent review has proposed, that differences in metabolism in normolipidaemic and hyperlipidaemic individuals, may provide some explanation for the absence of a reduction in total and LDL-cholesterol in hyperlipidaemic individuals that increase their eating frequency. If the changes in LDL-cholesterol in normolipidaemic individuals are due to alteration in insulin and its effect on HMGCoA reductase activity or due to altered reverse cholesterol transport, a difference in these mechanisms in hyperlipidaemic individuals might explain why their total and LDL-cholesterol levels did not change. There is clearly a need for future research concerning the effects of eating frequency on lipid levels in hypercholesterolaemic individuals. Mann, (1997) has advised that for the moment dietary recommendations aimed at lowering total and LDL-cholesterol should continue to focus on the

nature of dietary fat, which remains the most important nutritional determinant of this important risk indicator for CHD.

At this time, for those who have a more frequent pattern of eating, there is no evidence of adverse effects of an increased eating frequency on lipid metabolism. As advised by Mann, (1997), large-scale, long-term and costly studies are essential before, recommendations can be made to increase eating frequency due to its beneficial effects on lipid metabolism.

**Table 1.8: Studies of altered periodicity of eating on fasting blood lipids and lipoproteins in hyperlipidaemic individuals**

| Authors | Subjects | Background diet* | Meal frequency & Duration of study | Results |
|---|---|---|---|---|
| **Young *et al.*, (1971)** | 11M, obese, 20-25y, baseline TC 7-8mmol/L | Restricted energy, 51% fat, 22% CHO | Baseline 3 meals/d for 16d., then 2 of 3 regimens: 1, 3 or 6 meals/d, 5 weeks on each diet | Significantly higher cholesterol on one meal/d compared to 3 or 6 meals/d |
| **Jordan & Novascone, (1989)** | 17M, 43-68y, baseline TC > 6.2mmol/L | Self selected, 33% fat | 3 vs. 6 meals/d, 6 weeks on each diet, crossover design | No significant differences in fasting TC, LDL-, HDL-cholesterol or TAG |
| **Arnold *et al.*, (1994)** | 16 (M&F), 34-66y, average cholesterol 6.8mmol/L | Self selected, 34% fat, 49% CHO | 3 meals/d vs. 9 meals/d, 4 weeks on each diet, crossover design | No significant differences in fasting TC, LDL-, HDL- cholesterol, TAG, apolipoprotein A-1 & B; no variation in response of plasma TAG or insulin to high-fat meal on 2 diets, similar 24h urinary peptide |
| **Thomsen *et al.*, (1997)** | 10 subjects with NIDDM | | 3 meals/d vs. 8 meals/d, 2 weeks on each diet, cross over design | Increased meal frequency lowered HDL levels |
| **King & Gibney, (1999)** | 80M, 25-65y, baseline TC > 6.0mmol/L, BMI 23-30 | Self selected, 29%-36% fat, 40-45% CHO | Baseline eating frequency of 5meals/d changed to 3 meals/d +/- fat reduction to 30%, baseline of 5 meals/d + fat reduction, baseline of 4 meals/d increased to 6 meals/d with no change in fat intake, 4 weeks on each | Decrease in TC, LDL-cholesterol & apo B with reduction in fat intake & eating frequency. No significant decrease in TC or LDL-cholesterol with increased eating frequency. Increase in $HDL_2$ cholesterol level & a decrease in apo B with increased eating frequency |

* % values are % of total energy; CHO=carbohydrate; M=men; F=women; TC=total cholesterol; NR=not reported; TAG=triacylglycerol; HDL= high density lipoprotein; LDL=low density lipoprotein

### 1.4.2 INCREASED PERIODICITY OF EATING & CARBOHYDRATE TOLERANCE & DIABETES MELLITUS

An increased eating frequency has been associated with improved blood glucose tolerance (Gwinup *et al.*, 1963b; Fabry *et al.*, 1964). Therefore it was proposed that altered eating frequency may have a beneficial effect in the treatment of diabetes mellitus. Increased eating frequency improved carbohydrate tolerance in type II diabetes (Jenkins *et al.*, 1992; Bertelsen *et al.*, 1993). Consequently dietary guidelines for diabetics advocate increased eating frequency (Franz *et al.*, 1994). Despite this advice the only long-term study of the effect of eating frequency and diabetes mellitus failed to show a benefit on either carbohydrate or lipid metabolism (Arnold *et al.*, 1997). Jenkins, (1997) recently reviewed the association between eating frequency, dietary carbohydrate and blood glucose control in diabetics, the main findings of which are presented here.

Approaches to slow the rate of glucose absorption and blunt the insulin response are considered important aspects of the treatment of diabetes mellitus (Jenkins *et al.*, 1994; Jenkins & Jenkins, 1995). These approaches include soluble dietary fibers, low glycaemic index foods and inhibitors of carbohydrate absorption (gastrointestinal digestive enzyme inhibitors). A common feature of these approaches is that they 'spread the nutrient load over time' or lengthen the absorption time, which is comparable to consuming smaller meals more frequently. Experimental studies which have spread carbohydrate loads over the day have shown reduced insulin responses and lower mean blood glucose levels in healthy subjects and subjects with type II diabetes (Jenkins *et al.*, 1983; 1990; 1992; Bertelsen *et al.*, 1993). Segura *et al.*, (1995) investigated the effect of three, six, nine and twelve meals consumed over a 12 hour period and showed that insulin concentrations were significantly reduced by six meals but further increases in eating frequency had no additional effect (Segura *et al.*, 1995). When healthy volunteers consumed their daily food intake as 17 eating occasions/d compared to 3 eating occasions/d for a period of 2 weeks, there was no improvement in glucose tolerance to a standard test meal (Jenkins *et al.*, 1989). A study of thirteen people with non-insulin dependent diabetes, completed two 4-week experimental periods in which three or nine meals daily were eaten (Arnold *et al.*, 1997). Comparable blood lipid and glucose levels were

observed fasting and following a glucose load. Jenkins, (1997) suggested that for carbohydrate metabolism there may be no residual effects and the advantage is only present as long as small frequent meals are taken. This lack of evidence of long-term benefit of an increased eating frequency required further investigation.

'Spreading the nutrient load over the day' appears to have advantages in reducing the need for insulin in the disposal and uptake of blood glucose. An increased eating frequency poses as a valuable option. However future research is required to determine the effect of increased eating frequency on carbohydrate tolerance, glycaemic control and markers of protein glycation, such as $Hb_{A1}C$, in diabetic populations (Jenkins, 1997). The minimum number of eating occasions required to achieve a beneficial physiological effect needs to be defined. Also the optimal duration of dietary intervention to effect this physiological change needs to be addressed. The interactions between several dietary factors such as, soluble fibre and low glycaemic index foods, which enhance the effect of an increased eating frequency must be defined. Patient compliance with an alteration in eating frequency must also be addressed in individuals with diabetes, given the findings of King & Gibney, (1999). This study showed that an alteration in eating frequency was one of the most difficult aspects of dietary change for hyperlipidaemic patients (King & Gibney, 1999). Since dyslipidaemia is associated with diabetes mellitus (Cullen *et al.*, 1999; Goldberg, 2000) and increased eating frequency has beneficial effects on total and LDL-cholesterol concentrations in non-diabetic subjects (see Section 1.4.1), the effect of increased eating frequency on lipoprotein metabolism in patients with diabetes mellitus warrants further research.

### 1.4.3 AN INCREASED PERIODICITY OF EATING & BODY WEIGHT BALANCE & REGULATION

There is evidence that a high eating frequency can help body weight control. However, the traditional eating pattern of three meals a day and avoiding eating between meals is deeply ingrained in the publics mind, as the ideal eating pattern (British Nutrition Foundation, 1985; Kearney, 1994). The elimination of snacks is also a common practice in weight reduction strategies (Bellisle *et al.*, 1995; French *et al.*, 1999). Whether and how, an increased

frequency of eating may help body weight control has been reviewed by a number of researchers recently (Drummond *et al.*, 1996; Bellisle *et al.*, 1997; Kirk, 2000).

### 1.4.3.1 Methodological factors to consider in interpreting studies

One of the major conclusions of these reviews was that caution should be taken in the interpretation of the results of studies. This is because a number of methodological factors, which can influence the results, are not always considered within the design of these studies. Factors including the method used to classify habitual eating frequency and dietary under-reporting were not controlled for. Dietary under-reporting by overweight, obese, post-obese and diet-restrained subjects is well recognised (Prentice *et al.*, 1986; Lichtman *et al.*, 1992; Black *et al.*,1993). There is also evidence that snacks are under-reported, which would influence the validity of the eating frequency estimate (Livingstone *et al.*, 1990; Heitmann & Lissner, 1995; Poppitt *et al.*, 1998). Assessment of the validity of the food intake data through an assessment of the validity of reported energy intake data, using published cut-off points for energy intake in relation to BMR (Goldberg *et al.*, 1991b), is critical to the interpretation of these studies. Inaccurate dietary data represents a major issue when trying to detect possible effects of eating frequency on body weight (Bellisle *et al.*, 1997). The inclusion of under-reporters may create a biased negative association or mask an actual positive association between eating frequency and body weight (Kirk, 2000). The issue of reverse causality is another important issue to be considered. Rather than being a cause of overweight, infrequent eating in overweight individuals may actually be used as a means of losing weight or preventing further weight gain, in response to gaining weight (Summerbell *et al.*, 1996; Bellisle *et al.*, 1997). Such *post hoc* alterations in diet pattern greatly confound the interpretation of the data and may also explain the inverse relationship found in some studies.

### 1.4.3.2 Main findings of studies of an increased eating frequency & body weight status

Kirk, (2000) discussed the results of observational studies that examined the relationship between frequency of eating and body weight. Of the twelve studies reviewed, six found an inverse relationship between eating frequency and body weight status (Fabry *et al.*, 1964; Metzner *et al.*, 1977; Kant *et al.*, 1995; Edelstein *et al.*, 1992; Drummond *et al.*, 1998; Whybrow & Kirk, 1997) and six found no relationship (Charzewska *et al.*, 1981; Dreon *et al.*,

1988; Basdevant *et al.*, 1993; Ruxton *et al.*, 1996; Summerbell *et al.*, 1996; Crawley & Summerbell *et al.*, 1997). Many of these studies were criticised for not taking account of the methodological factors described above. Only four more recent studies excluded under-reporters (Summerbell *et al.*, 1996; Whybrow & Kirk, 1997; Crawley & Summerbell, 1997; Drummond *et al.*, 1998), with two of these studies reporting the inverse relationship between eating frequency and body weight status (Whybrow & Kirk, 1997; Drummond *et al.*, 1998). It cannot go unmentioned however, that the method used to define individual eating occasions or mean daily eating frequency varied, among these four studies, as seen in Table 1.2, and this will greatly influence the findings, by influencing the estimate of mean daily eating frequency. Indeed, McBride *et al.*, (1990) found the relationship between energy intake and eating frequency to be dependent on the definition of a 'meal'. A correlation between eating frequency and energy intake was only significant with 'meals' when defined as providing more than 0.5MJ.

Attempts have been made to understand the mechanisms by which eating frequency may influence body weight status. The influence of feeding frequency on total energy expenditure was examined and found to have no discernible effect on 24h energy expenditure (Drummond *et al.*, 1996; Bellisle *et al.*, 1997). Evaluation of the association of eating frequency with body weight status must also be undertaken in the context of physical activity levels. Drummond *et al.*, (1998) hypothesise that frequent snackers may be more physically active than infrequent snackers, with higher levels of energy expenditure resulting in an increase in energy expenditure and acting as an appetite stimulant. There is currently little information however on the relationship of eating frequency with activity levels, metabolic rates and body composition. More research is needed.

#### 1.4.3.3 Four possible advantages of frequent eating & body weight control

Nonetheless Kirk, (2000) has proposed four possible physiological advantages that are associated with frequent eating and may improve body weight control. Firstly frequent eating could help control hunger and improve the accuracy of energy compensation. Burley *et al.*, (1993) showed that spreading daily energy intake across five eating occasions (three meals and two snacks) rather than three eating occasions, resulted in a flatter profile of hunger during

the day. Similarly, Speechly & Buffenstein, (1999) reported that when eight young lean men were fed a breakfast meal divided into five equal portions (served hourly) as opposed to as one single meal, they consumed less energy at a subsequent *ad libitum* lunch. They felt equally satiated despite eating significantly less food. Hunger was thus less likely to build up before main meals, thus helping to prevent gorging at meals. By adjusting the size of subsequent meals, frequent eaters were also shown to be better able to compensate for energy deficits and excesses (Westerterp-Plantenga *et al.*, 1994).

Secondly, it was proposed that frequent eating was associated with a greater dietary carbohydrate:fat ratio (Kirk, 2000). Generally snacks and drinks are higher in carbohydrate and lower in fat compared to main meals (Basdevant *et al.*, 1993; Summerbell *et al.*, 1995; Whybrow & Kirk, 1997; Drummond *et al.*, 1998), see Section 1.3.4 (Table 1.6). The encouragement of snacking may be a possible strategy to increase the carbohydrate:fat ratio of the diet (Drummond *et al.*, 1998). Lawton *et al.*, (1998; 1999) suggested that the consumption of low-fat snacks is an effective strategy to reduce dietary fat intake without an increase in energy intake.

Thirdly, frequent eating was considered to shift the temporal distribution of energy intake away from the latter part of the day and towards the earlier part of the day. Kirk, (2000) noted that some studies suggested that obese individuals consumed a high proportion of their daily energy intake in the evening (Beaudoin & Mayer, 1953; Baecke *et al.*, 1983; Bellisle *et al.*, 1988; Fricker *et al.*, 1990). They tended to skip breakfast and daytime snacks and eat large evening meals. It was also suggested that energy consumed in the later half of the day may be more readily stored as fat than an isoenergetic amount consumed earlier and that infrequent eating concentrated in the evening may promote weight gain (Fricker *et al.*, 1990).

The fourth possible physiological way that frequent eating may improve body weight control, is that a pattern of eating 'little and often' may be more compatible with a physically active lifestyle, than a pattern of eating two or three large meals a day (Kirk, 2000). Athletes achieve a high energy intake by eating frequently (Lindeman, 1990; Butterworth *et al.*, 1994). Recent unpublished analysis of Scottish adults revealed a positive correlation between eating

frequency and physical activity level (Kirk, 2000). Kirk, (2000) suggested that in response to an increase in physical activity, the general population may increase their energy intake by eating more frequently as opposed to eating larger meals. Such an approach could avoid the gastric discomfort and lethargic mood, which often accompanies the consumption of large meals and reduces the motivation to exercise.

At this time there is no conclusive evidence that an increased frequency of eating will benefit body weight control (Bellisle *et al.*, 1997; Kirk, 2000). However, nor is there evidence to suggest an adverse effect of an increased frequency of eating and some evidence has indeed suggested benefits. Kirk, (2000) concluded that for most individuals advice to avoid snacking may not be appropriate for body weight control and indeed for some individuals it may be counterproductive. Further research is needed in this area. Kirk, (2000) has highlighted three areas for future research. Firstly, to investigate the effects on energy compensation of varying snack composition (e.g. by varying macronutrient composition, energy density and energy content of snacks) and snacking pattern (e.g. timing of snacks vs. meals). Johnstone *et al.*, (2000) recently found that alteration of the temporal distribution of energy intake across the day, through the inclusion of relatively low energy dense fixed snacks lead to compensatory adjustments in *ad libitum* food intake and energy intake in normal weight men. It was acknowledged however, that under free-living conditions where subjects can alter the energy density and composition of the foods eaten, results may differ. Secondly, research is needed to determine the association of physical activity and eating frequency. Thirdly, Kirk, (2000) called for identification of whether different subgroups of the population respond differently to changes in eating frequency. Drummond *et al.*, (1998) have found differences between men and women. There was a negative correlation between eating frequency and body weight in men, but not in women and energy intakes did not increase with an increased eating frequency in men but did in women. These findings suggest that men compensated by reducing the energy content of each eating occasion.

With a great proportion of the population consuming at least 5-6 times per day and the prevalence of obesity (18%) a major health problem in Ireland today (McCarthy *et al.*, 2001),

future research in this area is urgently needed to clearly define the associations of eating more frequently with body weight status, physical activity levels and food choice.

In summary, the potential health benefits of an increased periodicity of eating to coronary heart disease, diabetes mellitus and obesity are important though not confirmed. More research and longer term studies are needed.

### 1.4.4 AN INCREASED FREQUENCY OF EATING & EFFECT ON DENTAL CARIES

An increased frequency of eating has implications for the promotion of dental caries, the basis of this statement being outlined here. Firstly, a recent review on new perspectives of caries prevention, by Kandelman, (1997), stated that the carious process must be considered a dynamic process in which the specificity of the microflora and the inter-relationship between diet variables, protective mechanisms of saliva and the acquired host resistance are of paramount importance. The theory of dental caries as a multifactorial disease (Miller, 1890) involving factors such as bacteria in dental plaque, patterns of sucrose consumption, host susceptibilty and the resultant acid dissolution of enamel tooth structure is now considered an oversimplification of the carious process. Secondly, it is the consumption of fermentable carbohydrates which has the detrimental effect on dental health. Fermentable carbohydrates refer to any type of sugars or cooked starches that are digested by the oral bacteria to produce acids in the dental plaque and sugars refers to not only sucrose but also the other mono- and disaccharides. It is thus no longer correct for sucrose to be considered the main causative dietary factor in caries, rather, attention must be directed to the intake and frequency of intake of 'fermentable carbohydrates' and its interrelationship with the individual mechanisms of saliva and host resistance. Thus, an increased frequency of eating has implications for the promotion of dental caries (Kandelman, 1997).

Most eating and drinking eating occasions contain some carbohydrate; the more often foods and drinks are consumed, the greater the potential risk to teeth. It is difficult to determine exactly how often each day it is 'safe' to eat, since a number of inter-related factors are involved. These include the amount of time the food stays in the mouth, as well as intervals

between eating and drinking occasions and whether or not the teeth are cleaned and exposed to fluoride regularly. At each fermentable-carbohydrate challenge the teeth are exposed to an increased acidity of the oral environment and possible demineralization can be initiated at the outer enamel surfaces. In addition, frequent acidic conditions in the oral environment do not allow the mineralization process to take place because resting periods are too short to permit the buffering capacities of saliva to neutralise plaque acid. Despite the potential adverse consequences of an increased frequency of eating on dental caries, it is now recognised that people who receive adequate fluoride intake and regular oral hygiene measures can safely use dietary carbohydrates preferably during meals and two to three times daily in snacks and drinks (Kandelman, 1997; Duggal *et al.*, 2000). When oral hygiene is poor or when flouride is not available though, the frequency of consumption of fermentable carbohydrates, particularly between meals, should be restricted as it becomes an important caries-related factor (Burt *et al.*, 1988). Kandelman, (1997) recommended that future research be undertaken to determine the influence of eating frequency in relation to the types of foods in meals and in snacks, fermentable carbohydrates vs. sucrose snacks and caries-free vs. caries-risk populations.

## 1.5 THE POTENTIAL VALUE OF RESEARCH ON PERIODICITY OF EATING TO OTHER AREAS OF NUTRITION RESEARCH

Undertaking research on periodicity of eating is important to understand the dietary and health implications of an increased frequency of eating and it is particularly timely since this eating pattern is now a very common eating pattern (Section 1.1). The results of investigations of periodicity of eating will also be of value to other areas of nutrition research. The development of dietary guidelines for a population, in particular food-based dietary guidelines, is one such area. Studies of nutrition research, which require the use of test meals, will also value the results of studies of periodicity of eating since they will provide data on the nutrient content of eating occasions of everyday life of free-living individuals. These issues and the value of studies of periodicity of eating to these areas is briefly discussed below.

### 1.5.1 THE DEVELOPMENT OF FOOD-BASED DIETARY GUIDELINES (FBDG)

In 1995, a joint FAO/WHO consultation on food-based dietary guidelines (FBDG) was convened and its report gives the rational and the over-all strategy for the development of FBDG (FAO/WHO, 1996). To be useful in public health nutrition programmes and meaningful to individual members of the general public, it was advised that nutritional recommendations be translated into FBDG. It was recommended that consideration be given to both the prevailing public health problem of the population and the customary dietary patterns of the population. FBDG are guidelines derived from nutrient targets that are translated into 'food-based guidelines' to promote their adoption by the general population. They represent the practical way to reach the nutritional goals of the population and so it is essential that they are practical, comprehensible and culturally acceptable and they must reflect food patterns rather than numeric goals. FBDG may be fairly broad and unspecific, specific, targeted and detailed, product specific or eating occasion-based (Eurodiet, 2000).

In 1998, the Institute of European Studies conducted a study to examine the prevailing patterns of food and nutrient intakes in the EU, to examine the lower and upper nutrient intakes within EU member states (Williams *et al.*, 1999). This study enabled exploration of principles and options for the derivation of FBDG. Between 1998 – 2000, the Eurodiet project was commissioned by the EC with the aim of contributing towards a co-ordinated European Union (EU) and a member state health promotion program on nutrition, diet and healthy lifestyles (Eurodiet, 2000). This was achieved by establishing a network, strategy and action plan for the development of European dietary guidelines. One working group specifically addressed the development of FBDG and acknowledged that although FBDG do exist in some EU countries, either nationally developed or adopted from US FBDG, they have seldom been developed through the strategies outlined in the FBDG report. Furthermore the validity of the approaches taken is seldom documented and many of the widely accepted views have been shown to be invalid when tested using food and nutrient databases.

The approaches taken by the FAO/WHO report were advised as the starting point for member states. The Eurodiet group discussed a number of approaches to the practical development of FBDG. At the most simple level, there is the identification of the major food sources of the

intake of the target nutrient at mean population level. The next level of analysis is to examine the intakes of foods in the total population and among consumers only and among subjects with opposite patterns of intake of the target nutrient. The use of, upper and lower quartiles or tertiles of intakes of the target nutrient or compliers vs. non-compliers (Wearne & Day, 1999), are among the methods which can be used to characterise the food patterns. This task requires dietary survey data at the level of individuals and allows for statistical determination of the foods, which distinguish between higher and lower intakes of the target nutrient. Once a food is found to be an important determinant of nutrient intake, for which a change is desirable, then different strategies are possible to alter its level of consumption. If a key food is consumed by a large proportion of the population, there are two options that may be considered to increase its consumption: increase the portion size or frequency of eating occasions. The same but opposite approach is applicable if a decrease in consumption is desired (Eurodiet, 2000).

The next step, the actual formulation of FBDG involves aspects such as menu-planning in terms of portions, frequencies, combination of portions and frequencies into eating occasions. This requires detailed information about prevailing patterns of food intake and eating occasion habits, which dishes are used, which foods are eaten together, in-between meals, etc. Based on the results, different types of FBDG can be formulated. These strategies for dietary change refer to nutrition education, whereas another strategy is that of changing the food supply through the development of new products or modification of existing products (Eurodiet, 2000).

Studies of periodicity of eating, which investigate the food and nutrient content of the individual eating occasions of populations and of those with opposite patterns of nutrient intake, are thus of value to the development of FBDG. As described in section 1.3.5, a limited number of such studies have been undertaken to date, with lack of standardisation on the appropriate methodology being an important limiting factor. Determination of the temporal pattern of nutrient intake of a population, during eating occasions throughout the day, which was investigated in this thesis, will thus make an important contribution to the provision of

baseline data for the formulation of FBDG that target specific eating occasions and thus make consumer health messages more relevant.

### 1.5.2 NUTRITION RESEARCH STUDIES THAT USE TEST MEALS

There are many different areas of nutrition research which use test meals that are meant to represent the nutrient content of eating occasions of everyday life as part of their investigations. These include studies of energy metabolism and the impact of diet on physical activity, glucose tolerance, lipid metabolism, appetite, mental performance to mention but a few (Verboeket-van de Venne *et al.*, 1993; Green *et al.*, 1994; Raben *et al.*, 1994; Rogers & Lloyd, 1994; Roche & Gibney, 1995; Stubbs *et al.*, 1996; Jenkins, 1997; Daly *et al*, 1998; Gill et al., 2001). Studies of postprandial lipaemia are one area in which test meals are used to get a better understanding of the postprandial lipaemic response and its association with the development of CHD. As one aspect of this thesis specifically addressed the implications of studying periodicity of eating to studies of postprandial lipeamia, a description of the postprandial response is next described.

#### 1.5.2.1 Postprandial Lipaemia

The postprandial lipaemic response refers to a series of biochemical events, which occur following the ingestion of a fat-containing meal and the postprandial state is the time period between food ingestion and approximately 6-8 hours thereafter (Roche & Gibney, 1995; 2000). In reality, as most individuals eat a number of times a day, therefore most people are in an almost constant postprandial state for 12-18 hours of the day (Williams, 1997). Triacylglycerol (TAG) is the main constituent of dietary fat, with small amounts of cholesterol esters and phospholipids.

The specific biochemical events that occur during postprandial lipaemia are of great scientific interest and it is now recognised that postprandial TAG metabolism affects the pathogenesis and progression of CHD (Roche & Gibney, 1995). Comprehensive descriptions of the biochemical events that occur during postprandial lipaemia have been provided elsewhere (Sethi *et al.*, 1993; Roche & Gibney, 1995; 2000) of which a brief outline is given here.

In summary, blood lipids, being insoluble in water, are transported in plasma in lipoprotein complexes, in association with specialized proteins, apolipoproteins. Chylomicrons (CMs) and very low density lipoproteins (VLDLs) are the main TAG carrying lipoproteins or TAG-rich lipoproteins (TRL). High density lipoproteins (HDLs) and low density lipoproteins (LDLs) are the main cholesterol carrying lipoproteins. Following fat digestion and absorption, dietary TAG is released from the intestine into the circulation in CMs. These lipoproteins transport TAG to the adipose tissue. In adipose tissue, the enzyme lipoprotein lipase (LPL) hydrolyses the TAG in the CMs for uptake by the cells. The resultant CM remnants are smaller in size, contain less TAG and are mainly composed of cholesterol esters. CM remnants are catabolized by the liver. The precise mechanism of CM remnant uptake has not been fully defined. As LPL is the rate-limiting hydrolytic enzyme, which controls TRL removal from the circulation, LPL activity in turn determines the extent and duration of postprandial lipaemia (Roche & Gibney, 2000).

VLDLs are also significant carriers of plasma TAG during the postprandial state and are identified from CMs by their apolipoprotein apoB-100 content. The CMs carry apoB-48 (Chan, 1992). VLDLs carry endogenous TAG and are synthesized continuously in the liver, with their secretion rate partly determined by the availability of TAG (Chan, 1992). During postprandial lipaemia, CMs and VLDLs compete for LPL-mediated hydrolysis and as CMs are preferentially hydrolysed by LPL, VLDL removal is delayed and there is an increase in VLDL concentration postprandially (Karpe *et al.*, 1993; Schneeman *et al.*, 1993). VLDL remnants are produced following removal of TAG by LPL and are catabolised by the liver or transformed into LDL.

LDLs represent the primary mode of transport of hepatic cholesterol to the extrahepatic tissues for membrane synthesis and are derived from degradation of VLDLs. HDLs play a vital role transporting cholesterol from peripheral cells back to the liver and are formed in a series of steps (Grundy, 1990). Nascent HDLs are synthesised in the liver and small intestine. This premature HDL accepts free cholesterol from cells and other lipoproteins. The cholesterol is transformed into cholesterol ester (CE) through the action of the enzyme lecithin:cholesterol acyltransferase (LCAT). The resultant lipoprotein is known as the $HDL_3$. $HDL_3$ continues to

acquire more cholesterol enlarging the lipoprotein to become $HDL_{2a}$. $HDL_{2a}$ becomes $HDL_{2b}$ through the exchange of cholesterol esters for TAG from the TAG-rich lipoproteins, which is mediated by a protein, cholesterol-ester transfer protein (CETP) (Yamashita *et al.*, 2001). $HDL_{2b}$ is transformed back to $HDL_3$ by hydrolysis of its TAG at the liver. This important cycle, which results in the transfer of cholesterol from peripheral tissues to the liver, is known as reverse cholesterol transport. This process is significantly stimulated during postprandial lipaemia. Cholesterol can only be degraded and excreted by the liver and this process provides a number of pathways for cholesterol excretion, via VLDL remnant, LDL or HDL uptake by the liver. It can thus be considered anti-atherogenic in that it prevents the accumulation of excess cholesterol in cells, which cannot degrade it.

*Beneficial & adverse effects of postprandial lipaemia*

The influx of dietary TAG within the circulation during the postprandial state promotes the formation of HDL (Patsch *et al.*, 1987) and the stimulation of reverse cholesterol transport by increasing the activity of LCAT and CETP (Tall *et al.*, 1986; Fielding, 1987). These are beneficial effects of postprandial lipaemia. However, if TAG clearance is delayed, the postprandial lipaemic response is associated with pro-atherogenic and pro-thrombotic effects (Roche & Gibney, 2000). When plasma TAG concentrations increase during postprandial lipaemia CE is transferred from LDL and HDL by CETP to CM and VLDL remnants in exchange for TAG. These small CE enriched CM and VLDL remnants are very atherogenic (Zilversmit, 1979; Rapp *et al.*, 1994). The TAG enriched LDLs are subject to hydrolysis by lipases, which form small dense LDL particles, which are particularly atherogenic (Griffin *et al.*, 1994). Prolonged lipaemia promotes the catabolism of HDL because they become over enriched with TAG and are catabolised, which decreases their concentration (Patsch *et al.*, 1984). Therefore the cardioprotective effect of the HDL fraction is lost. Finally the postprandial response is associated with activation of coagulation factor VII (Mennen *et al.*, 1996), which may induce a pro-thrombotic state, which in turn may increase CHD risk (Ruddock & Meade, 1994).

The magnitude of the postprandial response depends on a number of physiological factors such as age, gender, body weight, exercise, LPL activity and most importantly fasting plasma

TAG concentrations and nutritional factors. The importance of these has been reviewed elsewhere (Roche & Gibney, 1995).

Postprandial lipaemia studies usually involve subjects who have fasted overnight. Subjects have a fasting blood sample drawn, consume a fat-rich test meal and then have a series of postprandial blood samples collected during fasting periods of 8 to 10 hours. The test meals used are most often formula feeds containing large amounts of fat usually between 20-140g (Patsch *et al.*, 1983; Cohen *et al.*, 1989; Griffiths *et al.*, 1994; Hallett *et al.*, 1994; Roche & Gibney, 1996). Little is known however, of the extent to which these doses of fat represent the amount of fat ingested in single eating occasions, by free living subjects on self-selected diets. In reality, most individuals eat regular meals and snacks and are in a postprandial state for a major part of the day, because of the long duration of fat clearance. Studies of periodicity of eating, which investigate the food and nutrient content of the individual eating occasions of populations are thus of value to studies of postprandial lipaemia. Such data will enable an assessment of the nutrient content of test meals currently used, in terms of whether they reflect the macronutrient content of typical eating occasions.

## 1.6 OBJECTIVE & SPECIFIC AIMS OF THIS THESIS

This thesis set out to provide an objective understanding of periodicity of eating in a group of free-living adults, by determining the temporal pattern of nutrient intake during eating occasions throughout the day.

To determine the temporal pattern of nutrient intake during eating occasions throughout the day, a tailor-made database had to be created by undertaking a dietary survey in 133 adults. Chapter 2 provides details of the methodology used and the issues addressed in collecting dietary data to allow the study of periodicity of eating. Subsequently the most appropriate methods of data analysis were explored and identified (Chapter 3). This approach was used to provide data relevant to studies of postprandial lipaemia (Chapter 4). It was also used to provide baseline data for the development of evidence based dietary guidelines that may

involve specific eating occasions of the day and thus set out to make consumer messages more relevant (Chapters 5 to 7). Three issues were addressed. Firstly, it is not known whether and how the nutrient composition of eating occasions differ between high-fat and low-fat consumers, whether these groups eat similar amounts of nutrients during eating occasions throughout the day or whether high-fat consumers eat more fat during eating occasions than low-fat consumers. This information could contribute to the development of focused dietary guidelines to reduce dietary fat intake. Secondly, it is not clear whether those with different periodicities of eating have different mean daily nutrient intakes or whether they differ in the amount of nutrients consumed during eating occasions throughout the day. This information could contribute to evidence-based dietary advice with regard to eating frequency. A third area investigated was whether there is variation in nutrient intake between weekdays and weekend days, and whether the nutrient quality of eating occasions varied on weekdays and weekend days. This investigation may have valuable implications for the development of evidence-based nutrition advice specific to days of the week.

The food and nutrient intake observations in a small non-random population must be observed in a large randomly selected and representative population before recommendations can be formulated. The Irish Universities Nutrition Alliance (a formal association of nutrition departments in University College Cork, Trinity College Dublin & University of Ulster at Coleraine) employed the investigator (KEH) at Trinity College Dublin, as joint coordinator of a food consumption survey, which was carried out in an adult population, on the island of Ireland between 1997-1999. As part of this food consumption survey, attention was specifically given to ensure the data collected could be analysed in terms of periodicity of eating and food and nutrient intakes of the population. As part of this thesis, macronutrient intakes and their primary food sources were described for a representative sample of Irish adults using the Irish Universities Nutrition Alliance (IUNA) North/South Ireland Food Consumption Survey database. Adherence of the population to current dietary recommendations was also assessed.

**The specific aims of the research described in this thesis are as follows:**

1. To assess the dietary intake of a group of free-living Irish adults on self-selected diets, with particular attention to usual periodicity of eating (Chapter 2).

2. To identify and explore methods of data analysis to determine the temporal pattern of nutrient intake during eating occasions throughout the day in everyday life (Chapter 3).

3. To determine the temporal pattern of the average amounts of macronutrients consumed during eating occasions throughout the day in everyday life & to use this information to assess whether test meals used as part of postprandial lipaemia studies represent the macronutrient content of eating occasions of free-living adults on self-selected diets, with particular reference to dietary fat intake (Chapter 4).

4. To characterise the temporal pattern of macronutrient intake during eating occasions throughout the day of habitual free-living high-fat and low-fat consumers and to address the relevance of the findings for the formulation of eating-occasion based dietary guidelines (Chapter 5).

5. To determine the effect of differences in periodicity of eating on mean daily macronutrient intakes and the temporal pattern of macronutrient intake during eating occasions throughout the day and to discuss the findings in the context of dietary advice in relation to eating frequency (Chapter 6).

6. To determine differences between weekdays and weekend days in mean daily macronutrient intakes and the temporal pattern of macronutrient intake during eating occasions throughout the day and to discuss the findings in the context of dietary advice in relation to weekdays and weekend days (Chapter 7).
7. To determine the macronutrient intakes and food sources of a representative sample of adults and to assess the adherence of the population to current dietary guidelines so as to identify the nutrients of concern in the development of food-based dietary guidelines (Chapter 8 & 9).

## 1.7 REFERENCES


Anderson, A.O., Gatenby, S.J., Walker, A.D., Mela, D.J., & Southon, S. (1997). Dietary patterns in healthy adult volunteers: a preliminary investigation. *American Journal of Clinical Nutrition, 65(suppl.),* S1355-S1368.

Anderson, A.S., Macintyre, S., & West, P. (1993). Adolescent meal patterns: grazing habits in the west of Scotland. *Health Bulletin, 51,* 158-165.

Arnold, L., Mann, J.I., & Ball, M.J. (1997). Metabolic effects of alterations in meal frequency in type 2 diabetes. *Diabetes Care, 20,* 1651-1654.

Arnold, L.M., Ball, M.J., Duncan, A.W., & Mann, J. (1993). Effect of isoenergetic intake of three or nine meals on plasma lipoproteins and glucose metabolism. *American Journal of Clinical Nutrition, 57,* 446-451.

Arnold, L.M., Ball, M.J., Duncan, A.W., & Mann, J. (1994). Metabolic effects of alterations in meal frequency in hypercholesterolaemic individuals. *Atherosclerosis, 108,* 167-174.

Baecke, J.A.H., van Staveren, W.A., & Burema, J. (1983). Food consumption, habitual physical activity and body fatness in young Dutch adults. *American Journal of Clinical Nutrition, 37,* 278-286.

Ballard-Barbash, R., Graubard, B.I., Krebs-Smith, S.M., Schatzkin, A., & Thompson, F.E. (1996). Contribution of dieting to the inverse association between energy intake and body mass index. *European Journal of Clinical Nutrition, 50,* 98-106.

Ballard-Barbash, R., Thompson, F.E., Graubard, B.I., & Krebs-Smith, S.M. (1994). Variability in percent energy from fat throughout the day: implications for application of total diet goals. *Journal of Nutrition Education, 26,* 278-283.

Bartkiw, T.P. (1993). Children's eating habits:a question of balance. *World Health Forum, 14,* 404-406.

Basdevant, A., Craplet, C., & Guy-Grand, B. (1993). Snacking Patterns in Obese French Women. *Appetite, 21,* 17-23.

Beaudoin, R., & Mayer, J. (1953). Food intake of obese and non-obese women. *Journal of the American Dietetic Association, 29,* 29-33.

Bellisle, F., Dalix, A.M., & De Castro, J.M. (1999). Eating patterns in French subjects studied by the "weekly food diary" method. *Appetite, 32,* 46-52.

Bellisle, F., McDevitt, R., & Prentice, A.M. (1997). Meal frequency and energy balance. *British Journal of Nutrition, 77,* S57-S70.

Bellisle, F., Monneuse, M., Steptoe, A., & Wardle, J. (1995). Weight concerns and eating patterns: A survey of university students in Europe. *International Journal of Obesity, 19,* 723-730.

Bellisle, F., Rolland-Cachera, M.F., Deheeger, M., & Guilloud-Bataille, M. (1988). Obesity and food intake in children: evidence for a role of metabolic and/or behavioural daily rhythms. *Appetite, 11,* 111-118.

Bernstein, I.L., Zimmerman, J.C., Czeisler, C.A., & Weitzman, E.D. (1981). Meal Patterns in "Free-Running" Humans. *Physiology & Behaviour, 27,* 621-623.

Bertelsen, J., Christiansen, C., Thomsen, C., Poulsen, P.L., Vestergaard, S., Steinov, A., Rosmussen, L.H., Rosmussen, O., & Hermansen, K. (1993). Effect of meal frequency on blood glucose, insulin and free fatty acids in NIDDM subjects. *Diabetes Care, 16,* 3-7.

Bigler-Doughten, S., & Jenkins, R.M. (1987). Adolescent snacks: nutrient density and nutritional contribution to total intake. *Journal of the American Dietetic Association, 87,* 1678-1679.

Bingham, S.A. (1987). The dietary assessment of individuals: methods, accuracy, new techniques and recommendations. *Nutrition Abstracts and Reviews, 57,* 705-742.

Bingham, S.A. (1994). The use of 24-h urine samples and energy expenditure to validate dietary assessments. *American Journal of Clinical Nutrition, 59, S*227-S231.

Bingham, S.A., Gill, C., Welch, A., Day, K., Cassidy, A., Khaw, K.T., Sneyd, M.J., Key, T.J.A., Roe, L., & Day, N.E. (1994). Comparison of dietary assessment methods in nutritional epidemiology: weighed records v. 24 h recalls, food-frequency questionnaires and estimated diet-records. *British Journal of Nutrition, 72,* 619-643.

Bingham, S.A., Cassidy, A., Cole, T.J., Welch, A., Runswick, S.A., Black, A.E., Thurnham, D., Bates, C., Khaw, K.T., & Day, N.E. (1995). Validation of weighed records and other methods of dietary assessment using the 24hr urinary nitrogen technique and other biological markers. *British Journal of Nutrition, 73,* 531-550.

Bingham, S.A., Nelson, M., Paul, A.A., Haraldsdottir, J., Bjorge Loken, E., & van Staveren, W.A. (1988). Methods for data collection at househol or institutional level. In M.E. Cameron & W.A. Van Staveren (Eds.), *Manual on Methodology for Food Consumption Studies.* (pp. 53-106). Oxford: Oxford Medical Publications.

Black, A.E., Prentice, A.M., Goldberg, G.R., Jebb, S.A., Bingham, S.A., Livingstone, M.B.E., & Coward, W.A. (1993). Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. *Journal of the American Dietetic Association, 93,* 572-579.

Black, A.E. (2000a). Critical evaluation of energy intake using the Goldberg cut-off for energy intake:basal metabolic rate. A practical guide to its calculation, use and limitations. *International Journal of Obesity, 24,* 1119-1130.

Black, A.E. (2000b). The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying dietary reports of poor validity. *European Journal of Clinical Nutrition, 54,* 395-404.

Black, A.E., Coward, W.A., & Prentice, A.M. (1996). Human energy expenditure in affluent societies: an analysis of 574 doubly-labelled water measurements. *European Journal of Clinical Nutrition, 50,* 72-92.

Black, A.E., Goldberg, G.R., Jebb, S.A., Livingstone, M.B.E., Cole, T.J., & Prentice, A.M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *European Journal of Clinical Nutrition, 45,* 583-599.

Black, A.E., Jebb, S.A., Bingham, S.A., Runswick, S.A., & Poppitt, S.D. (1995). The validation of energy and protein intakes by doubly labelled water and 24-hour urinary nitrogen excretion in post-obese subjects. *Journal of Human Nutrition and Dietetics, 8,* 51-64.

Blair, A.J., Booth, D.A., Lewis, V.J., & Wainwright, C.J. (1989). The relative success of official and informal weight reduction techniques: retrospective correlational evidence. *Psychology and Health, 3,* 195-206.

Blokstra, A., Burns, C.M., & Seidell, J.C. (1999). Perception of weight status and dieting behaviour in Dutch men and women. *International Journal of Obesity, 23,* 7-17.

Bone, A. (1992). Methods for studying food consumption (specified time methods). In J.R. Kemm & D. Booth (Eds.), *Promotion of Healthier Eating.* (pp. 169-188). London: HMSO.

Booth, D.A. (1996). Measurement of hunger and satiety for long-term weight control. In A. Angel, G.H. Anderson, C. Bouchard, D. Lau, L. Leiter, & R. Mendelson (Eds.), *Progress in Obesity Research.* (pp. 355-358). London: John Libby.

Bortz, W.M., Howat, P., & Holmes, W.L. (1969). The effect of feeding frequency on diurnal plasma free fatty acids and glucose levels. *Metabolism, 18,* 120-123.

Bortz, W.M., Wroldsen, A., Issekutz, B., & Rodahl, K. (1966). Weight loss and frequency of feeding. *New England Journal of Medicine, 274,* 376-379.

Briefel, R.R., McDowell, M.A., Alaimo, K., Caughman, C.R., Bischof, A.L., Carroll, M.D., & Johnson, C.L. (1995). Total energy intake of the US population: the third National Health and Nutrition Examination Survey, 1988-1991. *American Journal of Clinical Nutrition, 62, S*1072-S1080.

Briefel, R.R., Sempos, C.T., McDowell, M.A., Chien, S., & Alaimo, K. (1997). Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *American Journal Clinical Nutrition, 65(Suppl), S*1203-S1209.

British Nutrition Foundation. (1985). *Eating in the early 1980's. Attitudes and Behaviour: Main Findings.* London: British Nutrition Foundation.

Burley, V.J., Cotton, J.R., Weststrate, J.A., & Blundell, J.E. (1993). Effect on appetite of replacing natural fat with sucrose polyester in meals or snacks across one whole day. In H. Ditschuneit, F.A. Gries, H. Hauner, V. Schusdziarra, & J.G. Wechsler (Eds.), *Obesity in Europe.* (pp. 213-219). London: John Libbey & Co.

Burt, B.A., Eklund, S.A., Morgan, K.J., Larkin, F.E., Guire, K.E., Brown, L.O., & Weintraub, J.A. (1988). The effect of sugars intake and frequency of ingestion on dental caries increment in a three year longitudinal study. *Journal of Dental Research, 67,* 1422-1429.

Butterworth, D.E., Nieman, D.C., Butler, J.V., & Herring, J.L. (1994). Food intake patterns of marathon runners. *International Journal of Sport Nutrition, 4,* 1-7.

Cala, R.F., Zabik, E., & Morgan, K.J. (1980). Snacking and its nutrient contribution to the diet of school-age children. *School Food Service Research Review, 4,* 113-117.

Chan, L. (1992). Apolipoprotein B, the major protein component of triglyceride-rich and low density lipoprotein. *Journal of Biological Chemistry, 267,* 25621-25624.

Chapman, G., & Maclean, H. (1993). "Junk Food" and "Healthy Food": meanings of food in adolescent women's culture. *Journal of Nutrition Education, 25,* 108-113.

Charzewska, J., Kulesza, W., Brzezinska, J., & Chwojnowska, Z. (1981). Relationship between obesity or overweight development and the frequency of meals, their distribution during the day and consumption of atherogenic food products. *Zywienie Czlowieka, 8,* 217-227.

Cohen, J.C., Noakes, T.D., & Benade, A.J.S. (1989). Postprandial lipaemia and chylomicron clearance in athletes and in sedentary men. *American Journal of Clinical Nutrition, 49,* 443-447.

Cohn, C. (1964). Feeding patterns and some aspects of cholesterol metabolism. *Federation Proceedings, 23,* 76-81.

Crawley, H., & Summerbell, C. (1997). Feeding frequency and BMI among teenagers aged 16-17 years. *International Journal of Obesity , 21,* 159-161.

Cross, A.T., Babicz, D., & Cushman, L.F. (1994). Snacking patterns among 1,800 adults and children. *Journal of the American Dietetic Association, 94,* 1398-1403.

Cullen, P., von Eckardstein, A., Souris, A., Schulte, H., & Assmann, G. (1999). Dyslipidaemia and cardiovascular risk in diabetes. *Diabetes & Obesity Metabolism, 4,* 189-198.

Daly, M.E., Vale, C., Walker, M., Littlefield, A., Alberti, K.G.M.M., & Mathers, J.C. (1998). Acute effects on insulin sensitivity and diurnal metabolic profiles of a high-sucrose compared with a high-starch diet. *Americal Journal of Clinical Nutrition, 67,* 1186-1196.

De Castro, J.M. (1987). Circadian Rhythms of the Spontaneous Meal Pattern, Macronutrient intake and Mood of Humans. *Physiology and Behaviour, 40,* 437-446.

De Castro, J.M. (1997). Socio-cultural determinants of meal size and frequency. *British Journal of Nutrition, 77,* S39-S55.

Dreon, D.M., Frey-Hewitt, B., Ellsworth, N., Williams, P.T., Terry, R.B., & Wood, P.D. (1988). Dietary fat : carbohydrate ratio and obesity in middle-aged men. *American Journal of Clinical Nutrition, 47,* 995-1000.

Drummond, S., Kirk, T., Crombie, N. (unpublished results). Cited by Gatenby, S. (1997). Eating frequency: methodological and dietary aspects. *British Journal of Nutrition,* 77, S7-S20.

Drummond, S., Crombie, N., Cursiter, M.C., & Kirk, T.R. (1998). Evidence that eating frequency is inversely related to body weight status in male, but not female, non-obese adults reporting valid dietary intakes. *International Journal of Obesity, 22,* 105-112.

Drummond, S., Crombie, N., & Kirk, T.R. (1996). A critique of the effects of snacking on body weight status. *European Journal of Clinical Nutrition, 50,* 779-783.

Dugdale, A.E., Townsend, B., & Rigsby, B. (1988). The eating and snacking patterns of young people in Brisbane, Australia. *Journal of Human Nutrition and Dietetics, 1,* 95-104.

Duggal, M.S. (2000). Enamel demineralisation in situ with varying frequency of carbohydrate consumption with and without fluoride toothpaste. *Caries Research, 34,* 309.

Eastwood Garcia, S., Kaiser, L.L., & Dewey, K.G. (1990). The relationship of eating frequency and caloric density to energy intake among rural Mexican pre-school children. *European Journal of Clinical Nutrition, 44,* 381-387.

Edelstein, S.L., Barrett-Connor, E.L., Wingard, D.L., & Cohn, B.A. (1992). Increased meal frequency associated with decreased cholesterol concentrations; Rancho Bernado, CA, 1984-1987. *American Journal of Clinical Nutrition, 55,* 664-669.

Edington, J., Thorogood, M., Geekie, M., Ball, M., & Mann, J. (1989). Assessment of nutritional intake using dietary records with estimated weights. *Journal of Human Nutrition and Dietetics, 2,* 407-414.

Eurodiet. (2000): http://eurodiet.med.uoc.gr

Fabry, P., Fodor, J., Hejl, Z., Braun, T., & Zvolankova, K. (1964). The frequency of meals: its relation to overweight, hypercholesterolaemia and decreased glucose-tolerance. *Lancet, ii,* 614-615.

Fabry, P., Fodor, J., Hejl, Z., Geizerova, H., & Balcarova, O. (1968). Meal frequency and ischaemic heart disease. *Lancet, ii,* 190-191.

Farris, R.P., Cresanta, J.L., Croft, J.B., Webber, L.B., Frank, G.C., & Berenson, G.S. (1986). Macronutrient intakes of 10-year-old children, 1973 to 1982. *Journal of the American Dietetic Association, 86,* 765-770.

Fielding, C.J. (1987). Factors affecting the rate of catalyzed transfer of cholesteryl esters in plasma. *American Heart Journal, 113,* 532-537.

Food and Agriculture Organization/World Health Organisation of the United Nations. Preparation and use of Food-Based-Dietary-Guidelines. Report of a joint FAO/WHO consultation Nicosia, Cyprus. WHO. (1996). WHO/NUT/96.6.

Franz, M.J., Horton, E., Bantle, J.P., Beebe, C.A., Brunzell, J.D., Coulston, A.M., Henry, R.R., Hogwerf, B.J., & Stacpoole, P.W. (1994). Nutrition principles for the manangement of diabetes and related complications. *Diabetes Care, 17,* 490-518.

French, S.A., Jeffery, R.W., & Murray, D. (1999). Is dieting good for you?: Prevalence, duration and associated weight and behaviour changes for specific weight loss strategies over four years in US adults. *International Journal of Obesity , 23,* 320-327.

Fricker, J., Giroux, S., Funeron, F., & Apfelbaum, M. (1990). Circadian rhythm of energy intake and corpulence status in adults. *International Journal of Obesity, 14,* 387-393.

Gatenby, S., Anderson, A.O., Walker, A.D., Southon, S., & Mela, D.J. (1995). "Meals" and "Snacks" - Implications for Eating Patterns In Adults. *Appetite, 24,* 292.

Gatenby, S.J. (1997). Eating frequency: methodological and dietary aspects. *British Journal of Nutrition, 77,* S7-S20.

Gibney, M.J., & Wolever, T.M.S. (1997). Periodicity of eating and human health: present perspective and future directions. *British Journal of Nutrition, 77,* S3-S5.

Gill, J.M., Mees, G.P., Frayn, K.N., & Hardman, A.E. (2001). Moderate exercise, postprandial lipaemia and triacylglycerol clearance. *European Journal of Clinical Investigation, 31,* 201-207.

Gillespie, A. (1983). Assessing snacking behaviour in children. *Ecology of Food and Nutrition, 13,* 167-172.

Gnardellis, C., Boulou, C., & Trichopoulou, A. (1998). Magnitude, determinants and impact of under-reporting of energy intake in a cohort study in Greece. *Public Health Nutrition, 1,* 131-137.

Goldberg, G.R., Black, A.E., Jebb, S.A., Cole, T.J., Murgatroyd, P.R., Coward, W.A., & Prentice, A.M. (1991b). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off values to identify under-recording. *European Journal of Clinical Nutrition, 45,* 569-581.

Goldberg, G.R., Prentice, A.M., Coward, W.A., Davies, H.L., Murgatroyd, P.R., Sawyer, M.B., Ashford, J., & Black, A.E. (1991a). Longitudinal assessment of the components of energy balance in well-nourished lactating women. *American Journal of Clinical Nutrition, 54,* 788-798.

Goldberg, R.B. (2000). Hyperlipidaemia and cardiovascular risk factors in patients with type 2 diabetes. *Am J Manag Care, 6,* S682-S691.

Green, S.M., Burley, V.J., & Blundell, J.E. (1994). Effect of fat- and sucrose-containing foods on the size of eating episodes and energy intake in lean males: potential for causing overconsumption. *European Journal of Clinical Nutrition, 48,* 547-555.

Griffin, B.A., Freeman, D.J., Tait, G.W., Thompson, J., Caslake, M.J., Packard, C.J., & Shepherd, J. (1994). Role of plasma triglyceride in the regulation of plasma low density lipoprotein (LDL) subfractions: relative contribution of small, dense LDL to coronary heart disease risk. *Atherosclerosis , 106,* 241-253.

Griffiths, A.J., Humphreys, S.M., Clark, M.L., Fielding, B.A., & Frayn, K.N. (1994). Immediate metabolic availability of dietary fat in combination with carbohydrate. *American Journal of Clinical Nutrition, 59,* 53-59.

Grundy, S.M. (1990). *Cholesterol and Atherosclerosis Diagnosis and Treatment.* New York: Gower Medical Publishing.

Gwinup, G., Bryon, R.C., Roush, W.H., Kruger, F.A., & Hamwi, G.J. (1963a). Effect of nibbling versus gorging on serum lipids in man. *American Journal of Clinical Nutrition, 13,* 209-213.

Gwinup, G., Roush, W.H., Byron, R.C., & Kruger, F.A. (1963b). Effect of nibbling versus gorging on glucose tolerance. *Lancet*, 165-167.

Hallett, C., Hourani, S.M.O., & Williams, C.M. (1994). The effect of postprandial lipaemia on platelet aggregation. *Proceedings of the Nutrition Society, 53,* 81A.

Haveman-nies, A., de Groot, L.C.P.G.M., & van Staveren, W.A. (1998). Snack patterns of older Europeans. *Journal of the American Dietetic Association, 98,* 1297-1302.

Health Promotion Wales. Diet and young people in Wales, 1986-1992. Health Promotion Wales. (1993). Tecnical Report no 3.

Heitmann, B.L. (1993). The influence of fatness, weight change, slimming history and other lifestyle variables on diet reporting in Danish men and women aged 35-65 years. *International Journal of Obesity, 17,* 329-336.

Heitmann, B.L., & Lissner, L. (1995). Dietary underreporting by obese individuals - is it specific or non-specific? *British Medical Journal, 311,* 986-989.

Heywood, P., Harvey, P.W.J., & Marks, G.C. (1993). An evaluation of energy intakes in the 1983 Australian National Dietary Survey of Adults. *European Journal of Clinical Nutrition, 47,* 603-606.

Hirvonen, T., Mannisto, S., Roos, E., & Pietinen, P. (1997). Increasing prevalence of underreporting does not necessarily distort dietary surveys. *European Journal of Clinical Nutrition, 51,* 297-301.

Irwin, M.I., & Feeley, R.M. (1967). Frequency and size of meals and serum lipids, nitrogen and mineral retention, fat digestibility, and urinary thiamine and riboflavin in young women. *American Journal of Clinical Nutrition, 20,* 816-824.

Jenkins, D.A. (1997). Carbohydrate tolerance and food frequency. *British Journal of Nutrition, 77,* S71-S81.

Jenkins, D.J.A., Wolever, T.M.S., Vuksan, V., Brighenti, F., Cunnane, S.C., Rao, A.V., Jenkins, A.L., Buckley, G., Patten, R., Singer, W., Corey, P., & Josse, R.J. (1989). Nibbling versus gorging: metabolic advantages of increased meal frequency. *New England Journal of Medicine, 321,* 929-934.

Jenkins, D.J.A., Wolever, T.M.S., Ocana, A.M., Vuksan, V., Cunnane, S.C., Jenkins, A.L., Wong, G.S., Singer, W., Bloom, S.R., Blendis, L.M., & Josse, R.G. (1990). Metabolic effects of reducing rates of glucose ingestion by single bolus versus continous sipping. *Diabetes, 39,* 775-781.

Jenkins, D.J.A., Ocana, A., Jenkins, A.L., Wolever, T.M.S., Vuksan, V., Katzman, L., Hollands, M., Greenberg, G., Corey, P., Patten, R., Wong, G., & Josse, R.J. (1992). Metabolic advantages of spreading the nutrient load: effects of increased meal frequency in non-insulin diabetes. *American Journal of Clinical Nutrition,* 461-467.

Jenkins, D.J.A., Jenkins, A.L., Wolever, T.M.S., Vuksan, V., Rao, A.V., Thompson, L.U., & Josse, R.G. (1994). Low glycaemic index: lente carbohydrates and physiological effects of altered food frequency. *American Journal of Clinical Nutrition, 59, S*706-S709.

Jenkins, D.J.A., & Jenkins, A.L. (1995). Nutrition principles and diabetes. A role for 'lente carbohydrate'? *Diabetes Care*, *18,* 1491-1498.

Jenkins, D.J.A., Wolever, T.M.S., Taylor, R.H., Kannen, W., Sarson, D., & Bloom, S.R. (1983). Reply to letter by Abraira and Lawrence. *American Journal of Clinical Nutrition*, *37,* 153-154.

Johansson, L., Solvoll, K., Bjørneboe, G.A., & Drevon, C.A. (1998). Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. *American Journal of Clinical Nutrition*, *68,* 266-274.

Johnstone, A.M., Shannon, E., Whybrow, S., Reid, C.A., & Stubbs, R.J. (2000). Altering the temporal distribution of energy intake with isoenergetically dense foods given as snacks does not affect total daily energy intake in normal-weight men. *British Journal of Nutrition*, *83,* 7-14.

Jones, P.J.H., Leitch, C.A., & Pederson, R.A. (1993). Meal frequency effects on plasma hormone concentrations and cholesterol synthesis in humans. *American Journal of Clinical Nutrition*, *57,* 868-874.

Jordan, J.A., & Novascone, M.A. (1989). Effect of altered feeding patterns on serum lipids and lipoproteins in adult males. *Journal of Human Nutrition and Dietetics*, *2,* 19-24.

Juhel, C., Pafumi, Y., Senft, M., Lafont, H., & Lairon, D. (2000). Chronically gorging v. nibbling fat and cholesterol increases postprandial lipaemia and atheroma deposition in the New Zealand white rabbit. *British Journal of Nutrition*, *83,* 549-559.

Kandelman, D. (1997). Sugar, alternative sweeteners and meal frequency in relation to caries prevention: new perspectives. *British Journal of Nutrition*, *77,* S121-S128.

Kant, A.K., Schatzkin, A., Graubard, B.I., & Ballard-Barbash, R. (1995). Frequency of eating occasions and weight change in the NHANES I Epidemiologic Follow-up Study. *International Journal of Obesity, 19,* 468-474.

Karpe, F., Steiner, G., Olivecrona, T., Carlson, L.A., & Hamsten, A. (1993). Metabolism of triglyceride-rich lipoproteins during alimentary lipemia. *Journal of Clinical Investigation, 91,* 748-758.

Kearney, M. (1994). Studies on attitudes and beliefs for healthy eating promotion. Trinity College Dublin: PhD Thesis.

Khan, M.A., & Lipke, L.K. (1982). Snacking and its contribution to food and nutrient intake of college students. *Journal of the American Dietetic Association, 81,* 583-587.

King, S., & Gibney, M.J. (1999). Dietary advice to reduce fat intake is more successful when it does not restrict habitual eating patterns. *Journal of the American Dietetic Association, 99,* 685-689.

Kirk, T.R. (2000). Role of dietary carbohydrate and frequent eating in body-weight control. *Proceedings of the Nutrition Society, 59,* 349-358.

Kirk, T.R., & Crombie, N. (1996). Snacking and Body Weight. *CHO, 7,* 1-3.

Kirk, T.R., Drummond, S., & Ruxton, C.H.S. (1995). The effect of snacking on overall energy and nutrient intakes and body weight status. In, *Summaries of the Seventh European Nutrition Conference.* (pp. 17).

Kistemaker, I.C., & Aarnink, E.J.M. Vetconsumptie door de Nederlandse bevolking per maaltijdmoment, naar leeftijd en geslacht. Voedselconsumptiepeiling 1987-1988 (Fat intake of the Dutch population per eating moment by age and sex). TNO. (1989). V 89.503, 1 p.

Kistemaker, I.C., & Löwik, M.R.H. (1991). Wat eet Nederland werkelijk? *Voeding, 52,* 64-67.

Klesges, R.C., Eck, L.E., & Ray, J.W. (1995). Who underreports dietary intake in a dietary recall? Evidence from the Second National Health and Nutrition Examination Survey. *Journal of Consulting and Clinical Psychology, 63,* 438-444.

Klesges, R.C., Mizes, J.S., & Klesges, L.M. (1987). Self-help dieting strategies in college males and females. *International Journal of Eating Disorders, 6,* 71-79.

Lafay, L., Basdevant, A., Charles, M., Vray, M., Balkau, B., Borys, J., Eschwège, E., & Romon, M. (1997). Determinants and nature of dietary underreporting in a free-living population: the Fleurbaix Laventie Ville Santé (FLVS) study. *International Journal of Obesity, 21,* 567-573.

Lawton, C., Delargy, H., Smith, F., Hamilton, V., & Blundell, J.E. (1999). Low fat snacks reduce daily fat intake in high fat consumers by 17%. *International Journal of Obesity, 23,* S56.

Lawton, C.L., Delargy, H.J., Smith, F.C., Hamilton, V., & Blundell, J.E. (1998). A medium-term intervention study on the impact of high- and low-fat snacks varying in sweetness and fat content: large shifts in daily fat intake but good compensation for daily energy intake. *British Journal of Nutrition, 80,* 149-161.

*The UK Snack-foods Report.* UK: Leatherhead Food Research Association. (1992).

Lennernäs, M., & Andersson, I. (1999). Food-based Classification of Eating Episodes (FBCE). *Appetite, 32,* 53-65.

Lennernäs, M.A.C., Akerstedt, T., Hagman, U., Bruce, A., & Hambraeus, L. (1993). A new approach for evaluation of meal quality and meal patterns. *Journal of Human Nutrition and Dietetics, 6,* 261-273.

Lichtman, S.W., Pisarska, K., Raynes Berman, E., Pestone, M., Dowling, H., Offenbacher, E., Weisel, H., Heshka, S., Matthews, D.E., & Heymsfield, S.B. (1992). Discrepancy between self-reported and actual caloric intake and exercise in obese subkects. *New England Journal of Medicine*, *327,* 1893-1898.

Lindeman, A.K. (1990). Eating and training habits of triathletes: A balancing act. *Journal of the American Dietetic Association*, *90,* 993-995.

Lipid Research Clinics Program. (1984). The lipid research clinics coronary primary prevention trial results: II the relationship of incidence of coronary heart disease to cholesterol lowering. *Journal of the American Medical Association*, *251,* 365-374.

Livingstone, M.B.E., Prentice, A.M., Strain, J.J., Coward, W.A., Black, A., Barker, M.E., McKenna, P.G., & Whitehead, R.G. (1990). Accuracy of weighed dietary records in studies of diet and health. *British Medical Journal*, *300,* 708-712.

Livingstone, M.B.E. (1991). CHO International Dialogue on Carbohydrates. Children's food and snacking. London: Advisa Medica. 2.

Livingstone, M.B.E. (1995). Assessment of food intakes: are we measuring what people eat? *American Journal of Clinical Nutrition*, *52,* 58-67.

Longnecker, M.P., Harper, J.M., & Kim, S. (1997). Eating frequency in the Nationwide Food Consumption Survey (U.S.A.), 1987-1988. *Appetite*, *29,* 55-59.

Macdiarmid, J.I., & Blundell, J.E. (1997). Dietary under-reporting: what people say about recording their food intake. *European Journal of Clinical Nutrition*, *51,* 199-200.

Magarey, A., Nichols, J., & Boulton, J. (1987). Food intake at age 8 3. Distribution and food density by meal. *Australian Paediatric Journal*, *23,* 217-221.

Mäkelä, J., Kjaernes, U., Pipping Ekström, M., L'Orange Fürst, E., Gronow, J., & Holm, L. (1999). Nordic meals: Methodological notes on a comparative survey. *Appetite, 32,* 73-79.

Mann, J. (1997). Meal frequency and plasma lipids and lipoproteins. *British Journal of Nutrition, S1,* S83-S90.

Marr, J.W. (1971). Individual dietary surveys: purposes and methods. *World Review of Nutrition and Dietetics, 13,* 105-164.

McBride, A., Wise, A., McNeill, G., & James, W.P.T. (1990). The pattern of food consumption related to energy intake. *Journal of Human Nutrition and Dietetics, 3,* 27-32.

McCarthy, S.N., Livingstone, M.B.E., Harrington, K.E., Kiely, M., Robson, P.J., & Gibney, M.J. (2001). Analyses of anthropometric data from the North/South Ireland Food Consumption Survey. *Public Health Nutrition, In Press.*

McCoy, H., Moak, S., Kenney, M.A., Kirby, A., Chopin, L., Billon, W., Clark, A., Disney, G., Ercarli, F.G., Glover, E., Korslund, M., Lewis, H., Ritchey, J., Schilling, S., Schuffner, S., & Wakefield, T. (1986). Snacking patterns and nutrient density of snacks consumed by Southern girls. *Journal of Nutrition Education, 18,* 61-66.

McGrath, S.A., & Gibney, M.J. (1994). The effects of altered frequency of eating on plasma lipids in free-living healthy males on normal self-selected diets. *European Journal of Clinical Nutrition, 48,* 402-407.

Medaugh-Abernethy, M., & Fanelli-Kuczmarski, M.T. (1994). Food intake and food-related attitudes of older women: implications for nutrition education. *Journal of Nutrition Education, 26,* 3-9.

Mennen, L.I., Schouten, E.G., Grobbee, D.E., & Kluft, C. (1996). Coagulation factor VII, dietary fats and blood lipids: a review. *Thromb Haem, 76,* 492-499.

Metzner, H.L., Lamphiear, D.E., & Wheeler, N.C. (1977). The relationship between frequency of eating and adiposity in adult men and women in the Tecumseh Community Health Study. *American Journal of Clinical Nutrition, 30,* 712-715.

Miller, W.D. (1890). Cited by König, K. (Editor) (1973). *The Microorganisms of the Human Mouth.* Basel: S. Karger.

Morgan, K.J., Johnson, S.R., & Stampley, G.L. (1988). Relationship between snack and meal consumption. *Nutrition Research, 8,* 708-719.

Murphy, M.C., Chapman, C., Lovegrove, J.A., Isherwood, S.G., Morgan, L.M., Wright, J.W., & Williams, C.M. (1996). Meal frequency; does it determine postprandial lipaemia? *European Journal of Clinical Nutrition, 50,* 491-497.

National Dairy Council. (1995). *Teenage Eating Habits: a summary of a survey carried out in conjunction with Youth Express Magazine.* London: NDC.

Nunes, W.T., & Canham, J.E. (1963). The effect of varied periodicity of eating on serum lipids and carbohydrate tolerance in man. *American Journal of Clinical Nutrition, 12,* 334.

O'Flaherty, L., & Gibney, M.J. (1994). The effect of very low, moderate and high-fat snacks on postprandial reverse cholesterol transport in healthy volunteers. *Proceedings of the Nutrition Society, 53,* 124A.

Oltersdorf, U. (1996). Impact of changing food choices and eating habits on nutritional status in European countries. *Appetite, 27,* 91-94.

Oltersdorf, U., Schlettwein-Gsell, D., & Winkler, G. (1999). Assessing eating patterns - an emerging research topic in nutritional sciences: Introduction to the symposium. *Appetite, 32,* 1-7.

Patsch, J.R., Karlin, J.B., Scott, L.W., Smith, L.C., & Gotto, A.M. (1983). Inverse relationship between blood levels of high density lipoprotein subfraction 2 and magnitude of postprandial lipaemia. *Proceedings of the National Academy of Sciences USA, 80,* 1449-1453.

Patsch, J.R., Prasad, S., Gotto, A.M., & Bengtsson-Olivecrona, G. (1984). Postprandial lipemia. A key for the conversion of high density lipoprotein$_2$ into high density lipoprotein$_3$ by hepatic lipase. *Journal of Clinical Investigation, 74,* 2017-2023.

Patsch, J.R., Prasad, S., Gotto, A.M., & Patsch, W. (1987). High density lipoprotein$_2$. Relationship of the plasma levels of this lipoprotein species to its composition, to the magnitude of postprandial lipemia, and to the activities of lipoprotein lipase and hepatic lipase. *Journal of Clinical Investigation, 80,* 341-347.

Peters, J.R., Rhodes, J., & Owens, D.R. (1979). Metabolic effects of altered meal frequency in man. *Hormone Metabolism Research, 11,* 524-525.

Pfau, C. (1999). Methodology of a survey on meal patterns in private senior households. *Appetite, 32,* 38-45.

Poppit, D., Swann, D., Black, A., & Prentice, A.M. (1998). Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *International Journal of Obesity, 22,* 303-311.

Powell, J.T., Franks, P.J., & Poulter, N.R. (1999). Does nibbling or grazing protect the peripheral arteries from atherosclerosis? *Journal of Cardiovascular Risk, 6,* 19-22.

Prättälä, R., & Roos, E. (1999). From regional ethnographies to interdisciplinary approaches - research on meals in Finland. *Appetite, 32,* 66-72.

Prentice, A.M., Black, A.E., Coward, W.A., Davies, H.L., Goldberg, G.R., Murgatroyd, P.R., Ashford, J., Sawyer, M.B., & Whitehead, R.G. (1986). High levels of energy expenditure in obese women. *British Medical Journal , 292,* 983-987.

Price, G.M., Paul, A.A., Cole, T.J., & Wadsworth, M.E.J. (1997). Characteristics of the low-energy reporters in a longitudinal national dietary survey. *British Journal of Nutrition, 77,* 833-851.

Pryer, J.A., Vrihjheid, M., Nichols, R., Kiggins, M., & Elliot, P. (1997). Who are the 'low energy reporters' in the Dietary and Nutritional Survey of British Adults? *International Journal of Epidemiology, 26,* 146-153.

Raben, A., Kiens, B., & Richter, E.A. (1994). Increased postprandial thermogenesis after simple compared with complex carbohydrates in two carbohydrate-rich isoenergetic meals. *American Journal of Clinical Nutrition, 59, S*789.

Rapp, J.H., Lespine, A., Hamilton, R.L., Colyvas, N., Chaumeton, A.H., Tweedie-Hardman, J., Kotite, L., Kunitake, S.T., Havel, R.J., & Kane, J.P. (1994). Triglyceride-rich lipoproteins isolated by selective-affinity anti-apoprotein B immunosorbtion from human atherosclerotic plaque. *Arteriosclerosis Thrombosis, 14,* 1767-1774.

Rebro, S., Patterson, R.E., Kristal, A.R., & Cheney, C.L. (1998). The effect of keeping food records on eating patterns. *Journal of the American Dietetic Association, 98,* 1163-1165.

Redondo, M.R., Ortega, R.M., Zamora, M.J., Quintas, M.E., Lopez-Sobaler, A.M., Andres, P., & Gaspar, M.J. (1997). Influence of the number of meals taken per day on cardiovascular risk factors and the energy and nutrient intakes of a group of elderly people. *International Journal of Vitamin and Nutrition Research, 67,* 176-182.

Robson, P.J., & Strain, J.J. (1991). Snack energy and nutrient intakes of Northern Ireland adolescents. *Proceedings of the Nutrition Society, 50,* 180A.

Roche, H.M., & Gibney, M.J. (1995). Postprandial triacylglycerolaemia - nutritional implications. *Progress in Lipid Research, 34,* 249-266.

Roche, H.M., & Gibney, M.J. (1996). Postprandial triacylglycerolaemia: the effect of low-fat dietary treatment with and without fish oil supplementation. *European Journal of Clinical Nutrition, 50,* 617-624.

Roche, H.M., & Gibney, M.J. (2000). The impact of postprandial lipemia in accelerating atherothrombosis. *Journal of Cardiovascular Risk, 7,* 313-324.

Rogers, P.J., & Lloyd, H.M. (1994). Nutrition and mental performance. *Proceedings of the Nutrition Society, 53,* 443-456.

Roos, E., & Prättälä, R. (1997). Meal pattern and nutrient intake among adult Finns. *Appetite, 29,* 11-24.

Roos, G.M., Quandt, S.A., & DeWalt, K.M. (1993). Meal patterns of the elderly in rural Kentucky. *Appetite, 21,* 295-298.

Rossner, S. (1995). Realistic expectations of obesity treatments. In R. Cotrell (Ed.), *Weight control - the current perspectives.* London: Chapman and Hall.

Rotenberg, R. (1981). The impact of industrialization on meal patterns in Vienna, Austria. *Ecology of Food and Nutrition, 11,* 25-35.

Ruddock, V., & Meade, T.W. (1994). Factor VII activity and ischaemic heart disease: fatal and non-fatal events. *Quarterly Journal of Medicine, 87,* 403-406.

Rugg-Gunn, A.J., Hackett, A.F., Appleton, D.R., & Moynihan, P.J. (1986). The Dietary Intake of Added and Natural Sugars in 405 English Adolescents. *Human Nutrition: Applied Nutrition, 40A,* 115-124.

Rutishauser, I.H.E., Wheeler, C.E., Conn, J.A., & O'Dea, K. (1994). Food and nutrient intake in a randomly selected sample of adults: demographic and temporal influences on energy and nutrient intake. *Australian Journal of Nutrition and Dietetics, 51,* 157-166.

Ruxton, C.H.S., Kirk, T.R., & Belton, N.R. (1996). The contribution of specific dietary patterns to energy and nutrient intakes in 7-8-year-old Scottish schoolchildren. III. Snacking habits. *Journal of Human Nutrition and Dietetics, 9,* 23-31.

Samuelson, G. (1971). An epidemiological study of child health and nutrition in a northern Swedish county. 1. Food consumption survey. *Acta Paediatrica Scandinavica, 60,* 653-665.

Samuelson, G., Bratteby, L., Enghardt, H., & Hedgren, M. (1996). Food habits and energy and nutrient intake in Swedish adolescents approaching the year 2000. *Acta Paediatrica, Suppl 415, S*1-S20.

Schlettwein-Gsell, D., & Barclay, D. (1996). Longitudinal changes in dietary habits and attitudes of elderly Europeans. *European Journal of Clinical Nutrition, 50,* S56-S66.

Schlierf, G., & Dorrow, E. (1973). Diurnal patterns of triglycerides, free fatty acids, blood sugar and insulin, during carbohydrate-induction in man and their modification by nocturnal suppression of lipolysis. *Journal of Clinical Investigation, 52,* 732-740.

Schneeman, B.O., Kotite, L., Todd, K.M., & Havel, R.J. (1993). Relationships between the responses of triglyceride-rich lipoproteins in blood plasma containing apolipoproteins B-48 and B-100 to a fat-containing meal in normolipidemic humans. *Proceedings of the Natural Academy of Sciences USA, 90,* 2069-2073.

Schoeller, D.A. (1990). How accurate is self-reported dietary energy intake? *Nutrition Reviews, 48,* 373-379.

Schofield, W.N., Schofield, C., & James, W.P.T. (1985). Basal metabolic rate-review and prediction. *Human Nutrition Clinical Nutrition, 39,* 1-96.

Segura, A.G., Josse, R.G., & Wolever, T.M.S. (1995). Acute metabolic effects of increased meal frequency in type II diabetics: three vs six, nine and twelve meals. *Diabetes Nutrition and Metabolism, 8,* 331-338.

Sethi, S., Gibney, M.J., & Williams, C.M. (1993). Postprandial lipoprotein metabolism. *Nutrition Research Reviews, 6,* 161-183.

Siega-Riz, A.M., Carson, T., & Popkin, B. (1998). Three squares or mostly snacks - what do teens really eat? *Journal of Adolescent Health, 22,* 29-36.

Skinner, J.D., Salvetti, N.N., Ezell, J.M., Penfield, M.P., & Costello, C.A. (1985). Appalachian adolescents' eating patterns and nutrient intakes. *Journal of the American Dietetic Association, 85,* 1093-1099.

Speechly, D.P., & Buffenstein, R. (1999). Greater appetite control associated with an increased frequency of eating in lean males. *Appetite, 33,* 285-297.

St.Jeor, S.T., Harrington, M.E., Brunner, R.L., Scott, B.J., Foreyt, J.P., & Dyer, A.R. (1995). How eating patterns may relate to obesity. *International Journal of Obesity and Related Metabolic Disorders, 19,* 28.

Stubbs, R.J., van Wyk, M.C.W., Johnstone, A.M., & Harbron, C.G. (1996). Breakfasts high in protein, fat or carbohydrate: effect on within-day appetite and energy balance. *European Journal of Clinical Nutrition, 50,* 409-417.

Stunkard, A.J., & Messick, S. (1985). The Three-Factor Eating Questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research, 29,* 71-83.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1995). Sources of energy from meals versus snacks in 220 people in four age groups. *European Journal of Clincical Nutrition, 49,* 33-41.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1996). Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. *European Journal of Clinical Nutrition, 50,* 513-519.

Tall, A., Sammett, D., & Granot, E. (1986). Mechanisms of enhanced cholesteryl ester transfer from high density lipoproteins to apolipoprotein B-containing lipoproteins during alimentary lipemia. *Journal of Clinical Investigation, 77,* 1163-1172.

Thomas, B., & British Dietetic Association. (1994). *Manual of Dietetic Practice.* Oxford: Blackwell Scientific Publications.

Thomas, J.A., & Call, D.L. (1973). Eating between meals - a nutrition problem in teenagers? *Nutrition Reviews, 31,* 137-139.

Thomsen, D., Christiansen, C., Rasmussen, O.W., & Hermansen, K. (1997). Comparison of the effects of two weeks intervention with different meal frequencies on glucose metabolism, insulin sensitivity and lipid levels in non-insulin dependent diabetic patients. *Annals of Nutrition and Metabolism, 41,* 173-180.

Truswell, A.S., & Darnton-Hill, I. (1981). Food habits of adolescents. *Nutrition Reviews, 39,* 73-88.

Tuschl, R.J., Laessle, R.G., Platte, P., & Pirke, K. (1990). Differences in food-choice frequencies between restrained and unrestrained eaters. *Appetite, 14,* 9-13.

UK Slimmer Magazine. National Snack Survey. UK Slimmer Magazine. (1997).

Ursell, A. 1999. Don't forget about the nibbles. *Irish Independent*, (1999).

van Gent, C.M., Pagano Mirani-Oostdijk, C., van Reine, P.H., Frolich, M., Hessel, L.W., & Terpstra, J. (1979). Influence of meal frequency on diurnal lipid, glucose and insulin levels in normal subjects on a high fat diet; comparison with data obtained on a high carbohydrate diet. *European Journal of Clinical Investigation*, *9,* 443-446.

Van Strien, T., Frijters, J.E.R., Bergers, G.P.A., & Defares, P.B. (1986). The Dutch Eating Behaviour Questionnaire (DEBQ) for assessment of restrained, emotional and external eating behaviour. *International Journal of Eating Disorders*, *5,* 295-315.

vd Es, P.M., Kistemaker, I.C., & Hulshof, K.F.A.M. Maaltijdgebruik en gebruik van voedingsmiddelengroepen naar leeftijd en geslacht. Voedselconsumptiepeiling 1987-1988 (The consumption of meals and the consumption of food groups per age and sex. Food consumption survey 1987-1988). TNO. (1989). V 89.317, 1 p.

Verboeket-van de Venne, W.P.H.G., Westerterp, K.R., & Kester, A.D.M. (1993). Effect of the pattern of food intake on human energy metabolism. *British Journal of Nutrition*, *70,* 103-115.

Viglietti, G.C., & Skinner, J.D. (1987). Estimation of iron bioavailability in adolescents' meals and snacks. *Journal of the American Dietetic Association*, *87,* 903-908.

Wadhwa, P.S., Young, E.A., Schmidt, K., Elson, C.E., & Pringle, D.J. (1973). Metabolic consequences of feeding frequency in man. *American Journal of Clinical Nutrition*, *26,* 823-830.

Wahlqvist, M.L., Kouris-Blazos, A., & Wattanapaiboon, N. (1999). The significance of eating patterns : an elderly Greek case study. *Appetite*, *32,* 23-32.

Wearne, S.J., & Day.M.J.L. (1999). Clues for the development of food-based dietary guidelines: how are dietary targets being acheived by UK consumers? *British Journal of Nutrition, 81,* S119-S126.

Westerterp-Plantenga, M.S., Pasman, W.J., Yedema, M.J.W., & Wijckmans-Duijsens, N.E.G. (1996). Energy intake adaptation of food intake to extreme energy densities of food by obese and non-obese women. *European Journal of Clinical Nutrition, 50,* 401-407.

Westerterp-Plantenga, M.S., Wijckmans-Duijsens, N.E.G., & Ten Hoor, F. (1994). Food intake in the daily environment after energy-reduced lunch, related to habitual meal frequency. *Appetite, 22,* 173-182.

Whybrow, S., & Kirk, T.R. (1997). Nutrient intakes and snacking frequency in female students. *Journal of Human Nutrition and Dietetics, 10,* 237-244.

Williams, C.M. (1997). Postprandial lipid metabolism: effects of dietary fatty acids. *Proceedings of the Nutrition Society, 56,* 679-692.

Williams, C.M., Wiseman, M., & Buttriss, J. (1999). Food-based Dietary Guidelines - A staged approach. *British Journal of Nutrition, 81:*Suppl 2

Williamson, D.F., Serdula, M.K., Anda, R.F., Levy, A., & Byers, T. (1992). Weight loss attempts in adults: goals, duration, and rate of weight loss. *American Journal of Public Health, 82,* 1251-1257.

Winkler, G., Doring, A., & Keil, U. (1999). Meal patterns in middle-aged men in Southern Germany: results from the MONICA Augsburg Dietary Survey 1984/85. *Appetite, 32,* 33-37.

Wolever, T.M.S., Innocente, T., & Palmason, C. (1990). Effect of calorie distribution and diet glycaemic index on blood HbA1c and lipids in NIDDM. *Diabetes, 39,* 239A.

Yamashita, S., Sakai, N., Hirano, K., Ishigami, M., Maruyama, T., Nakajima, N., & Matsuzawa, Y. (2001). Roles of plasma lipid transfer proteins in reverse cholesterol transport. *Frontiers in Bioscience*, *6,* 366-387.

Young, C.M., Hutter, L.F., Scanlan, S.S., Rand, C.E., Lutwak, L., & Simko, V. (1972). Metabolic effects of meal frequency on normal young men. *Journal of the American Dietetic Association*, *61,* 391-398.

Young, C.M., Krankel, D.L., Simko, V., & Lutwak, L. (1971). Frequency of feeding, weight reduction, and nutrient utilisation. *Journal of the American Dietetic Association*, *59,* 473-480.

Zilversmit, D.B. (1979). Atherogenesis: a postprandial phenomenen. *Circulation*, *60,* 473-485.

# CHAPTER 2

## A study of the temporal pattern of nutrient intake throughout the day in free-living healthy Irish adults:

## Methodology and Baseline Results

## 2.1 INTRODUCTION

Dietary surveys of populations present the nutrient intake results almost exclusively as average nutrient intakes per day. The nutrient intakes of the different eating occasions of the day are only rarely investigated or presented. Investigation of the temporal pattern of nutrient intake during eating occasions throughout the day however, is invaluable to obtaining a clearer understanding of the eating patterns of free-living adults. Indeed, the International Union of Nutritional Sciences (IUNS) in 1994 established a Committee on Nutrition and Food Habits, to initiate interest and research into this neglected area of nutrition research (Oltersdorf, 1996; Oltersdorf *et al.*, 1999).

Information in relation to temporal patterns of eating is required for the development of food-based dietary guidelines (FBDG) that relate to individual eating occasions of the day. It is envisaged that FBDG may be more effective in changing eating behaviour since they relate directly to eating patterns rather than nutrient intakes. This is important as it is increasingly recognised that populations are not achieving current dietary guidelines (MAFF, 1994; Hulshof *et al.*, 1993; Krebs-Smith *et al.*, 1997). The study of temporal patterns of eating is also imperative, given the current prevalence of eating more often, in populations (Gatenby, 1997) and evidence of an increased frequency of eating being associated with health benefits. Such benefits include improved body weight control (Drummond *et al.*, 1998; Kirk, 2000), blood glucose tolerance (Fabry *et al.*, 1964; Jenkins *et al.*, 1992; Mann, 1997) and lipid metabolism (Jenkins *et al.*, 1989; Arnold *et al.*, 1993; Jenkins, 1997). Although these associations are as yet inconclusive (Gibney & Wolever, 1997). This information would also be invaluable to nutrition studies, which require the use of test meals at different times of the day. These include studies of appetite control and eating behaviour (Foltin *et al.*, 1990; Johnson & Vickers, 1993; Stubbs *et al.*, 1996) and studies of the effects of nutrients on different metabolic processes e.g. postprandial lipaemia (Roche & Gibney, 1995; 2000). This information would allow the nutrient composition of the test meals used in these studies, to be based on the nutrient composition of everyday eating occasions. Clearly, the study of the temporal pattern of nutrient intake throughout the day can provide opportunities to better understand the links between patterns in food and nutrient intake with health and disease.

Generally nutrition surveys do not generate information in relation to temporal food and nutrient intake patterns. In Ireland, the nutrient database of the last nutrition survey undertaken was not specifically designed to allow the study of the temporal pattern of eating (Lee & Cunningham, 1990). Although information may have been collected at the level of individual eating occasions during dietary assessment, nutrition analysis software generally only allows data entry of the name and weight of the food and drink items consumed and so data at the level of individual eating occasions was lost. It was thus necessary to create a tailor-made database, to determine the temporal pattern of nutrient intake during eating occasions throughout the day of free-living Irish adults. A dietary survey of a group of Irish adults was undertaken to provide the dietary data.

One of the greatest challenges in nutrition research is ensuring the food intake data collected during dietary assessment represents the usual dietary intake of those being surveyed (Black *et al.*, 1991; 1993). The collection of valid dietary data at the level of individual eating occasions is even more challenging. There are reports of individual eating occasions being omitted during dietary assessment (Livingstone *et al.*, 1990; Heitmann & Lissner, 1995; Summerbell *et al.*, 1996; Briefel *et al.*, 1997; Poppitt *et al.*, 1998) which may invalidate the data and any conclusions drawn from the results obtained. In the present study, much attention was given to the use of methodology, which would ensure valid dietary data were obtained.

This Chapter describes the methodology employed in collecting dietary data from a group of free-living healthy Irish adults to allow the study of temporal patterns of eating. A detailed description of the study procedures used, including details of subject recruitment and the dietary assessment method, is provided. The baseline results presented in this Chapter describe the study group in terms of the validity of the dietary data collected, the average daily nutrient intakes and the socio-demographic and lifestyle characteristics of the group. The nutrient intakes of this group are also compared to those of other Irish food intake studies, in order to assess their representativeness of the average Irish diet.

This Chapter serves as a reference for the following Chapters 3 to 7. Chapter 3 uses this dietary data, to explore data analysis methods to determine the temporal pattern of nutrient intakes throughout the day, in free-living adults. Chapters 4 to 7 are investigative Chapters, which specifically determine the temporal pattern of macronutrient intakes during eating occasions throughout the day in the full study sample and subgroups of the study sample.

## 2.2 METHODS

### 2.2.1 Subject Recruitment

Healthy male and female adults were recruited from a city local authority by displaying a letter and accompanying volunteer slips on departmental notice-boards. Two incentives were offered for participation: personal dietary advice from a qualified dietitian (i.e. investigator) and entry to a draw for a weekend away for two. Interested subjects returned volunteer slips and were contacted by telephone. Those considered eligible for the study were healthy male and female adults aged 18-64 years, who were not working shift-work or over-time and females who were not pregnant or lactating. Written informed consent was obtained from all subjects.

### 2.2.2 Dietary Assessment Procedure: 7-day food diary

Subjects kept a food diary for 7 consecutive days, in which they were asked to record, in as detailed a manner as possible, all individual items of food and drink consumed, the amount, brand name and method of cooking of each item, and the location and time of food/drink consumption. Subjects were instructed, encouraged and motivated to complete a 7-day unweighed or estimated food diary by a protocol devised by the investigator. Subjects attended a training meeting at their workplace in groups of up to five individuals (30 minutes to 1 hours duration). They received an explanation of the purpose of the study, a demonstration of the completion of the food diary, written guidelines for describing and quantifying food and drink consumed and 2 pocket-sized food diaries (Appendix I). Subjects were asked to continue their normal eating habits, to carry the diary with them at all times and were encouraged to record immediately after eating or drinking. The food diary was designed as an A6 (sized) pocket-sized booklet for its compact size, with the anticipation that subjects

would be more likely to carry it with them, thereby facilitating the immediate recording of food/drink consumed. The diary (20 pages/diary) included guidelines on how to record food and drink intake, recording pages and recipe pages. Subjects were asked to note weights of manufactured food products, to record quantities of other items in household measures or to describe quantities as small, medium or large portion sizes. Specific instructions were given on the recording of spread and milk used, eating out and recipe details. The work canteen menu and details of all foods and drinks available in the canteen were obtained for use at interviews, to probe for food/drink items that may have been omitted by subjects. Subjects were met at their workplace on the second day of diary recording (day 2) for 10 minutes and on the day after the food diary was completed (day 8) for 45 minutes, to assess recording detail, quantify amounts consumed, clarify any ambiguities and probe for missing data. All subjects who completed the food diary received personal qualitative dietary advice during a 30 minute session on a later date. Each subject received an advice pamphlet regarding his/her dietary intake based on the 7-day food diary data (Appendix II). The dietary advice was presented in the context of the food pyramid, the Irish nutritional education tool for healthy eating, together with the food pyramid leaflet 'A Guide to Daily Healthy Choices' (Health Promotion Unit, 1993) (Appendix III).

*Food Quantification*

There is no quantification method considered to be completely accurate for quantifying all food and drink collected during dietary assessment. As accurate information on individual eating occasions was the focus of this study, it was decided to use a combination of quantification methods in order to obtain best estimates for the weight of each item of food and drink consumed. The amounts of food and drink consumed were estimated by the subject, using both photographs of known portion weights of food (Lee & Cunningham, 1990; Doyle & Moloney, 1995) and household measures, during review meetings. The quantity of breakfast cereal consumed was estimated using manufacturer's individual portion packs at the review meetings. The actual weights of all foods and drinks and full details of composite dishes consumed in the work canteen were obtained from the catering officer. To quantify cooked foods and recipes for which raw weights were available, the cooked food weights were derived from the raw weights and adjusted for weight gain or loss on cooking according to

McCance and Widdowson guidelines (Holland *et al.*, 1991a; Chan *et al.*, 1995; 1996). Weights of all manufactured food and drink products were obtained from manufacturers' data. Details of composition and actual weights of foods and drinks eaten out were obtained from points of purchase. When necessary replicate portions of foods were bought, weighed and cooked. Fast food portions were derived from product data distributed from the relevant franchise. Average portion sizes (MAFF, 1994) were used only when quantification by any of the aforementioned methods was not possible.

*Nutrient Analysis*

Nutrient analysis was carried out using FOODBASE©, a computerised version of the Royal Society of Chemistry nutrient database of McCance and Widdowson's food tables (Holland *et al.*, 1991a) and published supplements (Holland *et al.*, 1988, 1989, 1991b, 1992a, Tan *et al.*, 1985). FOODBASE© (Institute of Brain Chemistry and Human Nutrition, London, U.K., 1993) was specifically chosen for nutrient analysis as this software program has been modified to allow specification of the amount and type of fat used in preparing or cooking foods with fat. This allows for more accurate determination of the fat content of eating occasions. Food diaries were coded using the FOODBASE© food codes. Manufactured foods or drinks which could not be coded using the existing nutrient database, due to differences in nutrient composition, were added to the database using more recently published supplement data (Chan *et al.*, 1994, 1995, 1996; Holland *et al.*, 1993, 1992b) or manufacturers' nutrient composition data. One hundred and twenty food codes were added to the database, primarily spreads, sauces and fortified products.

The food and drink information was also coded to allow analysis of the data in terms of individual eating occasions. Each eating occasion was coded to the nearest hour and an eating occasion included every item of food or drink consumed within an hourly period. An hour represented the 30 min before and the 29 min after an hour (e.g. all food or drink consumed between 06.30am and 07.29am was coded as an eating occasion which occurred at 7am). The consumption of more than one eating occasion within an hour e.g. dinner and dessert, was considered to be one eating occasion. If only one item of food or drink, such as tea with milk or a piece of fruit, was consumed during an hour it was defined as a single eating occasion.

Eating occasions of non-nutritive value (water, diet drinks, tea or coffee without milk or sugar and chewing gum) were not included in the analysis. The nutrient analysis of every eating occasion for each of the 7 days of diary recording for each subject was carried out using FOODBASE©.

A Microsoft® Excel spreadsheet was constructed which contained every hour (01.00-24.00hours) of each of the 7 days for each subject. The nutrient analysis data of every eating occasion of each of the 7 days for each subject was then entered into the Microsoft® Excel spreadsheet, at the specific hour of consumption (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.). The full Microsoft® Excel database was manually rechecked against the original FOODBASE© nutrient analysis printouts before import into the statistical software package, SPSS® 8.0 (SPSS Inc., Chicago, U.S.A.). Data was subjected to further quality control in SPSS® by assessing and clarifying extremes of nutrient intakes at the minimum and maximum level.

### 2.2.3 Anthropometry

Body weight and height were measured on day 2 or 8. Body weight (in light indoor clothing, pockets emptied, without shoes) was measured to the nearest 0.1kg using a portable weighing scales (EKS, London, U.K.). Height (without shoes) was measured to the nearest 0.1cm using a measuring tape. Subjects stood against the wall of the room, with both feet together and heels touching the wall surface. The height point was noted and a measuring tape was used to measure the reading. Body mass index (BMI) was calculated (weight (kg)/height ($m^2$)) and categorised according to WHO criteria (WHO, 1998).

### 2.2.4 Health & Lifestyle Questionnaire Data

Subjects completed a health and lifestyle questionnaire on day 2 or 8. The purpose of this questionnaire was to collect information on the socio-demographic and lifestyle characteristics of the group including information on age, social class, current smoking status, usual alcohol intake and vitamin and mineral supplement use. The social class of each subject was classified according to the Irish classification system for social class groups (Central Statistics Office, 1998).

Information on the dieting habits of the study sample was also collected using this questionnaire. Subjects were asked to answer 'yes/no' to the question 'have you tried to lose weight lately?'. Those subjects that reported 'yes', they were trying to lose weight, were further asked 'have you been successful in losing any weight?'. Only those subjects who were 'successful in losing weight' were considered to be dieters.

Anthropometric and questionnaire data were entered into Microsoft® Excel (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.) and imported to SPSS® (SPSS Inc., Chicago, U.S.A.). Quality control of this data was carried out in SPSS® by a review of all data to ensure data were correctly entered.

### 2.2.5 Quality & Validity of Dietary Data

All food diaries were completed during September to mid-December 1995. Dietary advice sessions were held during January and February 1996. Dietary assessment was completed by the 12th of December before social events associated with the Christmas period commenced, which may effect the assessment of usual dietary intake. One investigator (KEH) conducted all interviews and all other aspects of the methodology to control for observer effects.

The validity of the food intake data was assessed by measuring the validity of the energy intakes reported in the study. The mean ratio of energy intake to estimated basal metabolic rate ($EI/BMR_{est}$) was calculated as proposed by Goldberg *et al.*, (1991). Basal metabolic rate ($BMR_{est}$) was firstly estimated for each subject using age and measured weight (kg), using Schofield *et al.*, (1985) equations. The group mean $EI/BMR_{est}$ was then calculated. A study specific Goldberg cut-off value, which represented the lowest expected mean $EI/BMR_{est}$ for this study sample size with 7 days of food intake data, was calculated using the equation $EI/BMR > PAL \times \exp [SD_{min} \times {}^{S/100}/\sqrt{n}]$ (Goldberg *et al.*, 1991; Black, 2000a). PAL is the average physical activity level for the population and was assumed to be 1.55 as physical activity was not measured. $SD_{min}$ is –2 for 95% lower confidence limits, n is the number of individuals in the group (n=133) and $S = \sqrt{[CV_{wEI}{}^2/d + CV_{wB}{}^2 + CV_{tP}{}^2]}$. $CV_{wEI}$ is the within subject variation in energy intake (23%), d is the number of recording days (7 in this study), $CV_{wB}$ is the precision of estimated versus measured BMR (8.5%) and $CV_{tP}$ is the between-subject variation in PAL (15%) (Black, 2000a). A value of 19.3% was obtained for *S* and a

cut-off value of 1.50 was obtained. To evaluate the reported energy intakes in the study, the group mean $EI/BMR_{est}$ was compared with the study specific cut-off value of 1.50.

The validity of the reported energy intakes was also assessed at the individual level. The proportion of the study group that was under-reporting was calculated using the Goldberg equation presented above, with a value of 1 for the number of subjects (Goldberg, 1991; Black, 2000a). A value of 1.05 was obtained to represent the lowest expected $EI/BMR_{est}$ value for one individual with 7 days of food intake data. Individuals with an $EI/BMR_{est}$ value less than the cut-off of 1.05 were considered to be under-reporters, whose reported energy intakes did not reflect minimum expected estimates of energy intake during the recording week. Those individuals with an $EI/BMR_{est}$ value $\geq$ 1.05 were considered to have valid records and are referred to as adequate reporters.

The proportion of the study group that was over-reporting was also assessed using the equation $EI/BMR < PAL \times \exp [SD_{max} \times {}^{S/100}/\sqrt{n}]$ (Goldberg *et al.*, 1991; Black, 2000a). A value of 1 was used for the number of subjects, a PAL of 1.55 was used as the physical activity was not measured, the $SD_{max}$ is +2 for the 95% upper confidence limits and S was 19.3%. A value of 2.28 was obtained to represent the highest expected $EI/BMR_{est}$ value for one individual with 7 days of food intake data. Individuals with an $EI/BMR_{est}$ value above the cut-off of 2.28 were considered to be over-reporters with invalid reports of energy intake.

The distribution of the individual $EI/BMR_{est}$ values is presented in Figure 2.1. The cut-off values for identifying under-reporters and over-reporters are indicated.

### 2.2.6 Data Analysis & Statistical Analysis

Statistical analysis was performed using SPSS® 8.0 (SPSS Inc., Chicago, U.S.A.). Mean ± standard deviation (SD) values were calculated for anthropometric measurements, $EI/BMR_{est}$ values and nutrient intakes, for the total sample and for men and women separately. Differences in the mean $EI/BMR_{est}$ values, anthropometric measurements and macronutrient data (which was the focus of this study) between men and women were assessed. Independent t-tests were used to test for differences between men and women in normally distributed data.

The Mann-Whitney non-parametric test was used to test for sex differences in data, which was not normally distributed. The socio-demographic and lifestyle characteristics of the total sample and for men and women were summarised as the proportion of subjects with different characteristics. Differences in these proportions were calculated using the Chi-square test for independence (Coakes & Steed, 1999). Eating frequency was calculated for each subject as the sum of all eating occasions per day, where an eating occasion was defined as having greater than 0 MJ of energy. Descriptive statistics on eating frequency (mean daily, SD, median, minimum and maximum number of eating occasions/day) and the proportion of subjects with different mean daily eating frequencies was calculated. Values of $P<0.05$ were taken as statistically significant. Tables were created using Microsoft® Excel spreadsheets (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.).

## 2.3 BASELINE RESULTS

### 2.3.1 Response rate

Table 2.1 presents details of the response rate of the study sample. 146 subjects (61 men and 85 women) returned volunteer slips and met the study's eligibility criteria. 133 subjects participated in the study and the final response rate of 91% was calculated from the number of subjects who completed the 7-day food diary out of the total eligible sample. The 9% that did not participate consisted of 6% non-responders (not interested or too busy when contacted) and 3% dropouts (sick, lost diary, social reasons). The final study sample of 133 adults included 55 men and 78 women.

### 2.3.2 Validity of reported energy intakes

The mean ± SD $EI/BMR_{est}$ of the study sample was 1.54 ± 0.4 (1.63 ± 0.4 in men, 1.48 ± 0.3 in women) with a significant difference between men and women ($P=0.02$) (Table 2.2). This mean $EI/BMR_{est}$ value was higher than the calculated Goldberg cut-off value of 1.50, that represents the lowest expected mean $EI/BMR_{est}$ value, that could reflect actual energy intake of a population of this size with 7 days of food intake data. The proportion of this population identified as under-reporters was 7% (n=9, 4% of men, 9% of women) with 1% identified as over-reporters (n=1).

### 2.3.3 Mean daily nutrient intakes & anthropometric measurements

Characteristics of the study sample including mean anthropometric data and mean daily nutrient intakes are presented in Table 2.2 for men, women and the total sample. The age range of the total sample was 21 to 61 years, with a mean age of 36.6 years. Men were significantly older than women ($P<0.001$). The mean weight, height and BMI of men were significantly greater than those of women ($P<0.001$). The mean ± SD daily energy intake for the total sample was 10.4MJ ± 3.0 of which 35.8% came from fat, 45.2% from carbohydrate, 14.1% from protein and 4.9% from alcohol. Excluding alcohol, the percentage of energy derived from fat was 37.6%, with 47.5% from carbohydrate and 14.8% from protein. The mean ± SD daily energy intake of men was significantly higher than that of women (12.7MJ ± 2.8 vs. 8.8 ± 1.9 MJ respectively) and consequently men had higher absolute intakes of macronutrients than women. There was no significant difference however in the contribution of macronutrients to energy, when alcohol was included (% total energy) or excluded (% food energy), between the sexes.

### 2.3.4 Comparison of mean daily nutrient intakes with previous Irish food intake studies

Tables 2.3 and 2.4 compare the nutrient intakes of the men and women of this study respectively with the intakes of men and women surveyed in previous Irish food intake studies. The energy, macronutrient intakes (absolute and relative intakes) and the micronutrient intakes of both the men and women of the present study were largely comparable to those observed in previous surveys. The most notable difference observed in men was that of a higher absolute intake of sugar in these men compared to that observed in previous studies (Table 2.3). The most notable difference observed in women, was that of a 2-3 fold higher intake of alcohol (% energy) in the women of the present study compared to that observed by Gibney *et al.*, (1989) and by Lee & Cunningham, (1990) in the Irish National Nutrition Survey (INNS) (Table 2.4). The alcohol intake (% energy) of these women was comparable however to that of Flynn, (1993), who surveyed a group of women from higher and lower socio-economic groups. Although comparisons between studies is made difficult by the use of different methodologies in the collection of dietary data, there were clearly no remarkable differences between the nutrient intakes of the men and women in this study with those of previous Irish studies.

### 2.3.5 Socio-demographic and lifestyle characteristics

The socio-demographic and lifestyle characteristics of men, women and the total sample are presented in Table 2.5. The social class profile of this study sample was as follows: professional workers (SC1) 16.5%, managerial and technical (SC3) 6.8%, non-manual (SC4) 75.2% and semi-skilled (SC6) 0.8%. The social class profile of men was significantly different to that of women ($P<0.001$). Almost two-thirds of the study sample was married, 36.8% was single and 1.6% was separated/widowed. Significant differences were observed in the marital status profile of men and women ($P<0.001$). Almost one fifth of this study sample were current smokers, 88% consumed alcohol and approximately one third used vitamin and mineral supplements during the recording period. There were no significant differences observed between the sexes however, in smoking habits or in vitamin or mineral supplement use. There were also no significant sex differences in the proportions of the sample consuming alcohol but there was a significant difference between male and female alcohol consumers in the units of alcohol consumed per week ($P<0.001$). As much as 25% of this study sample reported having 'tried to lose weight lately', of which two-thirds (66.7%) of these individuals reported successfully losing weight. The 22 subjects who successfully lost weight were considered to be the dieters, comprising 17% of the total population. Significant differences were observed between sexes in those who 'tried to lose weight lately' ($P=0.017$).

The weight status profile of the study sample, using the WHO criteria (WHO, 1998), was observed to be significantly different between the sexes ($P=0.011$). A greater proportion of women were of normal weight compared to men with almost half of all women (53.8%) and only 29% of all men being of normal weight. Conversely, greater proportions of men than women were overweight and obese with 52.7% of men and 38.5% of women being overweight and 18.2% of men and 7.7% of women being obese. No individuals were found to be underweight.

### 2.3.6 Mean daily eating frequency

Descriptive data on the number of eating occasions per day of the group (eating frequency) is presented in Table 2.6. The mean and median daily eating frequency was 5.8 and 5.6 eating occasions per day respectively. The proportion of the study sample having different

frequencies of eating during the day is also presented. Over 70% of men and women (76% and 71% respectively) had more than 5 eating occasions per day. As few as 3% of women and no men reported eating less than or equal to 4 eating occasions per day.

## 2.4 DISCUSSION:

### 2.4.1 Validity of reported food (energy) intakes at group level & at the individual level

Evaluation of the validity of the dietary data collected in this study of free-living adults is critical to the understanding and interpretation of the baseline results presented in this Chapter and the subsequent results presented in Chapters 3 to 7 (Black *et al.*, 1991; Livingstone, 1995; Black, 2000a). Such an evaluation has recently been stressed as an important requisite of eating frequency research (Summerbell *et al.*, 1996; Bellisle *et al.*, 1997; Gatenby, 1997; Kirk, 2000) to avoid the interpretation of spurious relationships. The validity of the data at group and at individual level will be considered in turn.

The reported energy intakes of this study sample can be considered valid estimates of the actual intake during the recording period, at group level. The majority of self-reported dietary intakes however have been reported to be biased towards underestimation of usual energy intake (Schoeller, 1990; Livingstone, 1995). Underestimation of energy intake was observed to be less prevalent in this survey than has been reported by others. A review of 37 published studies by Black *et al.*, (1991) found that 68% of the subgroups examined, according to sex and survey method, had a mean $EI/BMR_{est}$ below the Goldberg *et al.*, (1991) study specific cut-off, with a mean ± SD $EI/BMR_{est}$ of 1.43 ± 0.19 (1.50 ± 0.16 in men, 1.37 ± 0.13 in women). In contrast, the mean ± SD $EI/BMR_{est}$ of 1.54 ± 0.4 (1.63 ± 0.4 in men, 1.48 ± 0.3 in women) observed in this study, was higher than the Goldberg study specific cut-off (1.50). The mean $EI/BMR_{est}$ in the present study was also higher than that observed in two national food surveys (in Sweden and Germany), which also used a 7-day unweighed food diary. Mean ± SD $EI/BMR_{est}$ values were 1.35 ± 0.38 and 1.33 ± 0.38 in Swedish men and women respectively (Becker *et al.*, 1999) with values of 1.5 ± 0.4 and 1.4 ± 0.4 in German men and women respectively (Hermann-Kunz & Thamm, 1999) compared to those of this study (1.63 ± 0.4 in men, 1.48 ± 0.3 in women). A mean $EI/BMR_{est}$ of 1.54 was previously calculated by

Black *et al.*, (1991) from data of a study of French men and women by Boggio *et al.*, (1986), which used a 7-day record with a weighed component. A review of current literature found only one study of eating frequency that reported the mean $EI/BMR_{est}$ for the study sample (Summerbell *et al.*, 1995; 1996). The mean $EI/BMR_{est}$ values of the men and women of four different populations (adolescent, young adult, middle-aged and elderly) were examined with three of the eight groups having values above and two with values close to the Goldberg *et al.*, (1991) study specific cut-off (Summerbell *et al.*, 1995; 1996). The validation of reported energy intakes using the Goldberg *et al.*, (1991) cut-offs, which are based on a PAL of 1.55 however, does not necessarily identify all under-reporting which has been reported to occur across the full range of energy intakes and expenditures. This is because this PAL value of 1.55 is low and higher PAL values have been seen in many populations. Black, (2000b) recently reported only that 50% of under-reporters were identified using the Goldberg *et al.*, (1991) criteria compared to actual energy expenditure data. Information on an individuals physical activity ideally needs to be collected, to calculate a study-specific PAL or to categorise individuals into low, medium or high activity, in order to increase the sensitivity of the cut-offs (Black *et al.*, 1996; Black, 2000b).

The validity of the reported energy intakes at an individual level was also found to be less of an issue in this study than has been reported by others. The majority of previously published studies show the prevalence of under-reporting to be greater than 12%, with reports of up to 52% in some studies (Heywood *et al.*, 1993; Ballard-Barbash *et al.*, 1996; Briefel *et al.*, 1997; Hirvonen *et al.*, 1997; Lafay *et al.*, 1997; Price *et al.*, 1997; Pryer *et al.*, 1997; Gnardellis *et al.*, 1998; Johansson *et al.*, 1998). This contrasts greatly to the lower proportion of 7% found in this study (with an $EI/BMR_{est}$ less than 1.05). Reports of less than 6% under-reporting were made by Jonnalagada *et al.*, (1996) in a study using the multiple-pass 24-hour telephone recall. Comparisons between studies are somewhat difficult however, as the dietary assessment method and the cut-off values used to determine proportions of under-reporters, varied considerably between studies. Becker *et al.*, (1999) reported that 26% of subjects had a mean $EI/BMR_{est}$ less than 1.10 using a 7-day food diary. Lower proportions of under-reporters were also observed in the present study compared to recent studies of eating frequency. Reports of 19% and 17% of subjects under-reporting (mean $EI/BMR_{est}$ of less than 1.10) were observed,

using a 7-day unweighed food diary with 95 Scottish adults (Drummond *et al.*, 1998) and a 7-day weighed record with 54 Scottish students (Whybrow & Kirk, 1997) respectively. Using a 7-day weighed diary and the same cut-off, Summerbell *et al.*, (1996) observed under-reporting levels of 18%, 30% and 11% in British adolescent, middle-aged and elderly groups respectively. In the same study Summerbell *et al.*, (1996) considered an adult group of 59 subjects to record valid estimates of their energy intake with 8% of the group classified as under-reporters.

### 2.4.2 Validity of reported eating pattern

In eating frequency research, evaluation of not only the validity of the reported energy intake but also evaluation of the validity of the reported eating pattern or eating frequency is imperative. Such concern comes from the evidence of under-reporting of meals and snacks (Livingstone *et al.*, 1990; Heitmann & Lissner, 1995; Summerbell *et al.*, 1996; Briefel *et al.*, 1997; Poppitt *et al.*, 1998). There was however no significant difference in mean ± SD daily eating frequency between the under-reporters and acceptable reporters in this study (5.32 ± 0.9 vs. 5.82 ± 1.0 respectively, data not shown) contrary to that found by others. In contrast, a lower mean daily eating frequency was observed in under-reporters by Drummond *et al.*, (1998) and a more gorging eating pattern was reported in study groups with a high proportion of under-reporting by Summerbell *et al.*, (1996), compared to those with valid records. The definition of an eating occasion in these two studies was however different to that used in this study (see Table 1.2).

### 2.4.3 Treatment of under-reporters in data analysis

There is no clear agreement in the literature on whether under-reporters should be included or excluded in any analysis (Black *et al.*, 1991; Price *et al.*, 1997). Current consensus would suggest that the objective of the study should determine such a decision. Kirk, (2000) recently advised identification of under-reporters and their exclusion from analysis to study the relationship of body weight with eating frequency. Under-reporters were excluded from analyses in the studies of Summerbell *et al.*, (1996), Crawley & Summerbell, (1997), Whybrow & Kirk, (1997) and Drummond *et al.*, (1998), all of which addressed the relationship of eating frequency and BMI. In this study under-reporters were included in all

analysis as the proportion of 7% (9 of 133 subjects) was considered to be of less significance than that observed in other studies. In addition, the mean $EI/BMR_{est}$ for this population was similar when under-reporters were included or excluded (1.54 ± 0.4 vs. 1.59 ± 0.3 respectively, data not shown).

### 2.4.4 Treatment of dieters in data analysis

Dieting subjects are frequently excluded from nutrition research analysis (Crawley & Summerbell, 1997; Price *et al.*, 1997; Pryer *et al.*, 1997; Whybrow & Kirk, 1997; Drummond *et al.*, 1998) as dieting affects not only reports of usual energy intake (Jeffrey *et al.*, 1991; Heitmann, 1993; Briefel *et al.*, 1997; French *et al.*, 1999) but also snack and meal patterns (Blair *et al.*, 1989; Bellisle *et al.*, 1995; Rossner, 1995; Booth, 1996; French *et al.*, 1999). Reducing calorie intake between meals was found to be strongly associated with weight loss maintenance (Blair *et al.*, 1989; Booth, 1996). In a study of 16,486 university students in 21 European countries, Bellisle *et al.*, (1995) observed that dieters reported fewer snacks and that female dieters also reported fewer meals than non-dieters. In a 4 year weight gain prevention study, participants mentioned reducing energy intake, eliminating snacks and skipping meals among the weight control behaviours used (French *et al.*, 1999).

In studies of the free-living situation dieters will be a significant part of a population and 17% (n=22) of the subjects in this study (24% of women and 5% of men) were considered dieters. Bellisle *et al.*, (1995) observed 18% of women and 2.3% of men to be dieting in Ireland in the International Health and Behaviour Survey. There have been suggestions that even higher proportions (25-43%) of a free-living population may be dieting (Klesges *et al.*, 1987; Jeffrey *et al.*, 1991; Williamson *et al.*, 1992; Price *et al.*, 1997; Blokstra *et al.*, 1999), but the most appropriate questions that should be asked to identify dieters is unclear, which makes the prevalence of dieting difficult to determine (French *et al.*, 1999). A recent market research survey in Ireland, on 1400 adults, revealed that as much of 37% of all adults would like to lose weight (Department of Health & Children, 1999), but the proportion of these adults that were currently dieting was not reported. In the present study there was no significant difference in the mean ± SD daily eating frequency of the dieters and non-dieters (5.4 ± 0.9 vs. 5.9 ± 1.1 respectively, data not shown) and the mean ± SD $EI/BMR_{est}$ of the population was similar

when dieters were excluded or included (1.59 ± 0.3 vs. 1.54 ± 0.4 respectively), data not shown. As the main objective of this study was to survey free-living adults and considering the preceding two points, the dieters of this study were thus not excluded from any analysis of the data.

It is noteworthy however, that not all dieters have reduced energy intakes, that can be detected using the Goldberg *et al.*, (1991) criteria for identifying individual under-reporters. Only 4 out of 22 (18%) dieters in this study had an $EI/BMR_{est}$ value less than the cut-off of 1.05, which means a high proportion of dieters (82%) were considered to have acceptable energy intakes in this study ($EI/BMR_{est} \geq 1.05$). The mean ± SD $EI/BMR_{est}$ of the dieters was significantly lower than that of the non-dieters (1.32 ± 0.4 vs. 1.59 ± 0.3 respectively, P=0.001, data not shown) as observed by Briefel *et al.*, (1997) suggesting lower than usual energy intakes were reported by the dieters. These findings emphasise the importance of addressing the issue of dieting in studies of eating frequency research, to allow results to be correctly interpreted.

**2.4.5 Weight status and validity of reported food intake data**

As lower than expected energy intakes have been reported in overweight and obese individuals (Prentice *et al.*, 1986; Schoeller, 1990; Lichtman *et al.*, 1992; Heitmann, 1993; Ballard-Barbash *et al.*, 1996; Briefel *et al.*, 1997; Lafay *et al.*, 1997) the weight status of this population was determined to allow under-reporting to be addressed in terms of body weight. Obese individuals (BMI of > $30kg/m^2$) have in fact been excluded in recent studies of eating frequency (Whybrow & Kirk, 1997; Drummond *et al.*, 1998). There was no significant difference however in mean ± SD BMI between the under-reporters and acceptable reporters in the present study (26.9 ± 3.1 and 25.6 ± 3.3 respectively, data not shown), which is in contrast to the finding of a higher BMI in under-reporters, by others (Bingham *et al.*, 1991; Drummond *et al.*, 1998). There was however a higher proportion of obese individuals among under-reporters than acceptable reporters (33% vs. 11% respectively, data not shown) which was also observed by others (Johansson *et al.*, 1998). There were comparable proportions of overweight individuals among under-reporters and acceptable reporters (44% vs. 44% respectively, data not shown). The small number (n=11) of under-reporters in this population however, may make such comparisons difficult to interpret.

Such an assessment is particularly important in eating frequency research in light of evidence of specific eating occasions being under-reported by the obese (Heitmann & Lissner, 1995). It has been suggested that obese subjects under-report snacks, which would effect the validity of the reported eating frequency data of free-living populations. The under-eating of snacks by the overweight or obese as a method to lose weight following their weight gain, has also been suggested as a reason for the lower than expected energy intakes obtained during dietary assessment in these groups. Such alterations of eating frequency have been refered to as the issue of reverse causality or *post hoc* alterations in diet pattern (Bellisle *et al.*, 1997; Kirk, 2000). Indeed there have been reports that the overweight are more likely to be dieting at any point in time than are individuals who are not overweight (Ballard-Barbash *et al.*, 1996; Blokstra *et al.*, 1999). Only 7% of normal weight subjects were dieting in this study compared to 25% of overweight subjects and 19% of obese subjects (data not shown). More recent evidence however, which associated under-reporting with failure to record snack foods in between meals, reported no difference between lean and obese females in the under-reporting of snacks in a metabolic study (Poppitt *et al.*, 1998). Whether these results can be extrapolated to free-living adults is as yet unknown. Nonetheless the weight status of populations must be determined in studies of eating frequency to allow for a clear interpretation of the results.

### 2.4.6 Dietary assessment methodology to study periodicity of eating

There is currently no consensus on the dietary assessment method that yields the most precise or accurate information on the food intake of groups or individuals (Black *et al.*, 1991; Bingham, 1994; Livingstone, 1995). Methodologies to identify and assess eating patterns in free-living adults have also not been established in nutrition research (Gatenby, 1997; Oltersdorf *et al.*, 1999). The 7-day food diary was chosen for this study of eating patterns as, being a prospective method of dietary assessment, it reduces reliance on memory and recall errors and allows information on individual eating occasions to be recorded as eaten (Bone, 1992). Recording information at the time of food/drink consumption was considered important to increase the accuracy of information on individual eating occasions, which was the main focus of this study. An unweighed food diary was chosen as this is less demanding

for subjects than the weighed method (Bingham *et al.*, 1988). The unweighed food diary was also used because of reported evidence that a weighed intake had interfered with normal eating behaviour (Livingstone *et al.*, 1990). The weighing of snack foods was reported to be onerous and irritating, which could result in under-reporting of such eating occasions (Livingstone *et al.*, 1990). Macdiarmid & Blundell, (1997) more recently reported that 18% of subjects in the Leeds High Fat Study considered weighing of all foods to be of too much inconvenience, with under-recording of snack foods specifically mentioned.

A 7-day record has also been used in other studies of eating frequency in free-living subjects, in which collection of nutrient intake data was also the focus of the study. Both unweighed methods (De Castro, 1987; Gatenby *et al.*, 1995; Drummond *et al.*, 1998; Bellisle *et al.*, 1999; Winkler *et al.*, 1999) and weighed methods (McBride *et al.*, 1990; Gatenby *et al.*, 1995; Ruxton *et al.*, 1996; Summerbell *et al.*, 1995; 1996; Whybrow & Kirk, 1997) have been used. Other dietary assessment methods have also been used in such studies. Redondo *et al.*, (1997) used a 5-day unweighed food intake record to study eating frequency in independent elderly subjects and used a weighed method to study institutionalised subjects. The diet history method (Robson & Strain, 1991; Basdevant *et al.*, 1993), a 3-day food record (Arnold *et al.*, 1993), a 4-day food record (Crawley & Summerbell, 1997), a 3-day food record plus questionnaire (Prättälä & Roos, 1999) and a 7-day food diary plus 7-day diet history (King & Gibney, 1999) have also been used in the study of eating frequency and nutrient intakes. Methodologies to study eating patterns have recently been identified as a priority area of research by the International Union of Nutritional Sciences (IUNS) Committee II/2 on Nutrition and Food Habits (Oltersdorf, 1996; Oltersdorf *et al.*, 1999), with the need for standardization of methodology and identification of methods that are most appropriate to specific studies, being highlighted.

The dietary assessment protocol used in this study incorporated a number of specific methodological aspects in an effort to obtain reliable dietary data in terms of both energy intake and individual eating occasions. Such aspects warrant mention given the reliability of the dietary data obtained in comparison to other nutrition studies. (1) Subjects were fully informed of the reasons for and the objectives of the study. They were briefed firstly on the

existence of incorrect public opinion that considers eating frequently to be associated with poor health and increased body weight (Chapman & Maclean, 1993). Secondly they were informed of the importance of collecting dietary data from free-living healthy adults, to study the relationship between actual (or real-life) eating frequency with diet and health. A strong emphasis was placed on the importance of collecting usual dietary data in terms of specific food items, the amounts consumed and frequencies of eating. (2) On day 2 of diary recording subjects were met to ensure accurate diary recording, to assess possible changes in eating habits, to clarify any misunderstandings and to encourage and motivate the subjects. (3) On day 4 or 5, subjects who the investigator identified as requiring further motivation were contacted by telephone. (4) As the unweighed food diary was chosen to minimise subject burden and to encourage subjects to provide complete descriptive details of individual eating occasions, a comprehensive quantification protocol was used (as described under 'food quantification'). (5) The nutrient analysis software FOODBASE© (Institute of Brain Chemistry and Human Nutrition, London, U.K., 1993) was specifically chosen as it permitted more accurate determination of the fat content of eating occasions. (6) The use of personal dietary advice, as an incentive for participation, had been reported by others (De Castro, 1987; 1994) and was used to encourage subjects to record usual dietary data in order to receive the benefits of the consultation, i.e. accurate advice for accurate records.

The validity of the dietary data collected in this study may also be related to the socio-economic status of the sample surveyed. Dietary under-reporting has been associated with socio-economic status (Livingstone, 1995), with greater proportions of under-reporters seen in the lower social classes (Livingstone *et al.*, 1991; Price *et al.*, 1997; Pryer *et al.*, 1997). Approximately 99% of the population of the present study were actually from the higher social classes, 1 to 3.

The subjects in this study were not selected from a random sample of the Irish population, but rather volunteered to participate and thus cannot be considered representative of the population. It was therefore of interest to assess whether the nutrient intake of the subjects in this study compared to the diets of a random sample of the Irish population, to assess the general applicability of this study. Comparisons were made between the diets of the men and

women of this study with the diets of those randomly selected in the INNS (Lee & Cunningham, 1990). The absolute and relative intakes of nutrients observed in this study were remarkably comparable to those of the men and women of the INNS, though alcohol intakes were more than double in the women of the present study. The dietary recommendations for fat, of 35% of food energy from fat, (Food Advisory Committee, 1987) and the carbohydrate recommendations of > 50% of food energy from carbohydrate (Department of Health, UK, 1991, FAO/WHO, 1998) were not achieved by this population as observed in the population of the INNS (Lee & Cunningham, 1990). The failure of populations to achieve dietary recommendations stress the need to study 'meal' patterns in addition to the study of total daily intakes, as part of dietary surveys. Information on the actual pattern of nutrient intake by individuals during their everyday lives, could provide a better understanding of free-living eating patterns and allow the formulation of targeted, evidence-based and practical dietary guidelines based on specific eating occasions, to be used as part of health promotion and public health campaigns.

The mean daily eating frequency of 5.8 ± 1.1 for this adult population was consistent with recent reports that most people eat 5 to 6 times a day (Gatenby, 1997; Gibney & Wolever, 1997; Whybrow & Kirk, 1997). Only two studies previously addressed mean daily eating frequency in an Irish population. McGrath & Gibney, (1994) observed a mean daily eating frequency of 3.8 – 6.3 eating occasions per day in a group of 23 office workers and Bellisle *et al.*, (1995) found Irish students to be eating 5 times a day on average.

**Conclusion**

In conclusion, the reported energy intakes of this study sample were found to be acceptable and valid according to the Goldberg criteria (Goldberg *et al.,* 1991; Black, 2000a) and the proportion of individual under-reporters was considered lower than usually obtained. The dietary data of this study is thus considered robust, specifically in relation to eating frequency, to allow further investigation of the data.

**Table 2.1: Response Rate of the Study Sample**

| | Men | Women | All |
|---|---|---|---|
| | *n* | *n* | *n (%)* |
| No. of subjects who returned volunteer slips | 61 | 85 | 146 |
| No. of eligible subjects | 61 | 85 | 146 (100%) |
| Non-responders *(not interested or too busy)* | 5 | 4 | 9 (6%) |
| Dropouts *(ill, lost diary, social commitments)* | 1 | 3 | 4 (3%) |
| **No. of subjects who completed study requirements** | **55** | **78** | **133 (91%)** |

**Table 2.2: Mean and standard deviation (SD) values for EI/$BMR_{est}$ values, anthropometric measurements and daily nutrient intake data of men, women and the total sample**

| | Men *n=55* | | Women *n=78* | | All *n=133* | | *P†* |
|---|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | |
| EI/BMRest | 1.63 | (0.4) | 1.48 | (0.3) | 1.54 | (0.4) | * |
| Under-reporters (EI/$BMR_{est}$ < 1.05) | 4% | | 9% | | 7% | | |
| Age (yrs) | 40.8 | (8.7) | 33.7 | (8.8) | 36.6 | (9.4) | *** |
| Weight (kg) | 85.0 | (9.5) | 67.3 | (8.9) | 74.6 | (12.4) | *** |
| Height (m) | 1.78 | (0.1) | 1.65 | (0.1) | 1.70 | (0.1) | *** |
| BMI | 26.9 | (3.2) | 24.9 | (3.1) | 25.7 | (3.3) | *** |
| Kcal | 3016 | (667) | 2107 | (444) | 2483 | (706) | *** |
| MJ | 12.6 | (2.8) | 8.8 | (1.9) | 10.4 | (3.0) | *** |
| Protein (g) | 102.2 | (18.5) | 74.2 | (14.5) | 85.8 | (21.3) | *** |
| Carbohydrate (g) | 362.4 | (90.1) | 254.6 | (60.9) | 299.2 | (91.2) | *** |
| Fat (g) | 120.9 | (36.6) | 84.5 | (24.4) | 99.6 | (34.9) | *** |
| Total sugars (g) | 151.5 | (72.1) | 106.5 | (37.7) | 125.1 | (58.7) | *** |
| Sucrose (g) | 78.7 | (216.5) | 56.3 | (219.4) | 65.6 | (217.7) | |
| Alcohol (g) | 22.9 | (18.3) | 13.1 | (13.6) | 17.2 | (16.4) | ** |
| % total energy from protein | 13.7 | (1.7) | 14.3 | (2.3) | 14.1 | (2.1) | ns |
| % total energy from carbohydrate | 45.1 | (5.5) | 45.3 | (5.2) | 45.2 | (5.3) | ns |
| % total energy from fat | 35.8 | (5.3) | 35.7 | (5.0) | 35.8 | (5.1) | ns |
| % total energy from alcohol | 5.4 | (4.4) | 4.5 | (4.7) | 4.9 | (4.6) | ns |
| % food energy from protein | 14.6 | (1.9) | 15.0 | (2.6) | 14.8 | (2.4) | ns |
| % food energy from carbohydrate | 47.6 | (5.1) | 47.4 | (4.6) | 47.5 | (4.8) | ns |
| % food energy from fat | 37.8 | (5.2) | 37.4 | (4.9) | 37.6 | (5.0) | ns |
| Dietary Fibre (g) | 20.1 | (17.6) | 14.1 | (5.0) | 16.6 | (12.3) | |
| Calcium (mg) | 1101.4 | (351.1) | 869.9 | (279.5) | 965.6 | (330.3) | |
| Magnesium (mg) | 384.6 | (80.6) | 280.5 | (73.0) | 323.5 | (91.7) | |
| Iron (mg) | 16.1 | (4.0) | 12.0 | (2.9) | 13.7 | (4.0) | |
| Zinc (mg) | 12.0 | (2.8) | 8.6 | (2.2) | 10.0 | (3.0) | |
| Retinol (ug) | 1238.4 | (1507.5) | 820.4 | (1090.6) | 993.2 | (1290.8) | |
| Carotene (ug) | 2319.0 | (1014.5) | 1993.0 | (1075.6) | 2127.8 | (1059.2) | |
| Retinol equivalents (ug) | 1636.4 | (1597.9) | 1138.5 | (1090.8) | 1344.4 | (1341.4) | |
| Vitamin E (mg) | 12.2 | (6.0) | 8.4 | (3.2) | 9.9 | (4.9) | |
| Vitamin D (ug) | 4.2 | (2.5) | 2.9 | (1.6) | 3.4 | (2.1) | |
| Thiamin (mg) | 2.1 | (0.6) | 1.5 | (0.4) | 1.7 | (0.6) | |
| Riboflavin (mg) | 6.7 | (34.0) | 1.7 | (0.5) | 3.8 | (21.9) | |
| Niacin (mg) | 27.1 | (6.2) | 19.9 | (5.0) | 22.9 | (6.6) | |
| Potential niacin (mg) | 21.6 | (4.0) | 15.5 | (3.0) | 18.0 | (4.6) | |
| Vitamin B6 (mg) | 3.0 | (1.8) | 2.2 | (1.1) | 2.5 | (1.5) | |
| Folic acid total (ug) | 335.7 | (104.0) | 249.0 | (82.7) | 284.9 | (101.3) | |
| Vitamin B12 (ug) | 6.4 | (4.0) | 3.9 | (3.0) | 4.9 | (3.6) | |
| Vitamin C (mg) | 98.2 | (43.5) | 82.9 | (42.6) | 89.3 | (43.5) | |

† Comparison of means between men and women: * P<0.05, ** P<0.01, ***P<0.001, ns not significant P>0.05.

**Table 2.3: Comparison of the mean daily nutrient intakes of the men of this study with those of men in other Irish food intake studies**

| | Present Study[§] 21-61yrs *n=55* | Gibney *et al*[*] 1989 34-44yrs *n=30* | INNS[**] 1990 21-61yrs *n=221* | King[§] 1995 25-65yrs *n=80* | Murphy[++] 1995 *n=27* | Current Irish dietary recommendations |
|---|---|---|---|---|---|---|
| | *Mean* | *Mean* | *Mean* | *Mean* | *Mean* | |
| Kcal | 3016 | 2987 | 2867 | 2294 | 2366 | |
| MJ | 12.7 | 12.5 | 12 | 9.6 | 9.9 | |
| Protein (g) | 102.2 | 107 | 104 | 88.3 | 89.2 | 0.75g/kg body weight [‡‡] |
| Carbohydrate (g) | 362.4 | 344 | 347.5 | 254.4 | 285.2 | |
| Fat (g) | 120.9 | 119 | 113.9 | 87.7 | 101.3 | |
| Sugar (g) | 151.5 | 129 | 92.1 | 99.1 | | |
| Sucrose (g) | 78.7 | | | | | |
| Alcohol (g) | 22.9 | 27 | 17.4 | 28 | 6.7 | |
| % total energy from protein | 13.7 | 14.7 | 14.8 | 15.4 | 16 | |
| % total energy from carbohydrate | 45.1 | 43.3 | 45.7 | 41.6 | 46.4 | >47% [†] |
| % total energy from fat | 35.8 | 36 | 35.2 | 34.4 | 36.9 | <33% [†] |
| % total energy from alcohol | 5.4 | 6 | 4.2 | 8.6 | 1.8 | |
| % food energy from protein | 14.6 | 16 | 15 | 16.8 | 15.3 | |
| % food energy from carbohydrate | 47.6 | 46 | 48 | 45.4 | 46.1 | >50% [†] |
| % food energy from fat | 37.8 | 39 | 37 | 37.6 | 39.3 | <35% [† ‡] |
| Dietary Fibre (g) | 20.1 | 24 | 20.7 | | | |
| Calcium (mg) | 1101.4 | 1026 | 1197.2 | | | 800 [‡‡] |
| Magnesium (mg) | 384.6 | | 406.5 | | | |
| Iron (mg) | 16.1 | 15.8 | 14.3 | | | 10 [‡‡] |
| Zinc (mg) | 12.0 | | 13.7 | | | 9.5 [‡‡] |
| Retinol (ug) | 1238.4 | | 809 | | | |
| Carotene (ug) | 2319.0 | | 3750 | | | |
| Retinol equivalents (ug) | 1636.4 | 1180 | 1434 | | | 700 [‡‡] |
| Vitamin D (ug) | 12.2 | | 2.2 | | | 0-10 [‡‡] |
| Vitamin E (mg) | 4.2 | | 4.6 | | | |
| Thiamin (mg) | 2.1 | | 1.8 | | | 100ug/MJ [‡‡] |
| Riboflavin (mg) | 6.7 | 2.4 | 2.4 | | | 1.6 [‡‡] |
| Niacin (mg) | 27.1 | 28.1 | 25.2 | | | 1.6mg/MJ [‡‡] |
| Potential niacin (mg) | 21.6 | | 21.5 | | | |
| Vitamin B6 (mg) | 3.0 | | 2.3 | | | 15ug/g protein [‡‡] |
| Vitamin B12 (ug) | 335.7 | | 6.3 | | | 1.4 [‡‡] |
| Folic acid total (ug) | 6.4 | | 227.7 | | | 300 [‡‡] |
| Vitamin C (mg) | 98.2 | 89 | 75.5 | | | 60 [‡‡] |

INNS: this data was analysed by the investigator for 21-61year olds from the INNS database

[§] 7-day unweighed food diary, [*] 7-day weighed diary, [**] Diet history method [++] 2-day unweighed food diary

[†] Dietary Reference Values (Department of Health, UK, 1991)

[‡] Nutrient Recommendations of the Food Advisory Committee (Department of Health, Republic of Ireland, 1987)

[‡‡] Recommended Dietary Allowances for Ireland (FSAI, 1999)

**Table 2.4: Comparison of the mean daily nutrient intakes of the women of this study with those of women in other Irish food intake studies**

| | Present Study [§] | Gibney *et al* [*] | INNS [**] | Flynn [**] | Murphy [++] | Current Irish dietary recommendations |
|---|---|---|---|---|---|---|
| | | 1989 | 1990 | 1993 | 1995 | |
| | 21-61yrs | 35-44yrs | 21-61yrs | 25-50yrs | | |
| | *n=78* | *n=30* | *n=272* | *n=83* | *n=33* | |
| | *Mean* | *Mean* | *Mean* | *Mean* | *Mean* | |
| Kcal | 2107 | 2008 | 1811 | 2127 | 1816 | |
| MJ | 8.8 | 8.4 | 7.6 | 8.9 | 7.6 | |
| Protein (g) | 74.2 | 77 | 69.7 | 77.7 | 72.1 | 0.75g/kg body weight [‡‡] |
| Carbohydrate (g) | 254.6 | 232 | 226.5 | 230.2 | 217.4 | |
| Fat (g) | 84.5 | 87 | 71.9 | 96.6 | 72.6 | |
| Total sugars (g) | 106.5 | 82 | 70.5 | 93.2 | | |
| Sucrose (g) | 56.3 | | | | | |
| Alcohol (g) | 13.1 | 4 | 5.1 | 12 | 6.1 | |
| % total energy from protein | 14.3 | 15.6 | 16 | 14.6 | 17 | |
| % total energy from carbohydrate | 45.3 | 43.8 | 46.9 | 40.2 | 45.9 | >47% [†] |
| % total energy from fat | 35.7 | 39.1 | 35.1 | 40.9 | 35.3 | <33% [†] |
| % total energy from alcohol | 4.5 | 1.5 | 1.9 | 4.5 | 2.1 | |
| % food energy from protein | 15.0 | 15.9 | 15.7 | 15.2 | 16.2 | |
| % food energy from carbohydrate | 47.4 | 44.2 | 47.8 | 42.2 | 45.9 | >50% [†] |
| % food energy from fat | 37.4 | 39.7 | 36.4 | 42.5 | 36.9 | <35% [†‡] |
| Dietary Fibre (g) | 14.1 | 20 | 16.3 | 20.6 | | |
| Calcium (mg) | 869.9 | 761 | 851.5 | 844.7 | | 800 [‡‡] |
| Magnesium (mg) | 280.5 | | 272.4 | | | |
| Iron (mg) | 12 | 11.8 | 10.3 | 12.3 | | 14 [‡‡] |
| Zinc (mg) | 8.6 | | 9.1 | 9.5 | | 7 [‡‡] |
| Retinol (ug) | 820.4 | | 719.6 | 500 | | |
| Carotene (ug) | 1993 | | 3142.9 | 3900 | | |
| Retinol equivalents (ug) | 1138.5 | 1022 | 1288.4 | 1150 | | 600 [‡‡] |
| Vitamin D (ug) | 2.9 | | 1.6 | | | 0-10 [‡‡] |
| Vitamin E (mg) | 8.4 | | 3.4 | 5.3 | | |
| Thiamin (mg) | 1.5 | | 1.2 | 1.3 | | 100ug/MJ [‡‡] |
| Riboflavin (mg) | 1.7 | 1.7 | 1.7 | 1.7 | | 1.3 [‡‡] |
| Niacin (mg) | 19.9 | 20.2 | 16.6 | 16.2 | | 1.6mg/MJ [‡‡] |
| Potential niacin (mg) | 15.5 | | 14.5 | | | |
| Vitamin B6 (mg) | 2.2 | | 1.4 | 1.6 | | 15ug/g protein [‡‡] |
| Vitamin B12 (ug) | 3.9 | | 4.9 | 5.6 | | 1.4 [‡‡] |
| Folic acid total (ug) | 249 | | 173.5 | 222 | | 300 [‡‡] |
| Vitamin C (mg) | 82.9 | 73 | 70.3 | 79.2 | | 60 [‡‡] |

INNS: this data was analysed by the investigator for 21-61year olds from the INNS database

[§] 7-day unweighed food diary, [*] 7-day weighed diary, [**] Diet history method [++] 2-day unweighed food diary

[†] Dietary Reference Values (Department of Health, UK, 1991)

[‡] Nutrient Recommendations of the Food Advisory Committee (Department of Health, Republic of Ireland, 1987)

[‡‡] Recommended Dietary Allowances for Ireland (FSAI, 1999)

**Table 2.5: Socio-demographic & lifestyle characteristics of men, women and the total sample**

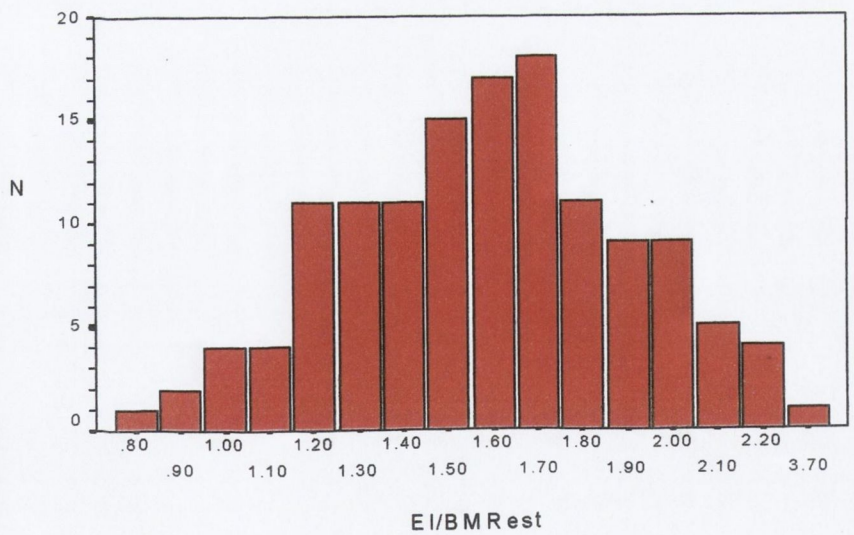
| | Men *n=55* | Women *n=78* | All *n=133* |
|---|---|---|---|
| ***Social Class (%)*** | | | |
| Professional workers (SC1) | 30.9 | 6.5 | 16.5 |
| Managerial & technical (SC2) | 10.9 | 3.9 | 6.8 |
| Non-manual (SC3) | 56.4 | 89.6 | 75.2 |
| Semi-skilled (SC5) | 1.8 | 0.0 | 0.8 |
| ***Marital Status (%)*** | | | |
| Married/co-habiting | 83.6 | 44.9 | 60.9 |
| Single | 16.4 | 51.3 | 36.8 |
| Separated/widowed | 0 | 2.6 | 1.6 |
| ***Smoking status, alcohol intake & supplement use*** | | | |
| A current smoker (%) | 29.1 | 16.7 | 21.8 |
| A consumer of alcohol (%) | 85.5 | 90.9 | 88 |
| Units of alcohol/week by alcohol consumers (mean) | 16.2 | 8.8 | 11.8 |
| A user of vitamin/mineral supplements (%) | 29.1 | 32.7 | 34.1 |
| ***Dieting status*** | | | |
| Tried to lose weight lately (%) | 14.5 | 32.5 | 25 |
| (%) been successful in losing weight while trying to lose weight lately | 5 | 24 | 17 |
| ***Classification of weight status (%)**** | | | |
| Normal range (BMI: 18.5-24.9) | 29.1 | 53.8 | 43.6 |
| Overweight (BMI: 25-29.9) | 52.7 | 38.5 | 44.4 |
| Obese (BMI: $\geq$ 30) | 18.2 | 7.7 | 12 |

* WHO, (1998)

**Table 2.6: Descriptive data on daily eating frequency for men, women and the total sample**

| | Men *n=55* | Women *n=78* | All *n=133* |
|---|---|---|---|
| mean | 5.8 | 5.8 | 5.8 |
| SD | 1.1 | 1.1 | 1.1 |
| median | 5.4 | 5.6 | 5.6 |
| minimum | 4.3 | 3.9 | 3.9 |
| maximum | 9.3 | 9.9 | 9.9 |
| % of subjects with ≤ 4 eating occasions /day | 0 | 3 | 2 |
| % of subjects with 4.1-5.0 eating occasions /day | 24 | 27 | 26 |
| % of subjects with 5.1-6.0 eating occasions /day | 38 | 35 | 36 |
| % of subjects with 6.1-7.0 eating occasions /day | 25 | 25 | 25 |
| % of subjects with 7.1-8.0 eating occasions /day | 9 | 9 | 9 |
| % of subjects with 8.1-9.0 eating occasions /day | 2 | 0 | 1 |
| % of subjects with 9.1-10.0 eating occasions /day | 2 | 1 | 1 |

**Figure 2.1: Distribution of individual $EI/BMR_{est}$ values derived from self-reported energy intake and estimated BMR in 133 subjects studied for 7 days**




**1.05** is the calculated Goldberg cut-off value for under-reporters. Individuals with an $EI/BMR_{est}$ value less than 1.05 were under-reporters.

**2.28** is the calculated Goldberg cut-off value for over-reporters. Individuals with an $EI/BMR_{est}$ > 2.28 were over-reporters.

## 2.5 REFERENCES


Arnold, L.M., Ball, M.J., Duncan, A.W., & Mann, J. (1993). Effect of isoenergetic intake of three or nine meals on plasma lipoproteins and glucose metabolism. *American Journal of Clinical Nutrition, 57,* 446-451.

Ballard-Barbash, R., Graubard, B.I., Krebs-Smith, S.M., Schatzkin, A., & Thompson, F.E. (1996). Contribution of dieting to the inverse association between energy intake and body mass index. *European Journal of Clinical Nutrition, 50,* 98-106.

Basdevant, A., Craplet, C., & Guy-Grand, B. (1993). Snacking Patterns in Obese French Women. *Appetite, 21,* 17-23.

Becker, W., Foley, S., Shelley, E., & Gibney, M.J. (1999). Energy under-reporting in Swedish and Irish dietary surveys: implications for food-based dietary guidelines. *British Journal of Nutrition, 81,* S127-S131.

Bellisle, F., Dalix, A.M., & De Castro, J.M. (1999). Eating patterns in French subjects studied by the "weekly food diary" method. *Appetite, 32,* 46-52.

Bellisle, F., McDevitt, R., & Prentice, A.M. (1997). Meal frequency and energy balance. *British Journal of Nutrition, 77,* S57-S70.

Bellisle, F., Monneuse, M., Steptoe, A., & Wardle, J. (1995). Weight concerns and eating patterns: A survey of university students in Europe. *International Journal of Obesity, 19,* 723-730.

Bingham, S.A. (1994). The use of 24-h urine samples and energy expenditure to validate dietary assessment. *American Journal of Clinical Nutrition, 59:* (Supplement). S277-S231.

Bingham, S.A., Nelson, M., Paul, A.A., Haraldsdottir, J., Bjørge Løken, E., & van Staveren, W.A. (1988). Methods for data collection at an individual level. In M.E. Cameron & W.A. van Staveren (Eds.), *Manual on Methodology for Food Consumption Studies.* (pp. 53-106). Oxford: Oxford University Press.

Bingham, S.A., Welch, A.A., Cassidy, A., Runswick, S., Gill, C., & Khaw, K.T. (1991). 24hr urine N used to detect bias in the reported habitual food intake of individuals assessed from weighed dietary records. *Proceedings of Nutrition Society, 50,* 32A.

Black, A.E., Prentice, A.M., Goldberg, G.R., Jebb, S.A., Bingham, S.A., Livingstone, M.B.E., & Coward, W.A. (1993). Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. *Journal of the American Dietetic Association, 93,* 572-579.

Black, A.E. (2000a). Critical evaluation of energy intake using the Goldberg cut-off for energy intake: basal metabolic rate. A practical guide to its calculation, use and limitations. *International Journal of Obesity, 24,* 1119-1130.

Black, A.E. (2000b). The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying dietary reports of poor validity. *European Journal of Clinical Nutrition, 54,* 395-404.

Black, A.E., Goldberg, G.R., Jebb, S.A., Livingstone, M.B.E., Cole, T.J., & Prentice, A.M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *European Journal of Clinical Nutrition, 45,* 583-599.

Blair, A.J., Booth, D.A., Lewis, V.J., & Wainwright, C.J. (1989). The relative success of official and informal weight reduction techniques: retrospective correlational evidence. *Psychology and Health, 3,* 195-206.

Blokstra, A., Burns, C.M., & Seidell, J.C. (1999). Perception of weight status and dieting behaviour in Dutch men and women. *International Journal of Obesity, 23,* 7-17.

Boggio, V., Moreau, D., Guilland, J.C., Fuchs, F., Spirelli, A., & Klepping, J. (1986). La ration alimentaire aux differents ages de la vie (de 1 mois à 98 ans). *Cah. Nutr. Dietet., 21,* 237-245.

Bone, A. (1992). Methods for studying food consumption (specified time methods). In J.R. Kemm & D. Booth (Eds.), *Promotion of Healthier Eating.* (pp. 169-188). London: HMSO.

Booth, D.A. (1996). Measurement of hunger and satiety for long-term weight control. In A. Angel, G.H. Anderson, C. Bouchard, D. Lau, L. Leiter, & R. Mendelson (Eds.), *Progress in Obesity Research.* (pp. 355-358). London: John Libby.

Briefel, R.R., Sempos, C.T., McDowell, M.A., Chien, S., & Alaimo, K. (1997). Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *American Journal Clinical Nutrition, 65(Suppl),* S1203-S1209.

Central Statistics Office. (1998). *Census 96 Occupations.* Dublin: Government of Ireland.

Chan, W., Brown, J., & Buss, D.H. (1994). *Miscellaneous Foods. Fourth Supplement to the Fifth Edition of McCance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Chan, W., Brown, J., Church, S.M., & Buss, D.H. (1996). *Meat products and dishes. Sixth supplement to the fifth edition of McCance & Widdowson's The Composition of Foods. The Royal College of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMMO.

Chan, W., Brown, J., Lee, S.M., & Buss, D.H. (1995). *Meat, Poultry and Game. Fifth Supplement to the Fifth Edition of McCance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Chapman, G., & Maclean, H. (1993). "Junk Food" and "Healthy Food": Meanings of food in adolescent women's culture. *Journal of Nutrition Education, 25,* 108-113.

Coakes, S.J., & Steed, L.G. (1999). *SPSS without Anguish Versions 7.0, 7.5, 8.0 for Windows.* Brisbane: John Wiley and Sons.

Crawley, H., & Summerbell, C. (1997). Feeding frequency and BMI among teenagers aged 16-17 years. *International Journal of Obesity, 21,* 159-161.

De Castro, J.M. (1987). Circadian Rhythms of the Spontaneous Meal Pattern, Macronutrient intake and Mood of Humans. *Physiology and Behaviour, 40,* 437-446.

De Castro, J.M. (1994). Methodology, correlational analysis, and interpretation of diet diary records of the food and fluid intake of free-living humans. *Appetite, 23,* 179-192.

Department of Health. (1991). *Dietary Reference Values for food energy and nutrients for the United Kingdom: Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy.* London: HMSO.

Department of Health and Children. Survey findings in the lead-up to National Healthy Eating Week. Department of Health and Children. (1999).

Doyle, S.M., & Moloney, M. (1995). Development of a food protein atlas as an educational tool in dietary counselling of renal patients. *Proceedings of the Nutrition Society, 54,* 164A.

Drummond, S., Crombie, N., Cursiter, M.C., & Kirk, T.R. (1998). Evidence that eating frequency is inversely related to body weight status in male, but not female, non-obese adults reporting valid dietary intakes. *International Journal of Obesity, 22,* 105-112.

Fabry, P., Fodor, J., Hejl, Z., Braun, T., & Zvolankova, K. (1964). The frequency of meals: its relation to overweight, hypercholesterolaemia and decreased glucose-tolerance. *Lancet, ii,* 614-615.

FAO/WHO. (1998). *Carbohydrates in human nutrition. Report of a joint FAO/WHO expert consultation, Rome, April 1997.* Rome: WHO.

Flynn, M.A.T. (, 1993). Nutritional Issues in Cardiac Dietetics. Trinity College Dublin;

Foltin, R.W., Fischman, M.W., Moran, T.H., Rolls, B.J., & Kelly, T.H. (1990). Caloric compensation for lunches varying in fat and carbohydrate content by humans in a residental laboratory. *American Journal of Clinical Nutrition, 52:*969-980.

Food Advisory Committee. (1987). *Guidelines for Preparing Information and Advice to the General Public on Healthy Eating.* Dublin, Ireland: Department of Health.

Food Safety Authority of Ireland. (1999). *Recommended Dietary Allowances for Ireland 1999.* Dublin: Food Safety Authority of Ireland.

French, S.A., Jeffery, R.W., & Murray, D. (1999). Is dieting good for you? Prevalence, duration and associated weight and behaviour changes for specific weight loss strategies over four years in US adults. *International Journal of Obesity , 23,* 320-327.

Gatenby, S., Anderson, A.O., Walker, A.D., Southon, S., & Mela, D.J. (1995). "Meals" and "Snacks" - Implications for Eating Patterns In Adults. *Appetite, 24,* 292.

Gatenby, S.J. (1997). Eating frequency: methodological and dietary aspects. *British Journal of Nutrition, 77,* S7-S20.

Gibney, M.J., Moloney, M., & Shelley, E. (1989). The Kilkenny Health Project: food and nutrient intakes in randomly selected healthy adults. *British Journal of Nutrition, 61,* 129-137.

Gibney, M.J., & Wolever, T.M.S. (1997). Periodicity of eating and human health: present perspective and future directions. *British Journal of Nutrition, 77,* S3-S5.

Gnardellis, C., Boulou, C., & Trichopoulou, A. (1998). Magnitude, determinants and impact of under-reporting of energy intake in a cohort study in Greece. *Public Health Nutrition, 1,* 131-137.

Goldberg, G.R., Prentice, A.M., Coward, W.A., Davies, H.L., Murgatroyd, P.R., Sawyer, M.B., Ashford, J., & Black, A.E. (1991). Longitudinal assessment of the components of energy balance in well-nourished lactating women. *American Journal of Clinical Nutrition, 54,* 788-798.

Health Promotion Unit. (1993). *Healthy Eating.* Dublin: Department of Health.

Heitmann, B.L. (1993). The influence of fatness, weight change, slimming history and other lifestyle variables on diet reporting in Danish men and women aged 35-65 years. *International Journal of Obesity, 17,* 329-336.

Heitmann, B.L., & Lissner, L. (1995). Dietary underreporting by obese individuals - is it specific or non-specific? *British Medical Journal, 311,* 986-989.

Hermann-Kunz, E., & Thamm, M. (1999). Dietary recommendations and prevailing food and nutrient intakes in Germany. *British Journal of Nutrition, 81,* S61-S69.

Heywood, P., Harvey, P.W.J., & Marks, G.C. (1993). An evaluation of energy intakes in the 1983 Australian National Dietary Survey of Adults. *European Journal of Clinical Nutrition, 47,* 603-606.

Hirvonen, T., Mannisto, S., Roos, E., & Pietinen, P. (1997). Increasing prevalence of underreporting does not necessarily distort dietary surveys. *European Journal of Clinical Nutrition, 51,* 297-301.

Holland, B., Brown, J., & Buss, D.H. (1993). *Fish and Fish Products. Third Supplement to the Fifth Edition of McCance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1988). *Cereal and Cereal Products. Third Supplement to McCance & Widdowson's The Composition of Foods (4th edition). Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1989). *Milk Products and Eggs. Fourth Supplement to McCance & Widdowson's The Composition of Foods (4th edition). Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1991b). *Vegetables, Herbs and Spices. Fifth Supplement to McCance & Widdowson's The Composition of Foods (4th edition). The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1992a). *Fruit and Nuts. First Supplement to McCance & Widdowson's The Composition of Foods (5th Edition). The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Welch, A.A., & Buss, D.H. (1992b). *Vegetable Dishes. Second Supplement to the Fifth Edition of Mc Cance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Welch, A.A., Unwin, I.D., Buss, D.H., Paul, A.A., & Southgate, D.A.T. (1991a). *McCance & Widdowson's The Composition of Foods. Fifth revised and extended edition. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Hulshof, K.A.M., Lowik, M.R.H., Kistemaker, C., Hermus, R.J.J., ten Hoor, F., & Ockhuizen, T. (1993). Comparison of dietary intake data with guidelines: some potential pitfalls (Dutch Nutrition Surveillance System). *Journal of the American College of Nutrition, 12,* 176-185.

Jeffery, R.W., Adlis, S.A., & Forster, J.L. (1991). Prevalence of dieting among working men and women: the healthy worker project. *Health Psychology, 10:* (4). 274-281.

Jenkins, D.A. (1997). Carbohydrate tolerance and food frequency. *British Journal of Nutrition, 77,* S71-S81.

Jenkins, D.J.A., Wolever, T.M.S., Vuksan, V., Brighenti, F., Cunnane, S.C., Rao, A.V., Jenkins, A.L., Buckley, G., Patten, R., Singer, W., Corey, P., & Josse, R.J. (1989). Nibbling versus gorging: metabolic advantages of increased meal frequency. *New England Journal of Medicine, 321,* 929-934.

Jenkins, D.J.A., Ocana, A., Jenkins, A.L., Wolever, T.M.S., Vuksan, V., Katzman, L., Hollands, M., Greenberg, G., Corey, P., Patten, R., Wong, G., & Josse, R.J. (1992). Metabolic advantages of spreading the nutrient load: effects of increased meal frequency in non-insulin diabetes. *American Journal of Clinical Nutrition,* 461-467.

Johansson, L., Solvoll, K., Bjorneboe, G.A., & Drevon, C.A. (1998). Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. *American Journal of Clinical Nutrition, 68,* 266-274.

Johnson, J., & Vickers, Z. (1993). Effects of flavor and macronutrient composition of food servings on liking, hunger and subsequent intake. *Appetite, 21,* 25-39.

Jonnalagadda, S.S., Mitchell, D.C., Smiciklas-Wright, H., Kris-Etherton, P.M., Van Heel, N., & Karmally, W. (1996). Underestimation of energy intake: comparison of self-reported and actual intake. *FASEB*, 10.

King, J.M. (1995). An evaluation of the use of meal frequency in the dietary treatment of free living hyperlipidaemic male patients. Trinity College Dublin; M.Sc. Thesis.

King, S., & Gibney, M.J. (1999). Dietary advice to reduce fat intake is more successful when it does not restrict habitual eating patterns. *Journal of the American Dietetic Association, 99,* 685-689.

Kirk, T.R. (2000). Role of dietary carbohydrate and frequent eating in body-weight control. *Proceedings of the Nutrition Society, 59,* 349-358.

Klesges, R.C., Mizes, J.S., & Klesges, L.M. (1987). Self-help dieting strategies in college males and females. *International Journal of Eating Disorders, 6,* 71-79.

Krebs-Smith, S.M., Cleveland, L.E., Ballard-Barbash, R., Cook, D.A., & Kahle, L.L. (1997). Characterizing food intake patterns of American adults. *American Journal of Clinical Nutrition, 65,* S1264-S1268.

Lafay, L., Basdevant, A., Charles, M., Vray, M., Balkau, B., Borys, J., Eschwege, E., & Romon, M. (1997). Determinants and nature of dietary underreporting in a free-living population: the Fleurbaix Laventie Ville Sante (FLVS) study. *International Journal of Obesity, 21,* 567-573.

Lee.P., & Cunningham, K. (1990). *The Irish National Nutrition Survey.* Dublin: Irish Nutrition and Dietetic Institute.

Lichtman, S.W., Pisarska, K., Raynes Berman, E., Pestone, M., Dowling, H., Offenbacher, E., Weisel, H., Heshka, S., Matthews, D.E., & Heymsfield, S.B. (1992). Discrepancy between

self-reported and actual caloric intake and exercise in obese subjects. *New England Journal of Medicine*, *327,* 1893-1898.

Livingstone, M.B.E., Prentice, A.M., Strain, J.J., Coward, W.A., Black, A., Barker, M.E., McKenna, P.G., & Whitehead, R.G. (1990). Accuracy of weighed dietary records in studies of diet and health. *British Medical Journal*, *300,* 708-712.

Livingstone, M.B.E. (1991). CHO International Dialogue on Carbohydrates. Children's food and snacking. London: Advisa Medica. 2.

Livingstone, M.B.E. (1995). Assessment of food intakes: are we measuring what people eat? *American Journal of Clinical Nutrition*, *52,* 58-67.

Macdiarmid, J.I., & Blundell, J.E. (1997). Dietary under-reporting: what people say about recording their food intake. *European Journal of Clinical Nutrition*, *51,* 199-200.

Mann, J. (1997). Meal frequency and plasma lipids and lipoproteins. *British Journal of Nutrition*, *S1,* S83-S90.

McBride, A., Wise, A., McNeill, G., & James, W.P.T. (1990). The pattern of food consumption related to energy intake. *Journal of Human Nutrition and Dietetics*, *3,* 27-32.

McGrath, S.A., & Gibney, M.J. (1994). The effects of altered frequency of eating on plasma lipids in free-living healthy males on normal self-selected diets. *European Journal of Clinical Nutrition*, *48,* 402-407.

Ministry of Agriculture, Fisheries and Food. (1994). *The Dietary and Nutritional Survey of British Adults - Further Analysis.* London: HMSO.

Murphy, P. (1995). The temporal distribution of macronutrient intake in free-living subjects. Trinity College Dublin;

Oltersdorf, U. (1996). Impact of changing food choices and eating habits on nutritional status in European countries. *Appetite*, *27,* 91-94.

Oltersdorf, U., Schlettwein-Gsell, D., & Winkler, G. (1999). Assessing eating patterns - an emerging research topic in nutritional sciences: Introduction to the symposium. *Appetite*, *32,* 1-7.

Poppit, D., Swann, D., Black, A., & Prentice, A.M. (1998). Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *International Journal of Obesity*, *22,* 303-311.

Prättälä, R., & Roos, E. (1999). From regional ethnographies to interdisciplinary approaches - research on meals in Finland. *Appetite*, *32,* 66-72.

Prentice, A.M., Black, A.E., Coward, W.A., Davies, H.L., Goldberg, G.R., Murgatroyd, P.R., Ashford, J., Sawyer, M.B., & Whitehead, R.G. (1986). High levels of energy expenditure in obese women. *British Medical Journal, 292,* 983-987.

Price, G.M., Paul, A.A., Cole, T.J., & Wadsworth, M.E.J. (1997). Characteristics of the low-energy reporters in a longitudinal national dietary survey. *British Journal of Nutrition*, *77,* 833-851.

Pryer, J.A., Vrihjheid, M., Nichols, R., Kiggins, M., & Elliot, P. (1997). Who are the 'low energy reporters' in the Dietary and Nutritional Survey of British Adults? *International Journal of Epidemiology*, *26,* 146-153.

Redondo, M.R., Ortega, R.M., Zamora, M.J., Quintas, M.E., Lopez-Sobaler, A.M., Andres, P., & Gaspar, M.J. (1997). Influence of the number of meals taken per day on cardiovascular risk factors and the energy and nutrient intakes of a group of elderly people. *International Journal of Vitamin and Nutrition Research*, *67,* 176-182.

Robson, P.J., & Strain, J.J. (1991). Snack energy and nutrient intakes of Northern Ireland adolescents. *Proceedings of the Nutrition Society, 50,* 180A.

Roche, H.M., & Gibney, M.J. (1995). Postprandial triacylglycerolaemia - nutritional implications. *Progress in Lipid Research, 34,* 249-266.

Roche, H.M., & Gibney, M.J. (2000). The impact of postprandial lipemia in accelerating atherothrombosis. *Journal of Cardiovascular Risk, 7,* 313-324.

Rossner, S. (1995). Realistic expectations of obesity treatments. In R. Cotrell (Ed.), *Weight control - the current perspectives.* London: Chapman and Hall.

Ruxton, C.H.S., Kirk, T.R., & Belton, N.R. (1996). The contribution of specific dietary patterns to energy and nutrient intakes in 7-8-year-old Scottish schoolchildren. III. Snacking habits. *Journal of Human Nutrition and Dietetics, 9,* 23-31.

Schoeller, D.A. (1990). How accurate is self-reported dietary energy intake? *Nutrition Reviews, 48,* 373-379.

Schofield, W.N., Schofield, C., & James, W.P.T. (1985). Basal metabolic rate-review and prediction. *Human Nutrition Clinical Nutrition, 39,* 1-96.

Stubbs, R.J., van Wyk, M.C.W., Johnstone, A.M., & Harbron, C.G. (1996). Breakfasts high in protein, fat or carbohydrate: effect on within-day appetite and energy balance. *European Journal of Clinical Nutrition, 50,* 409-417.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1995). Sources of energy from meals versus snacks in 220 people in four age groups. *European Journal of Clinical Nutrition, 49,* 33-41.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1996). Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. *European Journal of Clinical Nutrition, 50,* 513-519.

Tan, S.P., Wenlock, R.W., & Buss, D.H. (1985). *Immigrant foods: second supplement to McCance & Widdowson's The Composition of Foods.* London: HMSO.

Whybrow, S., & Kirk, T.R. (1997). Nutrient intakes and snacking frequency in female students. *Journal of Human Nutrition and Dietetics, 10,* 237-244.

Williamson, D.F., Serdula, M.K., Anda, R.F., Levy, A., & Byers, T. (1992). Weight loss attempts in adults: goals, duration, and rate of weight loss. *American Journal of Public Health, 82,* 1251-1257.

Winkler, G., Doring, A., & Keil, U. (1999). Meal patterns in middle-aged men in Southern Germany: results from the MONICA Augsburg Dietary Survey 1984/85. *Appetite, 32,* 33-37.

World Health Organisation. (1998). *Obesity: Preventing and Managing the Global Epidemic. International Obesity Task Force. Geneva, 3-5 June 1997.* WHO.

# CHAPTER 3

## The temporal pattern of macronutrient intake during eating occasions throughout the day: exploration of data analysis methods

## 3.1 INTRODUCTION

Mean daily intakes of nutrients are the most frequently used outputs of dietary surveys, and are often compared to dietary recommendations to assess the attainment of the recommendations by the population under study. These intakes, however, conceal information on the nutrient quality of individual eating occasions and the temporal pattern of nutrient intake during the day. Such information could be very valuable in public health nutrition programmes, particularly in terms of food-based dietary guidelines (FBDGs). Public health nutrition programmes increasingly use FBDGs to improve nutritional status of populations. Information in relation to temporal patterns of food and nutrient intake is required to define the baseline state, to determine the changes in food consumption patterns required to improve nutritional status and to measure the effectiveness of FBDG interventions.

Despite its potential value, little attention has been given to the study of eating patterns in dietary surveys to date. In particular the temporal pattern or variation in the nutrient content of eating occasions throughout the day has been scantily studied. Only 7 studies were found in the literature to have made investigations of the temporal pattern of nutrient intake throughout the day. Meal patterns were analysed and presented as nutrient intake on an hourly basis by De Castro, (1987) in a study of 38 American students and by Roos & Prättälä, (1997) in a dietary survey of 1689 adult Finns. De Castro, (1987) also presented nutrient intake during 6 three-hour time periods and per meal during 18 hourly time periods. Little detail was provided in both studies however as to the exact calculations that were used and a meal was defined by De Castro, (1987) as having an energy content of at least 50kcal (0.2MJ), 150kcal (0.6MJ) or 250kcal (1MJ). Analysis of the average food and nutrient content of traditional Dutch eating occasions throughout the day (i.e. breakfast, lunch, dinner, snacks) was presented in reports of the Dutch national food consumption survey of 1987-1988 (vd Es *et al.*, 1989; Kistemaker & Aarnick, 1989; Kistemaker & Löwik, 1991). Four different methods were presented to calculate the average intakes (food or nutrients) per eating occasion and particular attention was given to a number of issues to be considered during these calculations including the number of subjects and the consumers of a meal, food or nutrient. Lennernäs *et al.*, (1993) used a qualitative food based approach of nutritionally 'complete' and

'incomplete' meals to present the nutrient content of eating occasions of 16 Swedish male adult shift-workers. The nutrient content of four types of eating occasions (morning, midday, evening, snacks) which were defined by time and name of the meal, were presented by Ballard-Barbash *et al.*, (1994), using dietary intakes of 1032 American adult women, with full details of the calculations used. The nutrient composition of six eating occasions defined roughly by time were calculated by Westerterp-Plantenga *et al.*, (1996) in a study of energy intake adaptation in 68 Dutch women and the nutrient content of three eating occasions defined according to time periods (morning, afternoon, evening) was recently presented by Bellisle *et al.*, (1999) from a group of 16 French students, with little information on the calculations used in both studies. Interpretation of the results of these few studies of the temporal pattern of nutrient intake throughout the day and comparisons between studies is challenged however by a number of factors. The definition of an eating occasion varied between studies, the exact details of the calculations used were not always available, the dietary assessment methods differed, the study samples varied by age and gender and the samples were from different populations with different cultural aspects to eating behaviour.

In this Chapter the dietary data described in Chapter 2, is used to explore methods of data analysis to determine the intakes of macronutrients consumed during eating occasions throughout the day by free-living adults. The appropriateness of the different methods of data analysis to determine the temporal patterns of nutrient intake throughout the day is discussed, and recommendations are made.

## 3.2 METHODS

A comprehensive description of the methods used to collect dietary data from a group of 133 free-living Irish adults, using a 7-day food diary, to allow the study of temporal patterns of nutrient intake throughout the day is presented in Chapter 2. Chapter 2 describes details of the subject recruitment, the dietary assessment procedure and the quality and validity of the dietary data collected. An eating occasion included every item of food or drink consumed within an hourly period. The assessment of the validity of the dietary data was fully described in Chapter 2, with the conclusions that the dietary data of this study is acceptable.

### 3.2.1 Data analysis methods

Data analysis was conducted using SPSS® 8.0 (SPSS Inc, Chicago, USA.) and tables were created using Microsoft® Excel spreadsheets (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.). The SPSS® database had an entry for every hour (01.00-24.00hours) of each of the 7 days for each subject. The nutrient composition data, of every eating occasion of each subject during the 7 days, was presented at the specific hour of consumption.

The temporal pattern of the average nutrient intake of eating occasions throughout the day can be determined in several ways, depending on which factors are taken into consideration in the calculation. The temporal pattern of nutrient intake during eating occasions throughout the day in the present study was determined for each hour of the 24-hour day. Four methods were explored and examined as part of the data analysis in the present study and the specific characteristics of each are presented later in this section. Method 1 was used by De Castro, (1987) in a study of the circadian rhythms of meal patterns, which presented nutrient intake on an hourly basis for 18 one-hour periods. Each of the 4 methods (Methods 1 through 4) was fully described in reports of the Dutch national food consumption survey 1987/1988, as possible calculations of the mean nutrient or food intake of eating occasions (e.g. breakfast, lunch-bread, lunch-hot, dinner-bread, dinner-hot, between meals in the morning, afternoon or evening), (vd Es *et al.*, 1989; Kistemaker & Aarink, 1989; Kistemaker & Löwik, 1991). Method 4 has also been used by the U.S. National Cancer Institute in studying the variability of fat intake throughout the day according to 4 types of eating occasions defined as morning, midday, evening and snacks (Ballard-Barbash *et al.*, 1994).

These 4 methods are outlined in turn below, together with an example, to illustrate the calculations of each method in determining the temporal pattern of the mean nutrient intake of eating occasions at each hour throughout the day. For the purpose of the example, the mean energy intake of eating occasions at 7am, is calculated using data from 5 subjects with 7 days of nutrient intake data for each of the 4 methods. The kcal unit of energy is used in place of MJ to simplify the calculation. The energy (kcal) intake of the eating occasions that occur at a specific hour (e.g. 7am) is presented for each subject for each of the 7 days. This example

demonstrates that differences exist in the average energy intake of eating occasions at an hour when calculated using the 4 different methods. Average energy intakes (kcal) of the eating occasions at 7am in the example were 93kcal, 135kcal, 210kcal and 243kcal for methods 1 through 4 respectively.

**Method 1:** For each particular hour, nutrient intakes across all subjects and all days (7 days in the present study) were summed and divided by the total number of recording days (number of subjects x 7 days i.e. 133 x 7d ). In this method each subject had at least some hours during which no eating occasion took place.

*Example of Method 1 calculations:*

The mean energy (kcal) intake of the eating occasions at 7am of 93kcal is calculated by summing the nutrient intake across all subjects and all days to give 3780kcal and dividing by the total number of recording days (5 subjects x 7d = 35).

**Hour: 7am**

| **Subjects** | **Days** | | | | | | | **Sum of kcal intake** |
|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **across all days** |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 50 | 0 | 200 | 300 | 50 | 50 | 0 | 650 |
| 3 | 150 | 200 | 250 | 180 | 100 | 0 | 0 | 880 |
| 4 | 0 | 0 | 0 | 400 | 0 | 0 | 0 | 400 |
| 5 | 100 | 400 | 250 | 300 | 400 | 200 | 200 | 1850 |
| | | | | | | | | **3780** |

Sum of energy intake across all subjects and all days = 3780 = **93kcal**

Total no. of recording days (5 subjects x 7d=35) 35

**Method 2:** The mean nutrient intake for each subject at a particular hour during the 7 days was first calculated, irrespective of whether food or drink was consumed at that hour on all days. For each subject the intake consumed at a particular hour was summed across the 7 days and then divided by the number of recording days (7d). The group average of all eating occasions (energy content of greater than 0kcal) which occurred at an hour was then calculated.

*Example of Method 2 calculations:*

The mean energy (kcal) intake of the eating occasions at 7am of 135kcal is calculated as follows. Firstly the mean energy intake for each subject at the hour (7am) is calculated by summing the nutrient intake across the 7 days of recording, for each subject and dividing by the number of days (7d). The group mean energy intake of eating occasions with > 0kcal is then calculated. As only 4 subjects had a mean daily energy intake of > 0kcal at 7am, the group mean calculation in the example involved only 4 subjects, to give a mean value of 135kcal per eating occasions at 7am.

**Hour: 7am**

| **Subjects** | **Days** | | | | | | | **Mean daily kcal intake** | |
|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **at the hour** | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/7 | 0 |
| 2 | 50 | 0 | 200 | 300 | 50 | 50 | 0 | 650/7 | 93 |
| 3 | 150 | 200 | 250 | 180 | 100 | 0 | 0 | 880/7 | 126 |
| 4 | 0 | 0 | 0 | 400 | 0 | 0 | 0 | 400/7 | 57 |
| 5 | 100 | 400 | 250 | 300 | 400 | 200 | 200 | 1850/7 | 264 |
| | | | | | | | | | **540/4 = 135** |

**Method 3:** For each particular hour, the nutrient intake of eating occasions (energy content of greater than 0kcal) was summed across all subjects and all days (7 d). The mean nutrient intake of eating occasions/hour was then calculated by dividing by the total number of times an eating occasion (> 0kcal) occurred at that hour. The actual number of subjects, the number of subjects consuming at the hour and the number of recording days are only of indirect importance. Subjects who had eating occasions at a particular hour on all days contribute more to the estimate of the mean than those who had an eating occasion on fewer days.

*Example of Method 3 calculations:*

The mean energy (kcal) intake of the eating occasions at 7am of 210kcal is calculated by firstly summing the nutrient intake of eating occasions of > 0kcal only, across all subjects and days, to total 3780kcals. This value is divided by the total number of eating occasions (> 0kcal), 18 in the example, to give a mean of 210kcal per eating occasions at 7am using method 3.

**Hour: 7am**

| **Subjects** | **Days** | | | | | | | **Sum of kcal intake** |
|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **for each subject** |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 50 | 0 | 200 | 300 | 50 | 50 | 0 | 650 |
| 3 | 150 | 200 | 250 | 180 | 100 | 0 | 0 | 880 |
| 4 | 0 | 0 | 0 | 400 | 0 | 0 | 0 | 400 |
| 5 | 100 | 400 | 250 | 300 | 400 | 200 | 200 | 1850 |
| | | | | | | | | **3780** |

Sum of energy intake (> 0kcal) across all subjects and all days = 3780 = **210kcal**

Total no. of eating occasions (> 0kcal) 18

**Method 4:** This method ensures all individuals contribute in a similar way to the mean value. Firstly, for each subject, the total nutrient intake consumed during eating occasions at a particular hour during the 7 days was summed and divided by the frequency the subject had an eating occasion (energy content of greater than 0kcal) at that hour during the recording period. Thereafter the mean intake for each individual who ate at an hour was summed and divided by the number of consumers at that hour.

*Example of Method 4 calculations:*

The mean energy (kcal) intake of the eating occasions at 7am of 243kcal is calculated as follows. Firstly the mean energy intake of eating occasions of > 0kcal only, at the hour (7am) is calculated for each subject by summing the nutrient intake across the 7 days for each subject and dividing by the number of days an eating occasion (> 0kcal) was consumed. The group mean energy intake of eating occasions with > 0kcal is then calculated. As only 4 subjects had a mean daily energy intake of > 0kcal at 7am, the group mean calculation in the example involved only 4 subjects to give a mean value of 243kcal per eating occasions at 7am.

**Hour: 7am**

| **Subjects** | **Days** | | | | | | | **Mean kcal intake** | |
|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **/eating** | **occ (> 0kcal)** |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 50 | 0 | 200 | 300 | 50 | 50 | 0 | 650/5 | 130 |
| 3 | 150 | 200 | 250 | 180 | 100 | 0 | 0 | 880/5 | 176 |
| 4 | 0 | 0 | 0 | 400 | 0 | 0 | 0 | 400/1 | 400 |
| 5 | 100 | 400 | 250 | 300 | 400 | 200 | 200 | 1850/7 | 264 |
| | | | | | | | | | **970/4 = 243** |

## 3.3 RESULTS

Large differences were also observed in the average macronutrient intake of eating occasions per hour, using the 4 calculation methods. Table 3.1 presents descriptive data (mean, median, standard deviation, minimum and maximum) of the temporal pattern of the average fat intake (g) of eating occasions per hour for the 24 hours of the day according to the 4 different calculation methods. This table, together with the examples used to illustrate the calculations of each method, serve to illustrate the points referred to in the following discussion, on each method. The mean fat intake of the eating occasions at each hour are also presented in graphical form in Figure 3.1, to clearly illustrate the different mean results obtained with the 4 methods of data analysis. In general the mean nutrient intake of eating occasions per hour calculated using methods 1 and 2 was lower than that calculated using methods 3 and 4. Similar mean results were obtained for fat intakes of eating occasions, using methods 3 and 4.

The mean intakes of fat (g) per eating occasions (> 0MJ) per hour calculated using methods 3 and 4 were compared using the non-parametic Mann-Whitney test as the variables did not follow a normal distribution. The mean fat intakes of the eating occasions at each hour were not significantly different between methods 3 and 4, except for hours 16.00, 20.00 and 21.00. The mean fat intakes at these time points were in fact comparable although a significant difference between the means was obtained *($P<0.05$).* This is due to the difference in the range of fat intakes in the eating occasions at these hours.

## 3.4 DISCUSSION

The following discussion comments on the appropriateness of each of the 4 methods for analysing the temporal pattern of the nutrient content of eating occasions at each hour of the day in free-living individuals. The temporal pattern of nutrient intake throughout the day was determined specifically in relation to eating occasions which occurred at hourly periods, to avoid the use of pre-defined terms such as 'meals' and 'snacks' or 'breakfast', 'dinner' and 'tea', as these terms tend to be subjectively defined (Gatenby, 1997). The use of such terms can involve aggregation of the nutrient content of a number of eating occasions, which results in loss of the very detail being sought. Also the high degree of between person variation, in the nutrient composition of traditional meals and snacks, make these classifications inappropriate for measuring temporal patterns of nutrient intake. With no consensus on the definition of an eating occasion and with definitions varying between studies, the temporal pattern of the mean nutrient intake of eating occasions, during hourly periods, was considered a most objective approach with which to study periodicity of eating.

### Method 1

In the case of method 1, a large number of zeros were included in the calculation of the mean because the number of days of recording was used as the determinant of the number of times an eating occasion occurred at an hour, for each subject. Using method 1, the mean nutrient intake of eating occasions at a given hour in this study was considered to be the sum of all 133 intakes on each of the 7 days, divided by the total number of recording days (i.e. 133 x 7 =

931). There was no pre-definition of an eating occasion and hours with eating occasions of 0 MJ were thus included in these calculations. In reality however, it is highly improbable for an individual to consume food or drink at every hour of every day during 7 days of recording. A median value of 0g of nutrient intake at eating occasions was thus generally obtained using method 1 (Table 3.1). If every individual (n=133) always had an eating occasion at each of the time segments (n=24) considered on each day studied (n=7) there would have been 22,344 eating occasions with no zero values. Such analysis was carried out by De Castro, (1987) and revealed fat intakes of 2g-4g per eating occasion at most hours throughout the day (06.00-23.00 hours) except for 2 peaks in fat intake of 6-7g at 12.00-13.00 hours and 18.00-20.00 hours. These results are somewhat comparable to the mean fat intakes of eating occasions at each hour calculated using method 1 in the present study (Table 3.1). A problem arises with this analysis however in representing the average macronutrient intake of eating occasions at each hour of free-living individuals because, in reality, not all individuals eat at each hour and not all individuals eat at a given hour on different days. By including zero values in calculating the mean nutrient intake of eating occasions, the estimates of nutrient intakes at eating occasions are artificially reduced. The maximum nutrient intake value at an hour with method 1 however is useful as it represents the largest intake of a nutrient consumed at an eating occasion by free-living adults. For example, Table 3.1 shows that the maximum fat intake at 23.00hours was 255g which means that a fat intake of as much as 255g was consumed at a single eating occasion by an individual in this group of free-living adults.

**Method 2**

In the case of method 2, individuals are taken into account in the calculations of this method, as the mean nutrient intake of eating occasions at an hour during the 7 days is firstly calculated for each individual. In this method however the divisor is always the number of recording days which generates a large number of low mean values because many of these days did not involve consumption at a given hour. The mean nutrient intake of eating occasions per hour using method 2 is larger though, than that obtained using method 1, because the group mean is calculated for pre-defined eating occasions with an energy content of > 0MJ (Table 3.1). As with method 1 however, problems also arise with method 2 in representing the average macronutrient content of typical eating occasions at an hour. By dividing by 7, in calculating

the mean intake at an hour for individuals, there is the assumption that subjects consume at an hour on all 7 recording days which of course is not the case in reality. With regard to the maximum value for the nutrient content of an eating occasion at an hour using method 2, this value is lower at every hour than that obtained using method 1. This is because the initial calculation of the mean intake of eating occasions per hour during the 7 days, for each individual, reduces the large nutrient intakes at eating occasions at an hour, due to the inclusion of zero values.

It is thus clear that, the mean nutrient intake of eating occasions per hour of free-living populations cannot be represented by the calculations of method 1 and 2 because time-points with 0 MJ were included as eating occasions, which greatly reduces the actual nutrient intakes consumed during eating events.

**Methods 3 & 4**

In the case of methods 3 and 4, zero values are excluded at any given time point at all levels of data analysis. Only eating occasions with an energy content of > 0 MJ were included in the calculation of the mean nutrient intake per eating occasion per hour using methods 3 and 4. Subjects who did not consume at an hour are also not included in the calculations. Method 3 calculates the mean nutrient intake of eating occasions (> 0MJ) at each hour across all subjects and days with no account made for individuals or intra-person variation in the nutrient content of eating occasions. Method 4 calculates the mean nutrient intake of eating occasions (> 0MJ) at each hour, but this calculation takes individuals into account and ensures that all subjects contribute equally. By way of example, consider hour 13.00 for methods 3 and 4 in Table 3.1. The n value for method 3 refers to the mean of 550 eating occasions that occurred at 13.00 hours for 133 subjects with 7 days of food intake data. The n value for method 4, however, refers to the mean intake at 13.00hours of 124 subjects who had an eating occasion at least once during the 7 days of recording (having first taken into consideration the number of times per week an individual ate at an hour). The maximum value for the nutrient content of an eating occasion at an hour in method 3 represents the largest nutrient intake at an eating occasion consumed by free-living adults and is identical to that observed using method 1 (Table 3.1). The maximum value observed using method 4 is lower than that obtained using

method 3 as this method calculates intakes for each individual which reduces the nutrient intake at an eating occasion.

**Recommendations**

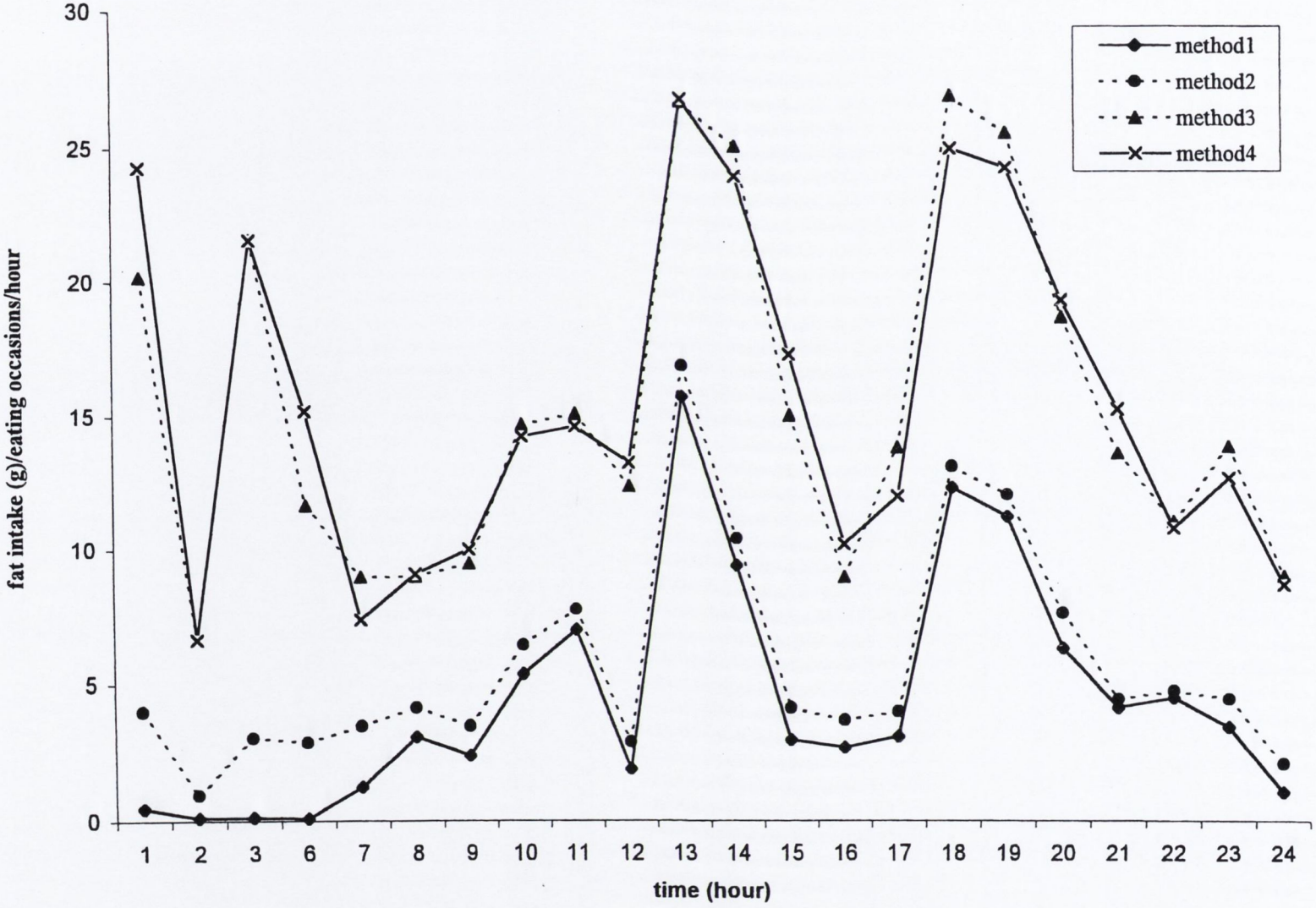
With regard to the latter two methods of data analysis, it is clear that both methods 3 and 4 are suitable for determining the temporal pattern of the mean nutrient intake of typical eating occasions per hour throughout the day. This is because only actual eating occasions with an energy content of > 0MJ are included in the calculations at all levels of analysis and in reality eating occasions generally involve calorific consumption, with the exception of diet beverages, and tea or coffee without the additions of milk or sugar. In addition, only subjects who consumed at an hour are included in the calculations with these latter methods. The choice of the method of data analysis to be used will however depend on the research question under investigation. To simplify the understanding of the calculations used in methods 3 and 4, these methods will be referred to by the following phrases hereafter. Method 3 will be termed 'the eating occasion method' and method 4 will be termed 'the eating occasion by individual method'. The following investigative Chapters (Chapters 4 and 5 through 7) use methods 3 or 4, to determine the temporal pattern of the mean macronutrient intake of eating occasions per hour and address the research question of interest.

This study makes an important contribution to a neglected area of nutrition research, the study of eating patterns. The International Union of Nutritional Sciences in 1994 established a Committee on Nutrition and Food Habits in recognition of this fact, with a task of reviewing the impact of changing food choice and habits on nutritional status (Oltersdorf, 1996; Oltersdorf *et al.*, 1999). Priority was given to developing methodology to identify and assess eating patterns. The focus of the present study contributes to this initiative. As different methods can be used to calculate the mean nutrient content of eating occasions with very different results, it is essential for investigators to give clear details of the exact calculations used. This allows for the correct interpretation of the results and comparisons with other studies thereby avoiding incorrect or misleading conclusions.

**Table 3.1: Mean fat (g) intake during eating occasions at each hour hour throughout the day, calculated by 4 different methods**

| Hour | Fat (g) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | METHOD 1 n=931 | | | | | METHOD 2 | | | | | | METHOD 3 | | | | | | METHOD 4 | | | | |
| | *Mean* | *Median* | *SD* | *Min.* | *Max.* | *n* | *Mean* | *Median* | *SD* | *Min.* | *Max.* | *n* | *Mean* | *Median* | *SD* | *Min.* | *Max.* | *n* | *Mean* | *Median* | *SD* | *Min.* | *Max.* |
| 1 | 0.5 | 0 | 8.3 | 0 | 242.9 | 15 | 4.0 | 0.9 | 8.9 | 0.0 | 34.7 | 21 | 20.2 | 4.5 | 52.8 | 0.0 | 242.9 | 15 | 24.3 | 5.5 | 61.3 | 0.0 | 242.9 |
| 2 | 0.1 | 0 | 1.1 | 0 | 19.0 | 13 | 0.9 | 0.4 | 1.0 | 0.0 | 2.7 | 13 | 6.6 | 2.5 | 7.2 | 0.0 | 19.0 | 13 | 6.6 | 2.5 | 7.2 | 0.0 | 19.0 |
| 3 | 0.1 | 0 | 3.1 | 0 | 93.8 | 5 | 3.1 | 0.6 | 5.8 | 0.0 | 13.4 | 5 | 21.6 | 4.5 | 40.6 | 0.0 | 93.8 | 5 | 21.6 | 4.5 | 40.6 | 0.0 | 93.8 |
| 6 | 0.1 | 0 | 1.5 | 0 | 42.6 | 4 | 2.9 | 2.7 | 2.6 | 0.3 | 6.1 | 7 | 11.7 | 7.0 | 13.8 | 2.0 | 42.6 | 4 | 15.2 | 8.2 | 18.5 | 2.0 | 42.6 |
| 7 | 1.2 | 0 | 4.4 | 0 | 35.3 | 47 | 3.5 | 2.1 | 4.7 | 0.0 | 19.7 | 129 | 9.0 | 7.1 | 8.4 | 0.0 | 35.3 | 47 | 7.4 | 6.5 | 7.0 | 0.0 | 28.1 |
| 8 | 3.1 | 0 | 6.1 | 0 | 39.8 | 99 | 4.2 | 3.3 | 3.7 | 0.1 | 14.5 | 322 | 9.0 | 7.3 | 7.5 | 0.0 | 39.8 | 99 | 9.1 | 7.2 | 7.3 | 0.3 | 33.3 |
| 9 | 2.4 | 0 | 7.4 | 0 | 79.9 | 92 | 3.5 | 1.7 | 4.7 | 0.0 | 28.3 | 238 | 9.5 | 5.1 | 12.2 | 0.0 | 79.9 | 92 | 10.1 | 6.0 | 11.9 | 0.0 | 66.0 |
| 10 | 5.4 | 0 | 10.5 | 0 | 68.7 | 111 | 6.5 | 4.2 | 6.5 | 0.0 | 32.4 | 341 | 14.8 | 15.3 | 12.8 | 0.0 | 68.7 | 111 | 14.3 | 13.1 | 11.8 | 0.0 | 65.1 |
| 11 | 7.1 | 0 | 11.6 | 0 | 85.4 | 120 | 7.8 | 5.4 | 6.3 | 0.0 | 24.0 | 433 | 15.2 | 13.7 | 12.9 | 0.0 | 85.4 | 120 | 14.7 | 13.5 | 11.0 | 0.0 | 68.7 |
| 12 | 1.9 | 0 | 7.3 | 0 | 65.3 | 87 | 2.9 | 2.1 | 3.3 | 0.0 | 19.3 | 143 | 12.5 | 6.7 | 14.8 | 0.0 | 65.3 | 87 | 13.3 | 9.4 | 13.3 | 0.0 | 65.3 |
| 13 | 15.8 | 7.6 | 20.3 | 0 | 111.9 | 124 | 17.0 | 15.5 | 9.6 | 0.0 | 45.1 | 550 | 26.8 | 22.9 | 20.1 | 0.0 | 111.9 | 124 | 26.9 | 25.5 | 13.8 | 0.3 | 78.9 |
| 14 | 9.5 | 0 | 19.2 | 0 | 118.6 | 120 | 10.5 | 7.2 | 10.7 | 0.0 | 63.6 | 351 | 25.2 | 19.1 | 24.2 | 0.0 | 118.6 | 120 | 24.0 | 19.9 | 17.4 | 0.1 | 81.5 |
| 15 | 3.0 | 0 | 10.2 | 0 | 91.6 | 96 | 4.2 | 2.5 | 4.4 | 0.0 | 20.9 | 186 | 15.1 | 9.6 | 18.5 | 0.0 | 91.6 | 96 | 17.4 | 12.2 | 18.7 | 0.0 | 86.8 |
| 16 | 2.7 | 0 | 8.7 | 0 | 106.8 | 97 | 3.7 | 2.5 | 3.9 | 0.0 | 17.1 | 281 | 9.1 | 4.4 | 13.9 | 0.0 | 106.8 | 97 | 10.3 | 6.5 | 12.0 | 0.0 | 73.2 |
| 17 | 3.1 | 0 | 10.5 | 0 | 128.6 | 103 | 4.1 | 2.3 | 5.2 | 0.0 | 27.7 | 210 | 13.9 | 7.2 | 18.3 | 0.0 | 128.6 | 103 | 12.1 | 8.4 | 12.1 | 0.0 | 64.6 |
| 18 | 12.4 | 0 | 21.4 | 0 | 225.0 | 125 | 13.2 | 10.1 | 11.7 | 0.0 | 49.7 | 428 | 27.0 | 22.8 | 24.6 | 0.0 | 225.0 | 125 | 25.1 | 23.6 | 16.7 | 0.0 | 85.9 |
| 19 | 11.3 | 0 | 19.2 | 0 | 153.0 | 124 | 12.2 | 9.9 | 10.2 | 0.0 | 43.4 | 411 | 25.7 | 20.6 | 21.6 | 0.0 | 153.0 | 124 | 24.4 | 22.8 | 16.2 | 0.0 | 79.8 |
| 20 | 6.4 | 0 | 14.6 | 0 | 103.4 | 110 | 7.7 | 6.4 | 6.5 | 0.0 | 29.0 | 315 | 18.8 | 12.7 | 20.0 | 0.0 | 103.4 | 110 | 19.4 | 17.2 | 14.4 | 0.0 | 57.7 |
| 21 | 4.2 | 0 | 12.3 | 0 | 112.8 | 124 | 4.5 | 2.7 | 4.9 | 0.0 | 25.4 | 285 | 13.7 | 7.3 | 19.1 | 0.0 | 112.8 | 124 | 15.4 | 9.4 | 17.8 | 0.0 | 105.2 |
| 22 | 4.5 | 0 | 10.7 | 0 | 77.0 | 126 | 4.8 | 3.4 | 4.5 | 0.0 | 17.8 | 380 | 11.1 | 7.1 | 14.3 | 0.0 | 77.0 | 126 | 10.9 | 8.6 | 10.1 | 0.0 | 61.2 |
| 23 | 3.5 | 0 | 13.4 | 0 | 255.0 | 103 | 4.5 | 2.5 | 6.9 | 0.0 | 51.5 | 233 | 13.9 | 7.7 | 24.0 | 0.0 | 255.0 | 103 | 12.8 | 7.9 | 15.7 | 0.0 | 120.1 |
| 24 | 1.1 | 0 | 5.2 | 0 | 65.0 | 66 | 2.1 | 1.0 | 3.3 | 0.0 | 19.2 | 109 | 9.1 | 2.7 | 12.6 | 0.0 | 65.0 | 66 | 8.7 | 5.5 | 10.8 | 0.0 | 42.1 |

**Figure 3.1: Temporal pattern of the mean fat intake (g) during eating occasions per hour**



## 3.5 REFERENCES


Ballard-Barbash, R., Thompson, F.E., Graubard, B.I., & Krebs-Smith, S.M. (1994). Variability in percent energy from fat throughout the day: implications for application of total diet goals. *Journal of Nutrition Education, 26,* 278-283.

Bellisle, F., Dalix, A.M., & De Castro, J.M. (1999). Eating patterns in French subjects studied by the "weekly food diary" method. *Appetite, 32,* 46-52.

De Castro, J.M. (1987). Circadian rhythms of the spontaneous meal pattern, macronutrient intake, and mood of humans. *Physiology & Behaviour, 40,* 437-446.

Gatenby, S. (1997). Eating frequency: methodological and dietary aspects. *British Journal of Nutrition, 77,* S7-S20.

Kistemaker, I.C., & Aarnink, E.J.M. Vetconsumptie door de Nederlandse bevolking per maaltijdmoment, naar leeftijd en geslacht. Voedselconsumptiepeiling 1987-1988 (Fat intake of the Dutch population per eating moment by age and sex). TNO. (1989). V 89.503, 1 p.

Kistemaker, I.C., & Löwik, M.R.H. (1991). Wat eet Nederland werkelijk? *Voeding, 52,* 64-67.

Lennernäs, M.A., Akerstedt, T., Hagman, U., Bruce, A., & Hambraeus, L. (1993). A new approach for evaluation of meal quality and meal patterns. *Journal of Human Nutrition and Dietetics, 6,* 261-273.

Oltersdorf, U. (1996). Impact of changing food choices and eating habits on nutritional status in European countries. *Appetite, 27,* 91-94.

Oltersdorf, U., Schlettwein-Gsell, D., & Winkler, G. (1999). Assessing eating patterns-an emerging research topic in nutritional sciences: introduction to the symposium. *Appetite, 32,* 1-7.

Roos, E., & Prättälä, R. (1997). Meal pattern and nutrient intake among adult Finns. *Appetite, 29,* 11-24.

v.d.Es, P.M., Kistemaker, I.C., & Hulshof, K.F.A.M. . Maaltijdgebruik en gebruik van voedingsmiddelengroepen naar leeftijd en geslacht. Voedselconsumptiepeiling 1987-1988 (The consumption of meals and the consumption of food groups per age and sex. Food consumption survey 1987-1988). TNO. (1989). V 89.317, 1 p.

Westerterp-Plantenga, M.S., Pasman, W.J., Yedema, M.J.W., & Wijckmans-Duijsens, N.E.G. (1996). Energy intake adaptation of food intake to extreme energy densities of food by obese and non-obese women. *European Journal of Clinical Nutrition, 50,* 401-407.

# CHAPTER 4

## The temporal pattern of the intake of dietary fat and other energy sources, during eating occasions throughout the day – implications to studies of postprandial lipaemia

## 4.1 INTRODUCTION

Serum triacylglycerol concentrations (TAGs) are currently considered an independent risk factor for Coronary Heart Disease (CHD) (Hokanson & Austin, 1996; Griffin., 1999). Postprandial lipaemia, the dynamic and co-ordinated process that metabolizes fat following ingestion of fat-containing meals is characterised by increased concentrations of serum TAGs. Prolonged postprandial lipaemia is considered a potentially atherogenic state that can determine the pathogenesis and progression of CHD (Roche & Gibney, 1995; Cohn, 1998; Dallongeville & Fruchart, 1998). Efficient removal of postprandial TAGs is associated with a healthy lipoprotein profile and promotes reverse cholesterol transport metabolism (Roche & Gibney 2000). Elevated and prolonged postprandial lipaemia promotes an atherogenic lipoprotein profile; chylomicron remnants (Zilversmit, 1979; Karpe *et al.*, 1994), small dense LDLs (Karpe *et al.*, 1993; Griffin *et al.*, 1994), small dense HDLs ($HDL_3$) (Patsch *et al.*, 1987), an enrichment of HDL with TAGs and a reduction in HDL-cholesterol concentration (Patsch *et al.*, 1984). Since an exaggerated postprandial lipaemic response has pro-atherogenic potential, investigators have thus sought to understand the nature of postprandial lipaemia. Several studies have investigated the factors that affect magnitude and duration of the postprandial lipaemic response in an attempt to determine the most effective means of achieving an optimal postprandial TAG response which is associated with a lesser risk of CHD.

In most studies of postprandial lipaemia subjects report to laboratories in the early morning hours after an overnight fast, where a fasting blood sample is drawn, a fat-rich test meal is ingested and a series of postprandial blood samples are collected during fasting periods of 8 to 10 hours. Subjects must be available for long periods of time and allow venous cannula insertion to enable blood sampling. Such studies have provided valuable information to our understanding of lipid metabolism, but they represent extreme conditions and it is not known whether the results can be extrapolated to the free-living situation.

A comprehensive review of 63 postprandial studies is presented in Table 4.6. The test meals used are most often formula feeds containing large amounts of fat usually between 20-140g

(Patsch *et al.*, 1983; Cohen *et al.*, 1989; Griffiths *et al.*, 1994; Hallett *et al.*, 1994; Roche & Gibney, 1996). Little is known however, of the extent to which these doses of fat represent the amount of fat ingested in single eating occasions, by free living subjects on self-selected diets, in Ireland today. The amount and type of carbohydrate in test meals has also been shown to influence postprandial lipaemia (Mann *et al.*, 1971; Cohen & Schall, 1988; van Amelsvoort *et al.*, 1990; Jeppesen *et al*, 1995a; 1995b; Byrnes *et al.*, 1998). It is thus also important to assess whether the carbohydrate content of test meals reflects that of the eating occasions of free-living adults. In reality, most individuals eat regular meals and snacks and are in a postprandial state for a major part of the day, because of the long duration of fat clearance.

Information on the variation of macronutrient intake during eating occasions throughout the day would provide data to enable the formulation of test meals that reflect the macronutrient content of typical eating occasions. Such data would also guide in the administration of test meals which have nutrient compositions comparable to those of eating occasions taken at those times in real life. The vast literature on nutrient intake however, focuses on mean daily intakes and their distributions, with few exceptions.

The present study therefore, set out to describe the temporal pattern of macronutrient intake throughout the day, in order to specifically explore the average fat intake and range of fat intakes that are ingested as part of everyday eating occasions by free-living adults on self-selected diets. It also set out to relate the fat in eating occasions to the other nutrients contributing to energy intake. Whether the macronutrient content of test meals used in postprandial lipaemic studies to date, especially the fat content, was representative of the macronutrient content of eating occasions of free-living adults is also discussed.

## 4.2 METHODS

### 4.2.1 Subject Recruitment

Details of the subject recruitment procedures are described in Chapter 2. In brief, healthy adults were recruited from a city local authority and eligible subjects were healthy male and

female adults aged 18 – 64 years, who were not working shift-work or over-time and females who were not pregnant or lactating.

### 4.2.2 Dietary Assessment Procedure

Subjects completed a 7-day food diary in which they recorded the amount of food and drink consumed and the time of consumption. A comprehensive description of the procedures used during the dietary assessment in order to obtain acceptable data on the nutrient content of eating occasions is described in Chapter 2, including the instructions given to subjects, the method of food quantification and details of the nutrient analysis. The definition of an eating occasion in the present study is also fully described in Chapter 2. In brief, eating occasions were defined by time and coded to the nearest hour such that an eating occasion included every item of food or drink consumed within an hourly period. Eating occasions of non-nutritive value were not included in the analysis.

### 4.2.3 Anthropometry

Body weight (kg) and height (m) were measured, with details of the procedures used described in Chapter 2.

### 4.2.4 Quality and validity of Dietary Data

All food diaries were completed during September to mid-December 1995 and details of the quality procedures used are described in Chapter 2.

The validity of the food intake data was assessed by measuring the validity of the energy intakes reported in the study, by calculating the mean ratio of energy intake to estimated basal metabolic rate ($EI/BMR_{est}$) as proposed by Goldberg *et al*, (1991). The validity of the reported energy intakes was evaluated at group level by comparing the mean $EI/BMR_{est}$ with the calculated Goldberg cut-off value, which represented the lowest expected mean $EI/BMR_{est}$ for this study sample size with 7 days of food intake data (Goldberg *et al.*, 1991; Black 2000). The validity of the reported energy intakes at the individual level was also assessed, by calculating the proportion of individuals in the study sample that were under-reporting and is fully described in Chapter 2.

### 4.2.5 Data analysis

Data analysis was conducted using the statistical package for social sciences SPSS® 8.0 (SPSS Inc, Chicago, USA.). The SPSS® database contained every hour (1.00-24.00hours) of each of the 7 days for each subject, together with the nutrient analysis data of every eating occasion, at the specific hour of consumption. When considering an overview of fat intake per eating occasion two approaches were used to describe an eating occasion. One approach defined an eating occasion as > 0MJ of energy and the other defined an eating occasion as > 0g of fat (Tables 4.2 and 4.3). When considering the temporal pattern of fat intake throughout the day only the former definition of an eating occasion (i.e. > 0MJ) was used. This is because the temporal pattern of fat intake must ultimately be related to that of the other macronutrients with which it is consumed and their respective contributions to energy intake (data presented in Figures 4.1 to 4.4 and Tables 4.4 and 4.5).

*Temporal pattern of the mean macronutrient content of eating occasions per hour*

To describe the temporal pattern of the mean macronutrient content of eating occasions throughout the day per hour, four approaches were explored and are fully described with examples in Chapter 3. Only two of these methods however, were considered appropriate to represent the temporal pattern of the average amount of macronutrients consumed during eating occasions, at each hour, by free-living individuals under everyday conditions. Both of these methods are recapped below:

*The eating occasion method (method 3):* For each particular hour, the nutrient intake of eating occasions (> 0MJ) was summed across all subjects and all days (7 d). The mean nutrient intake of eating occasions/hour was calculated by dividing the summed intake by the total number of times an eating occasion (> 0MJ) occurred at that hour. The actual number of subjects, the number of subjects consuming at the hour and the number of recording days, are only of indirect importance. Subjects who had eating occasions at a particular hour on all days contribute more to the estimate of the mean than those who had an eating occasion on fewer days do.

*The eating occasion by individual method (method 4):* This method ensures all individuals contribute in a similar way to the mean value. Firstly, for each subject, the total nutrient intake consumed during eating occasions at a particular hour during the 7 days was summed and divided by the frequency the subject had an eating occasion (> 0MJ) at that hour during the 7 days. Thereafter the mean intake for each individual who ate at an hour was summed and divided by the number of consumers at that hour.

As part of the exploration of each of the 4 approaches described in Chapter 3, descriptive data (mean, median, standard deviation, minimum and maximum value) were calculated for the temporal pattern of fat intake during eating occasions (> 0MJ) at each hour, using both methods and are presented in Table 3.1 (Chapter 3). As discussed in Chapter 3, this analysis demonstrated that *the eating occasion method* calculates the mean nutrient intake of eating occasions (> 0MJ) at each hour across all subjects and days, with no account made for individuals or intra-person variation in this calculation. Using this method, the average amount of nutrients that are consumed during eating occasions that exist in everyday life is determined, irrespective of intra-person variation in the nutrient content of eating occasions. *The eating occasion by individual method* however takes individuals into account in the calculations and ensures that all subjects contribute similarly in calculating the mean nutrient intake of eating occasions per hour. The mean fat intakes of eating occasions at each hour were nevertheless similar for almost every hour using both methods, despite the factors taken into account in the calculations with each method, with the exception of three hours, which showed differences in the mean intakes between the two methods (Table 3.1).

Determination of the largest or smallest amount of a nutrient that is consumed during everyday eating occasions during normal daily life however varies with these two methods. The range of nutrient intakes that is consumed as part of everyday eating occasions is concealed using *the eating occasion by individual method,* by the calculation of the mean nutrient content of eating occasions at an hour, for each individual. *The eating occasion method* however allows identification of the actual range of nutrient intakes that are consumed as part of individual eating occasions (> 0MJ) in the free-living environment by not taking intra-individual variation in nutrient intake into account. For example, the range of fat intakes of eating

occasions consumed at 13.00 hours was 0 - 112g using *the eating occasion method* and was 0.3 - 79g using *the eating occasion by individual method* (Table 3.1).

The *eating occasion method (method 3)* is therefore most appropriate to address the objectives of this study, which is to determine the mean and extremes of macronutrient intake, that are consumed during eating occasions under everyday conditions, by free-living adults. As the purpose of the present study was to determine whether the nutrient content of test meals used in postprandial studies reflect the nutrient content of everyday eating occasions, the median, SD, $2.5^{th}$ and $97.5^{th}$ percentile of macronutrient intakes consumed during eating occasions at each hour, were calculated in addition to the mean, using this method.

The *eating occasion method* was therefore used to present the temporal pattern of the mean macronutrient content of the eating occasions per hour in terms of absolute intakes (g) and as proportions of energy (Figures 4.1 to 4.4 & Tables 4.4 and 4.5). Analysis of the temporal pattern of mean macronutrient intake of eating occasions (> 0MJ) per hour for 24 hours showed there were no eating occasions at hours 04.00 and 05.00 and few eating occasions at hours 01.00, 02.00, 03.00 and 06.00. Together these accounted for only 7% of the total number of eating occasions observed at 13.00 hours. Therefore figures 4.1 to 4.4 and table 4.5 present data for 18 hours only (hours 7.00 to 24.00).

*Mean daily fat intakes & mean fat content of eating occasions/kg body weight of subject*

The mean daily fat intake in grams per kg body weight of subject was investigated by dividing the mean daily fat intake (g) of each subject by their body weight (kg). The mean fat content (g) of eating occasions per kg body weight of subject was also calculated for three time points, hours 8.00, 13.00 and 18.00. The *eating occasion by individual method* was used to calculate the latter data. For each of hours 8.00, 13.00 and 18.00, the average fat intake (g) of the eating occasions (> 0MJ) at an hour was firstly calculated for each individual, considering the frequency during the recording week that an individual ate at the hour. The average fat intake (g) per eating occasion per hour for each individual was then divided by the individual's weight. The group average was then calculated.

### 4.2.6 Statistical Analysis

Statistical analysis was conducted using SPSS® (version 8.0, SPSS Inc, Chicago, IL, U.S.A.) and tables were created using Microsoft® Word 97 and figures with Microsoft® Excel 97 (Microsoft Corporation, WA, U.S.A.). Mean ± standard deviation (SD) values were calculated for anthropometric measurements, $EI/BMR_{est}$ values and macronutrient intakes for the total sample and for the men and women separately. Mean ± SD values and percentiles of fat intake (g) were calculated for all eating occasions (> 0MJ) and per fat-containing eating occasions (> 0g fat) during the 7 days of food diary recording for the total sample and for men and women separately. Differences in mean intakes between males and females were assessed using independent t-tests.

The temporal pattern of the nutrient intakes of eating occasions at each hour is expressed in terms of mean nutrient intakes. Emphasis has been placed on presenting descriptive data of the nutrient content of everyday eating occasions and the data should be seen as an overview of the variation in the nutrient content of the eating occasions throughout the day. A comparison of the nutrient intakes of eating occasions between different hours was not made for the following reasons. It does not seem appropriate to consider the eating occasions which occur at each hour separately or to make comparisons between the individual hours as these time points are too close to be able to represent meaningful differences. The mean at each hour is calculated from all eating occasions (> 0MJ) which occur at that hour, with no consideration to the frequency with which individuals ate at that hour. Different numbers of eating occasions thus occur at each hour as both the number of individuals who ate at an hour varies and the number of record days on which individuals ate at an hour also varies. Although repeated measures analysis of variance (ANOVA) may seem like a suitable statistical test to apply, repeated measures (ANOVA) requires individuals to be present at all time points before this statistical test can be used and considered valid. The *eating occasion method* was specifically selected as the most suitable method in this study to determine the mean and extremes of nutrient intake of eating occasions per hour, as discussed above. The *n* value at each hour represents the number of eating occasions from which the mean is calculated and the subject profile at each time point is therefore different with this method,

which prevents comparisons between individuals. The repeated measures ANOVA test is thus not appropriate to use with this type of analysis.

## 4.3 RESULTS

### 4.3.1 Response Rate

133 subjects (55 men, 78 women) met the study's eligibility criteria, with a final response rate of 91%. Full details of the response rate of the study sample including details of the non-responders and dropouts are described in Chapter 2 (Table 2.1).

### 4.3.2 Validity of reported energy intakes

The mean ± SD EI/$BMR_{est}$ of the study sample was 1.54 ± 0.4 (1.63 ± 0.4 in men, 1.48 ± 0.3 in women) with a significant difference between men and women ($P$=0.02) (Table 4.1). This mean EI/$BMR_{est}$ value was higher than the calculated Goldberg cut-off of 1.50 proposed as the lowest expected mean EI/$BMR_{est}$ value, that could reflect the actual energy intake of a population of this size with 7 days of food intake data. The proportion of this population identified as under-reporters was 7% (9 of 133 subjects, 4% of men, 9% of women).

### 4.3.3 Mean daily nutrient intakes & anthropometric measurements

Characteristics of the study sample including mean anthropometric data and mean daily nutrient intake data are fully described as part of the results section in Chapter 2 and presented in Table 2.2 of Chapter 2. The socio-demographic and lifestyle characteristics of the men, women and the total sample are also fully described in Chapter 2 (Table 2.5). The mean anthropometric data and mean daily macronutrient intakes are presented in this Chapter in Table 4.1. Energy and absolute macronutrient intakes were significantly greater in men compared to women but there was no difference in the contribution of macronutrients to energy between men and women. The mean daily fat intake (g per kg body weight) was 1.4g and was significantly greater in men compared to women (1.4g Vs. 1.3g respectively, $P$=0.046).

### 4.3.4 Fat intake (g) per eating occasions (> 0MJ & > 0g fat)

The mean and percentiles of fat intake (g) for eating occasions defined as > 0MJ of energy and > 0g fat are shown in Table 4.2. There were 5391 eating occasions of > 0MJ (averaging 6 per subject per day) and 4957 fat-containing eating occasions of > 0g fat (averaging 5 per subject per day) consumed by 133 free-living subjects over a 7 day period. Of all eating occasions, 92% contained greater than 0g fat. The mean fat intake of all eating occasions (> 0MJ) and all fat-containing eating occasions (> 0g fat) was 17.2g and 18.7g respectively. The mean fat intake per eating occasions (> 0MJ) and the mean fat intake per fat-containing eating occasions (> 0g fat) were significantly greater in men compared to women ($P<0.001$). The mean fat intake of all eating occasions (> 0MJ) for men and women was 20.7g and 14.7g, respectively.

To evaluate further the fat content of eating occasions, the % of all and fat-containing eating occasions, within defined ranges of fat (g) intake, was examined (Table 4.3). Most eating occasions (89%) (both > 0MJ and > 0g fat) contained less than 40g of fat. Of the 5391 eating occasions (> 0MJ), 8.1% were fat-free, 68% contained less than 20g of fat, 28% contained 20-59.9g of fat and 4% contained greater than 60g of fat. Of the 4957 fat-containing eating occasions, 25% contained less than 5g of fat, 40% provided between 5g and 19.9g of fat and approximately 23% contained between 20g and 39.9g of fat.

### 4.3.5 Temporal pattern of the mean macronutrient content of eating occasions per hour

The temporal pattern of mean macronutrient intakes (g) and the mean percentage of total energy and food energy from macronutrients ingested at eating occasions (> 0MJ) at each hour are presented in Figures 4.1, 4.2 and 4.3 respectively, calculated by *the eating occasion method*. Table 4.4 presents descriptive data (mean, median, SD, $2.5^{th}$ and $97.5^{th}$) in relation to the energy and macronutrient content of eating occasions at each hour. The number of eating occasions included in the calculations is also presented in Table 4.4. The temporal pattern of macronutrient intakes revealed a similar temporal pattern for fat, carbohydrate and protein intake during the day (Figure 4.1). The absolute macronutrient content (g) of eating occasions increased over the course of the day. Two major peaks in intake were observed at 13.00-14.00 hours and 18.00-19.00 hours for these three macronutrients. These time-points are equivalent

to lunch time and evening meal times. Mean intakes (g) of fat and protein were found to remain constant from early morning (around 9g and 11g respectively) until 13.00-14.00 hours when they rose to a peak in intake of 27g and 23g respectively. Intakes fell in the mid-afternoon and rose again to peaks at 18.00-19.00 hours of 27g and 28g respectively. Carbohydrate intakes revealed a similar temporal pattern to fat and protein, with major peaks in intake at 13.00-14.00 hours (64-68g) and 18.00-19.00 hours (73-75g), except for an additional early morning peak in intake (50-63g).

The pattern of the proportion of energy from macronutrients during eating occasions at each hour is shown in Figure 4.2 and 4.3. Differences were observed in the proportions of total energy and food energy from macronutrients during eating occasions throughout the day. Eating occasions consumed in the early morning hours (07.00-10.00 hours) were of lowest fat content (23-26% of food energy) and highest carbohydrate content (58-62% of food energy) than those at any other time during the day. The fat content of eating occasions remained fairly constant between 10.00 and 19.00 hours (i.e. 31-38% of food energy) with a decrease to below 30% of food energy again in the later evening. Much of the decline in the percentage of energy from fat, in the later evening is possibly due to an increase in the percentage of energy from alcohol. The proportions of food energy from protein were also almost constant during the day (11-14%), with two peaks at 13.00-14.00 hours and 18.00-19.00 hours of 16%. Four peaks were observed throughout the day in the carbohydrate content of eating occasions: in the early morning hours, at 12.00 hours, during the mid-afternoon hours and the late evening hours. The carbohydrate content of eating occasions was in fact lowest in the eating occasions consumed at 13.00-14.00 hours and 18.00-19.00 hours and otherwise fell within a range of 47-60% (food energy) for most of the day (Figure 4.3). The carbohydrate content of eating occasions decreased as the fat content of eating occasions increased during the day. Alcohol made a contribution to energy intake from 12.00 hours onwards with intakes increasing through the day. The largest contribution of alcohol to energy intake was seen between 17.00 and 23.00 hours (Figure 4.2). Clearly, within this average pattern based on 133 subjects, there will be some variation in individual patterns. Nonetheless, these average patterns suggest a high-carbohydrate low-fat eating pattern in the early morning hours, with highest fat intakes (g) consumed at 13.00-14.00 hours and 18.00-19.00 hours in the free-living situation.

Examination of the temporal pattern of mean macronutrient intakes during eating occasions per hour by sex showed comparable patterns of nutrient intake to that for the group (Figure 4.4). The 2 peaks in macronutient intakes which were observed at 13.00 hours and 18.00 - 19.00 hours for the group (n=133) were also evident for men and women. Men however consumed more energy and fat on average per eating occasion per hour than women (Tables 4.5.1 and 4.5.2). Despite differences in absolute energy intake, the temporal pattern of the mean percentage of energy from macronutrients per eating occasion per hour also were comparable pattern between men and women (Tables 4.5.1 and 4.5.2).

### 4.3.6 Mean fat content (g) of eating occasions, per kg body weight of subject, at time points

Three time points, hours 8.00, 13.00 and 18.00 were further investigated in terms of the average fat content (g) of eating occasions per kg body weight of subject at the time points. The mean fat intake (g) during eating occasions per kg body weight of subject at 8.00, 13.00 and 18.00 hours was 0.1g, 0.4g and 0.3g respectively. Almost 100% of eating occasions (> 0MJ) which occurred at hours 13.00 and 18.00 had fat intakes of < 1g of fat per eating occasions per hour/kg body weight of subject. At 8.00, 13.00 and 18.00 hours, 100%, 81% and 89% of eating occasions (> 0MJ) at each hour, respectively, had fat intakes of ≤ 0.5g of fat during eating occasions per hour/kg body weight of subject. Furthermore 84%, 16% and 26% of eating occasions (> 0MJ) at 8.00, 13.00 and 18.00 hours respectively, had fat intakes of ≤ 0.2g of fat during eating occasions per hour/kg body weight of subject. There were no sex differences observed in g of fat during eating occasions per hour/kg body weight of subject except at 18.00 hours where 27% of men and 15% of women had intakes between > 0.5 and < 1g of fat per eating occasions per hour/kg body weight of subject.

## 4.4 DISCUSSION

The absolute and relative patterns of nutrient intakes observed in the present study are broadly similar to those previously observed in food intake studies of adult subjects in Ireland, as described in Chapter 2 (Tables 2.3 and 2.4). The validity of the reported dietary data has been comprehensively described in Chapter 2. In brief, the dietary data of this study is considered

acceptable and specifically robust for analysis of the temporal pattern of mean macronutrient intake of eating occasions per hour.

In the literature there is little information in relation to the temporal pattern or variation in the nutrient intake of eating occasions throughout the day. The results of the few studies conducted to date are difficult to interpret as the criteria used to define an eating occasion varied between the studies. Often, the exact details of the calculations used are not available, the dietary assessment methods differ and the study cohorts vary by age, gender and cultural aspects of eating behaviour (De Castro, 1987; Kistemaker & Löwik, 1991; Lennernäs *et al.*, 1993; Ballard-Barbash *et al.*, 1994; Westerterp-Plantenga *et al.*, 1996; Roos & Prättälä, 1997; Bellisle *et al.*, 1999). Mean daily nutrient intakes and their distributions are the primary focus of current nutrition research. Such analysis however, which collapses nutrient intakes from the many eating events that occur during a day into one mean value, conceals valuable information on the pattern of nutrient intake across the day. The need for information on the temporal pattern of nutrient intake during the day was recently highlighted by Gibney & Wolever, (1997). This information is required to sharpen our ability to design laboratory studies of the acute effects of single or multiple nutrient ingestions and to help our understanding of the metabolic and behavioural effects of different periodicities of eating. The lack of information on the nutrient content of free living eating occasions was also identified by the Committee on Nutrition and Food Habits, which was established by the International Union of Nutritional Sciences in 1994, to review the impact of changing eating patterns on nutritional status (Oltersdorf, 1996; Oltersdorf *et al.*, 1999). A lack of standardisation in the methodology used to identify and analyse eating patterns was particularly highlighted. Avoiding the use of subjective unclear definitions of eating occasions, such as 'meals' or 'snacks' (Gatenby, 1997), the temporal pattern of macronutrient intakes during eating occasions across the day, provides this much needed data. Given the paucity of data on the temporal pattern of nutrient intakes the results of this study cannot be easily compared to other studies. The general pattern of nutrient intake however, is broadly similar to that observed in two studies conducted in the Netherlands and Germany, which used colloquial definitions of eating occasions such as breakfast, lunch and dinner. The consumption of low-fat high-carbohydrate eating occasions in the morning, as observed in this

study, was also evident in the recent National Food Survey in the Netherlands (TNO, 1998). The mean fat content of meals and snacks consumed by Dutch adults (1252 males and 1472 females aged 22-50yrs) were almost all less than 40g of fat. Breakfasts had mean fat contents of 8g and 11g for women and men respectively, with mean fat intakes of 18g and 27g during lunch, 36g and 44g during dinner and 22g and 27g during the eating occasions in between-meals, for men and women respectively. A similar eating pattern was also found in the MONICA survey of middle-aged German men (n=899) with lowest mean fat intakes at breakfast (17g), fat intakes of 32g and 35g respectively at lunch and dinner and intakes of 5-7g of fat during snacks (Winkler *et al.*, 1999).

Since the primary objective of the present study was to explore norms of fat ingestion per eating occasion in the context of studying postprandial lipaemia, an alternative approach to discussing the results is to compare them to values used in studies of postprandial lipaemia. Table 4.6 summarises the main experimental parameters for 63 studies of postprandial lipaemia. These data can be compared to the results of the present study from three different perspectives: a) the actual fat content of the test meal, b) the relationship of fat to the other macronutrients in the test meal and c) the time of ingestion of test meals that have specific macronutrient compositions.

**a) The actual fat content of the test meal used in postprandial lipaemia studies**

The majority of the 5391 eating occasions (91.9%) observed in the present study actually involved fat ingestion. Of all fat-containing eating occasions (n=4957), 88% had fat intakes less than 40g of fat. A review of 63 papers investigating postprandial lipaemia (Table 4.6) however, revealed that only 41% of these studies included test meals with less than 40g of fat. As much as 65% of the fat-containing eating occasions in this study contained less than 20g of fat, whereas only 14% of the 63 postprandial studies reviewed included test meals with less than 20g of fat. Many postprandial studies define the fat content of a test meal in terms of g of fat per kg body weight of subject, using 1 to 1.7g of fat/kg body weight of subject per test meal (Tsetsonis *et al.*, 1997; Gill *et al.*, 1998; Orth *et al.*, 1999) although 0.5g of fat/kg body weight of subject has been used to define the fat content of test meals by some investigators (Roche & Gibney, 1996; Shishehbor *et al.*, 1999) When the mean total daily fat intake of this

study group was expressed as g per kg body weight of subject, the mean value was only 1.4g of fat however. This suggests that test meals with 1 to 1.7g of fat/kg body weight of subject contain fat intakes far in excess of that usually consumed during free-living eating occasions. It is therefore apparent that the majority of studies of postprandial lipaemia have used higher quantities of fat in test meals than that consumed in the fat-containing eating occasions observed in this study, irrespective of the method used to define the fat content of test meals.

It is noteworthy that a gender difference was observed in the mean fat content of the fat-containing eating occasions in this study. Women consumed lower mean fat intakes per fat-containing eating occasions than men did. Of the postprandial studies reviewed, 52% used male subjects, 6% used female subjects and 42% used both male and female subjects. When planning studies of the postprandial lipaemic response, that are to represent the typical response of free-living adults, it is particularly important to consider these gender differences in the fat content of eating occasions.

**b) the relationship of fat to the other macronutrients in the test meals used in postprandial lipaemia studies**

In the normal physiological situation, fat is consumed throughout the day as part of mixed meals in combination with varying amounts and types of carbohydrates and proteins. The usual practice of postprandial studies however, is the administration of a single test meal containing relatively large amounts of fat to subjects in the early morning hours, usually 8.00 am and the postprandial response is monitored during a period of starvation from 8-12 hours. Of the 63 studies reviewed, 78% administered a single test meal in the early morning hours (Table 4.6). Examination of the relationship of fat to the carbohydrate and protein content of test meals posed some difficulty due to the lack of such details provided by investigators. Investigators generally described the macronutrient composition of test meals in absolute amounts of nutrients or amounts of nutrients per kg body weight of subject and details of the energy content of test meals was not provided in all studies. Of the 63 studies of postprandial lipaemia reviewed, only 51% provided full details of the absolute amount of macronutrients per test meal and only 38% gave details of the macronutrient composition of the test meal in terms of proportions of energy. The macronutrient content of test meals, in terms of absolute

amounts and in terms of proportions of energy, was calculated where possible for all test meals as part of the review of these studies. This enabled 69 test meals out of a total of 112 (62%) used in these 63 studies to be considered in this review.

The data on the temporal pattern of macronutrient intakes in this study, expressed in both absolute amounts and as proportions of energy, revealed a most distinctive eating pattern of low-fat and high-carbohydrate eating occasions in the early morning hours. The fat content of the test meals in the 63 postprandial studies that were conducted in the early morning ranged from 11-100% of energy from fat. Only 10% (7) of the test meals, which were administered in the early morning hours, had a fat content of less than 30% of energy from fat. The carbohydrate content of the test meals administered in the early morning hours ranged from 14-75% of energy from carbohydrate with only 19% (13) of the test meals having greater than 50% of energy from carbohydrate, as observed in this study during these hours. When the proportion of energy from carbohydrate in the test meals was comparable to that of the early morning eating occasions in this study, the absolute intake of carbohydrate (g) in these test meals ranged from twice to four times (77-208g) that consumed in the eating occasions observed in this study (40-60g) (O'Flaherty & Gibney, 1994; Zampelas *et al.*, 1994; Lovegrove *et al.*, 1997). In the few test meals (7%) in which the absolute carbohydrate content (g) of the test meal was somewhat comparable to that of the early morning eating occasions in this study, the proportion of energy from carbohydrate in the test meals was only 1/3rd to 1/5th of that observed in the eating occasions in this study (Harris *et al.*, 1988; Ryu *et al.*, 1992; Murphy *et al.*, 1996). If the majority of individuals adopt a low-fat high-carbohydrate eating pattern in the early morning, it is not representative of habitual lipid metabolism to introduce a high-fat, low-carbohydrate test meal at this time. Higher fat intakes might best be administered at 13.00 and 18.00 hours at which times higher fat intakes were observed in this study. Indeed one group investigated the effects of early evening test meals, which were administered following a lunch test meal and revealed that the ingestion of the fat load was associated with a bi-phasic TAG response. This is different to the usual monophasic TAG response seen with early morning postprandial investigations (Peel *et al.*, 1993).

The protein content of the test meals that were administered in the early morning hours ranged from 1-27% of energy from protein, with 28% (19) of test meals having between 12-18% of energy from protein, as observed in this study during these hours. Protein intake however has been shown to have no effect on postprandial lipoprotein responses (Cohen, 1989).

**c) the time of ingestion of test meals, during postprandial lipaemia studies, with specific macronutrient compositions**

In postprandial lipaemia studies the administration of a single test meal is often necessary to allow the design of experiments which will not be confounded by periods of subsequent nutrient absorption, coinciding with periods of disposal of nutrients absorbed at an early stage. Possible later effects that may occur with subsequent meal consumption however are ignored with the use of single test meals. Recent evidence suggests that most individuals are eating a number of times a day (Section 1.1) and the results of this study support such evidence with a mean eating frequency of 5.8 eating occasions (> 0MJ)/day. In an attempt to study the more usual pattern of food consumption, where individuals are in fact in a postprandial state for most of the day, some investigators opted to use sequential meals or to administer evening test meals, to study postprandial lipid metabolism in the non-fasted state. The postprandial lipoprotein metabolic responses following a breakfast and lunch (Williams *et al.*, 1992; Fielding *et al.*, 1996; Evans *et al.*, 1998) and following a lunch and dinner have been observed by a few investigators (Peel *et al.*, 1993). The nutrient composition of these test meals however, did not represent the nutrient composition of the eating occasions consumed at these times in the present study. For instance, the fat content of the breakfast test meals (63g, 54g, 50g) was approximately 6 times higher than the absolute amount of fat (9g) and twice the proportion of energy from fat (23-26%) of the early morning eating occasions observed in the present study. The fat content of the lunch test meals given at 12.00 hours were almost double both the absolute amount of fat (57g, 61g Vs. 27g) and the proportion of energy from fat (61%, 74% Vs. 36-37%) of the lunch eating occasions of this study (Fielding *et al.*, 1996; Evans *et al.*, 1998). A low fat breakfast test meal (7g) was used by Fielding *et al.*, (1996) prior to consuming a high fat lunch (61g), but it was consumed by only 3 control subjects.

Attempts to study the postprandial lipaemic response which is representative of the eating patterns of free-living adults, were made in studies of the diurnal variations in plasma lipids and plasma lipoproteins (Terpstra *et al.*, 1978; van Gent *et al.*, 1979; Dewailly *et al.*, 1981; Rivera-Coll *et al.*, 1994). Although subjects in these studies followed a more usual eating pattern by eating three times a day, the studies were carried out on metabolic wards and no details were provided on the actual fat content or nutrient composition of the individual eating occasions ingested. This poses difficulties in drawing comparisons with these studies and the mean macronutrient intakes per eating occasion observed in this study.

It is clear, from each of the three preceding approaches used to compare the nutrient content of postprandial study test meals to the nutrient content of the eating occasions observed in the present study, that the former do not remotely represent what is observed in free-living subjects on self-selected diets. Studies of postprandial lipaemia conducted to date, using study protocols of carefully controlled laboratory conditions and high fat test meals, have been invaluable however to understanding the postprandial lipaemic response and to characterise the lipoprotein changes that occur. Since fat is the precursor of postprandial lipaemia, it is understandable that large amounts of fat were administered so that the metabolic response during postprandial lipaemia could be studied. The carbohydrate and protein content of test meals was also frequently kept constant to ensure the postprandial effects observed were solely due to the fat content of the test meal (Murphy *et al.*, 1995; Dubois *et al.*, 1998). It is therefore understandably difficult for investigators to have achieved macronutrient compositions in these test meals that were representative of the eating occasions observed in this free-living population. It is however questionable whether the observed beneficial or adverse physiological effects of the postprandial lipaemic response actually occur in normal daily life and are thus relevant to atherogenesis in every day life. Before laboratory findings can be extrapolated to free-living adults the postprandial response that occurs to lower fat doses, consumed as part of mixed meals representative of usual eating occasions and consumed at times comparable to those in normal daily life, must be determined.

Table 4.7 summarises details of seven postprandial studies out of the 63 studies reviewed, that have used test meals with fat intakes somewhat comparable to the fat content of the fat-

containing eating occasions observed in the present study. Two studies attempted to study free-living adults (Fainaru *et al.*, 1994; 1996). Postprandial lipaemic responses were observed following ingestion of fat intakes of 20-40g (Dubois *et al.*, 1994; Potts *et al.*, 1994; Murphy *et al.*, 1995). A dose response relationship was evident in these studies (Dubois *et al.*, 1994; Murphy *et al.*, 1995) with an increase in the postprandial TAG responses related to the amount of fat ingested, as observed by Cohen *et al.*, 1988.

Three studies used lower amounts of fat in test meals which were comparable to the median fat intake of 13.2g observed in the fat-containing eating occasions in the present study (Table 4.2). O'Flaherty & Gibney, (1994) demonstrated that 12g of fat stimulated reverse cholesterol transport to the same extent as 55g of fat. Dubois *et al.*, (1998) and Shishehbor *et al.*, (1999) observed increases in postprandial TAG responses following intakes of 15g and 14g of fat respectively. The ingestion of 14g of fat caused an increase in chylomicron-TAGs concentrations at 4 hours (Shishehbor *et al.*, 1999), while Dubois *et al.*, (1998) observed a maximal increase in chylomicron-TAGs at 2 hours after the intake of 15g of fat. Jeppesen *et al.*, 1995a found that the ingestion of 5g of fat had no effect on postprandial lipaemia.

It is difficult to draw definitive conclusions from these studies regarding the lipoprotein changes of postprandial lipaemia that occurred, as they differed in their criteria used to define fat intake, the nature and nutrient composition of the test meal and the indicators of postprandial lipeamia measured. For example, Dubois *et al.*, (1994) observed marked differences in postprandial lipoprotein changes following intakes of 42g and 31g of fat. In contrast, Murphy *et al.*, (1995) observed similar postprandial lipaemic responses after intakes of 40g and 20g of fat. Different test meals were used in these studies. Dubois *et al.*, (1994) used mixed meals plus a separate fat emulsion while Murphy *et al.*, (1995) used mixed meals and varied the fat content using full- or low-fat varieties of milk, cream or cheese. The nutrient composition of the test meals also varied. The 31g and 42g of fat test meals used by Dubois *et al.*, (1994) had a fat content of 36% and 43% of energy respectively, a difference of only 7%. The 20g and 40g fat test meals used by Murphy *et al.*, (1995) had a fat content of 19% and 30% of energy respectively, a difference of 11%. It is interesting that the test meals used by Murphy *et al.*, (1995), which had a greater difference in absolute fat intake of 20g did

not show significant postprandial variations. The fat density of the test meal may then be as important as the absolute amount of fat ingested, as the test meals with the greater fat densities showed the significant postprandial lipoprotein variations (Dubois *et al.*, 1994). The subject groups were by and large similar.

Two studies in the current literature by Fainaru *et al.*, (1994; 1996) attempted to study the postprandial lipaemic response occurring in free-living healthy individuals under normal physiological conditions i.e. while consuming their usual Israeli diet of 3 meals and 3 snacks and continuing their usual daily activities (Table 4.7). It was not stated whether the usual diets of these subjects was determined prior to the study, but subjects were encouraged to follow the diet for two weeks before the experimental day. The plasma TAG was shown to increase progressively from 1.1mmol/L in the early morning to a peak of 2.25mmol/L at 18.00hours. The plasma TAG levels remained elevated above 1.5mmol/L from 10.00am until 3.00am and above 2.0mmol/L from 18.00hours to 22.00hours, with an increase in the TAG content of all lipoproteins. Although the concentration of chylomicron remnants was not specifically measured the enrichment of LDL, $HDL_2$ and $HDL_3$ with TAG was established by the observed increase in the TAG to cholesterol mass ratio during the day. Such increases in the TAG concentration of the lipoproteins can lead to compositional changes in the lipoproteins that can affect their atherogenic potential through the formation of small dense LDL and $HDL_3$ and decreased concentrations of HDL-cholesterol (Patsch *et al.*, 1984; Patsch *et al.*, 1987; Griffin *et al.*, 1994). The degree and pattern of the diurnal TAGs differed among these subjects but was specific and constant for each individual with the authors encouraging future such studies. The absolute fat content of the meals in Fainaru's study was 20-25g, which was comparable to the amounts observed at 13.00 hours and 18.00 hours in this study but higher than the mean fat content of morning/breakfast eating occasions (9-15g, Figure 4.1). The snacks contained 0.4-2.3g of fat, which was lower than the fat content of most other eating occasions in this study, 9 to 19g of fat (Figure 4.1).

The ultimate aim of postprandial lipaemic studies is to develop a complete understanding of the metabolic events that occur postprandially and the association of these metabolic events with an increased risk of CHD. Postprandial lipaemia studies are carried out in populations

with different cultures and in different sub-groups (e.g. males, females, the obese, CHD patients) all of whom may have different eating patterns in terms of the nutrient content of eating occasions, daily periodicity of eating and the timing of eating occasions. The macronutrient composition, presentation and timing of test meals are fundamental to interpreting the results obtained in these studies. We therefore propose that postprandial studies that aim to represent the free-living situation should include a dietary assessment as part of the study protocol to determine the mean temporal pattern of macronutrient intake during eating occasions throughout the day, of the study group of interest. Such an investigation would identify the most usual times of eating occasions and the eating frequency of the group, and would thereby guide investigators in the formulation of test meals that represent the macronutrient intake of usual eating occasions. Test meals could then be administered at times of the day comparable to when they are consumed in the free-living situation. This would ensure that the free-living eating patterns of the study group are represented.

As the results of the studies presented in Table 4.7 suggest that lower postprandial lipaemic responses occur following the ingestion of lower fat loads, it appears that increasing one's eating frequency by dividing one's mean daily fat intake over more than 2-3 eating occasions/day, may reduce the postprandial lipaemic response after each eating event. The optimal eating pattern in terms of frequency of eating that may promote a low postprandial lipaemic response has indeed been under some investigation. A recent review by Mann, (1997) however, states that there is currently no evidence to promote any specific eating frequency, i.e. three meals a day or higher, for improved health. Analysis of the temporal pattern of nutrient intake in those with high and low eating frequencies needs to be determined, to assist in the planning of studies which investigate the effects of eating frequency on lipid and lipoprotein levels.

Advice to reduce dietary fat intake is fundamental to the dietary strategies to reduce the risk of CHD and recommendations are generally expressed in terms of percentages of energy intake. Current dietary recommendations for fat are 35% of food energy (Food Advisory Committee, 1987; Department of Health, 1991), 33% of total energy (Department of Health, 1991) with

even lower recommendations proposed by the WHO and EHN at 30% of energy (WHO, 1990; EHN, 1998; Wood, 1998). The mean daily fat intake of this study group was higher than these recommendations, at 38% of food energy, as observed in other Irish studies (Table 2.3 & 2.4). The temporal pattern of nutrient intake in those consuming low-fat and high-fat diets needs be determined. Such information could then be used to plan the nutrient composition and time of ingestion of test meals to reflect the free-living situation, in postprandial lipaemic studies of those consuming high-fat and low-fat diets. Such an investigation may also identify whether specific times of the day exist, during which those consuming high-fat or low-fat diets have eating occasions that are significantly higher in fat content than at other times of the day. These eating occasions could subsequently be targeted for dietary fat reduction.

In conclusion, the results of this study recommend that the nutrient content of eating occasions consumed by a study group should be determined as part of the planning of future postprandial lipaemic studies that aim to represent the free-living situation. This would ensure that a) test meals are representative of both the fat content and the carbohydrate and protein content of usual eating occasions and that b) the timing of test meals would represent the macronutrient composition of eating occasions taken at those times by free-living adults e.g. low-fat high-carbohydrate breakfast. These studies are essential to the determination of the postprandial lipaemic response that occurs in free-living adults and the determination of whether an optimal macronutrient composition of eating occasions exists that could maintain a low postprandial lipaemic response after meal consumption. Measurement of the postprandial lipaemic response of free-living adults will not be without its challenges, making it essential that investigators give full details of all study protocols used, to allow comparisons between studies and the establishment of the most suitable study conditions under which to conduct these studies.

**Table 4.1: Mean and standard deviation (SD) values of $EI/BMR_{est}$, anthropometric measurements and mean daily nutrient intakes of men, women and the total sample**

| | Men n=55 | | Women n=78 | | All n=133 | | *P* |
|---|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | |
| $EI/BMR_{est}$ | 1.63 | 0.40 | 1.48 | 0.30 | 1.54 | 0.40 | * |
| Under-reporters % | 4% | | 9% | | 7% | | |
| Age (yrs) | 40.8 | (8.7) | 33.7 | (8.8) | 36.6 | (9.4) | *** |
| Weight (kg) | 85.0 | (9.5) | 67.3 | (8.9) | 74.6 | (12.4) | *** |
| Height (m) | 1.8 | (0.1) | 1.7 | (0.1) | 1.7 | (0.1) | *** |
| BMI | 26.9 | (3.2) | 24.9 | (3.1) | 25.7 | (3.3) | *** |
| Kcal | 3016 | (667) | 2107 | (444) | 2483 | (706) | *** |
| MJ | 12.7 | (2.8) | 8.8 | (1.9) | 10.4 | (3.0) | *** |
| Protein (g) | 102.2 | (18.5) | 74.2 | (14.5) | 85.8 | (21.3) | *** |
| Carbohydrate (g) | 362.4 | (90.1) | 254.6 | (60.9) | 299.2 | (91.2) | *** |
| Fat (g) | 120.9 | (36.6) | 84.5 | (24.4) | 99.6 | (34.9) | *** |
| Total sugars (g) | 151.5 | (72.1) | 106.5 | (37.7) | 125.1 | (58.7) | *** |
| Alcohol (g) | 22.9 | (18.3) | 13.1 | (13.6) | 17.2 | (16.4) | ** |
| % total energy from protein | 13.7 | (1.7) | 14.3 | (2.3) | 14.1 | (2.1) | ns |
| % total energy from carbohydrate | 45.1 | (5.5) | 45.3 | (5.2) | 45.2 | (5.3) | ns |
| % total energy from fat | 35.8 | (5.3) | 35.7 | (5.0) | 35.8 | (5.1) | ns |
| % total energy from alcohol | 5.4 | (4.4) | 4.5 | (4.7) | 4.9 | (4.6) | ns |
| % food energy from protein | 14.6 | (1.9) | 15.0 | (2.6) | 14.8 | (2.4) | ns |
| % food energy from carbohydrate | 47.6 | (5.1) | 47.4 | (4.6) | 47.5 | (4.8) | ns |
| % food energy from fat | 37.8 | (5.2) | 37.4 | (4.9) | 37.6 | (5.0) | ns |
| Mean daily fat intake (g)/kg body weight of subject | 1.4 | (0.5) | 1.3 | (0.4) | 1.4 | (0.5) | * |

† Comparison of means between men and women: * P<0.05, ** P<0.01, ***P<0.001, ns not significant P>0.05.

**Table 4.2: Mean, standard deviation (SD) and percentiles of fat (g) intake per eating occasions (> 0 MJ) and per fat-containing eating occasions (> 0g fat) during 7 days of food diary recording, for the total sample and men and women**

| | Intake of fat (g) /all eating occasions (> 0 MJ) | | | Intake of fat (g) /fat-eating occasions (> 0g fat) | | |
|---|---|---|---|---|---|---|
| | All *(n=133)* | Men *(n=55)* | Women *(n=78)* | All *(n=133)* | Men *(n=55)* | Women *(n=78)* |
| *n* | 5391 | 2248 | 3143 | 4957 | 2026 | 2931 |
| Mean | 17.2 | 20.7* | 14.7* | 18.7 | 23.0* | 15.7* |
| SD | 19.5 | 23.4 | 15.7 | 19.6 | 23.6 | 15.7 |
| *Percentiles* | | | | | | |
| $2.5^{th}$ | 0 | 0 | 0 | 0.2 | 0.2 | 0.1 |
| $25^{th}$ | 2.6 | 3.4 | 2.3 | 4.9 | 6.6 | 3.9 |
| $50^{th}$ | 11.4 | 14.1 | 9.9 | 13.2 | 16.3 | 11.0 |
| $75^{th}$ | 24.3 | 29.3 | 21.6 | 25.7 | 32.7 | 22.6 |
| $95^{th}$ | 55.9 | 68.3 | 47.2 | 57.8 | 70.5 | 48.7 |
| 97.5th | 69.9 | 80.4 | 58.0 | 71.3 | 83.1 | 59.2 |

* significant differences in mean intakes of fat (g) between men and women within eating occasion definitions (> 0MJ and > 0g fat) at $P<0.001$

**Table 4.3: Percentages (%) of all eating occasions (> 0 MJ) and fat-containing eating occasions (> 0g fat) that are within defined ranges of fat intake (g) during 7 days of food diary recording in 133 subjects**

| Ranges of fat intake (g) | n eating occasions | All Eating occasions (> 0 MJ) *n=5391* % | Fat-eating occasions (> 0g fat) *n=4957* % |
|---|---|---|---|
| 0 | 434 | 8.1 | |
| 0.1 - 0.9 | 585 | 10.9 | 11.8 |
| 1.0 - 1.9 | 203 | 3.8 | 4.1 |
| 2.0 - 4.9 | 453 | 8.4 | 9.1 |
| 5.0 - 9.9 | 811 | 15.0 | 16.4 |
| 10.0 - 14.9 | 634 | 11.8 | 12.8 |
| 15.0 - 19.9 | 535 | 9.9 | 10.8 |
| 20.0 - 24.9 | 442 | 8.2 | 8.9 |
| 25.0 - 29.9 | 296 | 5.5 | 6.0 |
| 30.0 - 34.9 | 215 | 4.0 | 4.3 |
| 35.0 - 39.9 | 176 | 3.3 | 3.6 |
| 40.0 - 44.9 | 136 | 2.5 | 2.7 |
| 45.0 - 49.9 | 114 | 2.1 | 2.3 |
| 50.0 - 54.9 | 67 | 1.2 | 1.4 |
| 55.0 - 59.9 | 69 | 1.3 | 1.4 |
| ≥ 60 | 221 | 4.0 | 4.0 |

**Table 4.4: Descriptive data for energy & macronutrient intake (g) per eating occasions per hour for each hour of the day in 133 free-living Irish adults**

| | 1 | 2 | 3 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *n* | *21* | *13* | *5* | *7* | *129* | *322* | *238* | *341* | *433* | *143* | *550* | *351* | *186* | *281* | *210* | *428* | *411* | *315* | *285* | *380* | *233* | *109* |
| **Kcal** | | | | | | | | | | | | | | | | | | | | | | |
| Mean | 350 | 158 | 344 | 255 | 363 | 310 | 271 | 338 | 348 | 287 | 594 | 557 | 351 | 216 | 376 | 667 | 628 | 515 | 388 | 340 | 347 | 246 |
| Median | 135 | 145 | 121 | 195 | 297 | 274 | 241 | 347 | 356 | 210 | 544 | 449 | 206 | 128 | 247 | 617 | 567 | 434 | 251 | 246 | 229 | 132 |
| SD | 661 | 137 | 527 | 218 | 260 | 199 | 224 | 237 | 223 | 259 | 357 | 456 | 372 | 273 | 402 | 466 | 423 | 428 | 417 | 315 | 396 | 301 |
| 2.5th | 11 | 10 | 12 | 61 | 6 | 10 | 5 | 4 | 10 | 7 | 57 | 12 | 6 | 10 | 6 | 14 | 28 | 14 | 15 | 10 | 12 | 4 |
| 97.5th | 3032 | 440 | 1277 | 735 | 983 | 792 | 848 | 904 | 859 | 928 | 1546 | 1704 | 1326 | 1104 | 1601 | 1722 | 1586 | 1633 | 1595 | 1133 | 1607 | 956 |
| **kj** | | | | | | | | | | | | | | | | | | | | | | |
| Mean | 1461 | 660 | 1428 | 1072 | 1528 | 1431 | 1137 | 1418 | 1461 | 1197 | 2489 | 2330 | 1469 | 905 | 1577 | 2797 | 2632 | 2157 | 1621 | 1419 | 1449 | 1027 |
| Median | 567 | 600 | 510 | 823 | 1256 | 1193 | 1010 | 1455 | 1492 | 817 | 2281 | 1875 | 867 | 537 | 1033 | 2584 | 2374 | 1821 | 1041 | 1021 | 962 | 550 |
| SD | 2733 | 575 | 2183 | 906 | 1097 | 1259 | 938 | 995 | 935 | 1089 | 1491 | 1908 | 1557 | 1144 | 1683 | 1957 | 1771 | 1792 | 1742 | 1316 | 1647 | 1251 |
| 2.5th | 44 | 41 | 50 | 255 | 25 | 41 | 21 | 17 | 41 | 27 | 244 | 49 | 24 | 41 | 25 | 57 | 119 | 60 | 63 | 41 | 49 | 17 |
| 97.5th | 12535 | 1844 | 5296 | 3066 | 4129 | 3698 | 3550 | 3772 | 3573 | 3880 | 6449 | 7106 | 5532 | 4595 | 6674 | 7191 | 6633 | 6839 | 6627 | 4721 | 6686 | 3989 |
| **fat (g)** | | | | | | | | | | | | | | | | | | | | | | |
| Mean | 20 | 7 | 22 | 12 | 9 | 9 | 10 | 15 | 15 | 12 | 27 | 25 | 15 | 9 | 14 | 27 | 26 | 19 | 14 | 11 | 14 | 9 |
| Median | 5 | 3 | 5 | 7 | 7 | 7 | 5 | 15 | 14 | 7 | 23 | 19 | 10 | 4 | 7 | 23 | 21 | 13 | 7 | 7 | 8 | 3 |
| SD | 53 | 7 | 41 | 14 | 8 | 7 | 12 | 13 | 13 | 15 | 20 | 24 | 18 | 14 | 18 | 25 | 22 | 20 | 19 | 14 | 24 | 13 |
| 2.5th | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 97.5th | 243 | 19 | 94 | 43 | 30 | 28 | 48 | 50 | 54 | 55 | 76 | 90 | 69 | 50 | 67 | 86 | 76 | 69 | 74 | 56 | 71 | 44 |
| **CHO (g)** | | | | | | | | | | | | | | | | | | | | | | |
| Mean | 35 | 19 | 21 | 33 | 63 | 50 | 38 | 44 | 46 | 37 | 68 | 64 | 43 | 27 | 45 | 75 | 73 | 61 | 41 | 38 | 37 | 30 |
| Median | 15 | 14 | 14 | 30 | 48 | 45 | 36 | 44 | 44 | 28 | 61 | 55 | 28 | 19 | 31 | 64 | 62 | 45 | 26 | 30 | 29 | 21 |
| SD | 43 | 19 | 22 | 19 | 47 | 33 | 29 | 32 | 30 | 31 | 42 | 52 | 45 | 34 | 49 | 56 | 53 | 57 | 46 | 35 | 37 | 29 |
| 2.5th | 1 | 1 | 2 | 10 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 1 | 1 | 1 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 1 |
| 97.5th | 178 | 64 | 54 | 74 | 172 | 136 | 103 | 117 | 107 | 125 | 175 | 205 | 168 | 120 | 208 | 210 | 222 | 223 | 176 | 119 | 149 | 108 |
| **Protein (g)** | | | | | | | | | | | | | | | | | | | | | | |
| Mean | 8 | 4 | 14 | 6 | 12 | 10 | 9 | 10 | 10 | 9 | 23 | 20 | 13 | 6 | 13 | 28 | 26 | 18 | 11 | 7 | 8 | 6 |
| Median | 3 | 2 | 5 | 5 | 10 | 9 | 8 | 9 | 9 | 5 | 21 | 13 | 4 | 2 | 3 | 23 | 24 | 7 | 4 | 3 | 4 | 3 |
| SD | 12 | 4 | 24 | 6 | 8 | 7 | 9 | 9 | 8 | 11 | 16 | 20 | 17 | 13 | 20 | 24 | 22 | 22 | 17 | 10 | 13 | 9 |
| 2.5th | 1 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 97.5th | 45 | 12 | 57 | 19 | 28 | 27 | 31 | 36 | 37 | 39 | 60 | 77 | 61 | 52 | 65 | 75 | 76 | 75 | 68 | 40 | 50 | 40 |
| **ROH (g)** | | | | | | | | | | | | | | | | | | | | | | |
| Mean | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 1 | 4 | 5 | 3 | 6 | 10 | 10 | 7 | 4 |
| Median | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SD | 4 | 4 | 5 | 0 | 0 | 0 | 0 | 1 | 3 | 5 | 6 | 8 | 2 | 7 | 16 | 17 | 9 | 16 | 21 | 22 | 18 | 24 |
| 2.5th | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 97.5th | 17 | 16 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 13 | 25 | 11 | 11 | 60 | 57 | 33 | 61 | 84 | 73 | 59 | 41 |

CHO=carbohydrate; ROH=alcohol

**Table 4.5.1: Temporal pattern of mean energy & proportions of total energy (TE) from protein, carbohydrate, fat and alcohol during eating occasions/hour in Males**

| hour | n | Males | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Energy MJ | | % TE protein | | % TE carbohydrate | | % TE fat | | % TE alcohol | |
| | | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| 7 | 60 | 2.0 | (1.2) | 14.7 | (8.7) | 64.8 | (12.9) | 20.1 | (13.6) | 0.0 | (0.0) |
| 8 | 152 | 1.8 | (1.6) | 13.0 | (5.3) | 62.3 | (14.6) | 24.7 | (12.6) | 0.0 | (0.0) |
| 9 | 101 | 1.3 | (1.0) | 15.5 | (8.1) | 56.5 | (18.0) | 27.6 | (17.0) | 0.0 | (0.0) |
| 10 | 170 | 1.7 | (1.0) | 13.1 | (8.2) | 50.2 | (16.1) | 36.5 | (15.9) | 0.1 | (0.9) |
| 11 | 154 | 1.7 | (1.1) | 11.4 | (6.1) | 51.5 | (17.2) | 36.2 | (16.1) | 0.8 | (7.3) |
| 12 | 45 | 1.2 | (1.1) | 10.2 | (8.8) | 55.8 | (21.7) | 29.7 | (20.3) | 4.5 | (17.3) |
| 13 | 223 | 2.9 | (1.7) | 14.6 | (6.5) | 47.1 | (16.4) | 37.3 | (14.9) | 1.2 | (7.0) |
| 14 | 161 | 3.1 | (2.3) | 13.2 | (8.6) | 48.9 | (18.6) | 35.6 | (16.8) | 2.1 | (10.4) |
| 15 | 49 | 1.9 | (1.8) | 12.6 | (10.3) | 55.2 | (22.5) | 32.0 | (18.0) | 0.5 | (1.9) |
| 16 | 103 | 1.1 | (1.4) | 10.7 | (8.2) | 49.5 | (17.7) | 37.2 | (16.3) | 2.6 | (12.5) |
| 17 | 73 | 2.1 | (2.2) | 13.1 | (10.1) | 47.8 | (19.9) | 33.8 | (19.1) | 5.3 | (16.9) |
| 18 | 204 | 3.6 | (2.1) | 16.0 | (9.0) | 43.9 | (16.0) | 33.7 | (16.3) | 6.3 | (17.7) |
| 19 | 151 | 3.1 | (1.9) | 15.4 | (8.7) | 45.3 | (19.6) | 35.1 | (17.4) | 4.2 | (14.1) |
| 20 | 127 | 2.4 | (2.0) | 11.0 | (9.4) | 49.8 | (23.3) | 27.2 | (19.5) | 12.1 | (25.5) |
| 21 | 121 | 1.8 | (1.9) | 9.6 | (9.0) | 50.0 | (25.7) | 27.6 | (22.2) | 12.7 | (26.2) |
| 22 | 153 | 1.6 | (1.5) | 7.8 | (6.2) | 49.0 | (21.7) | 26.4 | (20.9) | 16.7 | (28.8) |
| 23 | 123 | 1.8 | (2.0) | 10.6 | (7.9) | 45.9 | (19.1) | 33.2 | (18.8) | 10.3 | (23.5) |
| 24 | 61 | 1.3 | (1.5) | 13.0 | (9.0) | 52.8 | (22.8) | 28.9 | (18.2) | 5.4 | (20.7) |

TE=total energy

**Table 4.5.2: Temporal pattern of mean energy & proportions of total energy (TE) from protein, carbohydrate, fat and alcohol during eating occasions/hour in Females**

| hour | n | Females | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Energy MJ | | % TE protein | | % TE carbohydrate | | % TE fat | | % TE alcohol | |
| | | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| 7 | 69 | 1.1 | (0.8) | 15.0 | (5.3) | 59.8 | (17.9) | 25.2 | (16.6) | 0.0 | (0.0) |
| 8 | 170 | 1.1 | (0.7) | 14.7 | (4.9) | 58.2 | (14.6) | 26.9 | (13.6) | 0.0 | (0.0) |
| 9 | 137 | 1.0 | (0.9) | 13.4 | (7.0) | 58.4 | (22.7) | 24.8 | (17.5) | 0.0 | (0.0) |
| 10 | 171 | 1.2 | (0.9) | 14.1 | (8.7) | 53.1 | (18.1) | 32.3 | (17.3) | 0.0 | (0.0) |
| 11 | 279 | 1.3 | (0.8) | 13.1 | (7.1) | 51.2 | (15.4) | 35.5 | (14.2) | 0.0 | (0.0) |
| 12 | 98 | 1.2 | (1.1) | 12.0 | (7.9) | 59.4 | (52.0) | 32.3 | (19.4) | 1.0 | (7.5) |
| 13 | 327 | 2.2 | (1.2) | 16.2 | (8.7) | 45.8 | (16.4) | 37.4 | (15.2) | 0.7 | (4.4) |
| 14 | 190 | 1.7 | (1.2) | 14.1 | (8.5) | 47.5 | (20.0) | 36.4 | (18.1) | 1.9 | (11.0) |
| 15 | 137 | 1.3 | (1.4) | 13.3 | (9.8) | 53.1 | (22.2) | 32.9 | (20.0) | 0.3 | (1.7) |
| 16 | 178 | 0.8 | (1.0) | 11.0 | (8.8) | 54.2 | (21.8) | 33.4 | (18.6) | 1.1 | (8.5) |
| 17 | 137 | 1.3 | (1.2) | 11.1 | (9.8) | 51.6 | (24.3) | 29.4 | (20.6) | 7.9 | (23.3) |
| 18 | 224 | 2.1 | (1.6) | 15.4 | (9.3) | 45.5 | (18.0) | 36.1 | (17.0) | 2.9 | (12.4) |
| 19 | 260 | 2.4 | (1.6) | 15.6 | (8.8) | 47.4 | (18.0) | 34.1 | (15.4) | 3.0 | (12.1) |
| 20 | 188 | 2.0 | (1.6) | 13.4 | (9.3) | 47.8 | (20.2) | 31.6 | (18.5) | 6.9 | (20.2) |
| 21 | 164 | 1.5 | (1.6) | 9.5 | (8.0) | 49.4 | (24.9) | 28.3 | (22.2) | 12.6 | (26.0) |
| 22 | 227 | 1.3 | (1.1) | 9.0 | (8.2) | 48.4 | (21.1) | 30.1 | (19.6) | 12.4 | (26.0) |
| 23 | 110 | 1.1 | (0.9) | 8.9 | (8.4) | 48.1 | (25.8) | 27.6 | (21.3) | 14.4 | (30.2) |
| 24 | 48 | 0.7 | (0.8) | 10.9 | (9.3) | 59.5 | (25.5) | 26.5 | (22.6) | 2.8 | (14.0) |

TE=total energy

**Table 4.6: Postprandial Studies: description of the amounts of fat, nutrient composition and nature of test meals (TM) used, subject details and study aims.**

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1999** | Le Fur *et al.*, | 38g | 40% estimated energy expend./day | 34%F 50%C (125g) 16%P (40g) 4186kj | Mixed meal of usual foods at 01.00h or 13.00h | 14 males NL 22-31yrs | Effect of mental stress & mealtime |
| **1999** | Orth *et al.*, | NS | 1g/kg b.w. | NS | Liquid | 21 males HL | Hemostatic factors & Postprandial lipaemia |
| **1999** | Shishehbor *et al.*, | 14g<br>43g | 0.2g/kg b.w.<br>0.6g/kg b.w. | 0.2g F/0.2gC/0.18gP/kg b.w. 979kj<br>0.6gF/0.2gC/0.18gP/kg b.w. 2051kj | Liquid blends of milk & oil | 8 (4M:4F) 22-36yrs | Effect of low and moderate fat intakes |
| **1998** | Byrnes *et al.*, | 48g | Specific amt. of fat (g) | 48gF (49%) 115gC (49%) 5gP (2%) 3.68MJ (75g glucose Vs. 75g sucrose) | NS | 20males | Effects of sucrose |
| **1998** | Dubois *et al.*, | 0<br>15<br>30<br>40<br>50g | Specific amt. of fat (g) | 1gF 75%C (125g) 15%P (22g) 2461kj<br>18.6%F 69%C 12%P 3025kj<br>31.4%F 58%C 10%P 3589kj<br>37.9%F 53%C 9.3%P 3965kj<br>43.3%F 48%C 8.5%P 4341kj | Mixed meal + fat emulsion | 8 males NL 24-31yrs | Effects of graded amounts of dietary fat |
| **1998** | Evans *et al.*, | 63g<br><br>57g | Specific amt. of fat (g) | 63gF (55%) 80gC (31%) 38gP (15%) 4328MJ<br>57gF (61%) 66gC (32%) 17gP (8%) 3511MJ | Mixed meals at 07.00h and 12.00h | 6 (4M:4F) NL 21-44yrs | Effect of sequential meals |
| **1998** | Gill *et al.*, | NS | 1.2g/kg bw | 1.2g F 1.2 gC 70kj/kg bw | Mixed meal | 15 NL 3 HL 22-40yrs | Effects of exercise |

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1998** | Mero *et al.*, | 63g<br>63g<br>63g | Specific amt. of fat (g) | 63gF 30gC 35gP 837kcal<br>63gF 25gC 35gP 665kcal<br>63gF 4.3gC 6.2gP 616kcal | Mixed meal<br>Liquid cream<br>Oil meal | 10 males<br>34-40yrs | Effect of 3 fat types of meals |
| **1998** | Noone *et al.*, | 40g | Specific amt. of fat (g) | NS | NS | 37M: 27F<br>22-42yrs | CETP and postprandial lipaemia |
| **1998** | Roche *et al.*, | 40g | Specific amt. of fat (g) | NS | Milkshake and mixed meal | 30 males<br>20-26yrs | Effect of MUFA test meals |
| **1998** | Saleh *et al.*, | 60g | Specific amt. of fat (g) | 58%F 85gC (36%) 13gP (6%) 932kcal | Mixed meal | 12 (2M:10F)<br>18-70yrs | ASP and tag clearance in human adipose tissue |
| **1998** | Shishehbor *et al.*, | NS | 0.5g fat/kg b.w. | 0.53gF 1.93gC 0.31gP/kg b.w. 4.1MJ<br>0.5gF 0.28gC 0.18gP/kg b.w. 1.9MJ | Oil based drink and bread/jam | 9 (4M:5F)<br>18-28yrs | Effects of cho based test meals |
| **1997** | Dallongeville *et al.*, | 62-99g<br>mean: 73g | 1g/kg bw | 65%F 20%C 15%P<br>80kj/kg body weight | Mixed meal | 20 males<br>20-26yrs | Study of apoA-IV |
| **1997** | De Lourdes *et al.*, | 35g | Specific amt. of fat (g) | 34.6gF (42%) 81.5gC (45%) 23.5gP (13%) 3.0MJ | Mixed meal of usual foods and fat rich drink | 19 females | Women and postprandial lipaemia |
| **1997** | Fielding *et al.*, | 60g | Specific amt. of fat (g) | 60gF (58%) 85gC (36%) 13gP (6%) 932kcal | Mixed meal of cereal & milkshake | 7 (1M:6F) | Chylomicron clearance |
| **1997** | Frape *et al.*, | 5.5g<br>33g | Specific amt. of fat (g) | 10.9%F 74.7%C (92g) 14%P(17.9g) 2.08MJ and 57.3%F 20.7%C (27g) 23%P (29.3g) 2.17MJ | Mixed meals of usual foods at 08.30h and 13.00h | 12 (6M:6F) | Diurnal changes of postprandial plasma insulin |

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1997** | Herd *et al.*, | NS | 1.4g/kg body mass | 1.4gF 1.2gC 0.2gP 73kj/kg body mass | Mixed meal | 8 males NL 23-31yrs | Effect of exercise |
| **1997** | Karpe *et al.*, | 60g | Specific amt. of fat (g) | 60gF 85gC | NS | 7 males | Lipoprotein lipase transport |
| **1997** | Lovegrove *et al.*, | 42g | Specific amt. of fat (g) | 42gF (35%) 150gC (56%) 24gP (96%) 1074kcal | Milkshake | 32 males | Differences between Southern and Northern Europeans |
| **1997** | Romon *et al.*, | NS | 40% est. EE/d | 40%F 45%C 15%P MJ: NS | Mixed meal of usual foods at night 1.00h or 13.00h. | 13 males NL 19-32yrs | Effect of meal time |
| **1997** | Sakr *et al.*, | 60g | Specific amt. of fat (g) | 67%F MJ not stated | Emulsion | 11 females NL 23-29yrs | Effects of fatty acids |
| **1997** | Tsetsonis *et al.*, | Approx. 77g | 1.7gF, 1.65gC, 0.25gP/kg fat-free mass | 76g F 74g C 11g P 4MJ (Untrained)<br>77g F 75g C 11gP 4.5MJ (Trained)<br>67%F 29%C 5%P | Mixed meal | 22 females 37-48yrs | Effect of exercise in trained and untrained women |
| **1996** | Fainaru *et al.*, | 21.8g<br>2.3g<br>25.6g<br>0.4g<br>20.7g<br>2.3g | Energy defined meals of 28kcal/kg bw | 36%F 49%C 15%P 543kcal - 7.30am<br>13%F 81%C 6%P 152kcal - 10.00<br>41%F 34%C 25%P 563kcal - 12.30<br>3%F 96%C 1%P 113kcal - 16.00<br>33%F 54%C 13%P 568kcal - 18.30<br>13%F 82%C 5%P 152kcal - 21.00 | Mixed meals of foods given as 3 meals and 3 snacks | 7 males 29-38yrs | LDL changes in free-living men |
| **1996** | Fielding *et al.*, | 54g<br><br>61g | Specific amt. of fat (g) | (44%) 140gC (42%) 12gP (1%) 1094kcal<br><br>(74%) 35gC (19%) 13gP (7%) 741kcal | Mixed meal of usual foods at 07.00h and 12.00h | 7 (2M:5F) 21-46yrs | Effect of sequential meals |
| **1996** | Murphy *et al.*, | 82g | Specific amt. of fat (g) | 82gF (72%) 63g C (22%) 20g P(7%) 4.3MJ | Mixed meal | 11 females 21-23 yrs | Effect of meal frequency |

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1996** | Roche & Gibney | 35g | 0.5g fat:5.2g skimmed milk/kg b.w. | NS | Drink of oil and skimmed milk | 32 (12M:20F) mean age:31yrs | Effect of fish oils |
| **1995** | Dubois *et al.*, | 70g | Specific amt. of fat (g) | 49.4%F 37.9%C (121g) 12.7% P (41g) 5350kj<br>+ 192.5mg cholesterol + 2.8g or 10g fibre | Mixed meal of food +/- 40g oat bran | 6 males NL 20-27 years | Effect of oat bran intake |
| **1995 a** | Jeppesen *et al.*, | 5g<br>40g<br>80g<br>5g + fructose | Specific amt. of fat (g) | NS | Dairy cream with or without fructose | 11 (8F:3M) NL 38-64yrs | Effects of variations in oral fat & carbohydrate |
| **1995 b** | Jeppesen *et al.*, | 40g | Specific amt. of fat (g) | 100% fat or + fructose | Cream +/- 50g fructose | 11 (7F:4M) 47-55yrs | Effects of fructose |
| **1995** | Murphy *et al.*, | 20g<br>40g<br>80g | Specific amt. of fat (g) | 19%F 64%C(168g) 18%P (44g) 4150kj<br>30%F 55%C (168g) 15%P (44g) 4810kj<br>49%F 41%C (167g) 11%P (43g) 6360kj | Mixed meals of food + fat content varied using with types of milk/cheese | 10 males 18-23yrs | Lipid and hormonal responses to meals |
| **1994** | Dubois *et al.*, | 31g<br>42g | Specific amt. of fat (g) | 35.9%F 50.7%C (98g) 13.3%P (26g) 3240kj<br>43.4%F 44.8%C 11.8%P 3649kj | Mixed meal + fat emulsion. | 8 males NL 22-33yrs | Effects of moderate dietary fat intakes |
| **1994** | Fainaru *et al.*, | 21.8g<br>2.3g<br>25.6g<br>0.4g<br>20.7g<br>2.3g | Energy defined meals of 28kcal/kg b.w./subject | 36%F 49%C 15%P 543kcal - 7.30am<br>13%F 81%C 6%P 152kcal - 10.00<br>41%F 34%C 25%P 563kcal - 12.30<br>3%F 96%C 1%P 113kcal - 16.00<br>33%F 54%C 13%P 568kcal - 18.30<br>13%F 82%C 5%P 152kcal - 21.00 | Mixed meals of foods given as 3 meals and 3 snacks | 12 males 22-38yrs | Diurnal changes in plasma liporproteins in free-living men |

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1994** | Gibney & Daly | 35g | 0.5g fish oil/kg b.w./subject | 73%F 16%C 11%P KJ - NS | Reconstituted milk (skimmed milk powder and fish oil) | 8 (4M:4F) NL mean age: 28yrs | Effects of n-3 PUFAs |
| **1994** | Griffiths *et al.*, | 80g<br><1g | Specific amt. of fat (g) | 65%F 80gC (29%) 18gP (7%) 4652kj<br><1gF + 80g C (80%) 18gP (18%) 1672kj | Mixed meals | 8 (5M:3F) 24-39yrs | Fat and CHO & NEFA response |
| **1994** | Hallett *et al.*, | 20g<br>80g | Specific amt. of fat (g) | NS | NS | 10 males 18-23yrs | Effect on platelet aggregation |
| **1994** | Isherwood *et al.*, | 20g<br>40g<br>80g | Specific amt. of fat (g) | NS | NS | 10 males | Effect of different amounts of fat in testmeals |
| **1994** | Isherwood *et al.*, | *20g*<br>*40g*<br>*80g* | Specific amt. of fat (g) | + 168gC + 44gP | *NS* | 14 males NL | Effects of exercise |
| **1994** | O' Flaherty & Gibney | 12.1g<br>54.7g | Specific amt. of fat (g) | 26.5%F 70.4%C (77g) 3.3%P (3.4g) 411kcal<br>64.8%F 20.5%C (41.5g) 15%P (28.5g) 780kcal | Mixed meal of usual foods | 10 (5M:5F) 20-22yrs | Reverse Cholesterol Transport |
| **1994** | Potts *et al.*, | 33g | 1/3 Daily nutrient intake | (31g) 41%F (93g) 47%C (21.9g) 12%P 3.1MJ | Mixed meal of usual foods | 20 (10M:10F) NL, HL, obese 24-64yrs | Effect of normal meal |
| **1994** | Zampelas *et al.*, | 44g | Specific amt. of fat (g) | 44gF (29%) 208gC (62%) 35gP (8%) 5650kj | Mixed meal of usual foods | 12 males NL 21-24yrs | Effect of different fatty acids |
| **1993** | Zampelas *et al.*, | 42g | Specific amt. of fat (g) | 42gF (38%) 150gC (56%) 24gP (10%) 4180kj | Oil and skimmed milk powder | 15 males NL | Effect of mufa content of meals |

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1993** | Harley Hartung *et al.,* | 130g | 65g fat/$m^2$b.s.a. | (130g) 86%F (48g) 14%C (9.5g) 2.8% 1362kcals | Cream-based drink | 27 males NL 24-56yrs | Effect of alcohol and exercise |
| **1993** | Peel *et al.,* | 40g oil | Specific amt. of fat (g) | NS | Mixed meal | 11 male NL 21-25yrs | Study of apo B-48 |
| **1993** | Dubois *et al.,* | 70g | Specific amt. of fat (g) | 49.4%F 37.9%C (121g) 12.7% P (41g) 1278kcal + 2.8gfibre (control) + 10g total dietary fibre as pea or soybean fibre | Mixed meal + fibre | 6 males NL young | Effect of pea & soybean fibres |
| **1992** | Ryu *et al.,* | 130g | 65g fat/$m^2$ b.s.a. | 86%F 14%C (48g) 2.8%P (9.5g) 1362kcal Chol 480mg, 0.06P:S ratio | Milkshake | 47 (24M:23F) Mod. HC | Carotid Atherosclerosis |
| **1992** | Williams *et al.,* | Approx.50g | Specific amt. of fat (g) | 53gF (48%) 101gC (38%) 36gP (14%) 4190kj<br>57gF (51%) 96gC (36%) 33gP (13%) 4199kj | Mixed meal of usual foods given at 09.00h or 18.00h | 14 (5M:9F) NL | Effects of n-3 fatty acids |
| **1991** | Potts *et al.,* | 33g fat | 1/3 daily nutrient intake | (31g) 41%F (93g) 47%C (21.9g) 12%P 3.1MJ | Mixed meal of usual foods | 9 (4M:4F) NL 28-64yrs | Fasting and Postprandial TAGS |
| **1990** | Coppack *et al.,* | 31g | 1/3 daily nutrient intake | (31g) 41%F (93g) 47%C (21.9g) 12%P 3.1MJ | Mixed meal of usual foods | 7 (3M:4F) 30-35yrs | Substrate movements in vivo |
| **1990** | Rifai *et al.,* | 70g | g/kg bw | 70g fat (56%fat), 580mg chol, 1100kcal other macros NS | Mixed meal of usual foods | 16 males NL 22-34yrs | Effect of a high-fat meal |
| **1990** | Traianedes *et al.,* | 14g | Specific amt. of fat (g) | 14gF (20%) 107gC (64%) 26gP (16%) 2662kj | Mixed meal of usual foods | 8 (4M:4F) NL 23-25yrs | Effect of different fats on metabolic responses |
| **1990** | van Amelsvoort *et al.,* | 31g<br>54g | CHO:fat ratio | 28%F 57%C (143g) 15%P (38g) 4 .2MJ<br>48%F 37%C (93g) 15% (38g) 4.2MJ | Mixed meal of usual foods | 30males 22-59yrs | Effect of starch and sugar |

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1989** | Cohen *et al.*, | 40g<br>140g | Specific amt. of fat (g) | 100% fat | 100/350ml cream + choc flavouring | 29 males NL<br>20-30yrs | Effect of exercise |
| **1989** | Cohen | 40g | Specific amt. of fat (g) | 100% fat or fat with protein | 100ml cream +/- 23g protein | 15(12M:3F)<br>NL<br>18-22yrs | Effect of protein |
| **1989** | van Amelsvoort *et al.*, | 24g<br>36g<br>46g<br>58g | CHO:fat ratio 40% daily energy | 23%F 59%C (141g) 18%P (43g) 4MJ<br>34%F 49%C (117g) 18%P (43g) 4MJ<br>44%F 38%C (90g) 18%P (43g) 4MJ<br>55%F 27%C (64g) 18%P (43g) 4MJ | Mixed meal of usual foods | 26 males<br>22-59yrs | Effects of CHO:fat ratio |
| **1988** | Cohen *et al.*, | 40g<br>80g<br>120g | Specific amt. of fat (g) | 100%fat | 100/200/300ml cream + choc flavouring | 12 males NL<br>20-25yrs | Effects of meal fat content |
| **1988** | Cohen & Schall | 40g<br>40g<br>40g<br>40g<br>40g<br>40g | Specific amt. of fat (g) | 0g cho<br>+ 50g glucose<br>+ 500ml of 100glucose/L<br>+ 50g fructose<br>+ 50g sucrose<br>+ 100g sucrose<br>+ 20% Intralipid<br>%NS | 100ml cream + choc flavouring +/- CHO | 21 (9M:12F)<br>NL<br>17-23yrs | Effect of simple carbohydrates |
| **1988** | Cohn et al | NS<br>Fat-rich | 1g fat/kg bw + 7mg chol/kg (1/2-2/3DEI) | 53%F 23.5%C 23.5%P | Milkshake: cream +/- oil, polycose, egg white protein, flavouring | 22 (9M:13F)<br>22-79yrs | Effect of age |

| Year | Authors | Fat g/TM | Definition of fat g/TM | Nutrient composition of TM | Nature of TM | Subjects | Study Aims |
|---|---|---|---|---|---|---|---|
| **1988** | Harris *et al.,* | 50g | Specific amt. of fat (g) | 50gF (56%) 42gC (21%) 43gP (22%) 800kcal | Liquid Formula | 21 (11M:10F) 21-84yrs NL | n-3 fatty acids |
| **1985** | Flatt *et al.,* | 6g<br>48g | Specific amt. of fat (g) | 11%F 62%C (75g) 27%P (33g) 482kcal<br>50%F 35%C (75g) 15%P (32g) 858kcal | Mixed meal | 7 males NL | Effect of postprandial substrate oxidation |
| **1983** | Kay *et al.,* | 25g<br>92g | Specific amt. of fat (g) | 25gF x 4 times/day OR<br>92gF + 4.3gF + 1.2gF + 2.4gF | Mixed meal + fat liquid | 8 males 21-33yrs | Effect of distribution of fat/d |
| **1983** | Patsch *et al.,* | 130g | Specific amt. of fat (g) | 86%F 14%C (48g) 2.8%P (9.5g) 1362kcal Chol 480mg, 0.06P:S ratio | Drink: 350ml cream | 28 (23M:5F) 28-42yrs NL | HDL response |
| **1980** | Kay *et al.,* | 130g<br>23g | Specific amt. of fat (g) | 129.7gF (84%) 45gC (13%) 9.8gP (3%) 1386kcal + 1.3gF 45gC 9.8gP 230kcal (5 times/d) *OR* 22.7gF (50%) 45gC (43%) 9.8gP (9%) 423kcal (6times/day) | Cream | 10 (9M:1F) 15-64yrs | HDL response & distribution of fat intake/day |
| **1971** | Mann *et al.,* | 25g | Specific amt. of fat (g) | 25gF (40%) 60gC (42%) 24gP (17%) 565kcal | Oil based drink | 9M, 30-58yrs<br>10M, 29-25yrs | Effects of sucrose and glucose |

NS –details not stated in paper, NL – normolipidaemic, HL – hyperlipidaemic, b.w. – body weight, Mod. HC – Moderately hypercholesterolaemic, DEI – daily energy intake

Mixed meal – a combination of foods consumed in quantities usually eaten (e.g. slice of bread) and not usually eaten (e.g. 100ml cream)

Mixed meal of usual foods – a combination of foods usually consumed and in quantities usually consumed

**Table 4.7: Postprandial Studies that used amounts of fat per test meal (TM) comparable to the fat content of eating occasions observed in this study**

| Author/Year | Fat g/ TM | Definition of fat content /TM | Nature of TM | Nutrient composition of TM | Subjects | Author's Conclusions |
|---|---|---|---|---|---|---|
| Dubois *et al.*, 1994 | 31g<br>42g | Specific amt. of fat (g) | Mixed meal + fat emulsion | 35.9%F 50.7%C (98g) 13.3%P (26g) 3240kj<br>43.4%F 44.8%C (98g) 11.8%P (26g) 3649kj | 8 males 22-33yrs | Marked PPR variations between both. PL, CE & FC changes after 42g were almost absent after 31g. |
| Potts *et al.*, 1994 | 33g | 1/3 daily nutrient intake | Mixed meal | 41%F 47%C (93g) 12%P (24g) 740kcal | 20 (10F) 24-64yrs | PPR occurs similar to that with larger fat loads. Higher fasting TAGs result in higher PPR. |
| Murphy *et al.*, 1995 | 20g<br>40g<br>80g | Specific amt. of fat (g) | Mixed meals of usual foods | 19%F 64%C (168g) 18%P (44.1g) 4150kj<br>30%F 55%C (168g) 15%P (44.1g) 4810kj<br>49%F 41%C (167g) 11%P (43g) 6360kj | 10 males 18-23yrs | 20g & 40g – similar PPR & ↑ in NEFA, but both < responses with 80g. |
| O'Flaherty *et al.*, 1994 | 12.1g<br>54.7g | Specific amt. of fat (g) | Mixed meal of usual foods | 27%F 70%C (77g) 3%P (3.4g) 411kcal<br>65%F 21%C (42g) 15%P (29g) 780kcal | 10 (5M:5F) 20-22yrs | RCT stimulated similarly with both 12g and 55g fat. *(RCT: LCAT activity, cholesterol flux and plasma TAGs)* |
| Dubois *et al.*, 1998 | 0g<br>15g<br>30g<br>40g<br>50g | Specific amt. of fat (g) | Mixed meal + fat emulsion | 1gF 125.1gC(75%) 22.1gP 2461kj<br>18.6%F 69%C 12%P 3025kj<br>31.4%F 58%C 10%P 3589kj<br>37.9%F 53%C 9.3%P 3965kj<br>43.3%F 48%C 8.5%P 4341kj | 8 males 24-31yrs | 0g & 15g – no noticeable difference in PPR although modest sig. ↑ in CM-TAGs and HDL-TAGs and HDL-PL seen with 15g. |
| Shishebor *et al.*, 1999 | 14g<br>43g | 0.2g fat/kg b.w.<br>0.6g fat/kg b.w. | Liquid blend of milk and oil | 0.2gF 0.2gC 0.18gP/kg bw 979kj/TM<br>0.6gF 0.2gC 0.18gP/kg bw 2051kj.TM | 8 (4M) 22-36yrs | Small short-lived PPR with 14g and greater PPR with 43g. |
| Jeppesen *et al.*, 1995[a] | 5g<br>40g<br>80g | Specific amt. of fat (g) | Dairy cream +/- fructose | 100% fat | 11(3M) 38-64yrs | 5g - no ↑ plasma TAGs<br>Add fructose to 5g - signig. ↑ PPR |

PPR – postprandial response, PL – phospholipid, CE – esterified cholesterol, FC – free cholesterol, RCT- reverse cholesterol transport, CM-chylomicron, TAGs – triacylglycerol concentrations, b.w. – body weight.

**Table 4.7 cont.: Postprandial Studies that used amounts of fat per test meal (TM) comparable to the fat content of eating occasions observed in this study**

| Author/Year | Fat g/ TM | Definition of fat g/TM | Nature of TM | Nutrient composition of TM | | | | Subjects | Author's Conclusions |
|---|---|---|---|---|---|---|---|---|---|
| Fainaru *et al.*, 1994 | 21.8g<br>2.3g<br>25.6g<br>0.4g<br>20.7g<br>2.3g | Energy defined meals of 28kcal/kg b.w. | Mixed meals of foods given as 3 meals and 3 snacks | 36%F<br>13%F<br>41%F<br>3%F<br>33%F<br>13%F | 49%C<br>81%C<br>34%C<br>96%C<br>54%C<br>82%C | 15%P<br>6%P<br>25%P<br>1%P<br>13%P<br>5%P | 543kcal - 07.30am<br>152kcal - 10.00<br>563kcal - 12.30<br>113kcal - 16.00<br>568kcal - 18.30<br>152kcal - 21.00 | 12 males<br>22-38yrs | Diurnal changes occur with ↑ in plasma tags in response to a standard diet. ↑ TAGs occur in CMs, VLDL, IDL, HDL, LDL during the day. |
| Fainaru *et al,* 1996 | 21.8g<br>2.3g<br>25.6g<br>0.4g<br>20.7g<br>2.3g | Energy defined meals of 28kcal/kg b.w. | Mixed meals of foods given as 3 meals and 3 snacks | 36%F<br>13%F<br>41%F<br>3%F<br>33%F<br>13%F | 49%C<br>81%C<br>34%C<br>96%C<br>54%C<br>82%C | 15%P<br>6%P<br>25%P<br>1%P<br>13%P<br>5%P | 543kcal - 07.30am<br>152kcal - 10.00<br>563kcal - 12.30<br>113kcal - 16.00<br>568kcal - 18.30<br>152kcal - 21.00 | 7 males<br>29-38yrs | No diurnal changes in LDL but markable changes in composition: ↑ LDL TAGs, size and bouyancy. |

PPR – postprandial response, PL – phospholipid, CE – esterified cholesterol, FC – free cholesterol, RCT- reverse cholesterol transport, CM-chylomicron, TAGs – triacylglycerol concentrations, , b.w. – body weight.

**Figure 4.1: Temporal pattern of mean macronutrient intake (g) during eating occasions/hour**

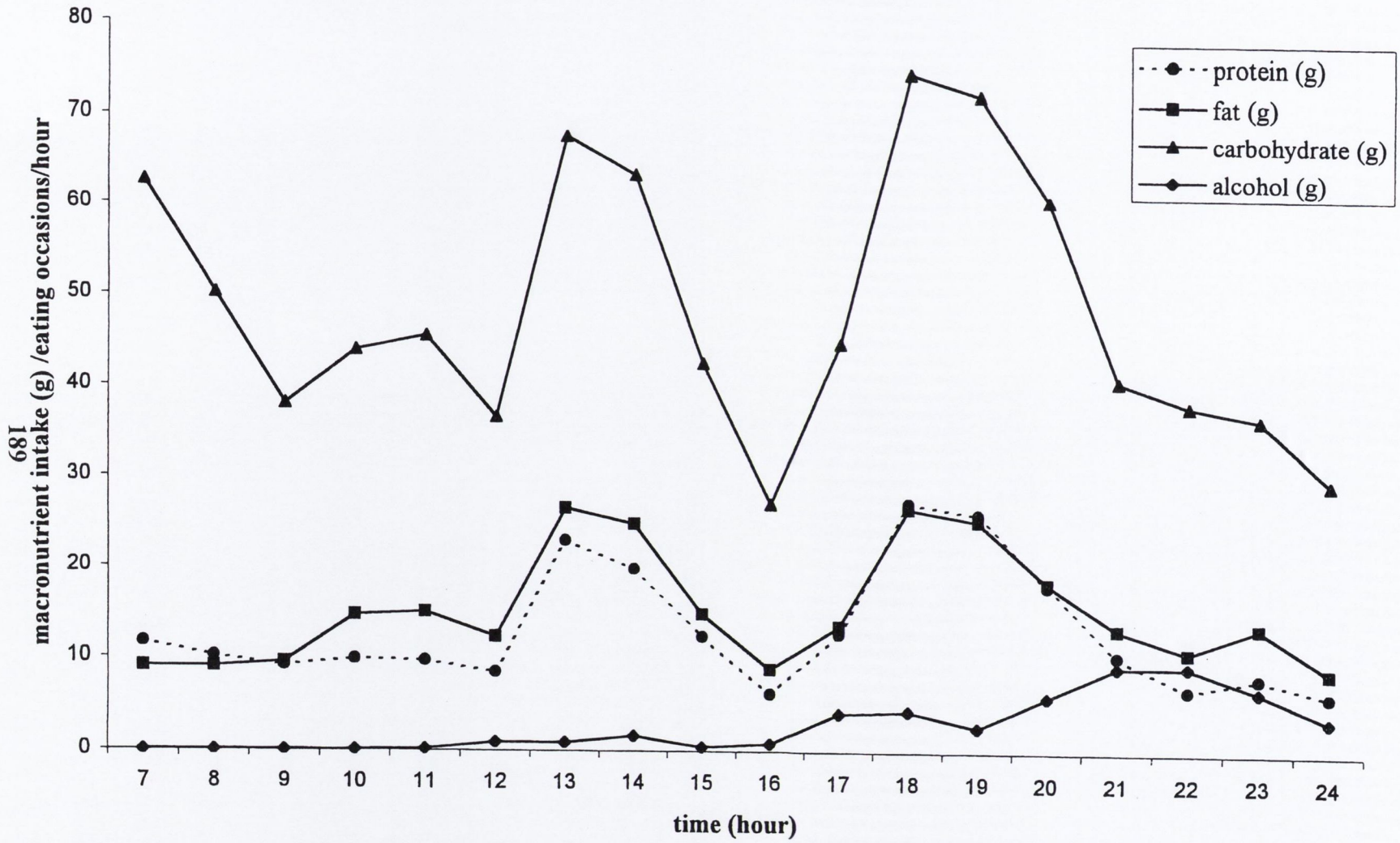


**Figure 4.2:Temporal pattern of mean proportion of total energy from macronutrients during eating occasions/hour**

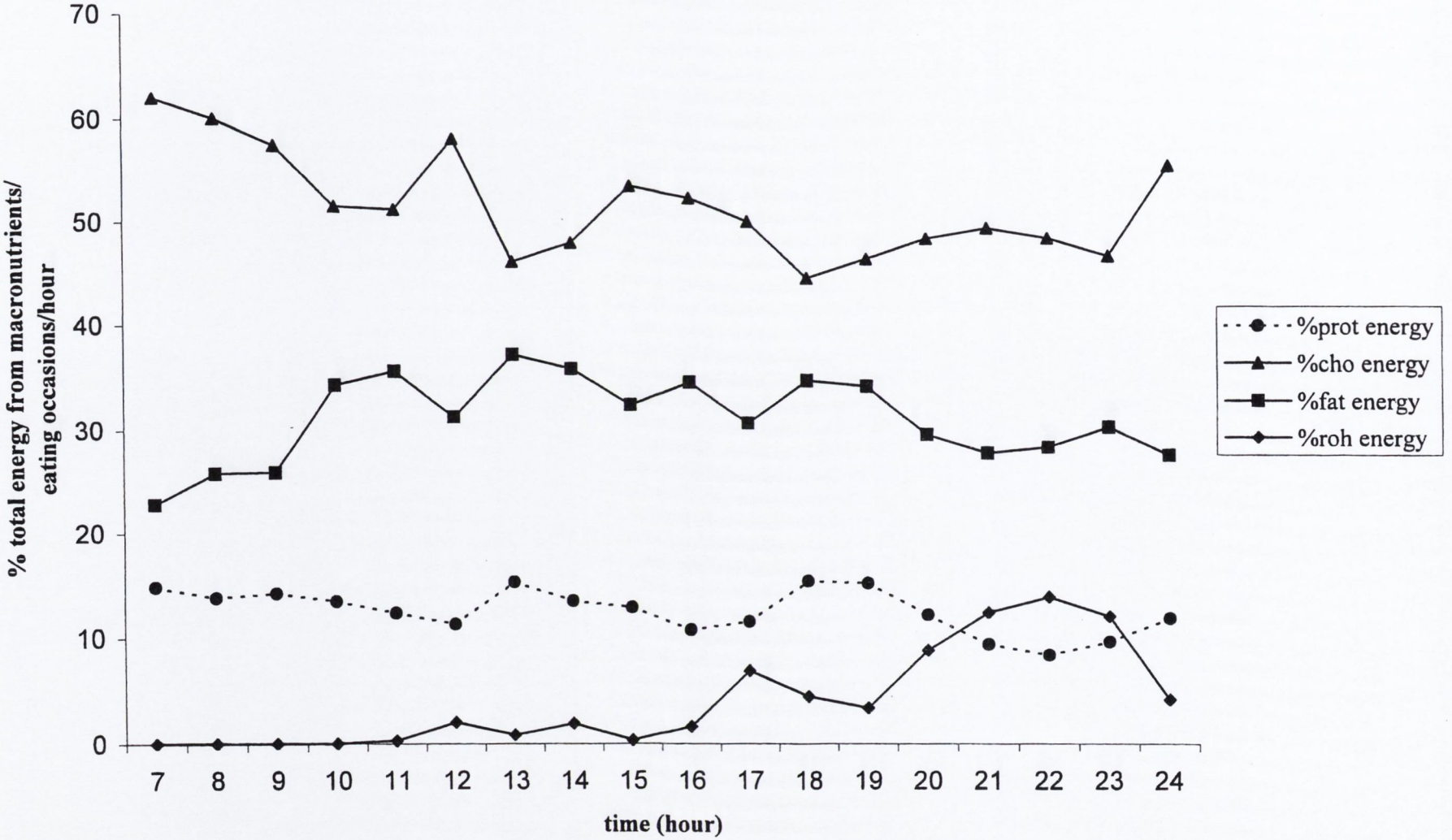


**Figure 4.3: Temporal pattern of mean proportion of food energy from macronutrients during eating occasions/hour**

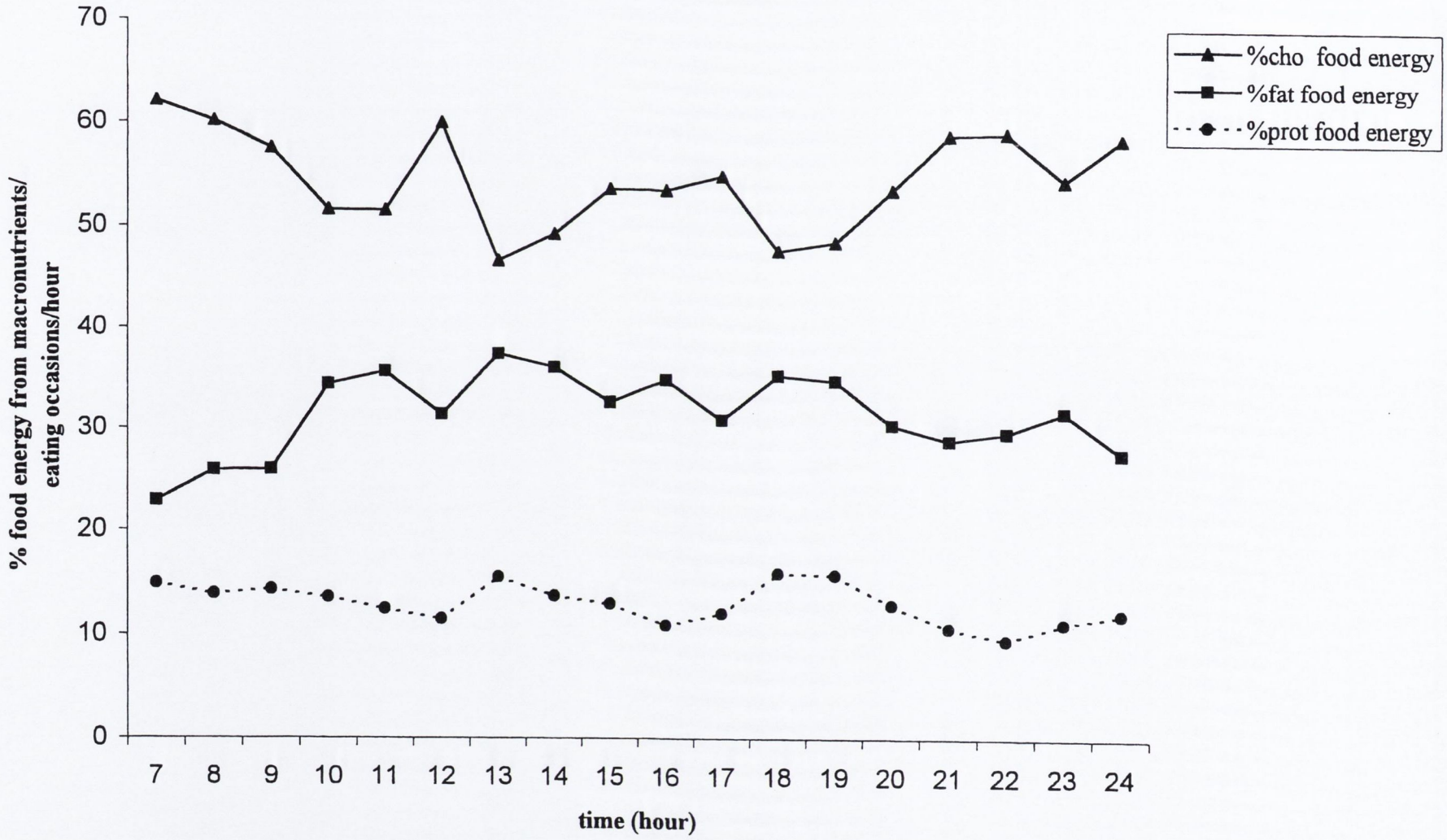
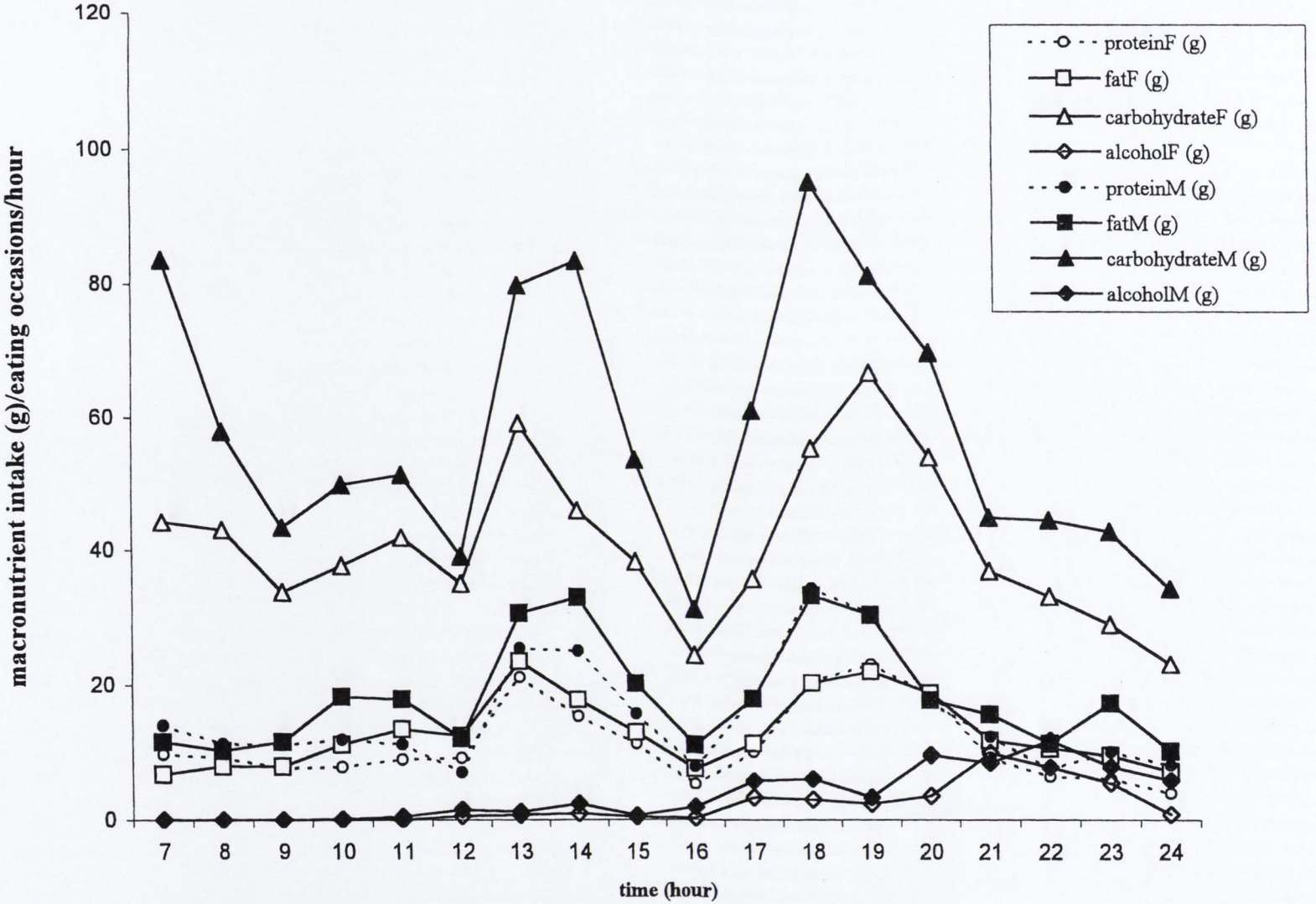


**Figure 4.4: Temporal pattern of mean macronutrient intake (g) during eating occasions/hour for males (M) & females (F)**



## 4.5 REFERENCES


Ballard-Barbash, R., Thompson, F.E., Graubard, B.I., & Krebs-Smith, S.M. (1994). Variability in percent energy from fat throughout the day: implications for application of total diet goals. *Journal of Nutrition Education, 26,* 278-283.

Bellisle, F., Dalix, A.M., & De Castro, J.M. (1999). Eating patterns in French subjects studied by the "weekly food diary" method. *Appetite, 32,* 46-52.

Byrnes, A.E., Edwards, C.M., & Frost, G.S. (1998). Postprandial lipaemia in response to sucrose intake in middle-aged men with CHD risk factors and matched controls. *Procedings of the Nutrition Society, 57,* 151A.

Cohen, J.C. (1989). Protein ingestion does not affect postprandial lipaemia or chylomicron-triglyceride clearance. *European Journal of Clinical Nutrition, 43,* 497-499.

Cohen, J.C., Noakes, T.D., & Benade, A.J.S. (1988). Serum triglyceride responses to fatty meals: effects of meal fat content. *American Journal of Clinical Nutrition, 47,* 825-827.

Cohen, J.C., Noakes, T.D., & Benade, A.J.S. (1989). Postprandial lipaemia and chylomicron clearance in athletes and in sedentary men. *American Journal of Clinical Nutrition, 49,* 443-447.

Cohen, J.C., & Schall, R. (1988). Reassessing the effects of simple carbohydrates on the serum triglyceride responses to fat meals. *American Journal of Clinical Nutrition, 48,* 1031-1034.

Cohn, J.S. (1998). Postprandial lipaemia: emerging evidence for atherogenicity of remnant lipoproteins. *Canadian Journal of Cardiology, 14,* 18B-27B.

Cohn, J.S., McNamara, J.R., Cohn, S.D., Ordovas, J.M., & Schaefer, E.J. (1988). Postprandial plasma lipoprotein changes in human subjects of different ages. *Journal of Lipid Research, 29,* 469-479.

Coppack, S.W., Fisher, R.M., Gibbons, G.F., Humphreys, S.M., McDonough, M.J., Potts, J.L., & Frayn, K.N. (1990). Postprandial substrate deposition in human forearm and adipose tissues in vivo. *Clinical Science, 79,* 339-348.

Dallongeville, J., & Fruchart, J.C. (1998). Postprandial dyslipidaemia: a risk factor for coronary heart disease. *Annals of Nutrition Metabolism, 42,* 1-11.

Dallongeville, J., Lebel, P., Parra, H.J., Luc, G., & Fruchart, J.C. (1997). Postprandial lipaemia is associated with increased levels of apolipoprotein A-IV in the triacylglycerol-rich fraction and decreased levels in the denser plasma fractions. *British Journal of Nutrition, 77,* 213-223.

De Castro, J.M. (1987). Circadian rhythms of the spontaneous meal pattern, macronutrient intake and mood of humans. *Physiology & Behaviour, 40,* 437-446.

de Lourdes C, M., Rodrigues, F., & da Costa, T.H.M. (1997). Postprandial lipid metabolism in women after reproductive cycles. *Proceedings of the Nutrition Society, 56,* 209A

Department of Health. Dietary Reference Values for food energy and nutrients for the United Kingdom: Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy. HMSO. (1991).

Dewailly, P., Moulin, S., Fievet, C., Dedonder, E., Sezille, G., & Jaillard, J. (1981). Circadian meal-related changes in serum lipoprotein levels in normal subjects. *Nouv Presse Med, 23,* 1913-1914.

Dubois, C., Armand, M., Azais-Braesco, V., Portugal, H., Pauli, A., Bernard, P., Latge, C., Lafont, H., Borel, P., & Lairon, D. (1994). Effects of moderate amounts of emulsified dietary

fat on postprandial lipaemia and lipoproteins in normolipidemic adults. *American Journal of Clinical Nutrition, 60,* 374-382.

Dubois, C., Armand, M., Senft, M., Portugal, H., Pauli, A.M., Bernard, P., Lafont, H., & Lairon, D. (1995). Chronic oat bran intake alters postprandial lipemia and lipoproteins in healthy adults. *American Journal of Clinical Nutrition, 61,* 325-333.

Dubois, C., Beaumier, G., Juhel, C., Armand, M., Portugal, H., Pauli, A.M., Borel, P., Latge, C., & Lairon, D. (1998). Effects of graded amounts (0-50g) of dietary fat on postprandial lipaemia and lipoproteins in normolipidemic adults. *American Journal of Clinical Nutrition, 67,* 31-38.

Dubois, C., Cara, L., Armand, M., Borel, P., Senft, M., Portugal, H., Pauli, A.M., Bernard, P., Lafont, H., & Lairon, D. (1993). Effects of pea and soybean fibre on postprandial lipaemia and lipoproteins in healthy adults. *European Journal of Clinical Nutrition, 47,* 508-520.

European Heart Network. Food, Nutrition & Cardiovascular Prevention in the European Union. European Heart Network. (1998).

Evans, K., Kuusela, P.J., Cruz, M.L., Wilhelmova, I., Fielding, B.A., & Frayn, K.N. (1998). Rapid chylomicron appearance following sequential meals:effects of second meal composition. *British Journal of Nutrition, 79,* 425-429.

Fainaru, M., Gavish, D., & Schafer, Z. (1996). Diurnal heterogeneity in structure and function of low density lipoproteins of normolipidemic males. *Israel Journal of Medical Sciences, 32,* 454-464.

Fainaru, M., Schafer, Z., Gavish, D., Skurnik, Y., Argov, R., & Kaplan, S. (1994). Diurnal changes in plasma lipoproteins of free-living healthy men consuming a standard diet. *Israel Journal of Medical Sciences, 30,* 83-89.

Fielding, B.A., Callow, J., Owen, R.M., Samra, J.S., Matthews, D.R., & Frayn, K.N. (1996). Postprandial lipemia: the origin of an early peak studied by specific dietary fatty acid intake during sequential meals. *American Journal of Clinical Nutrition, 63,* 36-41.

Fielding, B.A., Summers, L.K.M., Ilic, V., & Frayn, K.N. (1997). Characteristics of chylomicron clearance across human adipose tissue in healthy individuals. *Proceedings of the Nutrition Society, 56,* 200A.

Flatt, J.P., Ravussin, E., Acheson, K.J., & Jequier, E. (1985). Effects of dietary fat on postprandial substrate oxidation and on carbohydrate and fat balances. *Journal of Clinical Investigation, 76,* 1019-1024.

Food Advisory Committee. . Guidelines for Preparing Information and Advice to the General Public on Healthy Eating. Department of Health. (1987).

Frape, D.L., Williams, N.R., Scriven, A.J., Palmer, C.R., O Sullivan, K., & Fletcher, R.J. (1997). Diurnal trends in responses of blood plasma concentrations of glucose, insulin, and C-peptide following high- and low-fat meals and their relation to fat metabolim. *British Journal of Nutrition, 77,* 523-535.

Gatenby, S. (1997). Eating frequency: methodological and dietary aspects. *British Journal of Nutrition, 77,* S7-S20.

Gibney, M.J., & Daly, E. (1994). The incorporation of n-3 polyunsaturated fatty acids into plasma lipid and lipoprotein fractions in the postprandial phase in healthy volunteers. *European Journal of Clinical Nutrition, 48,* 866-872.

Gibney, M.J., & Wolever, M.S. (1997). Periodicity of eating and human health: present perspective and future directions. *British Journal of Nutrition, 77,* S3-S5.

Gill, J.M., Murphy, M.H., & Hardman, A.E. (1998). Postprandial lipemia: effects of intermittent versus continous exercise. *Medical and Science in Sprots and Exercise, 30,* 1515-1520.

Goldberg, G.R., Black, A.E., Jebb, S.A., Cole, T.J., Murgatroyd, P.R., Coward, W.A., & Prentice, A.M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *European Journal of Clinical Nutrition, 45,* 569-581.

Griffin, B.A. (1999). Lipoprotein atherogenecity: an overview of current mechanisms. *Proceedings of the Nutrition Society, 58,* 163-169.

Griffin, B.A., Freeman, D.J., Tait, G.W., Thompson, J., Caslake, M.J., Packard, C.J., & Shepherd, J. (1994). Role of plasma triglyceride in the regulation of plasma low density lipoprotein (LDL) subfractions: relative contribution of small, dense LDL to coronary heart disease risk. *Atherosclerosis, 106,* 241-253.

Griffiths, A.J., Humphreys, S.M., Clark, M.L., Fielding, B.A., & Frayn, K.N. (1994). Immediate metabolic availability of dietary fat in combination with carbohydrate. *American Journal of Clinical Nutrition, 59,* 53-59.

Hallett, C., Hourani, S.M.O., & Williams, C.M. (1994). The effect of postprandial lipaemia on platelet aggregation. *Proceedings of the Nutrition Society, 53,* 81A.

Harley Hartung, G., Lawrence, S.J., Reeves, R.S., & Foreyt, J.P. (1993). Effect of alcohol and exercise on postprandial lipemia and triglyceride clearance in men. *Atherosclerosis, 100,* 33-40.

Harris, W.S., Connor, W.E., Alam, N., & Illingsworth, D.R. (1988). Reduction of postprandial triglyceridemia in humans by dietary n-3 fatty acids. *Journal of Lipid Research, 29,* 1451-1460.

Herd, S.L., Hardman, A.E., & Boobis, L.H. (1997). Moderate intensity exercise postprandial lipaemia and muscle lipoprotein lipase activity. *Proceedings of the Nutrition Society, 56,* 205A.

Hokanson, J., & Austin, M.A. (1996). Plasma triglyceride level is a risk factor for cardiovascular disease independent of high-density lipoprotein cholesterol: a meta-analysis of population-based prospective studies. *Journal of Cardiovascular Risk, 3,* 213-219.

Isherwood, S.G., Sethi, S., Gould, B.J., Howland, R.J., & Williams, C.M. (1994). Meal fat content and postprandial lipaemia: apo B48 and retinyl palmitate as markers of chylomicron particles. *Proceedings of the Nutrition Society, 53,* 82A.

Jeppesen, J., Chen, Y.D.I., Zhou, M.Y., Wang, T., & Reaven, G.M. (1995b). Effect of variations in oral fat and carbohydrate load on postprandial lipaemia. *American Journal of Clinical Medicine, 62,* 1201-1205.

Jeppesen, J., Chen, Y.D.I., Zhou, M.Y., Schaaf, P., Coulston, A., & Reaven, G.M. (1995a). Postprandial triglyceride and retinyl ester responses to oral fat: effects of fructose. *American Journal of Clinical Nutrition, 61,* 787-791.

Karpe, F., Frayn, K.N., Humphreys, S.M., Olivecrona, G., & Olivecrona, T. (1997). Lipoprotein lipase transport in plasma: role of muscle and adipose tissues in regulating plasma levels of lipoprotein lipase. *Proceedings of the Nutrition Society, 56,* 202A.

Karpe, F., Steiner, G., Uffelman, K., Olivecrona, T., & Hamsten, A. (1994). Postprandial lipoproteins and progression of coronary atherosclerosis. *Atherosclerosis, 106,* 83-97.

Karpe, F., Tornvall, P., Olivecrona, T., Steiner, G., Carlson, L.A., & Hamsten, A. (1993). Composition of human low density lipoprotein: effects of postprandial triglyceride-rich lipoproteins, lipoprotein lipase, hepatic lipase and cholesterol ester transfer protein. *Atherosclerosis, 98,* 33-49.

Kay, R.M., Jacobs, M., & Rotstein, O.D. (1983). Sustained alterations in lipoprotein cholesterol concentrations dependent on the daily distribution of lipid intake. *Atherosclerosis, 47,* 63-69.

Kay, R.M., Rao, S., Arnott, C., Miller, N.E., & Lewis, B. (1980). Acute effects of the pattern of fat ingestion on plasma high density lipoprotein components in man. *Atherosclerosis, 36,* 567-573.

Kistemaker, C., & Lowik, M.R.H. (1991). Wat eet Nederland werkelijk? *Voeding, 3,* 64-67.

Le Fur, C., Romon, M., Lebel, P., Devos, P., Lancry, A., Gu don-Moreau, L., Fruchart, J.C., & Dallongeville, J. (1999). Influence of mental stress and circadian cyle on postprandial lipaemia. *American Journal of Clinical Nutrition, 70,* 213-220.

Lennernäs, M.A., Akerstdet, T., Hagman, U., Bruce, A., & Hambraeus, L. (1993). A new approach for evaluation of meal quality and meal patterns. *Journal of Human Nutrition and Dietetics, 6,* 261-271.

Lovegrove, J.A., Jackson, K.G., Zampelas, A., Gould, B.J., Gibney, M.J., Roche, H., Kafatos, A., & Williams, C.M. (1997). Differences in postprandial lipaemia in response to standard meals in Southern and Northern Europeans. *Proceedings of the Nutrition Society, 56,* 203A

Mann, J. (1997). Meal frequency and plasma lipids and lipoproteins. *British Journal of Nutrition, 77,* S83-S90.

Mann, J.I., Truswell, A.S., & Pimstone, B.L. (1971). The different effects of oral sucrose and glucose on alimentary lipaemia. *Clinical Science, 41,* 123-129.

Mero, N., Syvanne, M., Rosseneu, M., Labeur, C., Hilden, H., & Taskinen, M.R. (1998). Comparison of three fatty meals in healthy normolipidaemic men: high post-prandial retinyl ester response to soybean oil. *European Journal of Clinical Investigation, 28,* 407-415.

Murphy, M.C., Isherwood, S.G., Sethi, S., Gould, B.J., Wright, J.W., Knapper, J.A., & Williams, C.M. (1995). Postprandial lipid and hormone responses to meals of varying fat contents: modulatory role of lipoprotein lipase? *European Journal of Clinical Nutrition, 49,* 578-588.

Murphy, M.C., Chapman, C., Lovegrove, J.A., Isherwood, S.G., Morgan, L.M., Wright, J.W., & Williams, C.M. (1996). Meal frequency; does it determine postprandial lipaemia? *European Journal of Clinical Nutrition, 50,* 491-497.

Noone, E.J., Roche, H.M., Tully, A.M., & Gibney, M.J. (1998). The effect of a fat rich meal on cholesterol ester transfer protein mass and activity in normolipidaemic individuals during postprandial lipaemia. *Proceedings of the Nutrition Society, 57,* 152A.

O'Flaherty, L., & Gibney, M.J. (1994). The effect of very low-, moderate-, and high-fat snacks on postprandial reverse cholesterol transport in healthy volunteers. *Proceedings of the Nutrition Society, 53,* 124A

Oltersdorf, U. (1996). Impact of Changing Food Choices and Eating Habits on Nutritional Status in European Countries. *Appetite, 27,* 91-94.

Oltersdorf, U., Schlettwein-Gsell, D., & Winkler, G. (1999). Assessing eating patterns-an emerging research topic in nutritional sciences: introduction to the symposium. *Appetite, 32,* 1-7.

Orth, M., Mayer, H., Halle, M., & Luley, C. (1999). Hemostatic factors in hypertriglyceridemic men: effects of a fatty meal before and after triglyceride-lowering treatment with etofibrate. *Thrombosis Research, 94,* 341-351.

Patsch, J.R., Karlin, J.B., Scott, L.W., Smith, L.C., & Gotto, A.M. (1983). Inverse relationship between blood levels of high density lipoprotein subfraction 2 and magnitude of postprandial lipemia. *Proceedings of the National Academy of Sciences of the United States of America, 80,* 1449-1453.

Patsch, J.R., Prasad, S., Gotto, A.M., & Bengtsson-Olivecrona, G. (1984). Postprandial lipaemia. A key for the conversion of high density lipoprotein2 into high density lipoprotein3 by hepatic lipase. *Journal of Clinical Investigation, 74,* 2017-2023.

Patsch, J.R., Prasad, S., Gotto, A.M., & Patsch, W. (1987). High density lipoprotein2. Relationship of the plasma levels of the lipoprotein species to its composition, to the magnitude of postprandial lipaemia, and to the activities of lipoprotein lipase and hepatic lipase. *Journal of Clinical Investigation, 80,* 341-347.

Peel, A.S., Zampelas, A., Williams, C.M., & Gould, B.J. (1993). A novel antiserum specific to apolipoprotein B-48: application in the investigation of postprandial lipidaemia in humans. *Clinical Science, 85,* 521-524.

Potts, J.L., Fisher, R.M., Humphreys, S.M., Coppack, S.W., Gibbons, G.F., & Frayn, K.N. (1991). Peripheral triacylglycerol extraction in the fasting and postprandial states. *Clinical Science, 81,* 621-626.

Potts, J.L., Humphreys, S.M., Coppack, S.W., Fisher, R.M., Gibbons, G.F., & Frayn, K.N. (1994). Fasting plasma triacylglycerol concentrations predict adverse changes in lipoprotein metabolism after a normal meal. *British Journal of Nutrition, 72,* 101-109.

Rifai, N., Merrill, J.R., & Holly, R.G. (1990). Postprandial effect of a high fat meal on plamsa lipid, lipoprotein cholesterol and apoprotein measurements. *Annals of Clinical Biochemistry, 27,* 489-493.

Rivera-Coll, A., Fuentes-Arderiu, X., & Diez-Noguera, A. (1994). Circadian rhythmic variations in serum concentrations of clinically important lipids. *Clinical Chemistry, 40,* 1549-1553.

Roche, H.M., & Gibney, M.J. (1995). Postprandial triacylglycerolaemia-nutritional implications. *Progress in Lipid Research, 34,* 249-266.

Roche, H.M., & Gibney, M.J. (1996). Postprandial triacylglycerolaemia: the effect of low-fat dietary treatment with and without fish oil supplementation. *European Journal of Clinical Nutrition, 50,* 617-624.

Roche, H.M., & Gibney, M.J. (2000). The impact of postprandial lipaemia in accelerating atherosclerosis. *Journal of Cardiovascular Risk, 7,* 317-324.

Roche, H.M., Zampelas, A., Jackson, K.G., Williams, C.M., & Gibney, M.J. (1998). The effect of test meal monounsaturated fatty acid: saturated fatty acid ratio on postprandial lipid metabolism. *British Journal of Nutrition, 79,* 419-424.

Romon, M., Le Fur, C., Lebel, P., Edme, J.L., Fruchart, J.C., & Dallongeville, J. (1997). Circadian variation of postprandial lipaemia. *American Journal of Clinical Nutrition, 65,* 934-940.

Roos, E., & Prättälä, R. (1997). Meal pattern and nutrient intake among adult Finns. *Appetite, 29,* 11-24.

Ryu, J.E., Howard, G., Craven, T.E., Gene Bond, M., Hagaman, A.P., & Crouse, J.R. (1992). Postprandial triglyceridemia and carotid atherosclerosis in middle-aged subjects. *Stroke, 23,* 823-828.

Sakr, S.W., Attia, N., Haourigui, M., Paul, J.L., Soni, T., Vacher, D., & Girard-Globa, A. (1997). Fatty acid composition of an oral load affects chylomicron size in human subjects. *British Journal of Nutrition, 77,* 19-31.

Saleh, J., Summers, L.K.M., Cianflone, K., Fielding, B.A., Sniderman, A.D., & Frayn, K.N. (1998). Coordinated release of acylation stimulating protein (ASP) and triacylglycerol clearance by human adipose tissue in vivo in the postprandial period. *Journal of Lipid Research, 39,* 884-891.

Shishehbor, F., Roche, H.M., & Gibney, M.J. (1998). The effect of acute carbohydrate load on the monophasic or biphasic nature of the postprandial lipaemic response to acute fat ingestion in human subjects. *British Journal of Nutrition, 80,* 411-418.

Shishehbor, F., Roche, H.M., & Gibney, M.J. (1999). The effect of low and moderate fat intakes on the postprandial lipaemic and hormonal responses in healthy volunteers. *British Journal of Nutrition, 81,* 25-30.

Terpstra, J., Hessel, L.W., Seepers, J., & van Gent, C.M. (1978). The influence of meal frequency on diurnal lipid, glucose and cortisol levels in normal subjects. *European Journal of Clinical Investigation, 8,* 61-66.

TNO. (1998). *Zo eet Nederland Resultaten van de Voedselconsumptiepeiling 1997-1998.* Den Haag: Voedingsscentrum.

Traianedes, K., Collier, G.R., & Dea, K. (1990). Ingestion of different types of fat in the evening meal does not affect metabolic responses to a standard breakfast. *American Journal of Clinical Nutrition, 52,* 442-445.

Tsetsonis, N.V., Hardman, A.E., & Mastana, S.S. (1997). Acute effects of exercise on postprandial lipemia: a comparative study in trained and untrained middle-aged women. *American Journal of Clinical Nutrition, 65,* 525-533.

van Amelsvoort, J.M.M., van Stratum, P., Kraal, J.H., Lussenburg, R.N., & Dubbelman, G.P. (1990). Minor difference in postprandial responses of men between starch and sugar when replacing fat in a normal meal. *British Journal of Nutrition, 63,* 37-51.

van Amelsvoort, J.M.M., van Stratum, P., Kraal, J.H., Lussenburg, R.N., & Houtsmuller, U.M.T. (1989). Effects of varying the carbohydrate:fat ratio in a hot lunch on postprandial variables in male volunteers. *British Journal of Nutrition, 61,* 267-283.

van Gent, C.M., Pigano Mirani-Oostdijk, C., Van Reine, P.H., Frolich, M., Hessel, L.W., & Terpstra, J. (1979). Influence of meal frequency on diurnal lipid,glucose and insulin levels in normal subjects on a high fat diet; comparison with data obtained on a high carbohydrate diet. *European Journal of Clinical Investigation, 9,* 443-446.

Westerterp-Plantenga, M.S., Pasman, W.J., Yedema, M.J.W., & Wijckmans-Duijsens, N.E.G. (1996). Energy intake adaptation of food intake to extreme energy densities of food by obese and non-obese women. *European Journal of Clinical Nutrition, 50,* 401-407.

WHO. . Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series No. 797. WHO. (1990).

Williams, C.M., Moore, F., Morgan, L.M., & Wright, J.W. (1992). Effects of n-3 fatty acids on posrprandial triacylglycerol and hormone concentrations in normal subjects. *British Journal of Nutrition, 68,* 655-666.

Winkler, G., Doring, A., & Keil, U. (1999). Meal Patterns in Middle-aged Men in Southern Germany: Results from the MONICA Augsburg Dietary Survey 1984/85. *Appetite, 32,* 33-37.

Wood, D. (1998). European and American recommendations for coronary heart disease prevention. *European Heart Journal, 19,* A12-A19.

Zampelas, A., Murphy, M., Morgan, L.M., & Williams, C.M. (1994). Postprandial lipoprotein lipase, insulin and gastric inhibitory polypeptide responses to test meals of different fatty acid composition: comparison of saturated, n-6 and n-3 polyunsaturated fatty acids. *European Journal of Clinical Nutrition, 48,* 849-858.

Zampelas, A., Peel, A.S., Murphy, M., Knapper, J.A., Wright, J.W., Morgan, L.M., Howland, R.J., & Williams, C.M. (1993). The effect of test meal fatty acid composition on postprandial triacylglycerol and lipoprotein lipase responses in normal subjects. *Proceedings of the Nutrition Society, 52,* 283A.

Zilversmit, D.B. (1979). Atherogenesis: A postprandial phenomenon. *Circulation, 60,* 473-485.

# CHAPTER 5

## Characterisation of the temporal pattern of macronutrient intake during eating occasions throughout the day of habitual free-living high-fat and low-fat consumers: application to the formulation of eating-occasion based dietary guidelines

## 5.1 INTRODUCTION

A reduction in the consumption of dietary fat is central to the dietary recommendations of most developed countries, to reduce the risk of diseases such as cardiovascular disease, cancer and obesity (WHO, 1990; European Heart Network, 1998). At present, dietary guidelines in Ireland recommend a dietary fat intake of 35%, or less, of food energy from fat (Food Advisory Committee, 1987). Consumer healthy eating guidelines advise eating less fat, especially saturated fat and making lower fat food choices whenever possible (Nutrition Advisory Group, 1995). The World Health Organisation, (WHO), the European Heart Network, (EHN) and Eurodiet, (2000) have advised an even lower fat intake of 30% of energy from fat (WHO, 1990; European Heart Network, 1998, Eurodiet, 2000). Lee & Cunningham, (1990) have reported an average fat intake in Ireland of 37% of food energy from fat. This fat intake is not in line with current dietary guidelines. This is also the case in many other developed countries (Wheelock, 1997; Williams *et al.*, 1999). Despite the existing high-fat intake (Lee & Cunningham, 1990) however, a survey of consumer attitudes in a representative sample of Irish adults, found remarkable results. Two-thirds of Irish adults agreed with the statement 'I do not need to make any changes to the food I eat as it is already healthy enough' (Kearney *et al.*, 1997). Health promotion research is thus challenged in identifying and developing strategies, which will be effective in reducing dietary fat intake.

A food-based approach to dietary guidelines has been advised by the FAO/WHO (1998), with recommendations to consider both the prevailing public health problem of the population, and the customary dietary patterns of the population. Information on the temporal pattern of nutrient intake of a population, during eating occasions throughout the day, may assist in the formulation of food-based dietary guidelines that target specific eating occasions and thus make consumer health messages more relevant. Such guidelines may be more effective in changing eating behaviour by providing people with specific information on how to incorporate dietary advice into their individual eating occasions. While the determination of total daily food and nutrient intakes and the characterisation of those achieving and not achieving dietary fat recommendations, has received some attention in nutrition research (Macdiarmid *et al.*, 1996; Subar *et al.*, 1994; Baghurst *et al.*, 1994; Hampl & Betts 1995;

Williams *et al.*, 1999), little is known about the nutrient content of the individual eating occasions throughout the day, of high-fat and low-fat consumers. For example, it is not known whether or how the nutrient composition of eating occasions differ between high-fat and low-fat consumers, whether these groups eat similar amounts of nutrients during eating occasions throughout the day or whether high-fat consumers eat more fat during eating occasions than low-fat consumers. High-fat and low-fat consumers could possibly be differentiated according to their dietary fat intake during eating occasions at certain times of the day. This could contribute to the development of focused dietary guidelines to reduce dietary fat intake. There are suggestions that the lunchtime and evening meal should be the focus of dietary fat reduction advice with reports that these eating occasions are the main contributors to the fat content of the diet (Khan & Lipke 1982; Baecke *et al.*, 1983; Skinner *et al.*, 1985; Winkler *et al.*, 1999). Information on the nutrient composition of eating occasions throughout the day of high-fat and low-fat consumers will provide a better understanding of how people meet dietary fat recommendations as part of their everyday eating patterns and may assist in the development of more effective dietary fat reduction strategies. In the present study, a dietary survey was undertaken to investigate the temporal pattern of macronutrient intake during eating occasions throughout the day in habitual high-fat and low-fat consumers and to determine whether and how the temporal patterns of eating of high-fat and low-fat consumers differ.

## 5.2 METHODS

### 5.2.1 Subject Recruitment

Details of the subject recruitment procedures are described in Chapter 2. In brief, healthy adults were recruited from a city local authority and eligible subjects were healthy male and female adults, aged 18 – 64 years, who were not working shift-work or over-time and females who were not pregnant or lactating.

### 5.2.2 Dietary Assessment Procedure

Subjects completed a 7-day food diary in which they recorded the amount of food and drink consumed and the time at which food and drink was consumed. A comprehensive description

of the procedures used during the dietary assessment in order to obtain acceptable data on the nutrient content of eating occasions is described in Chapter 2, including the instructions given to subjects, the method of food quantification and details of the nutrient analysis. The definition of an eating occasion in the present study is also fully described in Chapter 2. In brief, eating occasions were defined by time and coded to the nearest hour such that an eating occasion included every item of food or drink, consumed within an hourly period. Eating occasions of non-nutritive value were not included in the analysis.

### 5.2.3 Anthropometry

Body weight (kg) and height (m) were measured and the details of the procedures used are described in Chapter 2.

### 5.2.4 Quality and Validity of Dietary Data

All food diaries were completed during September to mid-December 1995 and details of the quality control procedures used are described in Chapter 2.

The validity of the food intake data of the full population was assessed by measuring the validity of the energy intakes reported in the study and is fully described in Chapter 2. This involved the calculation of the mean ratio of energy intake to estimated basal metabolic rate ($EI/BMR_{est}$), as proposed by Goldberg *et al.*, (1991). The validity of the reported energy intakes was assessed at group level, by comparing the mean $EI/BMR_{est}$ with the cut-off value which represented the lowest expected mean $EI/BMR_{est}$ for this study sample size with 7 days of food intake data, calculated using the Goldberg equation.

The validity of the reported energy intakes was also assessed at the individual level. The proportion of individuals in the study sample that were under-reporting was calculated. A cut-off value of 1.05 was obtained using the Goldberg equation to represent the lowest expected $EI/BMR_{est}$ value for an individual with 7 days of food intake data. Individuals with an $EI/BMR_{est}$ value less than the cut-off of 1.05 were considered to be under-reporters, whose reported energy intakes did not reflect minimum expected estimates of energy intake

during the recording week. Those individuals with a mean $EI/BMR_{est}$ value $\geq$ 1.05 were considered to have valid records and were referred to as adequate reporters.

The validity of the food intake data of the high-fat and low-fat consumers investigated in the present study was also assessed. Specific cut-off values were calculated for each group.

### 5.2.5 Data analysis

Data analysis was conducted using SPSS® 8.0 (statistical software package (SPSS Inc, Chicago, USA.). The SPSS database contained every hour (01.00-24.00hours) of each of the 7 days for each subject, together with the nutrient composition data of every eating occasion over the 7 days, at the specific hour of consumption.

The sample was split into two groups, high-fat and low-fat consumers, using the median percentage of food energy from fat (38.02%). High-fat consumers were defined as those with a mean daily percentage of food energy from fat above the median value and low-fat consumers were those with a mean daily percentage of food energy from fat below the median value. These two groups are hereafter called HF consumers for the high-fat group and LF consumers for the low-fat group.

*Temporal pattern of the mean macronutrient intake during eating occasions*

To calculate the temporal pattern of the mean macronutrient intake during eating occasions throughout the day, four approaches were explored and are fully described with examples in Chapter 3. The *eating occasion by individual method* was selected as the most appropriate method to determine the temporal pattern of the mean macronutrient content of eating occasions (> 0MJ) at each hour in HF and LF consumers separately and is recapped below:

*The eating occasion by individual method (method 4):* This method ensures all individuals contribute in a similar way to the mean value. Firstly, for each subject, the total nutrient intake consumed during eating occasions at a particular hour during the 7 days was summed and divided by the frequency the subject had an eating occasion (> 0MJ) at that hour during the 7 days. Thereafter the mean nutrient intake for each individual who ate at an hour was

summed and divided by the numbers of consumers at that hour, to get the group mean intake at each hour.

When comparing the mean nutrient intakes of groups of individuals during eating occasions, such as HF and LF consumers, the mean intake during eating occasions for each individual must be calculated initially. *The eating occasion by individual method* met this requirement as average nutrient intakes during eating occasions (> 0MJ) at each hour, are first calculated for each individual, before calculating the group mean. This method was used to present the temporal pattern of mean macronutrient intake during eating occasions (> 0MJ) per hour, in terms of energy intakes (MJ), absolute amounts of macronutrients and macronutrient intakes as proportions of energy for the HF and LF consumers (Figures 5.1 to 5.4). Analysis of the temporal pattern of mean macronutrient intake during eating occasions (> 0MJ) per hour for 24 hours showed there were no eating occasions at hours 4.00 and 5.00 and few eating occasions at hours 1.00, 2.00, 3.00 and 6.00. Therefore, figures 5.1 to 5.4 present data for 18 hours only (hours 7.00 to 24.00).

### 5.2.6 Statistical analysis

Mean ± standard deviation (SD) values were calculated for anthropometric measurements, $EI/BMR_{est}$ values, energy and macronutrient intakes for the total sample, HF consumers, LF consumers and for the men and women of the each dietary fat group separately. The mean daily eating frequency was calculated for each individual as the sum of daily eating frequencies, where an eating occasion was defined as having greater than 0MJ of energy, divided by the number of recording days (7d). The group mean ± SD daily eating frequency was then calculated. Differences in the mean anthropometric measurements, $EI/BMR_{est}$ values, mean daily eating frequency, energy and macronutrient intakes, between the HF and LF consumers were assessed. The differences in these variables between men and women of each dietary fat group were also assessed. Independent t-tests were used to test for differences in normally distributed data and the Mann-Whitney non-parametric test was used to test for differences in data that was not normally distributed. Differences in mean macronutrient intakes between men and women of the HF and LF groups were carried out using 2-way analysis of variance (ANOVA). Differences in the temporal pattern of macronutrient intake

during eating occasions per hour between the HF and LF consumers and the effect of gender were carried out using Split-plot in Time Analysis of Variance (ANOVA), (Dunne, 2000). This statistical test assessed interactions of HF and LF consumers (HFLF) x hour, HFLF x sex, sex x hour and HFLF x hour x sex for energy (MJ), absolute intakes of macronutrients (g) and proportions of total and food energy from macronutrients. Values of $P<0.05$ were taken as statistically significant. Tables and figures were created using Microsoft® Excel spreadsheets (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.).

## 5.3 RESULTS:

### 5.3.1 Response Rate

133 subjects (55 men, 78 women) met the study's eligibility criteria and the final response rate was 91%. Full details of the response rate of the study sample are described in Chapter 2 (Table 2.1). The HF consumers comprised 66 subjects (29 men, 37 women) and the LF consumers comprised 67 subjects (26 men, 41 women).

### 5.3.2 Validity of reported energy intakes

The mean ± SD $EI/BMR_{est}$ of the total study sample was 1.54 ± 0.4 (1.63 ± 0.4 in men, 1.48 ± 0.3 in women) with a significant difference in $EI/BMR_{est}$ between men and women ($P=0.02$). This mean $EI/BMR_{est}$ value was higher than the calculated cut-off value of 1.50, that Goldberg *et al.*, (1991) proposed as the lowest expected mean $EI/BMR_{est}$ value that reflects actual energy intake of a population of this size with 7 days of food intake data. The proportion of this population identified as under-reporters was 7% (n=9, 4% of men, 9% of women).

The mean $EI/BMR_{est}$ value of the HF consumers was significantly higher than that of the LF consumers (P=0.024), 1.61 ± 0.4 Vs. 1.47 ± 0.3 respectively (Table 5.1). This observation held through within the sexes, for women only ($P=0.015$) but there was no difference in mean $EI/BMR_{est}$ values between male HF consumers and male LF consumers. There was no significant difference in mean $EI/BMR_{est}$ between men and women in the HF consumers but statistical significance was observed in mean $EI/BMR_{est}$ between men and women in the LF consumers ($P=0.02$). The mean $EI/BMR_{est}$ value of the group of HF consumers was higher

than the Goldberg cut-off value of 1.48, which was calculated for the HF group. The proportion of the HF consumers identified as under-reporters was 3% (n=2) (0% of men, 5% of women). The mean EI/$BMR_{est}$ value of the group of LF consumers was comparable to the group specific cut-off value of 1.48, which was calculated for the LF group. The proportion of the LF consumers identified as under-reporters was 10% (n=7), (8% of men and 12% of women).

### 5.3.3 Mean daily nutrient intakes & subject characteristics

Table 5.1 also presents the mean anthropometric measurements, mean daily eating frequency, energy and macronutrient intakes of the total sample, HF consumers, LF consumers and the men and women of each dietary fat group. There were no significant differences in the mean age, weight, height, BMI or mean daily eating frequency between HF and LF consumers. The HF consumers had significantly higher mean daily energy intakes than the LF consumers ($P$=0.023). The distribution of energy between the macronutrients was significantly different between the HF and LF consumers respectively for carbohydrate at 42% vs. 48% ($P$<0.001), fat at 40% vs. 32% ($P$<0.001) and protein at 13% vs. 15% ($P$<0.001) but not alcohol at 5% ($P$=0.864). Excluding alcohol, significant differences in the percentage of food energy derived from carbohydrate ($P$<0.001), fat ($P$<0.001) and protein ($P$<0.001) were also found between HF and LF consumers.

Men had higher energy intakes than women in both dietary fat groups ($P$<0.001), by 40-46%, and consequently higher intakes of all macronutrients (g). There were no significant differences in the contribution of macronutrients to energy, including or excluding alcohol, between men and women within the HF and the LF consumers, with the exception of the proportion of total energy from protein in LF consumers. There were no significant interactions for any nutrient between the variables, sex and fat group, except for the proportion of total energy from protein ($P$=0.024). Women who were LF consumers had higher proportions of total energy from protein than men in that group ($P$=0.009) whereas comparable protein intakes were observed between male and female HF consumers.

Characteristics of the total study sample, including mean anthropometric measurements and mean daily nutrient intakes are fully described in Chapter 2 (Table 2.2). The socio-demographic and lifestyle characteristics of the men, women and the total sample have also been fully described in Chapter 2 (Table 2.5).

### 5.3.4 Temporal pattern of macronutrient intakes during eating occasions

The temporal pattern of mean energy intakes (MJ), absolute macronutrient intakes (g) and macronutrient intakes expressed as proportions of total energy and food energy, consumed during eating occasions (> 0 MJ) at each hour by HF and LF consumers, are presented in Figures 5.1, 5.2, 5.3 and 5.4 respectively. The n values at each hour are presented in Table 5.2. The n value at each hour is the number of subjects who ate at least once at that hour during the 7 days of recording.

The mean energy content (MJ) of eating occasions increased over the course of the day in both HF and LF consumers, with peaks occurring at 13.00 - 14.00 hours and 18.00 - 19.00 hours. These time points are equivalent to lunch time and evening meal times. There was a significant difference in the pattern of energy intake throughout the day between the two groups, which was observed by the HFLF x hour interaction, ($P$=0.04), (Figure 5.1). The mean energy content of eating occasions at each hour of the HF consumers was slightly higher than those of the LF consumers at almost all hours (0.2 – 0.7MJ).

Mean protein, fat and carbohydrate intakes (g) showed a similar pattern to energy with increasing intakes throughout the day and peaks occurring at 13.00 – 14.00 hours and 18.00 – 19.00 hours (Figure 5.2a & 5.2b). The HF consumers had greater fat intakes (g) during eating occasions at every hour than the LF consumers. Carbohydrate intakes at each hour did not differ greatly between the HF and LF consumers and protein intakes were also very similar between dietary fat groups. There were no significant differences observed in the pattern of mean protein, carbohydrate or alcohol intakes (g) during eating occasions at each hour, between HF and LF consumers, according to the HFLF x hour interaction. The converse was found for fat intakes (g), ($P$=0.024).

The mean macronutrient composition (% total and food energy) of eating occasions at each hour of HF and LF consumers is shown in Figure 5.3 and 5.4 respectively. At each hour, the mean fat content of eating occasions per hour of HF consumers was higher than the mean fat content of eating occasions per hour of LF consumers. The mean carbohydrate and protein content of eating occasions per hour were higher in LF consumers than HF consumers. The macronutrient composition (% total and food energy) of eating occasions over the course of the day however showed comparable patterns between HF and LF consumers. There were no significant interactions observed between HFLF x hour, for the proportion of energy (total or food) from protein, fat carbohydrate and alcohol. The fat content (% food energy) of eating occasions was lowest in the morning hours, for both the HF (26-39% food energy) and the LF (20-30% food energy) consumers and the fat content of eating occasions throughout the rest of the day was remarkably similar within each dietary fat group (Figure 5.4). HF consumers had eating occasions with a mean fat content of greater than 37% of food energy from fat at almost all hours throughout the day, with the exception of the morning hours and had somewhat higher intakes at 13.00 - 14.00 hours and 18.00 - 19.00 hours. Similarly, the fat content of the eating occasions of the LF consumers did not differ remarkably from each other throughout the day, with the exception of the lower fat intakes in the morning hours. The LF consumers had eating occasions with a mean fat content of less than 33% of food energy from fat, at most hours throughout the day.

The mean carbohydrate content of eating occasions was highest in the early morning hours in both the HF (49-61% food energy) and LF (56-64% food energy) consumers. Carbohydrate intakes decreased throughout the morning and peaked in the afternoon at 16.00 – 17.00 hours and in the late evening at 22.00 hours, in both HF and LF consumers. There was little variation in the mean protein content of eating occasions (% food energy) throughout the day, with distinct increases in protein intake at 13.00 - 14.00 hours and 18.00 - 19.00 hours (Figure 5.4). Alcohol made a contribution to the mean total energy content of eating occasions from 11.00 – 12.00 hours in both HF and LF consumers, with a comparable pattern of alcohol intake observed in both groups. The alcohol content of eating occasions increased gradually over the course of the day with peaks at 17.00 hours and 22.00 hours in both groups (Figure 5.3).

The effect of gender on the temporal pattern of macronutrient intakes during eating occasions throughout the day in HF and LF consumers was investigated. The results of Split-plot in Time ANOVA revealed that there was a significant interaction between the variables HFLF x hour x sex ($P<0.05$). Men and women had different temporal patterns of energy (MJ), protein (g) and fat (g) intakes during eating occasions per hour and these differences were consistent in the dietary fat groups. Significant differences in the temporal pattern of carbohydrate intakes by sex were observed, which were not the same in each dietary fat group ($P<0.05$). The pattern of alcohol intake (g) in HF and LF consumers was not affected by gender differences. When macronutrients were expressed as proportions of energy, there were no significant interactions observed for protein, carbohydrate, fat and alcohol (% total and food energy) between men and women in each dietary fat group.

## 5.4 DISCUSSION

The validity of the reported energy intakes of the total study sample was examined and described in Chapter 2. The dietary data of the total sample was considered acceptable and valid, with a small proportion of individuals under-reporting energy intake. The validity of the dietary data of each of study groups, the HF and LF groups, must also be examined however, before their nutrient intakes can be compared and differences observed can be correctly interpreted. This examination is especially important in light of evidence that under-reporters have diets lower in fat than those of acceptable reporters (Bingham *et al.*, 1991; Briefel *et al.*, 1997; Price *et al.*, 1997; Pryer *et al.*, 1997; Goris *et al.*, 2000; Heitmann *et al.*, 2000; Tomoyasu *et al.*, 2000). This finding is currently inconclusive though, as some other studies have reported little difference in the proportions of energy from macronutrients between under-reporters and acceptable reporters (Hirvonen *et al.*, 1997; Margetts & Nelson, 1997; Becker *et al.*, 1999). The validity of the data at group level and individual level will be considered in turn.

**Validity of reported food (energy) intakes**

Although the mean EI/$BMR_{est}$ values of the HF and LF consumers were somewhat similar, a significant difference in mean EI/$BMR_{est}$ was observed between these groups which could suggest under-reporting of energy intakes by the LF consumers. The proportion of under-reporters in the LF consumers was triple that in the HF consumers. The proportion of under-reporters in dietary surveys however, is usually much greater than 12% and is often as much as 52% (Ballard-Barbash *et al.*, 1996; Briefel *et al.*, 1997; Hirvonen *et al.*, 1997; Pryer *et al.*, 1997; Price *et al.*, 1997; Gnardellis *et al.*, 1998; Johansson *et al.*, 1998). When evaluated using the group specific cut-off values however, the reported energy intakes of both the HF and LF consumers of the present study were considered valid estimates of actual energy intake during the recording week.

Comparable mean EI/$BMR_{est}$ values have been reported between HF and LF consumers in some studies (Flynn *et al.*, 1996; Hermann-Kunz & Thamm, 1999), but lower mean EI/$BMR_{est}$ values in those with low-fat intakes (% energy) compared to those with high-fat intakes (% energy) have also been reported (Valsta, 1999; Becker, 1999). As overweight and obese individuals have been found to report lower than expected energy intakes (Prentice *et al.*, 1986; Ballard-Barbash *et al.*, 1996), it is noteworthy that the BMI of the HF and LF consumers in the present study did not differ. This finding is in agreement with some studies (Hulshof *et al.*, 1993; Cooling & Blundell, 1998; Hermann-Kunz & Thamm, 1999) but in contrast to others (Flynn *et al.*, 1996; Macdiarmid *et al.*, 1996). As there is evidence that under-reporting is associated with the reporting of fewer eating occasions during the day (Livingstone *et al.*, 1990; Summerbell *et al.*, 1996; Heitmann & Lissner, 1995; Briefel *et al.*, 1997; Poppitt *et al.*, 1998), it is noteworthy that the mean daily eating frequency of the HF and LF consumers in the present study did not differ. Macdiarmid *et al.*, (1997) found that HF consumers reported eating fewer meals per day than LF consumers in the Leeds High-fat study.

Mean daily nutrient intakes are the focus of most nutrition studies and there is currently a scarcity of data available on the temporal pattern of nutrient intakes during the day. It was therefore considered important, to compare the mean daily nutrient intakes of the HF and LF

consumers in the present study with other published studies, to obtain an overview of the data in the context of the published literature, before discussing the temporal patterns of nutrient intake. Details and results of studies, which have addressed the mean daily nutrient intakes of HF and LF consumers, are summarised in Table 5.3.

**Mean daily macronutrient intakes of HF & LF consumers**

The nutrient composition of high-fat and low-fat diets was recently investigated using national food survey data from different countries as part of studies on the development of food-based dietary guidelines (Williams *et al.*, 1999). The overall finding was that the low-fat group had a lower energy intake and a higher carbohydrate and sugar intake in terms of proportions of energy, as observed in the present study (Becker, 1999; De Hanauw & De Backer, 1999; Haraldsdóttir, 1999; Löwik *et al.*, 1999; Valsta, 1999). This finding of a lower energy intake in those consuming low-fat diets was also reported by others (Hulshof *et al.*, 1993; Baghurst *et al.*, 1994; Lichtenstein *et al.*, 1998; Lawton *et al.*, 1999) but there have also been reports of comparable energy intakes between HF and LF groups (Flynn *et al.*, 1996; Macdiarmid *et al.*, 1996; Graça, 1999; Koenig & Elmadfa, 1999). The difference in reported energy intake between high and low-fat groups has been recently suggested to be due to under-reporting of energy intake (Becker, 1999). The finding of a higher carbohydrate and sugar intake (% energy) in those with a low-fat intake concurs with the established inverse relationship observed between the proportions of energy from fat and from sugar (Gibney *et al.*, 1989; Gibney, 1990; Hulshof *et al.*, 1993; Flynn *et al.*, 1996).

A higher protein intake as a proportion of total energy and food energy was observed in the LF consumers, with no difference in the proportion of energy from alcohol observed between the dietary fat groups. The differences in protein and alcohol intakes in other studies between those consuming high- and low-fat diets have been somewhat variable however.

Similar to the findings of the present study, some studies found those consuming low-fat diets to have a higher protein intake than those consuming high-fat diets (Hulshof *et al.*, 1993; De Henauw & De Backer, 1999; Haraldsdóttir, 1999; Löwik *et al.*, 1999; Serra-Majem *et al.*, 1999). In other studies a lower protein intake was observed in the LF consumers (Gibney &

Lee, 1991; Graça, 1999; Hermann-Kunz & Thamm, 1999). No difference in protein intake has also been observed between HF and LF groups (Flynn *et al.*, 1996; Macdiarmid *et al.*, 1996; Flynn & Kearney, 1999; Valsta, 1999). Previous reports regarding alcohol intakes have also been inconsistent. Some studies reported a higher alcohol intake in those consuming low-fat diets (Hulshof *et al.*, 1993; Baghurst *et al.*, 1994; Hampl *et al.*, 1995; De Henauw & De Backer, 1999; Graça, 1999; Haraldsdóttir, 1999; Hermann-Kunz & Thamm, 1999) and others reported no difference in alcohol intake between HF and LF groups (Flynn *et al.*, 1996; Flynn & Kearney, 1999; Koenig *et al.*, 1999; Valsta, 1999), as observed in the present study. As alcohol intake confounds the evaluation of dietary fat intake (Gibney & Lee, 1991; Hulshof *et al.*, 1993; Subar *et al.*, 1994; Hampl *et al.*, 1995) it is noteworthy, that the differences observed in macronutrient intakes (% total energy) between groups in the present study, were also observed when macronutrient intakes were expressed as proportions of food energy.

Overall, the differences observed in mean daily macronutrient intakes of the HF and LF consumers of the present study are in agreement with previously published work. The results of many studies are not, however, consistent. Such inconsistencies can be due to the use of different definitions to define HF and LF consumers (quartiles, tertiles, medians or those with dietary fat intakes above and below dietary fat recommendations) or may be due to true differences in nutrient intakes among the different populations studied.

**The temporal pattern of nutrient intake throughout the day of HF & LF consumers**

The main purpose of this study was to describe the temporal pattern of macronutrient intake during eating occasions throughout the day of habitual free-living high-fat and low-fat consumers. A clearly identifiable temporal eating pattern was observed in HF and LF consumers, as was observed for the total population (Chapter 4). The nutrient content of eating occasions throughout the day was not uniform for both HF and LF consumers. Eating occasions were low in energy in the early morning hours and were highest in energy at two time points 13.00 - 14.00 hours and 18.00 - 19.00 hours, during the day. The increase in energy intake during eating occasions in both HF and LF consumers was due to an increase in the intake of the three macronutrients, protein, fat and carbohydrate. Despite the remarkably

comparable temporal patterns of mean macronutrient intake between HF and LF consumers during the day, distinct differences were also observed.

HF consumers ate more during almost every eating occasion than the LF consumers, hence the difference in mean daily energy intakes between groups. The higher energy intake during eating occasions of the HF consumers was primarily due to dietary fat. HF consumers ate more fat (g) at every eating occasion throughout the day than LF consumers whereas absolute intakes of protein and carbohydrate at eating occasions were comparable between HF and LF consumers. Unexpectedly, the time points 13.00 - 14.00 hours and 18.00 - 19.00 hours were not the only time points during the day when fat intake (g) differed between HF and LF consumers.

Interesting observations were made when macronutrient intakes during eating occasions were expressed as proportions of energy i.e. controlling for the difference in energy intakes between eating occasions. The proportion of energy from fat during eating occasions was lowest in the early morning hours, but was similar during eating occasions throughout the rest of the day within each dietary fat group. In other words, the proportions of energy from fat during eating occasions showed little variation within each dietary fat group during the day, with the exception of the early morning eating events, with HF consumers having high-fat eating occasions and LF consumers having low-fat eating occasions throughout the day. HF consumers had high-fat eating occasions at every time point (generally > 37% of food energy) and LF consumers had low-fat eating occasions (< 33% of food energy) at almost every time point throughout the day, with the exception of the early morning hours.

These results of the temporal pattern of eating were unexpected. A specific time of the day was not identified, during which eating occasions were found to be remarkably higher in fat, between HF and LF consumers. The present results have clear implications for meal-based or eating occasion-based dietary advice. It was anticipated that eating occasions at a particular time point, such as the main meals, lunch or evening meal, may have had a higher fat content than eating occasions at other times of the day and therefore could be the focus of future advice to reduce dietary fat intake. It was previously reported that meals had a greater

proportion of energy from fat compared to snacks (Skinner *et al.*, 1985; Basdevant *et al.*, 1993; Summerbell *et al.*, 1995; Samuelson *et al.*, 1996; Roos & Prättälä, 1997; Whybrow & Kirk, 1997; Bellisle *et al.*, 1999) which suggested that meals should be specifically targeted with regard to dietary fat reduction. On the contrary, the eating occasions of the HF consumers in the present study were higher in fat, at every hour, than the eating occasions of the LF consumers. These results suggest that future investigations are needed before advice to reduce dietary fat intakes at specific eating occasions can be given.

These results highlight that before recommendations are made to target specific eating occasions, it is important to determine the differences in the temporal pattern of eating between those achieving and not achieving dietary recommendations for the nutrient of concern. The results also highlight the value of not defining eating occasions as simply 'meals' and 'snacks', as this approach loses the valuable detail that is obtained when the data is presented in terms of the temporal pattern of eating. Indeed, the results of studies, which have observed differences in fat intake between meals and snacks are limited for a number of reasons. To date, these studies investigated the full population rather than HF and LF consumers separately and they examined the nutrient content of all 'meals' and of all 'snacks' rather than of specific eating occasions. Furthermore differences in the specific criteria used to define 'meals' and 'snacks' between studies make it difficult to interpret the results.

No published studies were found to examine the temporal pattern of macronutrient intake during eating occasions at each hour of the day, in free-living HF and LF consumers, with which to draw comparisons. An American study of 1032 women examined the variability in fat intake at pre-defined eating occasions (morning, midday, evening and snacks) in HF and LF groups (Ballard-Barbash *et al.*, 1994). As in the present study, the fat content (% of energy) of all eating occasions of the HF consumers was greater than those of the LF consumers and morning eating occasions were found to be of lowest fat content (% of energy) in both HF and LF groups. Ballard-Barbash *et al.*, (1994) also observed a comparable proportion of energy from fat in snacks and morning eating occasions in both groups. This was not found in the present study, the proportion of energy from fat during eating occasions

of the mid-morning, mid-afternoon and evening hours, was higher than the morning eating occasions. It is difficult to compare these studies as different methods were used to examine eating patterns. Ballard-Barbash *et al.*, (1994) used the term snacks to include all eating occasions other than morning, midday or evening meals. In the present study however, single eating occasions were not predefined or aggregated over defined time periods, which would conceal the temporal eating pattern of free-living individuals throughout the day. Nonetheless, in agreement with the findings of this study, Ballard-Barbash *et al.*, (1994) indicated that restricting dietary fat intake at specific eating occasions, was unlikely to be a sufficient behaviour to achieve recommended total dietary goals, without an overall reduction in dietary fat intake. Haraldsdóttir *et al.*, (1999) reported that in the 1985 Danish national food survey, the fat content (% energy) of breakfast, lunch, supper and snack meals was higher in the HF consumers than the LF consumers. Although these findings are in agreement with the findings of the present study, the methods used to define eating occasions were not reported however.

As no other studies were found to examine the temporal pattern of macronutrient intake during eating occasions per hour throughout the day of HF and LF consumers, it is notable that the mean daily macronutrient intakes of HF and LF consumers, as proportions of energy, were similar to the macronutrient composition of their eating occasions, at almost every hour of the day. For example, the LF consumers had eating occasions of lower fat, higher carbohydrate and higher protein content (proportions of energy) than the HF consumers

The results of this study are also interesting in the context of studies investigating the influence of different macronutrients on appetite and subsequent food intake. There is evidence that dietary fat and carbohydrate have different effects on appetite and these effects can influence the energy content of an eating occasion and subsequent energy intake at the next eating occasion. Appetite is studied in terms of satiation (the process that brings eating to a halt and controls meal size) and satiety (inhibition of hunger and eating, as a consequence of food consumption), (Blundell *et al.*, 1994). Blundell, at the Psychology Department of the University of Leeds, reported that eating high-fat foods freely during an eating occasion had interesting effects, that of a large intake being eaten at that eating occasion due to passive over-consumption of fat. In addition, there was a weak effect on satiety, which resulted in

little reduction in the energy content of the next eating occasion (Smith *et al.*, 1991; Blundell *et al.*, 1992; 1993; Cotton *et al.*, 1992; Blundell & Macdiarmid, 1997). Conversely, eating high carbohydrate foods resulted in a lower energy intake during the eating occasion, due to an increase in satiation (within meal control). In this case the energy content of the subsequent eating occasion was also low. In summary, Blundell states that the consumption of high carbohydrate foods influences the pattern of eating, by limiting the energy content of meals and providing good postprandial control over hunger and 'snacking'. Other studies have also found that meals with a low fat-carbohydrate ratio suppress hunger to a greater degree than meals with a high fat-carbohydrate ratio (van Amelsvoort *et al.*, 1989). In the present study, HF consumers had greater energy intakes and fat intakes at every eating occasion than the LF consumers. Is it possible that these effects of dietary fat on appetite are occurring in the HF consumers of this study as they have high fat intakes at each eating occasion during the day? Studies which examine the affects of macronutrients on appetite often administer amounts of macronutrients during eating occasions which are in excess of the macronutrient content of the eating occasions of the HF and LF consumers of the present study. Before this question can be answered, such studies will have to be undertaken using more usual amounts of macronutrients, as consumed during eating occasions of free-living adults.

The temporal pattern of the macronutrient content of eating occasions of the LF consumers are consistent with current healthy eating guidelines that advocate eating less dietary fat and eating more dietary carbohydrate during every eating occasion (Health Promotion Unit, 1993). Before recommendations to reduce dietary fat intake during specific eating occasions can be made however, it is necessary to describe the temporal pattern of food intake of HF and LF consumers during eating occasions throughout the day. Furthermore, information on the food choices of HF and LF consumers at different times of the day is required. A clearer understanding of the temporal pattern of food intake of free-living HF and LF consumers will be valuable, given the fact that many people consuming high-fat diets actually believe that they are consuming low-fat diets (Greene *et al.*, 1993; Lloyd *et al.*, 1993; Brug *et al.*, 1994). Furthermore, people have been found to have a poor ability to correctly estimate the fat content of foods (Mela, 1993). This information could provide the basis for developing food based dietary guidelines for specific eating occasions, relevant to the population under study.

A food-based approach to dietary guidelines is currently considered the most effective means of developing dietary guidelines (FAO/WHO, 1998; Eurodiet, 2000). In addition, this approach could provide information for the development of practical strategies to enable people to correctly evaluate their own dietary fat intakes. The development of such strategies has been suggested as a means of increasing awareness of a high dietary fat intake (Mela, 1994; 1995; Kearney *et al.*, 1997). Information on a population's perception of actual dietary fat intake and their knowledge and attitudes towards dietary fat reduction should complement future investigations of the temporal pattern of eating.

In conclusion, the results of this study show that HF and LF consumers have similar, though distinctive, temporal patterns of macronutrient intake during eating occasions throughout the day. HF consumers eat more during eating occasions as a result of greater fat intakes during eating occasions. This study does not support the idea that a specific time point can be identified for targeting fat reduction in this population. The study of the temporal patterns of nutrient intakes during eating occasions of HF and LF consumers is an innovative approach to obtaining a clearer understanding of the eating patterns of free-living adults and the development of more effective and evidence-based dietary fat reduction strategies.

**Table 5.1: Mean and standard deviation (SD) values of anthropometric measurements, EI/BMR$_{est}$ values, daily eating frequency, energy and macronutrient intakes of high-fat (HF) and low-fat (LF) consumers by sex**

| | High-Fat Consumers (HF) | | | | | | | Low-Fat Consumers (LF) | | | | | | | All | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All (n=66) † | | Males (n=29) | | Females (n=37) | | | All (n=67) | | Males (n=26) | | Females (n=41) | | | (n=133) | |
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *P*‡ | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *P*‡ | *Mean* | *SD* |
| Age (years) | 37.2 NS | 9.9 | 41.9 | (9.0) | 33.4 | (9.2) | *** | 36.1 | (8.9) | 39.5 | (8.6) | 34.0 | (8.5) | * | 36.6 | (9.4) |
| Weight (kg) | 75.6 NS | 14.2 | 87.3 | (10.5) | 66.5 | (9.2) | *** | 73.6 | (10.9) | 82.5 | (7.7) | 68.0 | (8.7) | *** | 74.6 | (12.6) |
| Height (m) | 1.7 NS | 0.1 | 1.8 | (0.1) | 1.7 | (0.1) | ** | 1.7 | (0.1) | 1.8 | (0.1) | 1.6 | (0.1) | *** | 1.7 | (0.1) |
| BMI | 25.7 NS | 3.8 | 27.5 | (3.6) | 24.4 | (3.4) | *** | 25.7 | (2.7) | 26.3 | (2.5) | 25.3 | (2.8) | NS | 25.7 | (3.3) |
| EI/BMR$_{est}$ | 1.61* | 0.4 | 1.66 | (0.5) | 1.58 | (0.3) | NS | 1.47 | (0.3) | 1.59 | (0.3) | 1.40 | (0.3) | * | 1.54 | 0.4 |
| Under-reporters (%) | 3% | | 0% | | 5% | | | 10% | | 8% | | 12% | | | 7% | |
| Mean daily Eating Frequency | 5.7 NS | 1.0 | 5.7 | (1.1) | 5.7 | (1.0) | NS | 5.8 | (1.2) | 6.0 | (1.1) | 5.8 | (1.2) | NS | 5.8 | (1.1) |
| Kcal | 2622.0 * | 737.4 | 3119.3 | (746.6) | 2232.3 | (439.3) | *** | 2345.4 | (650.9) | 2900.2 | (556.7) | 1993.6 | (422.4) | *** | 2482.7 | (706.3) |
| MJ | 11.1 * | 3.2 | 13.3 | (3.2) | 9.3 | (1.8) | *** | 9.8 | (2.7) | 12.2 | (2.3) | 8.4 | (1.8) | *** | 10.4 | (3005.6) |
| Protein (g) | 86.7 NS | 22.6 | 104.0 | (20.1) | 73.1 | (13.3) | *** | 84.8 | (20.1) | 100.1 | (16.6) | 75.2 | (15.6) | *** | 85.8 | (21.3) |
| Carbohydrate (g) | 296.5 NS | 89.7 | 350.5 | (94.0) | 253.3 | (58.1) | *** | 302.3 | (93.3) | 375.6 | (85.3) | 255.8 | (64.0) | *** | 299.2 | (91.2) |
| Fat (g) | 115.6 *** | 35.2 | 137.7 | (36.6) | 98.2 | (22.2) | *** | 83.8 | (26.6) | 102.2 | (26.4) | 72.2 | (19.3) | *** | 99.6 | (34.9) |
| Sugars (g) | 118.9 NS | 52.2 | 135.9 | (67.0) | 105.6 | (32.0) | * | 131.1 | (64.3) | 168.9 | (74.8) | 107.2 | (42.6) | *** | 125.1 | (58.7) |
| Alcohol (g) | 17.5 NS | 16.1 | 21.3 | (17.4) | 14.6 | (14.6) | NS | 16.8 | (16.8) | 24.6 | (19.6) | 11.9 | (12.7) | ** | 17.2 | (16.4) |
| % energy from protein | 13.4 *** | 1.9 | 13.5 | (1.8) | 13.3 | (2.1) | NS | 14.7 | (2.0) | 14.0 | (1.5) | 15.2 | (2.1) | ** | 14.1 | (2.1) |
| % energy from carbohydrate | 42.3 *** | 3.8 | 42.0 | (3.9) | 42.4 | (3.8) | NS | 48.1 | (4.9) | 48.4 | (5.1) | 47.9 | (4.8) | NS | 45.2 | (5.3) |
| % energy from starch | 25.4** | 4.3 | 26.2 | (4.4) | 24.8 | (4.2) | NS | 27.5 | (5.3) | 26.6 | (5.9) | 28.1 | (4.9) | NS | 26.5 | (5.0) |
| % energy from total sugars | 16.8*** | 4.2 | 15.8 | (4.1) | 17.7 | (4.1) | NS | 20.5 | (6.6) | 21.8 | (8.3) | 19.8 | (5.2) | NS | 18.7 | (5.8) |
| % energy from fat | 39.6 *** | 2.5 | 39.6 | (2.4) | 39.5 | (2.7) | NS | 32.0 | (4.1) | 31.5 | (4.2) | 32.3 | (4.0) | NS | 35.8 | (5.1) |
| % energy from alcohol | 4.7 NS | 4.2 | 4.8 | (4.0) | 4.6 | (4.4) | NS | 5.1 | (5.0) | 6.2 | (4.8) | 4.4 | (5.0) | NS | 4.9 | (4.6) |
| % food energy from carbohydrate | 44.3 *** | 3.0 | 44.1 | (2.8) | 44.5 | (3.2) | NS | 50.7 | (4.1) | 51.6 | (4.2) | 50.1 | (3.9) | NS | 47.5 | (4.8) |
| % food energy from fat | 41.5 *** | 2.3 | 41.7 | (2.5) | 41.4 | (2.2) | NS | 33.7 | (3.7) | 33.5 | (4.0) | 33.8 | (3.6) | NS | 37.6 | (5.0) |
| % food energy from protein | 14.1 *** | 2 | 14.2 | (2.0) | 13.9 | (2.2) | NS | 15.6 | (2.4) | 14.9 | (1.8) | 16.0 | (2.7) | NS | 14.8 | (2.4) |

† * P<0.05 vs. All HF; ** P<0.01 vs. All HF; ***P<0.001 vs. All HF; NS, not significant, P>0.05 vs. All HF

‡ Comparison of mean daily nutrient intakes by gender within each fat group (HF and LF), * P<0.05, ** P<0.01, ***P<0.001, NS, not significant, P>0.05.

**Table 5.2: The number (*n*) of values per hour ***

| hour | HF consumers | LF consumers |
|---|---|---|
| | *n* | *n* |
| 1.00 | 8 | 7 |
| 2.00 | 7 | 6 |
| 3.00 | 3 | 2 |
| 6.00 | 4 | 0 |
| 7.00 | 21 | 26 |
| 8.00 | 45 | 54 |
| 9.00 | 47 | 45 |
| 10.00 | 57 | 54 |
| 11.00 | 61 | 59 |
| 12.00 | 45 | 42 |
| 13.00 | 62 | 62 |
| 14.00 | 61 | 59 |
| 15.00 | 40 | 56 |
| 16.00 | 51 | 46 |
| 17.00 | 46 | 57 |
| 18.00 | 63 | 62 |
| 19.00 | 62 | 62 |
| 20.00 | 54 | 56 |
| 21.00 | 60 | 64 |
| 22.00 | 62 | 64 |
| 23.00 | 48 | 55 |
| 24.00 | 34 | 32 |

* the number of subjects who ate at an hour, having taken into consideration the no. of times during the 7 days that an individual ate at the hour

**Table 5.3: Mean daily energy and macronutrient intakes (% total energy) in High-fat and Low-fat groups in previous studies**

| Authors | Subjects | High-Fat Group | | | | | Low-Fat Group | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MJ | Protein | Fat | CHO | ROH | MJ | Protein | Fat | CHO | ROH |
| **Becker *et al.*, 1999** | 81LF, 169HF 15-74y | 8.2 | 14 | 43 | 42 | 1.4 | 6.7 | 15 | 27 | 56 | 2.4 |
| **De Henauw & De Backer, 1999** | 555 LF, 590 HF 25-45y | 14.1 | 12.8 | 51.9 | 31.7 | 3.1 | 12.1 | 13.5 | 31.0 | 43.7 | 10.9 |
| **Flynn & Kearney, 1999** | 178LF, 179 HF 18+y | 9.7 | 14.7 | 37.3 | 48.5 | 1.5 | 8.2 | 14.5 | 26.3 | 57.9 | 3.1 |
| **Graça *et al.*, 1999** | 489 adults, 40y+ | 9.8 | 19.2 | 31.9 | 44.8 | 2.8 | 9.7 | 16.6 | 20.2 | 52.7 | 10.1 |
| **Haraldsdóttir, 1999** | 1682 others vs. 560 HF, 15-80y | 12.3 | 13 | 50 | 34 | 3 | 11.1 | 14 | 40 | 43 | 4 |
| **Hermann-Kunz & Thamm, 1999** | 1897 adult, 18-80y | 11.1 | 15.1 | 44.9 | 33.5 | 2.8 | 10.7 | 14.6 | 32.3 | 39.7 | 10.2 |
| **Löwik *et al.*, 1999** | 3833 adults, 18-60y | 10.2 | 14.6 | 44.9 | 38.4 | 2.2 | 9.1 | 16.2 | 30.1 | 48.4 | 5.4 |
| **Serra-Majem *et al.*, 1999** | 712 men, 18-60y | 10.2 | 18.7 | 41.1 | 38.0 | 3.5 | 9.3 | 19.4 | 33.2 | 40.2 | 6.9 |
| **Valsta, 1999** | 1861 adults, 25-64y | 9.7 | 15.9 | 41.4 | 40.9 | 1.8 | 8.2 | 16.1 | 26.3 | 54.1 | 3.4 |
| **Flynn *et al.*, 1996** | 83 women, 20-55y | 8.7 | 15.1 | 47.3 | 35.0 | 8.1 | 9.0 | 14.4 | 34.2 | 46.4 | 5.2 |
| **MacDiarmid *et al.*, 1996** | 169 men, 16y+ | 11.4 | 15 | 47 | 38 | - | 10.8 | 15 | 33 | 52 | - |
| **Baghurst *et al.*, 1994** | approx. 1500 men, 18y+ | 10.2 | 16.8 | 41.4 | 38.7 | 1.8 | 8.5 | 16.3 | 25.5 | 50.0 | 6.5 |
| **Hulshof *et al.*, 1993** | 183 LF, 64 HF, 22-49y men | 12.3 | 12.9 | 43.8 | 38.1 | 5.2 | 10.9 | 12.9 | 32.4 | 47.8 | 6.9 |

CHO=carbohydrate; ROH=alcohol

**Figure 5.1: Temporal pattern of mean energy (MJ) intake during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers**

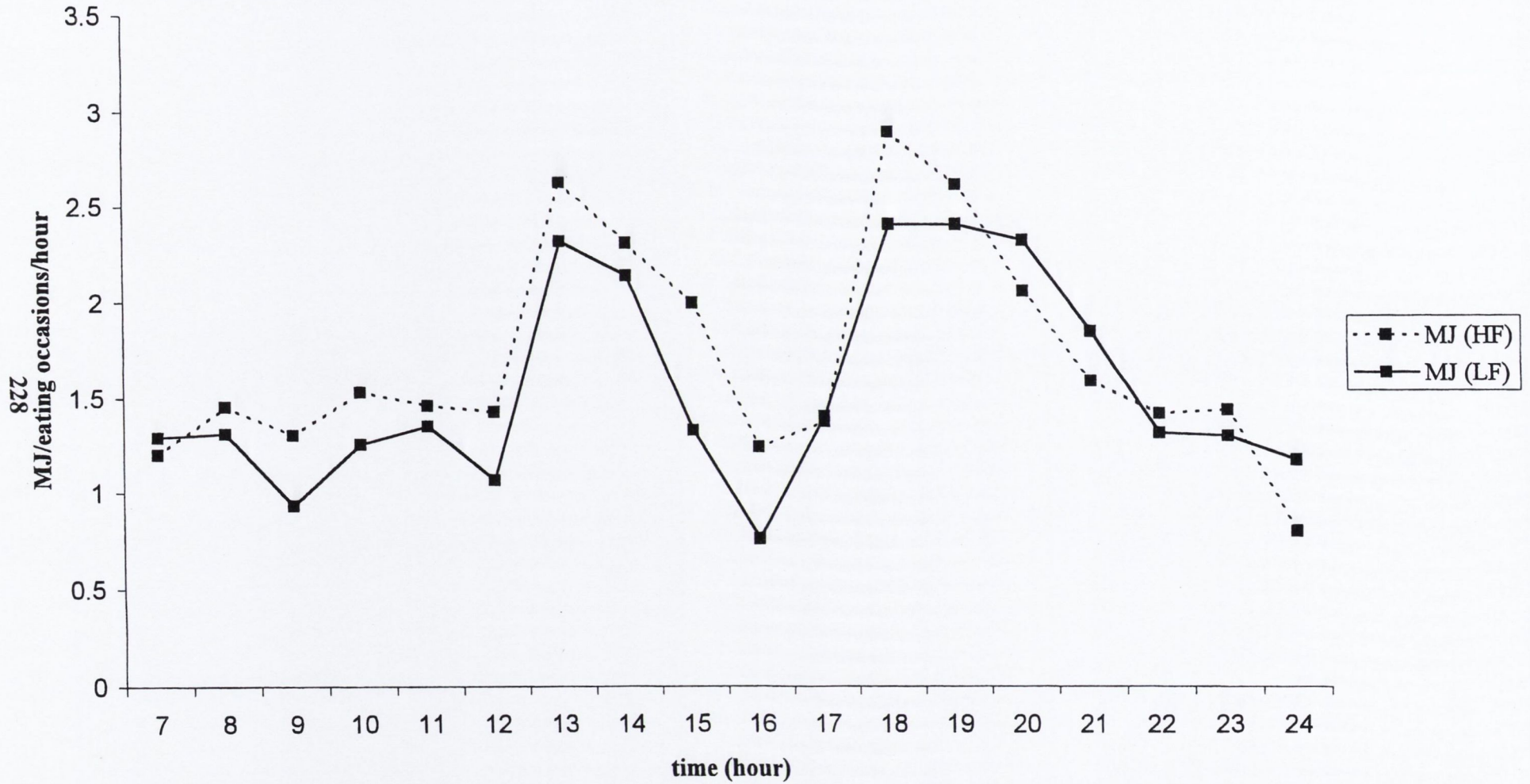


**Figure 5.2a: Temporal pattern of mean carbohydrate & fat intake (g) during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers**

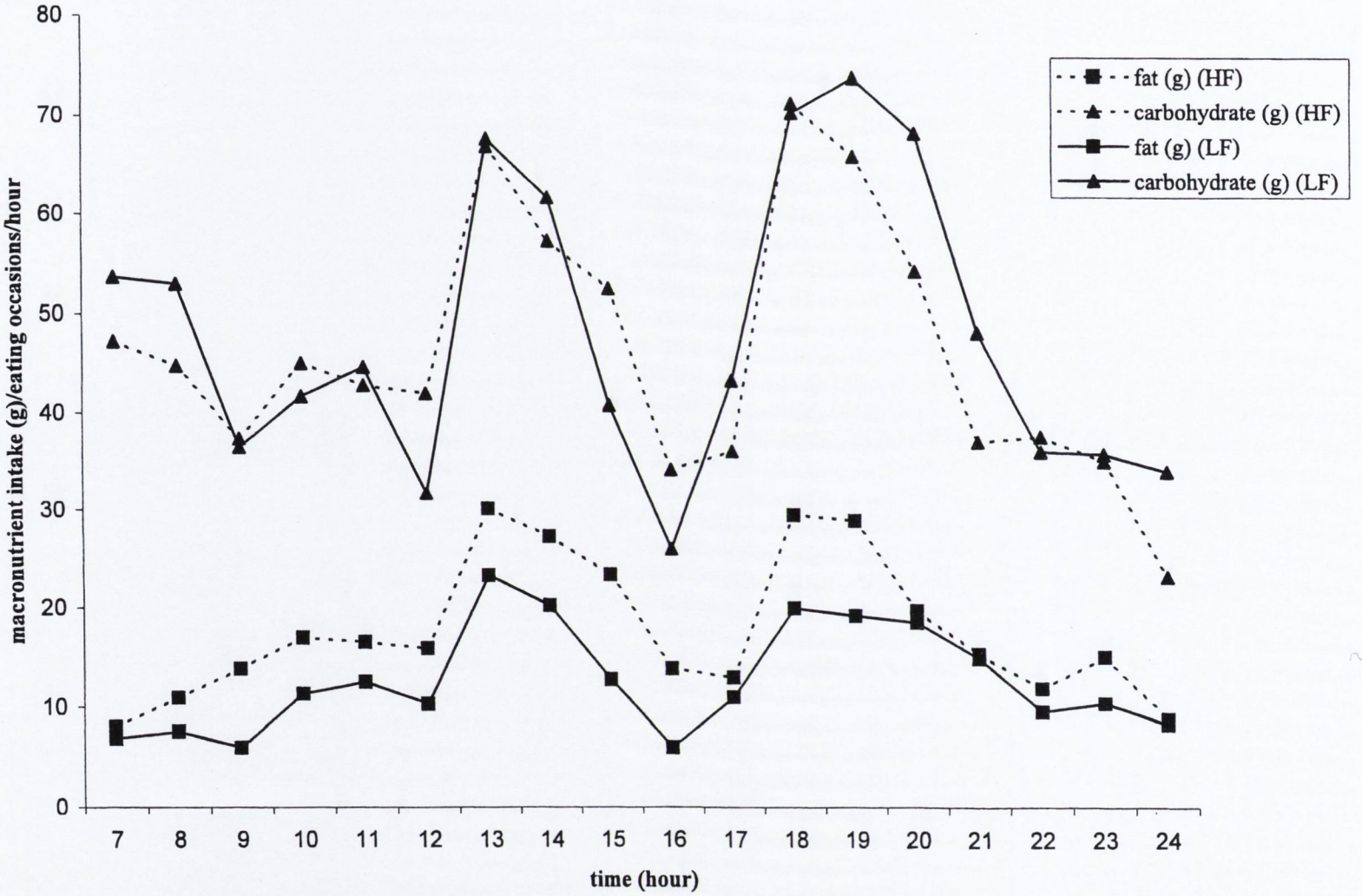


**Figure 5.2b: Temporal pattern of mean protein & alcohol intake (g) during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers**

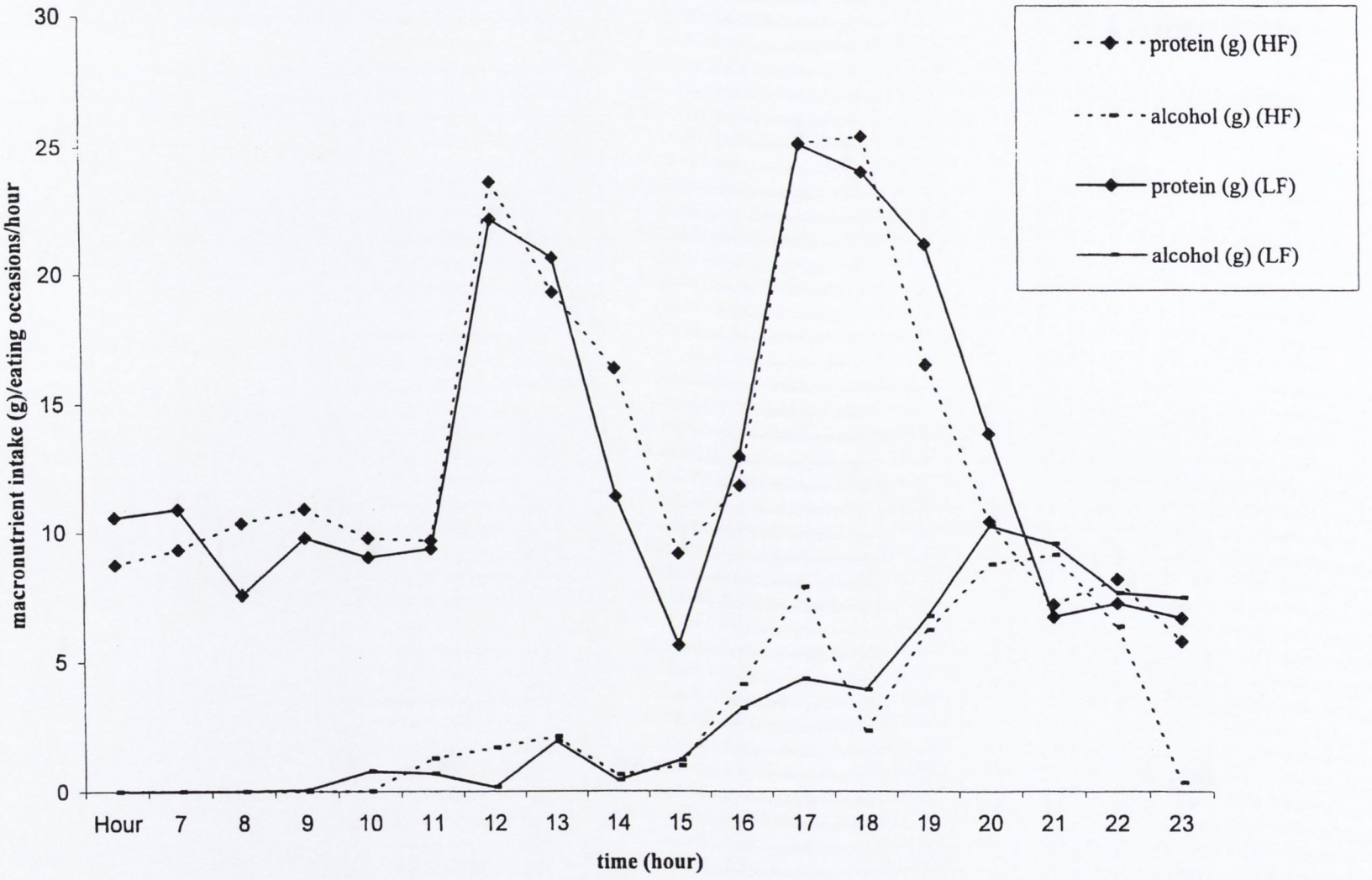


**Figure 5.3: Temporal pattern of mean proportion of total energy from macronutrients during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers**

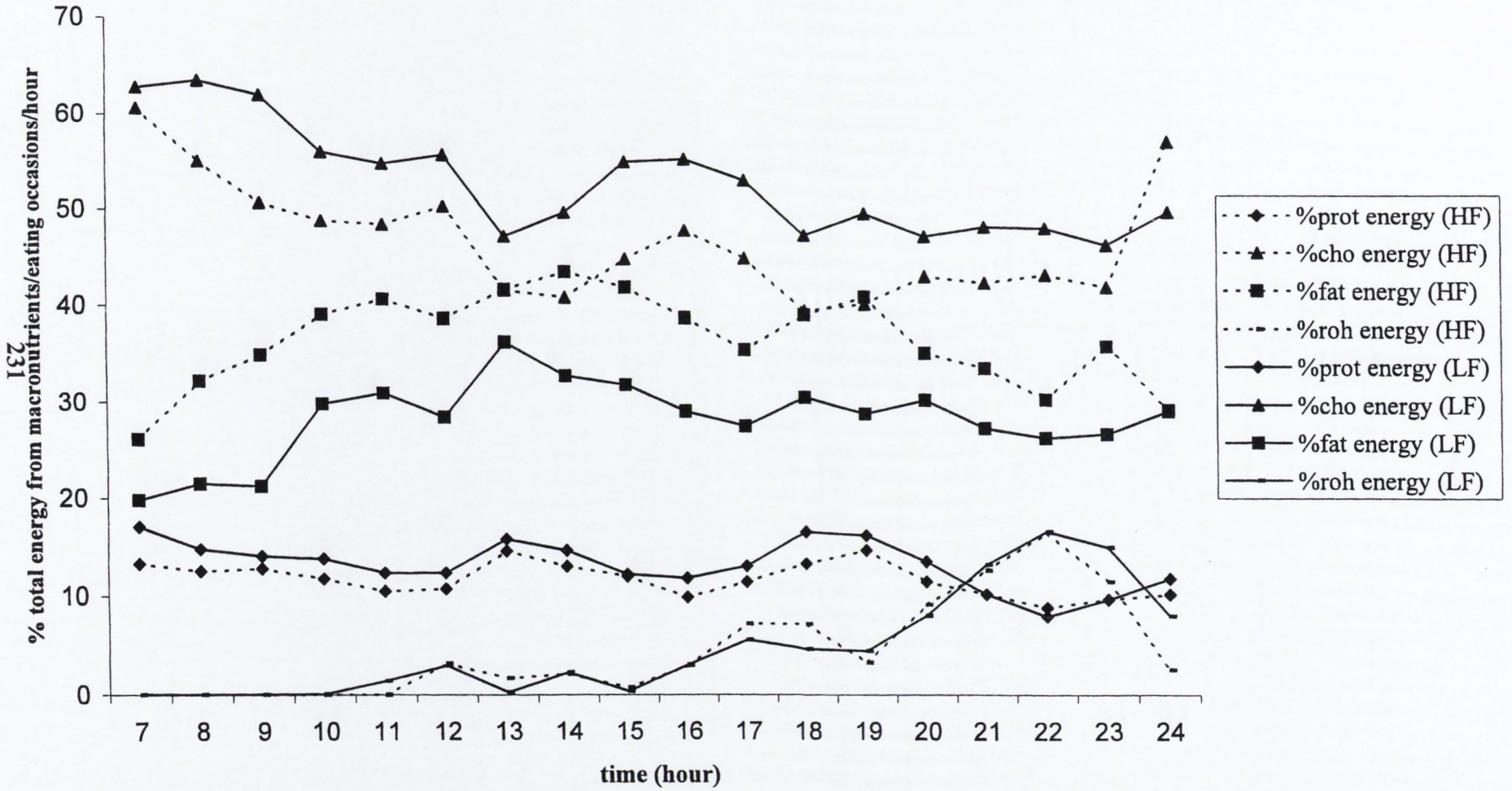
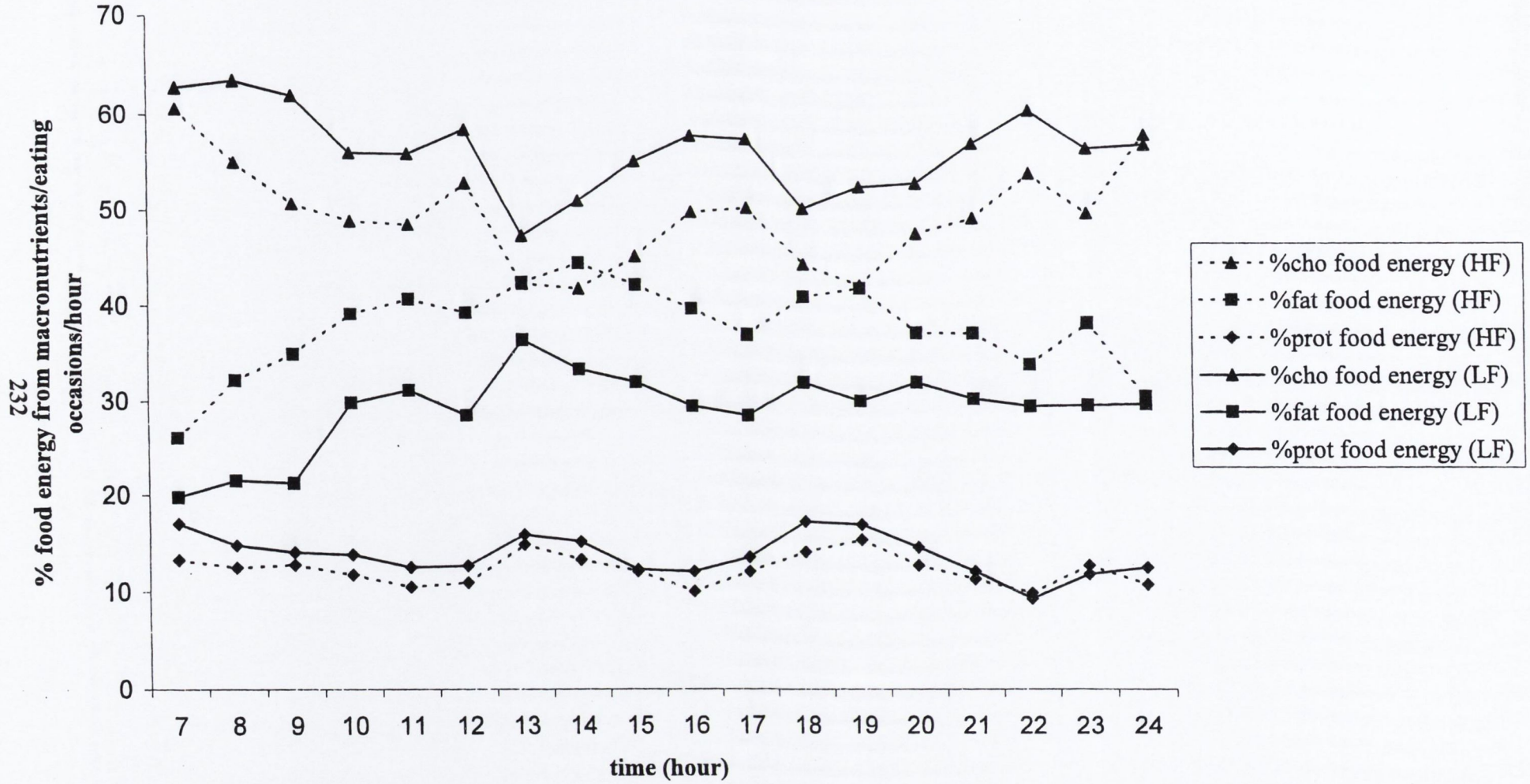


**Figure 5.4:Temporal pattern of mean proportion of food energy from macronutrients during eating occasions/hour of high-fat (HF) and low-fat (LF) consumers**



## 5.5 REFERENCES


Baecke, J.A.H., van Staveren, W.A., & Burema, J. (1983). Food consumption, habitual physical activity and body fatness in young Dutch adults. *American Journal of Clinical Nutrition, 37,* 278-286.

Baghurst, K.I., Baghurst, P.A., & Record, S.J. (1994). Demographic and dietary profiles of high and low fat consumers in Australia. *Journal of Epidemiology and Community Health, 48,* 26-32.

Ballard-Barbash, R., Graubard, B.I., Krebs-Smith, S.M., Schatzkin, A., & Thompson, F.E. (1996). Contribution of dieting to the inverse association between energy intake and body mass index. *European Journal of Clinical Nutrition, 50,* 98-106.

Ballard-Barbash, R., Thompson, F.E., Graubard, B.I., & Krebs-Smith, S.M. (1994). Variability in percent energy from fat throughout the day: implications for application of total diet goals. *Journal of Nutrition Education, 26,* 278-283.

Basdevant, A., Craplet, C., & Guy-Grand, B. (1993). Snacking Patterns in Obese French Women. *Appetite, 21,* 17-23.

Becker, W. (1999). Dietary guidelines and patterns of food and nutrient intakes in Sweden. *British Journal of Nutrition, 81,* S113-S117.

Becker, W., Foley, S., Shelly, E., & Gibney, M. (1999). Energy under-reporting in Swedish and Irish dietary surveys: implications for food-based dietary guidelines. *British Journal of Nutrition, 81,* S127-S131.

Bellisle, F., Dalix, A.M., & De Castro, J.M. (1999). Eating patterns in French subjects studied by the "weekly food diary" method. *Appetite, 32,* 46-52.

Bingham, S.A., Welch, A., Cassidy, A., Runswick, S., Gill, C., & Khaw, K.T. (1991). 24h urine N used to detect bias in the reported habitual food intake of individuals assessed from weighed dietary records. *Proceedings of The Nutrition Society, 50,* 32A

Blundell, J.E., Burley, V., Cotton, J.R., & Lawton, C. (1992). Dietary fat and appetite control: weak effects on satiation (within meals) and satiety (following meals). In D. Mela (Ed.), *Determinants of preference, selection and consumption of dietary fats.* (pp. 79-101). Cambridge, UK: Elsevier.

Blundell, J.E., Burley, V., Cotton, J.R., & Lawton, C. (1993). Dietary fat and the control of energy intake: evaluating the effects of fat on meal size and post-meal satiety. *American Journal of Clinical Nutrition, 57,* S772-S728.

Blundell, J.E., Green, S., & Burley, V. (1994). Carbohydrates and human appetite. *American Journal of Clinical Nutrition, 59,* S728-S734.

Blundell, J.E., & Macdiarmid, J.L. (1997). Fat as a risk factor for overconsumption: Satiation, satiety, and patterns of eating. *Journal of the American Dietetic Association, 97,* S63-S69.

Briefel, R.R., Sempos, C.T., McDowell, M.A., Chien, S., & Alaimo, K. (1997). Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *American Journal of Clinical Nutrition, 65(Suppl),* 1203S-1209S.

Brug, J., van Assema, P., Kok, O., Lenderink, T., & Glanz, K. (1994). Self-rated dietary fat intake: association with objective assessment of fat, psychosocial factors and intention to change. *Journal of Nutrition Education, 26,* 218-223.

Cooling, J., & Blundell, J. (1998). Differences in energy expenditure and substrate oxidation between habitual high fat and low fat consumers (phenotypes). *International Journal of Obesity, 22,* 612-618.

Cotton, J.R., Burley, V., & Blundell, J.E. (1992). Fat and satiety: no additional intensification of satiety following a fat supplemented breakfast. *International Journal of Obesity, 16,* 11

De Henauw, S., & De Backer, G. (1999). Nutrient and food intakes in selected subgroups of Belgian adults. *British Journal of Nutrition, 81,* S37-S42.

Dunne,A. (2000). Department of Statistics, University College Dublin. Personal Communication.

Eurodiet. (2000): htpp://eurodiet.med.uoc.gr

European Heart Network. (1998). *Food, Nutrition and Cardiovascular Prevention in the European Union.* Luxembourg: European Heart Network.

FAO/WHO. (1998). *Preparation and Use of Food-based Dietary Guidelines. WHO Technical Report Series 880.* Geneva: WHO.

Flynn, M.A.T., & Kearney, J.M. (1999). An approach to the development of food-based dietary guidelines for Ireland. *British Journal of Nutrition, 81,* S77-S82.

Flynn, M.A.T., Sugrue, D.D., Codd, M.B., & Gibney, M.J. (1996). Women's dietary fat and sugar intakes: implications for food based dietary guidelines. *European Journal of Clinical Nutrition, 50,* 713-719.

Food Advisory Committee. (1987). *Guidelines for Preparing Information and Advice to the General Public on Healthy Eating.* Dublin, Ireland: Department of Health.

Gibney, M.J. (1990). Dietary guidelines - A critical appraisal. *Journal of Human Nutrition and Dietetics, 3,* 245-254.

Gibney, M.J., & Lee, P. (1991). Formulation of practical advice for reducing fat intakes in unemployed in Dublin. *Journal of Human Nutrition and Dietetics, 4,* 179-184.

Gibney, M.J., Moloney, M., & Shelley, E. (1989). The Kilkenny Health Project: food and nutrient intakes in randomly selected healthy adults. *British Journal of Nutrition, 61,* 129-137.

Gnardellis, C., Boulou, C., & Trichopoulou, A. (1998). Magnitude, determinants and impact of under-reporting of energy intake in a cohort study in Greece. *Public Health Nutrition, 1,* 131-137.

Goldberg, G.R., Black, A.E., Jebb, S.A., Cole, T.J., Murgatroyd, P.R., Coward, W.A., & Prentice, A.M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off values to identify under-recording. *European Journal of Clinical Nutrition, 45,* 569-581.

Goris, A.H.C., Westerterp-Plantenga, M.S., & Westerterp, K.R. (2000). Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake. *American Journal of Clinical Nutrition, 71,* 130-134.

Graça, P. (1999). Dietary guidelines and food nutrient intakes in Portugal. *British Journal of Nutrition, 81,* S99-S103.

Greene, G.W., Rossi, S.R., & Reed, G. (1993). The effect of feedback on dietary intent to reduce fat. *Topics in Clinical Nutrition,* 20-28.

Hampl, J.S., & Betts, N.M. (1995). Comparisons of dietary intake and sources of fat in low- and high-fat diets of 18- to 24-year-olds. *Journal of the American Dietetic Association, 95,* 893-897.

Haraldsdóttir, J. (1999). Dietary guidelines and patterns of intake in Dennmark. *British Journal of Nutrition, 81,* S43-S48.

Health Promotion Unit. (1993). *Healthy Eating.* Dublin: Department of Health.

Heitmann, B.L., & Lissner, L. (1995). Dietary underreporting by obese individuals - is it specific or non-specific? *British Medical Journal, 311,* 986-989.

Heitmann, B.L., Lissner, L., & Osler, M. (2000). Do we eat less fat, or just report so? *International Journal of Obesity, 24,* 435-442.

Hermann-Kunz, E., & Thamm, M. (1999). Dietary recommendations and prevailing food and nutrient intakes in Germany. *British Journal of Nutrition, 81,* S61-S69.

Hirvonen, T., Männistö, S., Roos, E., & Pietinen, P. (1997). Increasing prevalence of underreporting does not necessarily distort dietary surveys. *European Journal of Clinical Nutrition, 51,* 297-301.

Hulshof, K.A.M., Löwik, M.R.H., Kistemaker, C., Hermus, R.J.J., ten Hoor, F., & Ockhuizen, T. (1993). Comparison of dietary intake data with guidelines: some potential pitfalls (Dutch Nutrition Surveillance System). *Journal of the American College of Nutrition, 12,* 176-185.

Johansson, L., Solvoll, K., Bjørneboe, G.A., & Drevon, C.A. (1998). Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. *American Journal of Clinical Nutrition, 68,* 266-274.

Kearney, M., Gibney, M.J., Martinez, J.A., de Almeida, M.D.V., Friebe, D., Zunft, H.J.F., Widhalm, K., & Kearney, J.M. (1997). Perceived need to alter eating habits among representative samples of adults from all member states of the European Union. *European Journal of Clinical Nutrition, 51,* S30-S35.

Koenig, J., & Elmadfa, I. (1999). Food-based dietary guidelines - the Austrian perspective. *British Journal of Nutrition, 81,* S31-S35.

Lawton, C., Delargy, H., Smith, F., Hamilton, V., & Blundell, J.E. (1999). Low fat snacks reduce daily fat intake in high fat consumers by 17%. *International Journal of Obesity, 243,* S56

Lee.P., & Cunningham, K. (1990). *The Irish National Nutrition Survey.* Dublin: Irish Nutrition and Dietetic Institute.

Lichtenstein, A.H., Kennedy, E., Barrier, P., Danford, D., Ernst, N.D., Grundy, S.M., Leveille, G.A., Van Horn, L., Williams, C.L., & Booth, S.L. (1998). Dietary fat consumption and health. *Nutrition Reviews, 56,* S3-S28.

Livingstone, M.B.E., Prentice, A.M., Strain, J.J., Coward, W.A., Black, A., Barker, M.E., McKenna, P.G., & Whitehead, R.G. (1990). Accuracy of weighed dietary records in studies of diet and health. *British Medical Journal, 300,* 708-712.

Lloyd, H.M., Paisley, C.M., & Mela, D.J. (1993). Changing to a low-fat diet: Attitudes and beliefs of UK consumers. *European Journal of Clinical Nutrition, 47,* 361-373.

Löwik, M.R.H., Hulshof, K.F.A.M., & Brussaard, J.H. (1999). Patterns of food and nutrient intakes of Dutch adults according to intakes of total fat, saturated fatty acids, dietary fibre, and of fruit and vegetables. *British Journal of Nutrition, 81,* S91-S98.

Macdiarmid, J.I., Cade, J.E., & Blundell, J.E. (1996). High and low fat consumers, their macronutrient intake and body mass index: further analysis of the National Diet and Nutrition Survey of British Adults. *European Journal of Clinical Nutrition, 50,* 505-512.

Macdiarmid, J.I., Hamilton, V., Cade, J.E., & Blundell, J.E. (1997). Leeds High Fat Study: Behavioural characterization of high and low fat consumers. *Proceedings of The Nutrition Society, 56,* 52A

Margetts, B.M., & Nelson, M. (1997). *Design Concepts in Nutritional Epidemiology.* Oxford: Oxford University Press.

Mela, D.J. (1993). Consumer estimates of the percent energy from fat in common foods. *European Journal of Clinical Nutrition, 47,* 735-740.

Mela, D.J. (1994). The intake and acceptance of fat in the diet. *Nutrition and Food Science, 3,* 19-21.

Mela, D.J. (1995). Understanding fat preference and consumption: applications of behavioural sciences to a nutritional problem. *Proceedings of The Nutrition Society, 54,* 453-464.

Nutrition Advisory Group. (1995). *Recommendations for a Food and Nutrition Policy for Ireland.* Dublin: The Stationery Office.

Poppit, D., Swann, D., Black, A., & Prentice, A.M. (1998). Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *International Journal of Obesity, 22,* 303-311.

Prentice, A.M., Black, A.E., Coward, W.A., Davies, H.L., Goldberg, G.R., Murgatroyd, P.R., Ashford, J., Sawyer, M.B., & Whitehead, R.G. (1986). High levels of energy expenditure in obese women. *British Medical Journal, 292,* 983-987.

Price, G.M., Paul, A.A., Cole, T.J., & Wadsworth, M.E.J. (1997). Characteristics of the low-energy reporters in a longitudinal national dietary survey. *British Journal of Nutrition, 77,* 833-851.

Pryer, J.A., Vrihjheid, M., Nichols, R., Kiggins, M., & Elliot, P. (1997). Who are the 'low energy reporters' in the Dietary and Nutritional Survey of British Adults? *International Journal of Epidemiology, 26,* 146-153.

Roos, E., & Prättälä, R. (1997). Meal pattern and nutrient intake among adult Finns. *Appetite, 29,* 11-24.

Samuelson, G., Bratteby, L.-E., Enghardt, H., & Hedgren, M. (1996). Food habits and energy and nutrient intake in Swedish adolescents approaching the year 2000. *Acta Paediatrica, Suppl 415,* 1-20.

Serra-Majem, L., Ribas, L., & Ramon, J.M. (1999). Compliance with dietary guidelines in the Spanish population. Results from the Catalan Nutrition Survey. *British Journal of Nutrition, 81,* S105-S112.

Skinner, J.D., Salvetti, N.N., Ezell, J.M., Penfield, M.P., & Costello, C.A. (1985). Appalachian adolescents' eating patterns and nutrient intakes. *Journal of the American Dietetic Association, 85,* 1093-1099.

Smith, J.R., Burley, V., Westrate, J., & Blundell, J.E. (1991). Fat and satiety: comparison of the suppressive effect of fat and carbohydrate supplements on energty and nutrient intakes in humans. *International Journal of Obesity, 15,* 11

Subar, A.F., Ziegler, R.G., Patterson, B.H., Ursin, G., & Graubard, B. (1994). US dietary patterns associated with fat intake: The 1987 National Health Interview Survey. *American Journal of Public Health, 84,* 359-366.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1995). Sources of energy from meals versus snacks in 220 people in four age groups. *European Journal of Clincical Nutrition, 49,* 33-41.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1996). Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. *European Journal of Clinical Nutrition, 50,* 513-519.

Tomoyasu, N.J., Toth, M.J., & Poehlman, E.T. (2000). Misreporting of total energy intake in older African Americans. *International Journal of Obesity, 24,* 20-26.

Valsta, L.M. (1999). Food-based dietary guidelines for Finland - a staged approach. *British Journal of Nutrition, 81,* S49-S55.

van Amelsvoort, J.M.M., van Stratum, P., Kraal, J.H., Lussenburg, R.N., & Houtsmuller, U.M.T. (1989). Effects of varying the carbohydrate:fat ratio in a hot lunch on postprandial variables in males volunteers. *British Journal of Nutrition, 61,* 267-283.

Wheelock, V. (1997). *Implementing Dietary Guidelines For Healthy Eating.* London: Blackie Academic & Professional.

WHO. (1990). *Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series No. 797.* Geneva: WHO.

Whybrow, S., & Kirk, T.R. (1997). Nutrient intakes and snacking frequency in female students. *Journal of Human Nutrition and Dietetics, 10,* 237-244.

Williams, C.M., Wiseman, M., & Buttriss, J. (1999). Food-based Dietary Guidelines - A staged approach. *British Journal of Nutrition, 81:*Suppl 2

Winkler, G., Doring, A., & Keil, U. (1999). Meal patterns in middle-aged men in Southern Germany: results from the MONICA Augsburg Dietary Survey 1984/85. *Appetite, 32,* 33-37.

# CHAPTER 6

## The effect of differences in periodicity of eating on mean daily macronutrient intakes and the temporal pattern of macronutrient intake during eating occasions throughout the day

## 6.1 INTRODUCTION

An increased periodicity of eating or eating several times a day, has become a more common eating pattern in many populations, replacing the more traditional eating pattern of having 3 meals a day. Reports of 4-8 eating occasions per day have been found in many populations in recent times (Bellisle *et al.*, 1995; Gatenby *et al.*, 1995; Gatenby, 1997; Kirk *et al.*, 1995; Drummond *et al.*, 1996). A mean daily eating frequency of 4-6 eating occasions per day, has also been reported in Ireland (McGrath & Gibney, 1994; Bellisle *et al.*, 1995). In the 1960s-70s, there was a significant interest in studying the implication of different eating frequencies on human health. An increased frequency of eating was found to be associated with weight maintenance (Fabry *et al.*, 1964; 1966; Metzner *et al.*, 1977), and improved glucose (Gwinup *et al.*, 1963a; Jenkins *et al.*, 1992; 1994) and lipid metabolism (Fabry *et al.*, 1968; Jenkins *et al.*, 1989; Edelstein *et al.*, 1992; Jones *et al.*, 1993). More recently a workshop reviewed much of this work and found these associations are as yet inconclusive (Gibney & Wolever, 1997). With an increased frequency of eating came the notion that snacks are high in fat and can have a negative effect on the nutrient content of the diet (Chapman & Maclean, 1993; Roos *et al.*, 1993; Drummond *et al.*, 1996). Studies were undertaken, which investigated the average nutrient composition of meals compared to snacks and found that contrary to popular opinion, snacks were of lower fat density than meals (Basdevant *et al.*, 1993; Summerbell *et al.*, 1995; Whybrow & Kirk, 1997). Snacks derived 26-38% of total energy from fat and meals derived 36-43% of total energy from fat. Although no difference in the fat content of meals and snacks was also observed (Gatenby *et al.*, 1995; Drummond *et al.*, 1998). Other studies addressed the contribution of different meals and snacks to mean daily nutrient intakes (Skinner *et al.*, 1985; Hackett *et al.*, 1986; Robson & Strain, 1991; Livingstone, 1991; Summerbell *et al.*, 1995; Ruxton *et al.*, 1996).

Few studies however, have examined the effect of different periodicities of eating on the nutrient content of the diet and no study has investigated the pattern of nutrient intake during eating occasions throughout the day, in those with different periodicities of eating. Two studies addressed the effect of eating frequency on the diet and in general, found little difference in average daily nutrient intakes, with different periodicities of eating. In a study of

44 Scottish female students, no difference in percentage energy from fat, protein, carbohydrate or micronutrient intakes was found between the top and bottom tertile of eating frequency (Whybrow & Kirk, 1997). Roos & Prättälä, (1997) divided 1689 Finnish men and women into two categories, those with at least 3 meals a day and those with 2 meals a day, and found no difference in average daily nutrient intakes between the two groups in men and only small effects in women.

The prevalence of an increased eating frequency in populations calls for more research of this area. This fact has been recognised more recently. In 1994, the International Union of Nutritional Sciences established the Committee on Nutrition and Food Habits to review the impact of changing food choice and habits on nutritional status (Oltersdorf, 1996; Oltersdorf *et al.*, 1999). Furthermore, in 1996, a workshop entitled 'Periodicity of Eating and Health' undertook a multi-disciplinary review of the metabolic and behavioural effects of eating frequency (Gibney & Wolever, 1999). The health implications of different periodicities of eating requires further investigation. Determination of the impact of different periodicities of eating, on both mean daily nutrient intakes and the pattern of nutrient intake during eating occasions throughout the day is required. It is not known whether and how, the pattern of nutrient intake during eating occasions throughout the day, of those with different periodicities of eating differ. It should be determined whether individuals with different periodicities of eating eat similar amounts of nutrients during eating occasions throughout the day or do those who eat more frequently eat less during eating occasions. The fat content of meals is higher than that of snacks according to some reports (Basdevant *et al.*, 1993; Summerbell *et al.*, 1995; Whybrow & Kirk, 1997). It is not known whether periodicity of eating determines the frequency and amount of fat consumed at eating occasions during the day. It is uncertain whether eating more or less often is characteristic or should be advocated, as a healthier eating pattern. Therefore a greater understanding, of the temporal pattern of eating and nutrient intakes of those with different periodicities of eating, will assist in the development of evidence-based dietary advice and food-based dietary guidelines (FBDG).

In the present study, a dietary survey was undertaken to investigate the effect of different periodicities of eating on mean daily macronutrient intakes and the temporal pattern of macronutrient intake during eating occasions throughout the day.

## 6.2 METHODS

### 6.2.1 Subject Recruitment

Details of the subject recruitment procedure are described in Chapter 2. In brief, healthy adults were recruited from a city local authority. Eligible subjects were healthy male and female adults aged 18 – 64 years, who were not working shift-work or over-time and females who were not pregnant or lactating.

### 6.2.2 Dietary Assessment Procedure

Subjects completed a 7-day food diary in which they recorded the amount of food and drink consumed and the time of consumption. A comprehensive description of the procedures used during the dietary assessment, to obtain acceptable data on the nutrient content of eating occasions, are described in Chapter 2, including the instructions given to subjects, the method of food quantification and details of the nutrient analysis. The definition of an eating occasion in the present study is also fully described in Chapter 2. In brief, eating occasions were defined by time and coded to the nearest hour such that an eating occasion included every item of food or drink consumed within an hourly period. Eating occasions of non-nutritive value were not included in the analysis.

### 6.2.3 Anthropometry

Body weight (kg) and height (m) were measured. Details of the procedures used are described in Chapter 2.

### 6.2.4 Quality and Validity of Dietary Data

All food diaries were completed during September to mid-December 1995 and details of quality procedures used are described in Chapter 2.

The validity of the food intake data of the full population was assessed by measuring the validity of the energy intakes reported in the study and is fully described in Chapter 2. This involved the calculation of the mean ratio of energy intake to estimated basal metabolic rate ($EI/BMR_{est}$), as proposed by Goldberg *et al*, (1991). The validity of the reported energy intakes was assessed, at group level, by comparing the mean $EI/BMR_{est}$ with the cut-off value which represented the lowest expected mean $EI/BMR_{est}$ for this study sample size with 7 days of food intake data, calculated using the Goldberg equation.

The validity of the reported energy intakes was also assessed at the individual level. The proportion of individuals in the study sample that were under-reporting was calculated. Individuals with an $EI/BMR_{est}$ value less than the cut-off of 1.05 were considered to have invalid energy intakes and were called under-reporters. The cut-off of 1.05 represents the lowest expected $EI/BMR_{est}$ value for an individual with 7 days of food intake data. Individuals with an $EI/BMR_{est}$ value $\geq$ 1.05 were considered to have valid reported energy intakes and were referred to as adequate reporters.

The validity of the food intake data in both the high eating frequency and low eating frequency groups, in the present study was also assessed. Specific cut-off values were calculated for each group.

### 6.2.5 Data analysis

Data analysis was conducted using SPSS® 8.0 statistical software package (SPSS Inc, Chicago, USA.). The SPSS® database had an entry for every hour (01.00-24.00hours) of each of the 7 days for each subject. The nutrient composition data, of every eating occasion of each subject during the 7 days, was presented at the specific hour of consumption.

The mean daily eating frequency was calculated for each subject as the sum of daily eating frequencies, where an eating occasion was defined as having greater than 0MJ of energy, divided by the number of recording days. The group median daily eating frequency was then calculated. The sample was split into two groups, high eating frequency and low eating frequency groups, using the median eating frequency per day (5.5714). Those with a high

eating frequency were defined as those with a mean daily eating frequency above the median value and those with a low eating frequency, were those with a mean daily eating frequency below the median value. These groups are hereafter referred to as the HEF group, for those with a high eating frequency and the LEF group, for those with a low eating frequency.

*Temporal pattern of mean macronutrient intake during eating occasions*

Four approaches were explored to calculate the temporal pattern of mean macronutrient intake during eating occasions throughout the day. They are fully described with examples in Chapter 3. The *eating occasion by individual method* was selected as the most appropriate method to determine the temporal pattern of mean macronutrient intake during eating occasions (> 0MJ) per hour in the HEF and LEF groups and is recapped below:

*The eating occasion by individual method (method 4):* This method ensures that all individuals contribute in a similar way to the mean value. Firstly, for each subject, the total nutrient intake consumed during eating occasions at a particular hour during the 7 days was summed and divided by the frequency the subject had an eating occasion (>0MJ) at that hour during the 7 days. Thereafter the mean intake for each individual who ate at an hour was summed and divided by the number of consumers at that hour to produce a mean population nutrient intake at each hour.

This method was used to present the temporal pattern of the mean macronutrient intake during eating occasions (> 0MJ) at each hour of the day, in terms of energy intakes (MJ), absolute intakes of macronutrients and macronutrient intakes as proportions of energy, for the HEF and LEF groups (Figures 6.1 to 6.4, respectively). Analysis of the temporal pattern of mean macronutrient intake during eating occasions (> 0MJ) per hour for 24 hours, showed that there were no eating occasions at hours 4.00 and 5.00 and few eating occasions at hours 1.00, 2.00, 3.00 and 6.00. Therefore Figures 6.1 to 6.4 present data for 18 hours only (hours 7.00 to 24.00).

### 6.2.6 Statistical analysis

Mean ± standard deviation (SD) values were calculated for anthropometric measurements, $EI/BMR_{est}$ values, energy and macronutrient intakes for the HEF and LEF groups and for the men and women of the each group separately. Differences in the mean anthropometric measurements, $EI/BMR_{est}$ values and mean daily eating frequency, energy and macronutrient intakes between the HEF and LEF group were assessed. Differences in these variables between men and women in each eating frequency group were also assessed. Independent t-tests were used to test for differences in normally distributed data and the Mann-Whitney non-parametric test was used to test for differences in data which did not follow a normal distribution. Differences in mean macronutrient intakes between men and women of the HEF and LEF groups were carried out using 2-way analysis of variance (ANOVA).

Differences in the temporal pattern of macronutrient intake during eating occasions per hour between the HEF and LEF groups and the effect of gender, were carried out using Split-plot in Time Analysis of Variance (Dunne, 2000). This statistical test assessed interactions of HEF and LEF groups (HEFLEF) x hour, HEFLEF x sex, sex x hour and HEFLEF x hour x sex for energy (MJ), absolute intakes of macronutrients (g) and proportions of total and food energy from macronutrients. Values of $P<0.05$ were taken as statistically significant. Tables and graphs were created using Microsoft® Excel spreadsheets (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.).

## 6.3 RESULTS

### 6.3.1 Response Rate

133 subjects (55 men, 78 women) met the study's eligibility criteria, with a final response rate of 91%. Full details of the response rate of the study sample are described in Chapter 2 (Table 2.1). The HEF group contained 70 subjects (27 men, 43 women) and the LEF group contained 63 subjects (28 men, 35 women).

### 6.3.2 Validity of reported energy intakes

The mean ± SD EI/$BMR_{est}$ of the total study sample was 1.54 ± 0.4 (1.63 ± 0.4 in men, 1.48 ± 0.3 in women) with a significant difference between men and women ($P$=0.02) as described in Chapter 2. This mean EI/$BMR_{est}$ value was higher than the calculated cut-off value of 1.50, that Goldberg *et al.*, (1991) proposed as the lowest expected mean EI/$BMR_{est}$ value, that could reflect actual energy intake of a population of this size, with 7 days of food intake data. Some 7% of this population was identified as under-reporters (4% of men, 9% of women).

The mean ± SD EI/$BMR_{est}$ was significantly higher in the HEF group than the LEF group ($P$<0.001), 1.66 ± 0.4 vs. 1.42 ± 0.3 respectively (Table 6.1). This observation held through within the sexes, with higher mean EI/$BMR_{est}$ values in the HEF group compared to the LEF group, within each sex ($P$<0.05). There was no significant difference in mean EI/$BMR_{est}$ between the sexes in the HEF group but the mean EI/$BMR_{est}$ was significantly greater in men compared to women in the LEF group ($P$=0.013). A group specific cut-off value of 1.48 was obtained for the HEF group using the Goldberg equation. This value was considered the lowest expected mean EI/$BMR_{est}$ value, that could reflect actual energy intake for the HEF group. The mean EI/$BMR_{est}$ value of the HEF group (1.66) was higher than this value. The mean EI/$BMR_{est}$ value of the LEF group (1.42) was marginally lower than the calculated Goldberg cut-off value of 1.48 that was specific to that group size. The proportion of the HEF group identified as under-reporters was 4.2% (n=3), (7.4% of men, 2.3% of women) and the proportion of the LEF group identified as under-reporters was 9.5% (n=6), (0% of men, 17.1% of women).

### 6.3.3 Mean daily nutrient intakes & subject characteristics

Table 6.1 presents the mean anthropometric measurements, mean daily eating frequency, energy and macronutrient intakes of the HEF and LEF groups and for men and women in each group. There were no significant differences in the mean age, weight, height or BMI between the HEF and LEF group. The HEF group had significantly higher mean daily energy intakes than the LEF group ($P$=0.015). The mean daily proportions of total energy from carbohydrate ($P$=0.006) and sugars ($P$=0.001) were higher in the HEF group compared to the LEF group and the proportion of total energy from protein was higher in the LEF group than in the HEF

group ($P$=0.002). There were no differences in the proportions of energy from fat, starch or alcohol between the groups. Excluding alcohol, the significant differences in the percentage of food energy derived from carbohydrate ($P$=0.007) and protein ($P$=0.001) between the two groups continued to be seen.

Men had higher energy intakes compared to women in both the HEF and the LEF groups ($P$<0.001) and consequently higher intakes of all macro-nutrients. There were no significant differences in the contribution of macronutrients to energy including or excluding alcohol, between the men and women, within the HEF and LEF groups. Differences in energy and macronutrient intakes, between the HEF and LEF group within each sex, were also investigated. Women in the HEF group had a significantly higher mean daily energy intake ($P$<0.001) and proportion of total energy from sugar ($P$=0.047) than women of the LEF group and the women in the LEF group had higher proportions of total and food energy from protein ($P$<0.05). There were no significant differences in the proportions of energy from fat (% total and food energy), carbohydrate (% total and food energy), starch (% total energy) and alcohol (% total energy), between women in the HEF and LEF groups. The differences observed between the men of the HEF and LEF groups were comparable to those differences observed for the women, with the exception of carbohydrate. A significantly higher carbohydrate intake (% total and food energy) was observed in the men of the HEF group compared to the men of the LEF group ($P$<0.01).

Characteristics of the total study sample, including mean anthropometric data and mean daily nutrient intakes, are fully described in the results section in Chapter 2 and presented in Table 2.2 of Chapter 2. The socio-demographic and lifestyle characteristics of the men, women and the total sample have also been fully described in Chapter 2 (Table 2.5).

### 6.3.4 Temporal pattern of macronutrient intake during eating occasions

The temporal pattern of mean energy intakes (MJ), absolute intakes of macronutrients (g) and macronutrient intakes expressed as percentages of total energy and food energy, consumed during eating occasions (>0 MJ) at each hour, by those with a HEF and LEF are presented in Figures 6.1, 6.2, 6.3 and 6.4 respectively. The n values at each hour are presented in Table 6.2.

The n value at each hour is the number of subjects included in the mean calculation at the hour, who ate at least once at that hour during the 7 days of recording.

The mean energy content (MJ) of eating occasions increased over the course of the day in both HEF and LEF groups, with peaks occurring at 13.00 - 14.00 hours and 18.00 - 19.00 hours (Figure 6.1). These time points are equivalent to lunch time and evening meal times. The energy content of eating occasions in the morning hours were almost identical between the groups, but the LEF group had somewhat higher energy intakes during eating occasions from 12.00 hours throughout the rest of the day. Differences of 0.2-0.7MJ of energy during eating occasions were observed between the two groups. There was no significant difference observed in the pattern of energy intake throughout the day between the two groups according to the HEFLEF x hour interaction ($P > 0.05$).

Mean intakes of protein, fat and carbohydrate (g) during eating occasions increased throughout the day in both HEF and LEF groups, with peaks occurring at 13.00 - 14.00 hours and 18.00 - 19.00 hours, as observed for the energy content of eating occasions (Figure 6.2a & 6.2b). The intakes of these macronutrients (g) during eating occasions in the morning hours were almost identical, between the HEF and LEF groups. The LEF group had greater intakes (g) of protein, fat and carbohydrate during eating occasions throughout the rest of the day, as observed with energy. Alcohol was consumed during eating occasions from 11.00 – 12.00 hours, in both the HEF and LEF groups. The average amounts consumed during eating occasions throughout the day and the patterns of alcohol intake were similar between the two groups ($P > 0.05$). Alcohol intake during eating occasions increased during the day, with peaks at 18.00 hours and 21.00 - 23.00 hours.

The mean macronutrient composition (% total and food energy) of eating occasions at each hour, of the HEF and LEF groups, is shown in Figure 6.3 and 6.4. When macronutrient intakes during eating occasions were expressed as percentages of food energy as opposed to total energy, there was little difference in the temporal patterns of nutrient intake. The distribution of energy between macronutrients, during eating occasions at each hour, was very similar for the HEF and LEF groups ($P > 0.05$). The percentage of energy from fat during

eating occasions at each hour was almost identical for the HEF and LEF groups. The percentage of energy from carbohydrate during eating occasions was also similar, with somewhat higher carbohydrate intakes (% energy) during eating occasions of the HEF group in the late morning (12.00 hours) and afternoon (16.00 - 17.00 hours). The percentage of energy from protein during eating occasions at each hour was almost identical for most hours of the day for the HEF and LEF groups, with the exception of slightly higher protein intakes during eating occasions in the evening hours (17.00 – 20.00 hours) of the LEF group. This was detected in the HEFLEF x hour interaction which showed significance for the proportion of food energy from protein ($P$=0.039). Overall the temporal pattern of macronutrient intake (% of energy) during eating occasions throughout the day was comparable for the HEF and LEF groups. The pattern of lowest fat containing (21-29% of food energy) eating occasions in the early morning hours and higher fat containing (32-40% of food energy) eating occasions throughout the rest of the day was observed. This was also seen for the HF and LF groups in Chapter 5.

## 6.4 DISCUSSION

The validity of the reported energy intakes of the total study sample was examined and described in Chapter 2. The dietary data of the total sample was considered acceptable and valid, with a small proportion of individuals under-reporting energy intake. The validity of the dietary data of the HEF and LEF group must also be examined, to avoid misinterpretation of unfounded relationships (Summerbell *et al.*, 1996; Bellisle *et al.*, 1997; Gatenby, 1997; Kirk, 2000). This is especially important in light of the evidence that meals and snacks are under-reported during dietary assessment (Livingstone *et al.*, 1990; Heitmann & Lissner, 1995; Summerbell *et al.*, 1996; Briefel *et al.*, 1997; Poppitt *et al.*, 1998). The validity of the data at group and at the individual level will be considered in turn.

### Validity of reported food (energy) intakes

The observation of a significantly higher mean EI/$BMR_{est}$ in the HEF group compared to the LEF group, could initially suggest under-reporting of energy intakes in the LEF group, which

would require caution in the interpretation of any comparisons made between these two groups. When compared to the group specific cut-off values though, the mean $EI/BMR_{est}$ of the HEF group was found to be higher than the relevant cut-off and the mean $EI/BMR_{est}$ of the LEF group was in fact close to its relevant cut-off. The reported energy intakes of both the HEF and LEF groups can thus be considered valid estimates of the actual intake during the recording period, at group level. Furthermore underestimation of energy intakes was observed to be less of an issue in this study than has been reported by other investigators. As discussed in Chapter 2, Black *et al.*, (1991) reported that a large proportion (68%) of the study groups examined in a review of 37 published studies, had a mean $EI/BMR_{est}$ below the Goldberg *et al.*, (1991) study specific cut-off.

The observation of a lower proportion of under-reporters in the HEF group compared to the LEF group, could also suggest a higher level of under-reporting in the LEF group. The prevalence of under-reporting in both of these groups was lower however, than the prevalence of under-reporting observed in most published studies (12-52%) (Heywood *et al.*, 1993; Ballard-Barbash *et al.*, 1996; Briefel *et al.*, 1997; Hirvonen *et al.*, 1997; Lafay *et al.*, 1997; Pryer *et al.*, 1997; Price *et al.*, 1997; Gnardellis *et al.*, 1998; Johansson *et al.*, 1998), as discussed in Chapter 2. Comparisons between studies are challenged by the fact that the dietary assessment method and the cut-off values used to determine the proportion of under-reporters, varied considerably between studies. The proportions of under-reporting observed in the HEF and LEF groups in the present study, were also lower than those observed in recent studies of eating frequency, which can be attributed to the intensive assessment methodology. Reports of 19% and 17% of subjects under-reporting (mean $EI/BMR_{est}$ of less than 1.10) were made in studies which used a 7-day unweighed food diary, with 95 Scottish adults (Drummond *et al.*, 1998) and a 7-day weighed record, with 54 Scottish students (Whybrow & Kirk, 1997) respectively. Using a 7-day weighed diary and the same cut-off, Summerbell *et al*, (1996) observed under-reporting levels of 18% and 30% in British adolescent and middle-aged groups respectively. In the same study Summerbell *et al.*, (1996) considered an adult group (n=59) with 8% of the group under-reporting, to record valid estimates of their energy intake and considered an elderly group (n=88) with 11% of the group under-reporting, to have valid estimates 'to a lesser extent'.

**Mean daily nutrient intakes**

Periodicity of eating has been scantily studied in adult populations and few studies, to date, have compared the nutrient intakes of those with different periodicities of eating. Early studies which investigated the implications of eating frequency on human health (obesity, plasma lipids and glucose), kept mean daily energy and macronutrient intakes constant, whilst the frequency of eating was altered (Gwinup *et al.*, 1963a 1963b; Jagannathan *et al.*, 1964; Knittle, 1966; Bortz *et al.*, 1969; Finkelstein & Fryer, 1971; Wadhwa *et al.*, 1973; Jenkins *et al.*, 1989; Jones *et al.*, 1993). Only 7 studies were found in the literature to have made reference to the average daily nutrient intakes of those with different periodicities of eating in adult populations (Basdevant *et al.*, 1993; Drummond *et al.*, 1998; Edelstein *et al.*, 1992; McGrath & Gibney, 1994; Redondo *et al.*, 1997; Roos & Prättälä, 1997; Whybrow & Kirk, 1997). Table 6.3 summarises details of these seven studies. Only two of these studies specifically examined the effect of eating frequency on mean daily nutrient intakes (Roos & Prättälä, 1997; Whybrow & Kirk, 1997). Differences in the dietary assessment methods used, the definition of an eating occasion, the definition of those with high and low frequencies of eating and the country of origin of the populations studied however, makes comparisons between these studies difficult.

The finding of higher mean daily energy intakes in the HEF group compared to the LEF group was previously reported. Edelstein *et al.*, (1992), in a study of 2034 American men and women, observed higher energy intakes in those who ate more frequently. Basdevant *et al.*, (1993) reported higher energy intakes in snackers (those deriving at least 15% of mean daily energy intake from snacks) compared to non-snackers, in a study of 273 obese French women. Roos and Prättälä, (1997) found higher energy intakes (in women only) in those consuming the conventional Finnish meal pattern (3 meals or more/day) compared to those consuming two meals or less per day, in a study of 1689 adult Finns. Whybrow & Kirk, (1997) reported higher energy intakes in the highest eating frequency tertile of 44 Scottish female students. Eating frequency was found to be positively correlated with energy intakes in women, but not men, in a study of 79 Scottish men and women (Drummond *et al.*, 1998). The large energy intakes of athletes have also been reported to be associated with a high eating frequency (Hawley & Burke, 1997).

Regarding fat intakes, Roos & Prättälä, (1997) and Whybrow & Kirk, (1997) observed no difference in proportions of total energy from fat between the HEF and LEF groups, as observed in the present study, although there have been reports of differences in fat intakes with different periodicities of eating. Edelstein *et al.*, (1992) reported higher absolute intakes of fat in those who ate more frequently and Basdevant *et al.*, (1993) reported higher fat intakes in snackers in terms of proportions of energy. Conversely, a lower fat intake (% total energy) was observed in subjects with a high meal-eating frequency by McGrath & Gibney, (1994), compared to when these subjects changed their eating pattern to that of a low meal-eating frequency.

Carbohydrate intake (proportions of total and food energy) in this study, was observed to be higher in those with a HEF, in men only. Of the studies presented in Table 6.3, a difference in carbohydrate intakes between HEF and LEF groups was only observed by Redondo *et al.*, (1997) and Drummond *et al.*, (1998). Redondo *et al.*, (1997) observed increasing carbohydrate intakes (both g and % of energy) with a greater number of meals consumed per day in a study of 150 Spanish elderly subjects. Drummond *et al.*, (1998) showed that eating frequency was positively correlated with carbohydrate intakes (% total energy) in both men and women. The proportion of energy from sugar in the present study was higher in men and women with a HEF. Drummond *et al.*, (1998) reported eating frequency to be correlated with absolute intakes of sugar in women only and there was no correlation with the proportion of energy from sugar. The lower protein intake (proportions of total energy) observed in the HEF group in the present study was also reported by other investigators (Basdevant, 1993; McGrath & Gibney, 1994), though no difference was observed by others (Roos & Prättälä, 1997; Whybrow & Kirk, 1997). Alcohol intakes (g and % energy) did not differ between HEF and LEF groups, as previously reported (Whybrow & Kirk, 1997; Drummond *et al.*, 1998), although alcohol intakes (g) have been reported to be lower (Edelstein *et al.*, 1992; Roos & Prättälä, 1997) in those who ate more frequently.

Overall, the main effects of a higher periodicity of eating on mean daily macronutrient intakes in the present study, was an increase in carbohydrate intake (in men only) and sugar intake (in both men and women) and a decrease in protein intake, when intakes are expressed as

proportions of energy. Mean daily fat and alcohol intakes were not effected. The fat intake of this population (37.8%) was higher than the current dietary recommendations of 35% of food energy from fat (Food Advisory Committee, 1987) and this was irrespective of the periodicity of eating of the population. This finding agrees with that of Whybrow & Kirk, (1997) who investigated periodicity of eating in Scottish female students.

**Temporal pattern of macronutrient intake during eating occasions throughout the day**

To date, no study has investigated the nutrient quality of the eating occasions of individuals eating more or less frequently. It is also unknown whether there is variation in the nutrient quality of eating occasions during the day with different periodicities of eating.

This study revealed remarkably comparable temporal patterns of eating for the HEF and LEF group. The energy content of the eating occasions of the HEF and LEF groups were low in the early morning hours and higher at two time points later in the day, 13.00 - 14.00 hours and 18.00 - 19.00 hours. The LEF group had eating occasions with a somewhat greater energy content (0.2 – 0.7M of energy) from 12.00 hours throughout the rest of the day. This observation was explained by the fact that, on average, those who eat less often during the day eat more during eating occasions, which was the converse of that observed for the mean daily energy intakes (i.e. the HEF group had higher daily energy intakes than the LEF group). When the mean daily energy intake of each group was divided by its relative mean daily eating frequency, the LEF group was found to have a greater average energy intake per eating occasion than the HEF group (1.99MJ ± 0.53 vs. 1.67MJ ± 0.46 respectively, $P<0.001$, data not shown). Whybrow & Kirk, (1997) reported similar findings, with a decrease in the size (energy content) of both meals and snacks (though not significant), in the highest tertile of eating frequency compared to the lowest tertile of eating frequency. Whybrow & Kirk, (1997) also observed higher mean daily energy intakes in the highest tertile of eating frequency, as observed in the present study.

The increase in energy intake during eating occasions in both the HEF and LEF groups was due to an increase in the intake of the three macronutrients, protein, fat and carbohydrate. This reflected the pattern of energy intake during eating occasions throughout the day. The

intake of the three macronutrients during eating occasions, were somewhat greater in the LEF group from 12.00hours, which reflected the energy differences during eating occasions, between the groups.

It was interesting that, despite the slightly higher energy content of the eating occasions of the LEF group from 12.00 hours, the fat content of eating occasions (as percentages of energy) did not differ between the two groups. This observation reflected the difference in mean daily percentages of energy from fat between the groups. The temporal pattern of fat intake during eating occasions (as percentages of energy) throughout the day, varied little with periodicity of eating. A particular pattern of periodicity of eating was not associated with eating occasions of higher fat content (% of energy) at any time during the day. Both HEF and LEF groups had a temporal eating pattern of lowest fat eating occasions in the morning hours. The groups had similar fat intakes during eating occasions throughout the rest of the day. The eating occasions of the HEF group in the afternoon and late evening hours were of somewhat greater carbohydrate content (% of energy), which may explain the greater mean daily carbohydrate intakes of the HEF group. These hours may relate to times when the additional eating occasions of the HEF group were consumed in the form of snacks. Indeed snacks have been found to be of high carbohydrate content (% of energy) in adult populations, (Basdevant *et al.*, 1993; Gatenby *et al.*, 1995; Drummond *et al.*, 1998), in contrast to earlier beliefs when snacks were thought to be higher in fat (Roos *et al.*, 1993; Drummond *et al.*, 1996. The somewhat greater protein intake (% of energy) during eating occasions of the LEF group in the late evening, may explain the higher mean daily protein intake (% of energy) of the LEF group. Overall however, these findings suggest that the temporal pattern of macronutrient intake during eating occasions, does not vary to a great extent throughout the day, with different periodicities of eating. Those with a HEF do not have eating occasions of higher fat content than those with a LEF.

The temporal pattern of fat intake (as percentages of energy) during eating occasions throughout the day revealed very interesting results. With concerns that eating more frequently and the consumption of snacks may increase the fat content of the diet some studies have investigated the macronutrient composition of meals compared to snacks (Basdevant *et*

*al.*, 1993; Summerbell *et al.*, 1995; Whybrow & Kirk, 1997). In general it has been found that meals are higher in fat (% of energy) compared to snacks. This observation is confounded by the fact that all meals of the day were combined together and all snacks were also combined together in the calculations. The temporal pattern of fat intake (% of energy) during eating occasions per hour in the present study, provided greater insight into the fat content of eating occasions during the day. Eating occasions in the morning hours were lowest in fat (% energy) but fat intakes were generally comparable during eating occasions at all other hours of the day. Eating occasions during the late morning, mid-afternoon and late evening, which represents traditional snack times of eating, were not remarkably different in fat content (% energy) to eating occasions at other times of the day, with the exception of the morning eating events. Furthermore, studies, which compared the nutrient composition of meals and snacks, are difficult to interpret due to inconsistencies in defining 'meals' and 'snacks', which is a well recognised challenge in eating frequency research (Gatenby, 1997; Lennernäs & Andersson, 1999). The findings of the present study suggest it may not be appropriate to specifically target meals for dietary fat reduction. This is supported by the observation in Chapter 5, that periodicity of eating did not differ between those consuming a high- or low-fat diet.

Overall these findings suggest that periodicity of eating did not influence the macronutrient composition of mean daily macronutrient intakes of this population, as concluded by Gibney & Wolever, (1997). The temporal pattern of macronutrient intake during eating occasions throughout the day was also not influenced by periodicity of eating. A particular periodicity of eating was not associated with a daily macronutrient intake that approached the dietary recommendations for fat or carbohydrate. The somewhat higher carbohydrate intake (% energy) in those with a HEF was probably due to the consumption of high carbohydrate eating occasions or possibly snacks, in the late morning, mid-afternoon and late evening. The findings of this study provide no evidence for advocating a particular periodicity of eating to improve the macronutrient composition of the diet. These results are important as attempts to alter established eating frequency have been found to be extremely difficult (King & Gibney, 1999). King & Gibney, (1999) found that advice to reduce dietary fat intake was more easily achieved, without advice to alter usual eating frequency.

In conclusion, the results of the present study found periodicity of eating to have little impact on the mean daily macronutrient intake or temporal pattern of macronutrient intake. The impact of periodicity of eating on the intake of other nutrients, such as fibre and the micronutrients, and on food intake needs to be established. How does periodicity of eating influence the overall nutrient density of the diet? At present there is limited information in relation to this (Ruxton *et al.*, 1996; Whybrow & Kirk, 1997). The data are an important basis in relation to temporal patterns of nutrient intake however, as the study showed that more than 70% of the men and women in this study had a mean daily eating frequency of 5 eating occasions per day. The potential effects of eating frequency on lipoprotein metabolism and energy balance stresses the importance of future investigations of the metabolic effects of periodicity of eating. Furthermore within the context of FBDG this study provides fundamental data, for the development of public health nutrition policies to promote and improve health, by defining the baseline state in relation to current patterns of temporal nutrient intakes in Ireland.

**Table 6.1: Mean and standard deviation (SD) values of anthropometric measurements, $EI/BMR_{est}$ values, daily eating frequency, energy and macronutrient intakes of high eating frequency (HEF) and low eating frequency (LEF) groups by sex**

| | High Eating Frequency Group (HEF) | | | | | | | Low Eating Frequency Group (LEF) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All (n=70) † | | Males (n=27) | | Females (n=43) | | | All (n=63) | | Males (n=28) | | Females (n=35) | | |
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *P* ‡ | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *P* ‡ |
| Age (years) | 36.8 NS | (8.1) | 40.9 | (6.4) | 34.3 | (8.1) | ** | 36.5 | (10.7) | 40.7 | (10.5) | 33 | (9.8) | ** |
| Weight (kg) | 72.9 NS | (11.8) | 82.7 | (9.3) | 66.7 | (8.6) | *** | 76.5 | (13.4) | 87.2 | (9.3) | 67.9 | (9.4) | *** |
| BMI | 25.3 NS | (3.2) | 26.6 | (3.0) | 24.5 | (3.1) | ** | 26.1 | (3.4) | 27.3 | (3.4) | 25.2 | (3.1) | * |
| $EI/BMR_{est}$ | 1.66 *** | (0.4) | 1.74 | (0.5) | 1.6 | (0.3) | NS | 1.4 | (0.3) | 1.52 | (0.2) | 1.34 | (0.3) | * |
| Under-reporters (%) | 4.2 | | 7.4 | | 2.3 | | | 9.5 | | 0 | | 17.1 | | |
| Mean daily Eating Frequency | 6.6 *** | (0.9) | 6.7 | (0.8) | 6.5 | (0.9) | NS | 4.9 | (0.4) | 5 | (0.3) | 4.8 | (0.4) | NS |
| Kcal | 2615.1 * | (741.8) | 3174.9 | (807.8) | 2263.6 | (414.9) | *** | 2335.6 | (638.7) | 2862.2 | (459.7) | 1914.3 | (406.0) | *** |
| MJ | 11041.8 * | (3179.9) | 13525.5 | (3388.5) | 9482.2 | (1746.1) | *** | 9782.1 | (2670.5) | 11982.3 | (1923.2) | 8021.8 | (1700.2) | *** |
| Protein (g) | 87.2 NS | (21.5) | 103 | (21.6) | 77.3 | (14.5) | *** | 84.1 | (21.1) | 101.4 | (15.3) | 70.4 | (13.8) | *** |
| Carbohydrate (g) | 323.2 ** | (93.9) | 125.1 | (46.5) | 91.4 | (24.4) | ** | 272.5 | (80.8) | 116.8 | (23.6) | 76.2 | (21.9) | *** |
| Fat (g) | 104.4 NS | (38.1) | 396.5 | (96.6) | 277.2 | (55.5) | *** | 94.2 | (30.4) | 329.5 | (70.4) | 226.9 | (56.2) | ** |
| Sugars (g) | 142.2 *** | (66.5) | 178.6 | (85.4) | 119.4 | (36.9) | ** | 106.1 | (41.5) | 125.4 | (43.9) | 90.6 | (32.5) | * |
| Alcohol (g) | 16.1 NS | (15.4) | 21.3 | (17.3) | 12.9 | (13.2) | * | 18.4 | (17.5) | 24.4 | (19.5) | 13.5 | (14.3) | NS |
| % energy from protein | 13.6 ** | (1.9) | 13.2 | (1.7) | 13.8 | (1.9) | NS | 14.7 | (2.2) | 14.3 | (1.5) | 15 | (2.6) | NS |
| % energy from carbohydrate | 46.4 ** | (4.7) | 47 | (4.9) | 46 | (4.5) | NS | 43.9 | (5.6) | 43.1 | (5.4) | 44.5 | (5.8) | NS |
| % energy from starch | 26.1 NS | (5.0) | 26 | (5.5) | 26.2 | (4.7) | NS | 26.9 | (4.9) | 26.8 | (4.8) | 26.9 | (5.1) | NS |
| % energy from total sugars | 20.3 *** | (6.3) | 21.1 | (8.3) | 19.8 | (4.8) | NS | 17.0 | (4.7) | 16.3 | (4.7) | 17.6 | (4.6) | NS |
| % energy from fat | 35.5 NS | (5.2) | 34.8 | (5.6) | 36 | (4.9) | NS | 36.0 | (5.0) | 36.8 | (4.8) | 35.4 | (5.2) | NS |
| % energy from alcohol | 4.4 NS | (4.2) | 5 | (4.4) | 4.1 | (4.1) | NS | 5.4 | (5.0) | 5.9 | (4.5) | 5 | (5.4) | NS |
| % food energy from carbohydrate | 48.6 ** | (4.5) | 49.5 | (4.7) | 48 | (4.4) | NS | 46.3 | (4.8) | 45.8 | (5.0) | 46.8 | (4.8) | NS |
| % food energy from fat | 37.2 NS | (5.0) | 36.5 | (5.3) | 37.5 | (4.7) | NS | 38.1 | (5.1) | 39.1 | (4.9) | 37.3 | (5.1) | NS |
| % food energy from protein | 14.2 ** | (2.0) | 13.9 | (2.0) | 14.4 | (2.0) | NS | 15.5 | (2.6) | 15.2 | (1.6) | 15.8 | (3.1) | NS |

† * P<0.05 vs. All LEF; ** P<0.01 vs. All LEF; ***P<0.001 vs. All LEF; NS, not significant, P>0.05 vs. All LEF

‡ Comparison of mean daily nutrient intakes by gender within each eating frequency group (HEF and LEF), * P<0.05, ** P<0.01, ***P<0.001, NS, not significant, P>0.05.

**Table 6.2: The number ($n$) of values per hour ***

| hour | High Eating Frequency (HEF) | Low Eating Frequency (LEF) |
|---|---|---|
| | $n$ | $n$ |
| 7.00 | 25 | 22 |
| 8.00 | 55 | 44 |
| 9.00 | 52 | 40 |
| 10.00 | 58 | 53 |
| 11.00 | 67 | 53 |
| 12.00 | 58 | 29 |
| 13.00 | 68 | 56 |
| 14.00 | 64 | 56 |
| 15.00 | 56 | 40 |
| 16.00 | 58 | 39 |
| 17.00 | 63 | 40 |
| 18.00 | 69 | 56 |
| 19.00 | 67 | 57 |
| 20.00 | 61 | 49 |
| 21.00 | 68 | 56 |
| 22.00 | 69 | 57 |
| 23.00 | 59 | 44 |
| 24.00 | 38 | 28 |

* the number of subjects who ate at an hour, having taken into consideration the number of times during the 7 days, that an individual ate at the hour

**Table 6.3: Periodicity of Eating and mean daily macronutient intakes in adult populations**

| Authors | Subject details | Eating Frequency Categories: Low vs. High | Low Eating Frequency | High Eating Frequency | *P* |
|---|---|---|---|---|---|
| **Drummond *et al.*, 1998** | 79 Scottish men and women, age 20-55y | Correlation ( C ) co-efficient of dietary intake & eating frequency (EF) | EF +ve C with energy (MJ)/day (women only), EF + ve C with % CHO (TE) EF + ve C with g total CHO & g total sugar (women only) | | |
| **Redondo *et al.*, 1997** | 150 Spanish elderly men and women, age 65 – 85y | 2 meals/d vs. 4 meals/d | energy – NR | energy – NR | |
| | | | 41.3% fat (TE) | 38.9% fat (TE) | ns |
| | | | 18.1% protein (TE) | 16.9% protein (TE) | ns |
| | | | 36.5% CHO (TE) | 42.0% CHO (TE) | * |
| | | | 3.5% ROH (TE) | 1.6% ROH (TE) | ns |
| **Roos & Prattala, 1997** | 1689 adult Finns, age 25 – 64y *(results are for women only as men showed no differences)* | ≤ 2 meals/day (other meal pattern) vs. ≥ 3 meals/day (conventional meal pattern) | 7.5MJ energy | 8.1MJ energy | * |
| | | | 34.4% fat (TE) | 33.8% fat (TE) | ns |
| | | | 16.3% protein (TE) | 16.5% protein (TE) | ns |
| | | | 50.5% CHO (TE) | 51.7% CHO (TE) | ns |
| | | | 1.9% ROH (TE) | 1.2% ROH (TE) | * |

TE =% of total energy; CHO= carbohydrate; ROH = alcohol; * = significantly different; ns = not significantly different; NR = not reported

**Table 6.3 cont.: Periodicity of Eating and mean daily macronutient intakes in adult populations**

| Authors | Subject details | Eating Frequency Categories: Low vs. High | Low Eating Frequency | High Eating Frequency | *P* |
|---|---|---|---|---|---|
| **Whybrow & Kirk, 1997** | 44 Scottish female university students, age 17-30y | Lowest vs. highest tertile of eating frequency | 7.6MJ energy<br>35% fat (TE)<br>13.3% protein (TE)<br>45.3% CHO (TE)<br>5.5% ROH (TE) | 8.4MJ energy<br>35.4% fat (TE)<br>11.9% protein (TE)<br>45.5% CHO (TE)<br>6.4 ROH (TE) | *<br>ns<br>ns<br>ns<br>ns |
| **McGrath & Gibney, 1994** | 12 Irish men changed eating pattern from snacking to meal-eating, age 19-39y | Meal-eating pattern (3 EO/d) vs. Snacking (6 EO/d) | 10.9MJ energy<br>41% fat (TE)<br>14% protein (TE)<br>42.7% CHO (TE)<br>2.3% ROH (TE) | 11.4MJ energy<br>38.6% fat (TE)<br>12.8% protein (TE)<br>44.2% CHO (TE)<br>4.4% ROH (TE) | ns<br>*<br>*<br>ns<br>* |
| **Basdevant *et al.*, 1993** | 273 obese French women, age 18-65y | 0 % vs. at least 15% of total energy from snacks | 6.6MJ<br>38% fat (TE)<br>21% protein (TE)<br>39% CHO (TE) | 9.3MJ<br>41% fat (TE)<br>18% protein (TE)<br>41% CHO (TE) | *<br>*<br>*<br>ns |
| **Edelstein *et al.*, 1992** | 2034 American men & women, age 50-89y | No. of meals and /or snacks/day, 1-2 vs. ≥ 4 | 6.9MJ (1658kcals)<br>55g total fat | 8.2MJ (1962kcals)<br>73.3g total fat | *<br>* |

TE =% of total energy; CHO= carbohydrate; ROH = alcohol; * = significantly different; ns = not significantly different; NR = not reported

**Figure 6.1: Temporal pattern of mean energy intake (MJ) during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups**

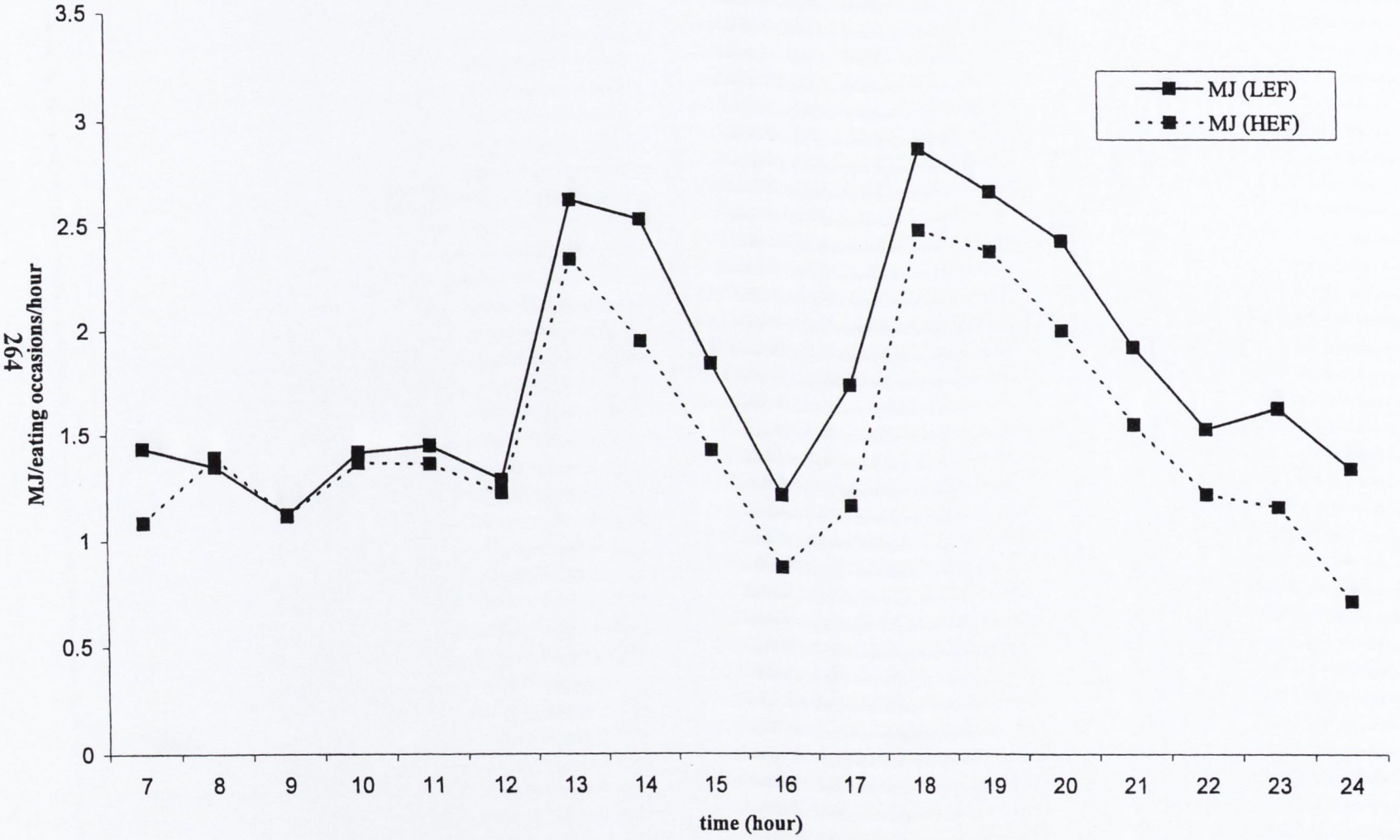


**Figure 6.2a: Temporal pattern of mean carbohydrate and fat intake (g) during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups**

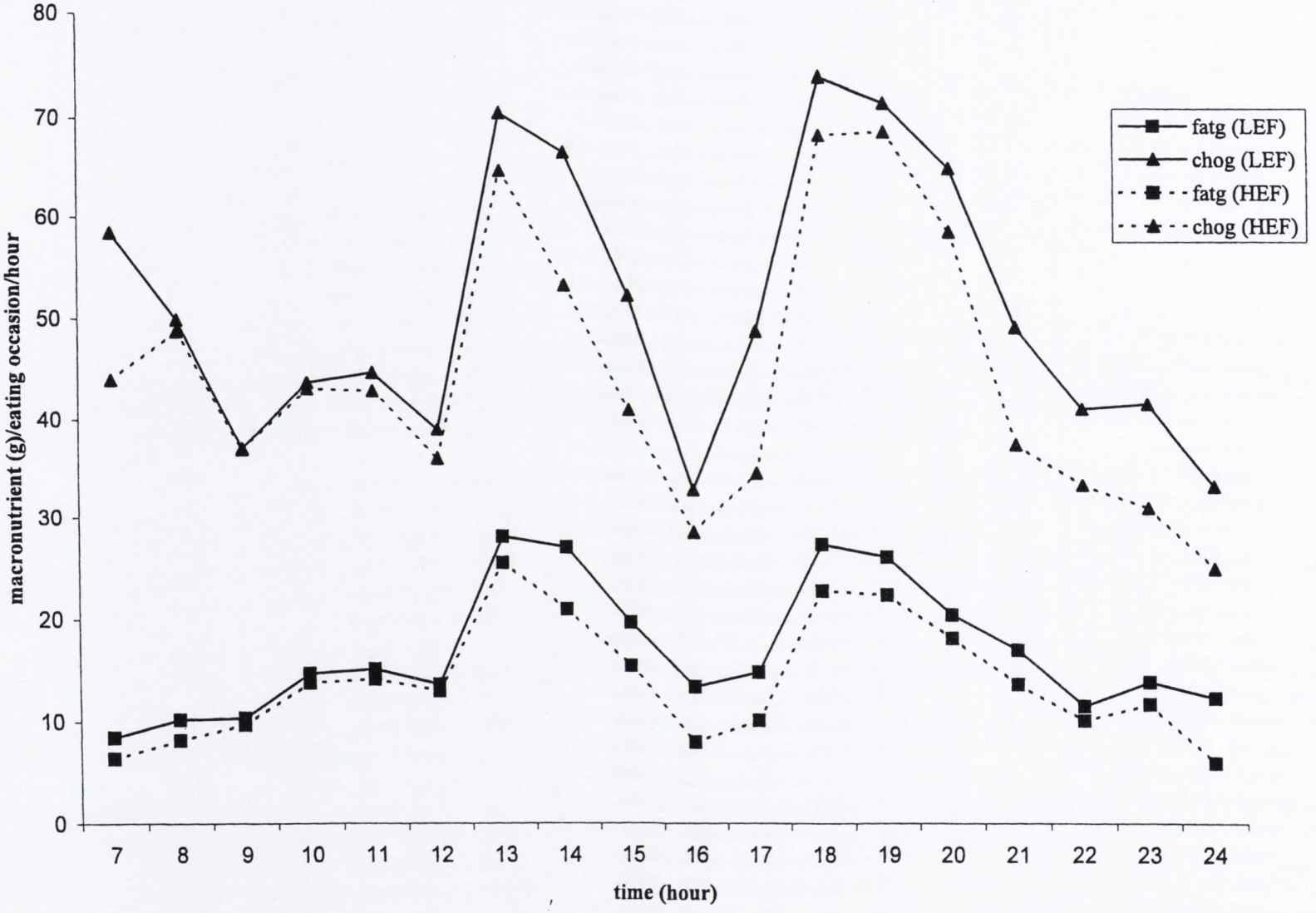


**Figure 6.2b: Temporal pattern of mean protein and alcohol intake (g) during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups**

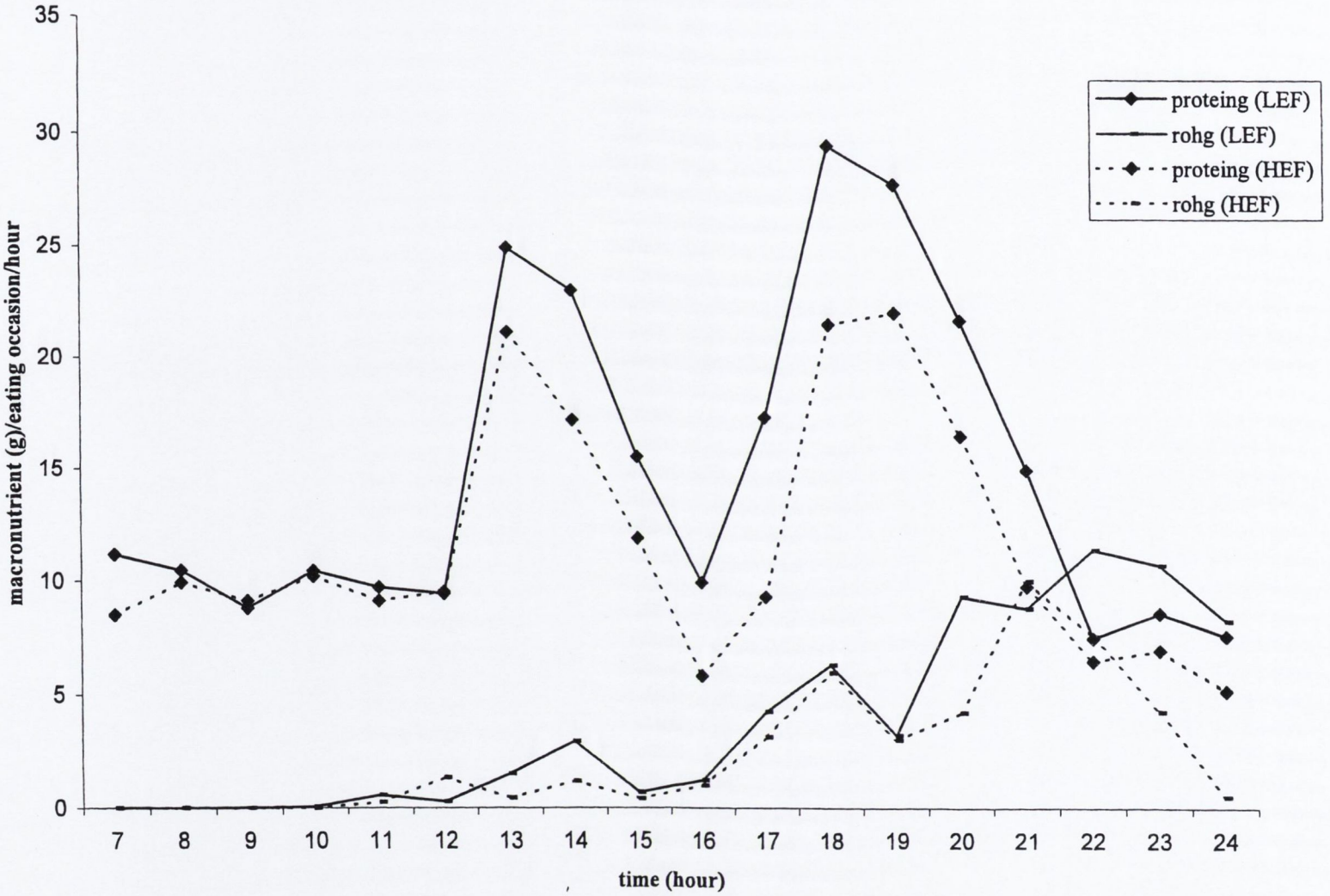


**Figure 6.3: Temporal pattern of mean proportion of total energy from macronutrients during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups**

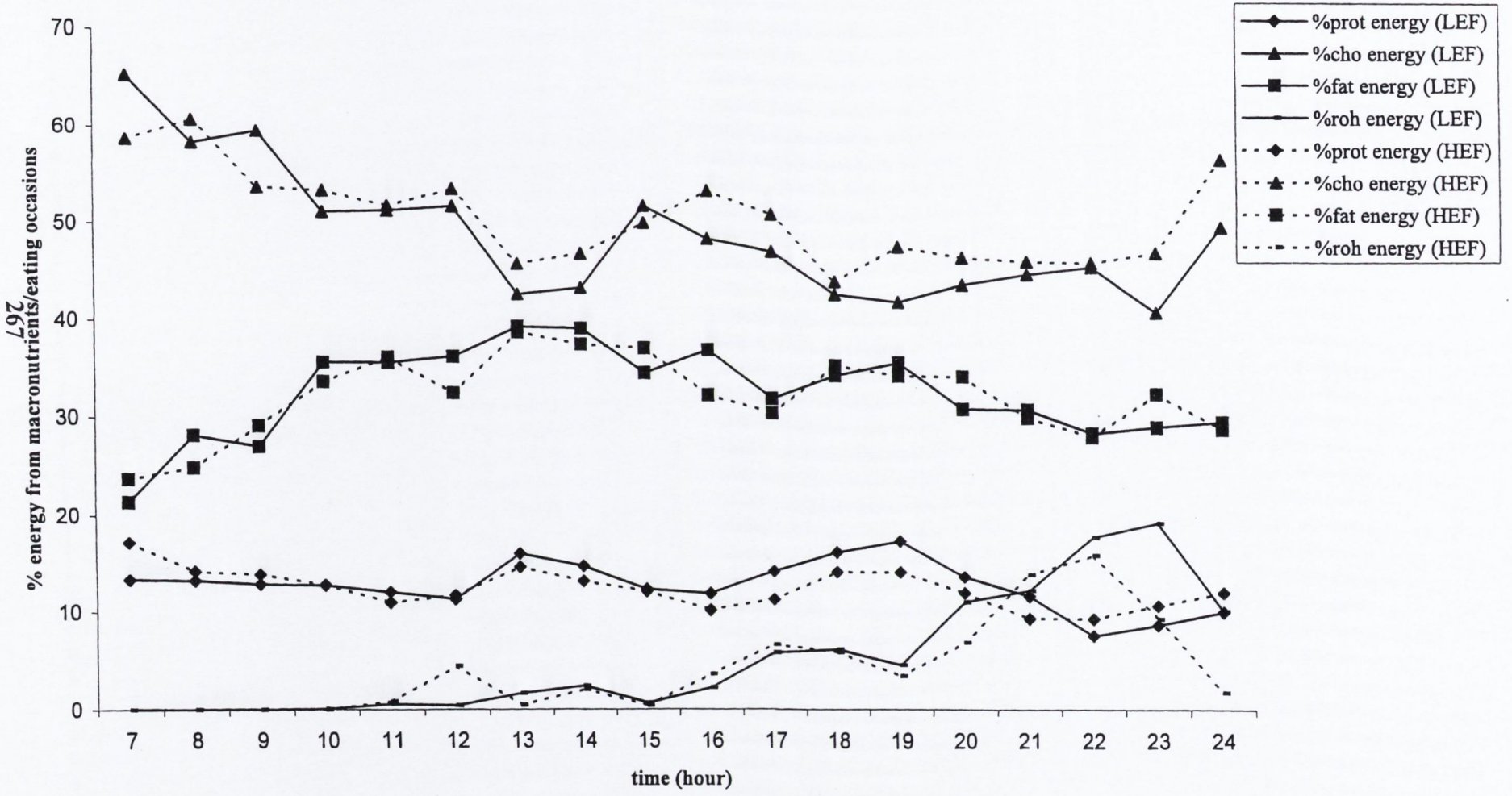
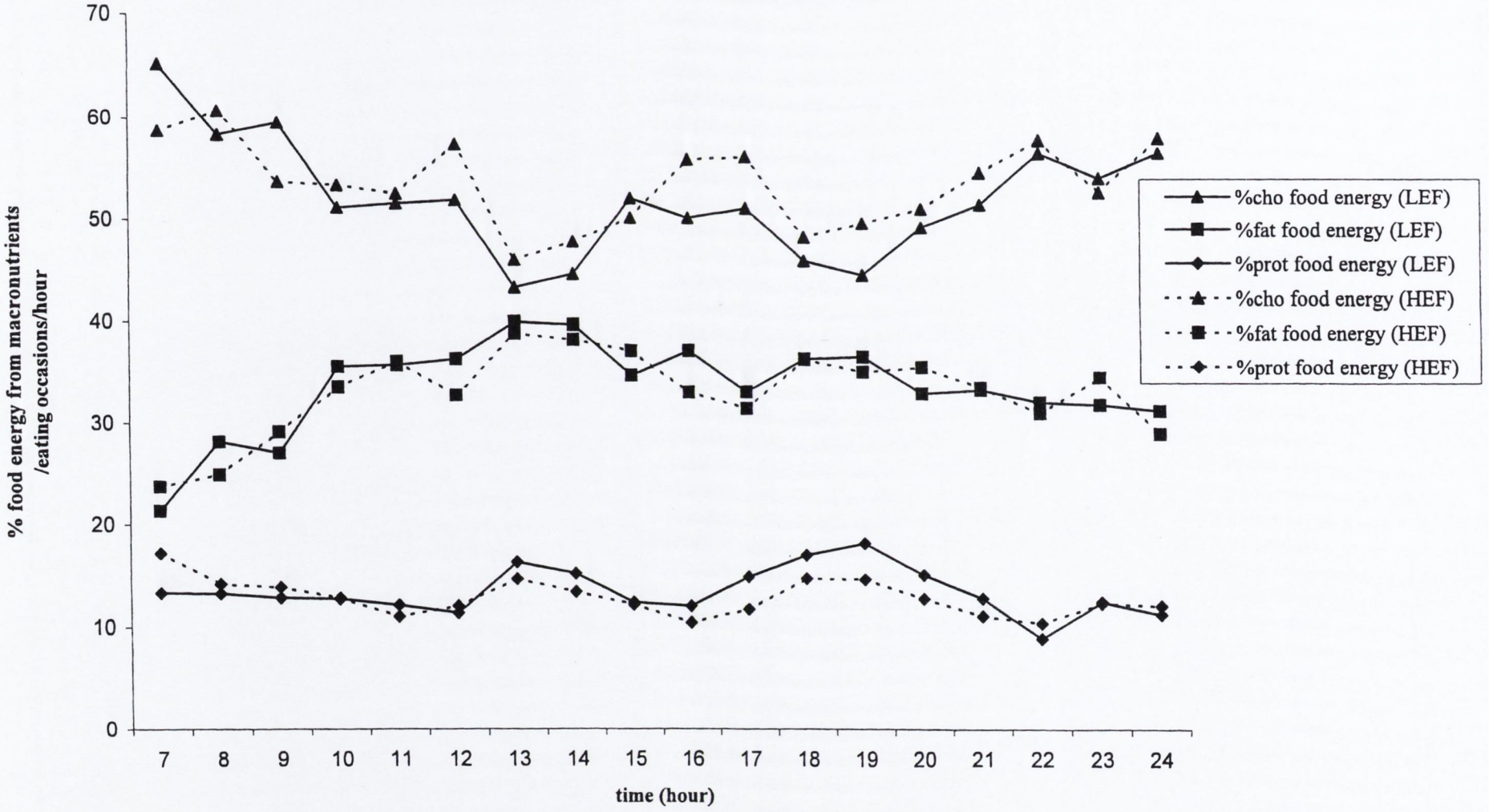


**Figure 6.4: Temporal pattern of mean proportion of food energy from macronutrients during eating occasions/hour for High Eating Frequency (HEF) and Low Eating Frequency (LEF) Groups**



## 6.5 REFERENCES


Ballard-Barbash, R., Graubard, B.I., Krebs-Smith, S.M., Schatzkin, A., & Thompson, F.E. (1996). Contribution of dieting to the inverse association between energy intake and body mass index. *European Journal of Clinical Nutrition, 50,* 98-106.

Basdevant, A., Craplet, C., & Guy-Grand, B. (1993). Snacking Patterns in Obese French Women. *Appetite, 21,* 17-23.

Bellisle, F., McDevitt, R., & Prentice, A.M. (1997). Meal frequency and energy balance. *British Journal of Nutrition, 77,* S57-S70.

Bellisle, F., Monneuse, M., Steptoe, A., & Wardle, J. (1995). Weight concerns and eating patterns: A survey of university students in Europe. *International Journal of Obesity, 19,* 723-730.

Black, A.E., Goldberg, G.R., Jebb, S.A., Livingstone, M.B.E., Cole, T.J., & Prentice, A.M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *European Journal of Clinical Nutrition, 45,* 583-599.

Bortz, W.M., Howat, P., & Holmes, W.L. (1969). The effect of feeding frequency on diurnal plasma free fatty acids and glucose levels. *Metabolism, 18,* 120-123.

Briefel, R.R., Sempos, C.T., McDowell, M.A., Chien, S., & Alaimo, K. (1997). Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *American Journal Clinical Nutrition, 65(Suppl),* S1203-S1209.

Chapman, G., & Maclean, H. (1993). "Junk Food" and "Healthy Food": Meanings of Food in Adolescent Women's Culture. *Journal of Nutrition Education, 25,* 108-113.

Drummond, S., Crombie, N., Cursiter, M.C., & Kirk, T.R. (1998). Evidence that eating frequency is inversely related to body weight status in male, but not female, non-obese adults reporting valid dietary intakes. *International Journal of Obesity, 22,* 105-112.

Drummond, S., Crombie, N., & Kirk, T. (1996). A critique of the effects of snacking on body weight status. *European Journal of Clinical Nutrition, 50,* 779-783.

Edelstein, S.L., Burrett-Connor, E.L., Wingard, D.L., & Cohen, B.A. (1992). Increased meal frequency associated with decreased cholesterol concentrations; Rancho Bernardo, CA, 1984-1987. *American Journal of Clinical Nutrition, 55,* 664-669.

Fabry, P., Fodor, J., Hejl, Z., Braun, T., & Zvolankova, K. (1964). The frequency of meals: its relation to overweight, hypercholesterolaemia and decreased glucose-tolerance. *Lancet, ii,* 614-615.

Fabry, P., Fodor, J., Hejl, Z., Geizerova, H., & Balcarova, O. (1968). Meal frequency and ischaemic heart disease. *Lancet, ii,* 190-191.

Fabry, P., Hejda, S., Cerna, K., Osoncova, K., Pechor, J., & Zvolankova, K. (1966). Effect of meal frequency in school children: changes in weight-height proportion and skinfold thickness. *American Journal of Clinical Nutrition, 18,* 358-361.

Finkelstein, M.S., & Fryer, B.A. (1971). Meal frequency and weight reduction of young women. *American Journal of Clinical Nutrition, 24,* 465-468.

Food Advisory Committee. (1987). *Guidelines for Preparing Information and Advice to the General Public on Healthy Eating.* Dublin, Ireland: Department of Health.

Gatenby, S., Anderson, A.O., Walker, A.D., Southon, S., & Mela, D.J. (1995). "Meals" and "Snacks" - Implications for Eating Patterns In Adults. *Appetite, 24,* 292

Gatenby, S.J. (1997). Eating frequency: methodological and dietary aspects. *British Journal of Nutrition, 77,* S7-S20.

Gibney, M.J., & Wolever, T.M.S. (1997). Periodicity of eating and human health: present perspective and future directions. *British Journal of Nutrition, 77,* S3-S5.

Gnardellis, C., Boulou, C., & Trichopoulou, A. (1998). Magnitude, determinants and impact of under-reporting of energy intake in a cohort study in Greece. *Public Health Nutrition, 1,* 131-137.

Goldberg, G.R., Black, A.E., Jebb, S.A., Cole, T.J., Murgatroyd, P.R., Coward, W.A., & Prentice, A.M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off values to identify under-recording. *European Journal of Clinical Nutrition, 45,* 569-581.

Gwinup, G., Roush, W.H., Byron, R.C., & Kruger, F.A. (1963a). Effect of nibbling versus gorging on glucose tolerance. *Lancet,* 165-167.

Gwinup, G., Bryon, R.C., Roush, W.H., Kruger, F.A., & Hamwi, G.J. (1963b). Effect of nibbling versus gorging on serum lipids in man. *American Journal of Clinical Nutrition, 13,* 209-213.

Hackett, A.F., Rugg-Gunn, A.J., Appleton, D.R., & Coombs, A. (1986). Dietary sources of energy, protein, fat and fibre in 375 English adolescents. *Human Nutrition and Applied Nutrition, 40,* 176-184.

Hawley, J.A., & Burke, L.M. (1997). Effect of meal frequency and timing on physical performance. *British Journal of Nutrition, 77,* S91-S103.

Heitmann, B.L., & Lissner, L. (1995). Dietary underreporting by obese individuals - is it specific or non-specific? *British Medical Journal, 311,* 986-989.

Heywood, P., Harvey, P.W.J., & Marks, G.C. (1993). An evaluation of energy intakes in the 1983 Australian National Dietary Survey of Adults. *European Journal of Clinical Nutrition, 47,* 603-606.

Hirvonen, T., Mannisto, S., Roos, E., & Pietinen, P. (1997). Increasing prevalence of underreporting does not necessarily distort dietary surveys. *European Journal of Clinical Nutrition, 51,* 297-301.

Jagannathan, S.N., Connell, W.F., & Beveridge, J.M.R. (1964). Effects of gormandizing and semicontinous eating of equicaloric amounts of formula-type high fat diets on plasma cholesterol and triglyceride levels in human volunteer subjects. *American Journal of Clinical Nutrition, 15,* 90-93.

Jenkins, D.J.A., Jenkins, A.L., Wolever, T.M.S., Vuksan, V., Rao, A.V., Thompson, L.U., & Josse, R.G. (1994). Low glycaemic index: lente carbohydrates and physiological effects of altered food frequency. *American Journal of Clinical Nutrition, 59,* S706-S709.

Jenkins, D.J.A., Ocana, A., Jenkins, A.L., Wolever, T.M.S., Vuksan, V., Katzman, L., Hollands, M., Greenberg, G., Corey, P., Patten, R., Wong, G., & Josse, R.J. (1992). Metabolic advantages of spreading the nutrient load: effects of increased meal frequency in non-insulin diabetes. *American Journal of Clinical Nutrition,* 461-467.

Jenkins, D.J.A., Wolever, T.M.S., Vuksan, V., Brighenti, F., Cunnane, S.C., Rao, A.V., Jenkins, A.L., Buckley, G., Patten, R., Singer, W., Corey, P., & Josse, R.J. (1989). Nibbling versus gorging: metabolic advantages of increased meal frequency. *New England Journal of Medicine, 321,* 929-934.

Johansson, L., Solvoll, K., Bjorneboe, G.A., & Drevon, C.A. (1998). Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. *American Journal of Clinical Nutrition, 68,* 266-274.

Jones, P.J.H., Leitch, C.A., & Pederson, R.A. (1993). Meal frequency effects on plasma hormone concentrations and cholesterol synthesis in humans. *American Journal of Clinical Nutrition, 57,* 868-874.

King, S., & Gibney, M.J. (1999). Dietary advice to reduce fat intake is more successful when it does not restrict habitual eating patterns. *Journal of the American Dietetic Association, 99,* 685-689.

Kirk, T., Drummond, S., & Ruxton, C. (1995). The effect of snacking on overall energy and nutrient intakes and body weight status. *Summaries of the Seventh European Nutrition Conference,* 17

Kirk, T.R. (2000). Role of dietary carbohydrate and frequent eating in body-weight control. *Proceedings of the Nutrition Society, 59,* 349-358.

Knittle, J.L. (1966). Meal-eating versus nibbling: effect on human adipose tissue metabolism. *American Journal of Clinical Nutrition, 18,* 310-311.

Lafay, L., Basdevant, A., Charles, M.-A., Vray, M., Balkau, B., Borys, J.-M., Eschwege, E., & Romon, M. (1997). Determinants and nature of dietary underreporting in a free-living population: the Fleurbaix Laventie Ville Sante (FLVS) study. *International Journal of Obesity, 21,* 567-573.

Lennernäs, M., & Andersson, I. (1999). Food-based classification of eating episodes (FBCE). *Appetite, 32,* 53-65.

Livingstone, M.B.E (1991). CHO International Dialogue on Carbohydrates. Children's food and snacking. London: Advisa Medica. 2.

Livingstone, M.B.E., Prentice, A.M., Strain, J.J., Coward, W.A., Black, A., Barker, M.E., McKenna, P.G., & Whitehead, R.G. (1990). Accuracy of weighed dietary records in studies of diet and health. *British Medical Journal, 300,* 708-712.

McGrath, S.A., & Gibney, M.J. (1994). The effects of altered frequency of eating on plasma lipids in free-living healthy males on normal self-selected diets. *European Journal of Clinical Nutrition, 48,* 402-407.

Metzner, H.L., Lamphiear, D.E., & Wheeler, N.C. (1977). The relationship between frequency of eating and adiposity in adult men and women in the Tecumseh Community Health Study. *American Journal of Clinical Nutrition, 30,* 712-715.

Oltersdorf, U. (1996). Impact of changing food choices and eating habits on nutritional status in European countries. *Appetite, 27,* 91-94.

Oltersdorf, U., Schlettwein-Gsell, D., & Winkler, G. (1999). Assessing eating patterns - an emerging research topic in nutritional sciences: Introduction to the symposium. *Appetite, 32,* 1-7.

Poppitt, D., Swann, D., Black, A., & Prentice, A.M. (1998). Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *International Journal of Obesity, 22,* 303-311.

Price, G.M., Paul, A.A., Cole, T.J., & Wadsworth, M.E.J. (1997). Characteristics of the low-energy reporters in a longitudinal national dietary survey. *British Journal of Nutrition, 77,* 833-851.

Pryer, J.A., Vrihjheid, M., Nichols, R., Kiggins, M., & Elliot, P. (1997). Who are the 'low energy reporters' in the Dietary and Nutritional Survey of British Adults? *International Journal of Epidemiology, 26,* 146-153.

Redondo, M.R., Ortega, R.M., Zamora, M.J., Quintas, M.E., Lopez-Sobaler, A.M., Andres, P., & Gaspar, M.J. (1997). Influence of the number of meals taken per day on cardiovascular risk factors and the energy and nutrient intakes of a group of elderly people. *International Journal of Vitamin and Nutrition Research, 67,* 176-182.

Robson, P.J., & Strain, J.J. (1991). Snack energy and nutrient intakes of Northern Ireland adolescents. *Proceedings of the Nutrition Society, 50,* 180A

Roos, E., & Prättälä, R. (1997). Meal pattern and nutrient intake among adult Finns. *Appetite, 29,* 11-24.

Roos, G.M., Quandt, S.A., & DeWalt, K.M. (1993). Meal patterns of the elderly in rural Kentucky. *Appetite, 21,* 295-298.

Ruxton, C.H.S., Kirk, T.R., & Belton, N.R. (1996). The contribution of specific dietary patterns to energy and nutrient intakes in 7-8-year-old Scottish schoolchildren. III. Snacking habits. *Journal of Human Nutrition and Dietetics, 9,* 23-31.

Skinner, J.D., Salvetti, N.N., Ezell, J.M., Penfield, M.P., & Costello, C.A. (1985). Appalachian adolescents' eating patterns and nutrient intakes. *Journal of the American Dietetic Association, 85,* 1093-1099.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1995). Sources of energy from meals versus snacks in 220 people in four age groups. *European Journal of Clinical Nutrition, 49,* 33-41.

Summerbell, C.D., Moody, R.C., Shanks, J., Stock, M.J., & Geissler, C. (1996). Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. *European Journal of Clinical Nutrition, 50,* 513-519.

Wadhwa, P.S., Young, E.A., Schmidt, K., Elson, C.E., & Pringle, D.J. (1973). Metabolic consequences of feeding frequency in man. *American Journal of Clinical Nutrition, 26,* 823-830.

Whybow, S., & Kirk, T.R. (1997). Nutrient intakes and snacking frequency in female students. *Journal of Human Nutrition and Dietetics, 10,* 237-244.

# CHAPTER 7

## Differences in daily macronutrient intakes between weekdays and weekend days & the temporal pattern of macronutrient intake during eating occasions throughout the day

## 7.1 INTRODUCTION

It is generally accepted that food and nutrient intakes differ on weekdays compared to weekend days (De Boer *et al.*, 1987; Post *et al.*, 1987; Thomson *et al.*, 1988a; McBride *et al.*, 1990; De Castro, 1991). This general understanding has come largely from studies which examined the day-of-the-week effect on nutrient intake as part of investigations of the variability in nutrient intake within individuals, from one day to the next (Chalmers *et al.*, 1952; Beaton *et al.*, 1979; 1983; Achenson *et al.*, 1980; McGee *et al.*, 1982; St Jeor *et al.*, 1983; Basiotis *et al.*, 1989; Tarasuk & Beaton, 1992). In fact, Tarasuk & Beaton, (1992) have advised proportional sampling of weekend days, as well as weekdays, in dietary surveys, to avoid bias in the estimate of usual food and nutrient intake and within-person variation. Consequently, most nutrition studies that involve dietary assessment, tend to ensure that one or both weekend days are surveyed as part of the study.

Energy intakes are generally found to increase at the weekend (McGee *et al.*, 1982; Beaton *et al.*, 1979; Thomson *et al.*, 1988a; Basiotis *et al.*, 1989; De Castro, 1991). In some populations an increase in alcohol intake at the weekend has been reported to be somewhat responsible for this increase in energy (Thomson *et al.*, 1988b; McBride *et al.*, 1990). While some studies have observed a day-of-the-week effect on macronutrient intakes (Post *et al.*, 1987; Beaton *et al.*, 1979; De Castro, 1991; Tarasuk & Beaton, 1992), others have shown no differences (Thomson *et al.*, 1988a; St Jeor *et al.*, 1983). These divergent results may occur because studies vary in their presentation of macronutrient intakes, some presenting absolute intakes and others presenting intakes as percentages of energy, which makes it difficult to compare results between studies and to draw conclusions from them. Studies also vary in the variables under investigation, with specific macronutrients, micronutrients or food groups being investigated. Furthermore, although the weekend is colloquially understood to be Saturday and Sunday, studies have used one weekend day, to draw their conclusions regarding differences between weekend days and weekdays (Beaton *et al.*, 1979; 1983). Within modern lifestyle and work practices however, non-working days are no longer limited to Saturday or Sunday only. Overall, the day-of-the-week effect has not shown consistent differences between studies to date.

Despite the present uncertainty surrounding the actual differences that occur in food and nutrient intakes, between weekdays and weekend days, it is essential to obtain a clear understanding of these differences in populations. It is likely that they may have valuable implications for the development of targeted dietary guidelines. It is increasingly recognised that populations are having difficulties in attaining current dietary recommendations (Hulshof *et al.*, 1993; MAFF, 1994; Krebs-Smith *et al.*, 1997). Obtaining a clear understanding of the factors that influence food and nutrient intake, such as the day-of-the-week effect, may offer an opportunity for focused and evidence-based nutrition interventions that aim to achieve healthier diets. Such investigations may identify differences in food or nutrient intake with particular days of the week, which may be compromising the nutritional quality of the overall diet of the population. For example, fat intakes have been observed to be higher on weekend days (Post *et al.*, 1987; De Boer *et al.*, 1987; De Castro, 1991; Tarasuk & Beaton, 1992). This could suggest that strategies to reduce dietary fat intake should focus on food and nutrient patterns of the weekend days. Few studies have investigated the day-of-the-week effect on food and nutrient intake with this purpose in mind.

The influence of the day-of-the-week effect on the nutrient quality of eating occasions, as opposed to daily nutrient intakes, is also largely unknown. It is a generally assumed that people eat more on weekend days. How this occurs and whether weekend eating occasions are generally higher in fat or vary in nutrient composition compared to weekday eating occasions, is not known. One study compared the average nutrient composition of all eating occasions, on each day of the week, between the different days (De Castro, 1991). De Castro, (1991) observed greater energy and macronutrient intakes during weekend eating occasions compared to those during the week. It is not known however, whether the differences in the average nutrient composition of eating occasions, that occur between weekdays and weekend days, also occur across all eating occasions at any time of the day. In other words, are all eating occasions on weekend days higher in energy and macronutrient intakes than those on weekend days?

The purpose of the present study was to obtain a better understanding of the difference in macronutrient intakes between weekdays and weekend days in a free-living population of Irish

adults. This study firstly investigated the day-of-the-week effect on macronutrient intakes. Secondly, as Saturday and Sunday are generally understood to represent the weekend for this study sample of office workers, whose working week dictated working Monday through Friday, average macronutrient intakes on weekdays (Monday through Friday) were also compared to average intakes on weekend days (Saturday & Sunday). The temporal pattern of macronutrient intake during eating occasions throughout the day, was also investigated for weekdays (Monday through Friday) and weekend days (Saturday & Sunday), to determine whether and how temporal patterns of macronutrient intake differed between weekdays and weekend days.

## 7.2 METHODS

### 7.2.1 Subject Recruitment

Details of the subject recruitment procedure are described in Chapter 2. In brief, healthy adults were recruited from a city local authority and eligible subjects were healthy male and female adults aged 18 – 64 years, who were not working shift-work or over-time and females who were not pregnant or lactating.

### 7.2.2 Dietary Assessment Procedure

Subjects completed a 7-day food diary in which they recorded the amount of food and drink consumed together with the time of consumption. A comprehensive description of the procedures used during the dietary assessment in order to obtain acceptable data on the nutrient content of eating occasions are described in Chapter 2, including the instructions given to subjects, the method of food quantification and details of the nutrient analysis. The definition of an eating occasion in the present study is also fully described in Chapter 2. In brief, eating occasions were defined by time and coded to the nearest hour such that an eating occasion included every item of food or drink consumed within an hourly period. Eating occasions of non-nutritive value were not included in the analysis.

### 7.2.3 Anthropometry

Body weight (kg) and height (m) were measured, with details of the procedures used described in Chapter 2.

### 7.2.4 Quality and Validity of Dietary Data

All food diaries were completed during September to mid-December 1995 and details of quality procedures used are described in Chapter 2.

The validity of the food intake data of the full population was assessed by, measuring the validity of the energy intakes reported in the study and is fully described in Chapter 2. This involved the calculation of the mean ratio of energy intakes to estimated basal metabolic rate ($EI/BMR_{est}$), as proposed by Goldberg *et al*, (1991). The validity of the reported energy intakes was assessed at group level by comparing the mean $EI/BMR_{est}$ with the cut-off value which represented the lowest expected mean $EI/BMR_{est}$ for this study sample size with 7 days of food intake data, calculated using the Goldberg equation.

### 7.2.5 Data analysis & Statistical analysis

Data analysis was conducted using SPSS® 8.0 statistical software package (SPSS Inc, Chicago, USA.). The SPSS® database had an entry for every hour (01.00-24.00hours) of each of the 7 days for each subject. The nutrient composition data, of every eating occasion of each subject during the 7 days, was presented at the specific hour of consumption.

The day-of-the-week effect on macronutrient intakes was carried out by comparing average nutrient intakes on each day of the week. Mean and standard deviation (SD) values were calculated for each day of the week, Monday through Sunday. Differences in intakes between days of the week were assessed using one-way analysis of variance (ANOVA) for multiple comparisons. When statistically significant effects were seen ($P<0.05$), comparisons of means were made using the Scheffe post hoc multiple comparative test to ascertain which specific means differed. When no differences were detected using the Scheffe post hoc test, LSD post hoc tests were used. 2-way ANOVA tests were used to test for day-of-the-week and sex effects and any interaction. The database was then split into weekdays (Monday through

Friday) and weekend days (Saturday and Sunday) and mean and SD values were calculated for weekdays and weekend days for the total sample, and for men and women. This facilitated comparisons between the weekdays and weekend days, which are hereafter referred to as WD for 'weekdays' and WE for 'weekend days'.

The mean daily eating frequency was calculated for each subject as the total number of eating occasions during the week, divided by 7. An eating occasion was defined as having greater than 0MJ of energy, divided by the number of recording days. The group mean and SD values for daily eating frequency were then calculated. Differences in mean macronutrient intakes and mean daily eating frequency between WD and WE were assessed. Differences in macronutrient intakes between WD and WE were also assessed within and between the men and women. Independent t-tests were used to test for differences in normally distributed data and the Mann-Whitney non-parametric test was used to test for differences in data which were not normally distributed. Comparisons between mean macronutrient intakes of men and women on weekdays and weekend days were carried out using 2-way ANOVA. Values of $P<0.05$ were taken as statistically significant. Tables and figures were created using Microsoft® Excel spreadsheets (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.) and Microsoft® Word (V. SR-2 1997, Microsoft Corporation, Washington, U.S.A.).

*Temporal pattern of the mean macronutrient content of eating occasions*

To calculate the temporal pattern of the mean macronutrient content of eating occasions throughout the day, four approaches were explored and are fully described with examples in Chapter 3. The *eating occasion by individual method* was selected as the most appropriate method to determine the temporal pattern of the mean macronutrient intake during eating occasions (> 0MJ) per hour throughout the day, for WD (Monday through Friday) and WE (Saturday & Sunday) and is recapped below:

*The eating occasion by individual method (method 4):* This method ensures that all individuals contribute to the mean value in a similar way. For the WD calculations, for each subject, the total nutrient intake consumed during eating occasions at a particular hour during the 5 days, was summed and divided by the frequency the subject had an eating occasion (>0MJ) at that

hour during the 5 days. Thereafter, the mean intake for each individual who ate at an hour was summed and divided by the number of consumers at that hour. For the WE calculations, for each subject, the total nutrient intake consumed during eating occasions at a particular hour during the 2 days was summed and divided by the frequency the subject had an eating occasion (>0MJ) at that hour during the 2 days. Thereafter the mean intake for each individual who ate at an hour was summed and divided by the numbers of consumer at that hour.

This method was used to present the temporal pattern of the mean macronutrient intake during eating occasions (> 0MJ) at each hour in terms of energy intakes (MJ), absolute intakes of macronutrients and macronutrient intakes as proportions of energy (Figures 7.1 to 7.4) for WD and WE. Analysis of the temporal pattern of mean macronutrient intake during eating occasions (> 0MJ) per hour for 24 hours showed there were no eating occasions at hours 4.00 and 5.00 and few eating occasions at hours 1.00, 2.00, 3.00 and 6.00. Therefore figures 7.1 to 7.4 present data for 18 hours only (hours 7.00 to 24.00).

## 7.3 RESULTS

### 7.3.1 Response Rate

133 subjects (55 men, 78 women) met the study's eligibility criteria, with a final response rate of 91%. Full details of the response rate of the study sample including details of the non-responders and dropouts have been described in Chapter 2 (Table 2.1).

### 7.3.2 Validity of reported energy intakes

The mean $EI/BMR_{est}$ of the study sample was 1.54 ± 0.4 (1.63 ± 0.4 in men, 1.48 ± 0.3 in women), with a significant difference between men and women ($P$=0.02) as described in Chapter 2. This mean $EI/BMR_{est}$ value was higher than the calculated Goldberg cut-off value of 1.50, proposed as the lowest expected mean $EI/BMR_{est}$ value, that reflects actual energy intake of a population of this size with 7 days of food intake data. The proportion of this population identified as under-reporters was 7% (9 of 133 subjects, 4% of men, 9% of women).

### 7.3.3 Mean daily nutrient intakes

Table 7.1 presents the mean daily energy and macronutrient intakes for the total study sample by day-of-the-week. A significant day-of-the-week effect was observed for energy intakes ($P$=0.017), with energy intakes on Friday and Saturday significantly higher than on Monday, Tuesday and Sunday ($P$<0.05) but similar to energy intakes on Wednesday and Thursday. There was no difference in energy intakes however between Sunday and Monday, Tuesday, Wednesday or Thursday. The day-of-the-week had no significant effect on absolute intakes of macronutrients, with the exception of alcohol ($P$<0.001). Highest alcohol intakes (g and % energy) were observed on Friday, Saturday and Sunday ($P$<0.05), with no significant differences in intake between Friday, Saturday and Sunday. Although alcohol intakes on Friday and Saturday were higher ($P$<0.05) than on Monday through to Thursday, there were no significant differences in alcohol intakes (g and % energy) between Sunday and Monday through to Thursday. When energy from alcohol was subtracted from total daily energy intake for each day of the week, there was no significant difference in energy intakes between the days of the week.

The differences in the proportions of total energy from protein ($P$=0.003) and carbohydrate ($P$<0.001) between the days of the week were no longer observed when energy from alcohol was excluded. The proportion of total energy from carbohydrate was significantly lower on Saturday compared to Tuesday and Wednesday only. The proportion of total energy from protein was significantly lower on Friday and Saturday compared to Monday and Sunday.

Table 7.2 presents the mean daily energy and macronutrient intakes of weekdays (WD, Monday through to Friday) and weekend days (WE, Saturday & Sunday) for the total sample and for men and women separately. There were no significant differences in mean daily energy or absolute intakes of macronutrients between WD and WE except for alcohol intake which was higher at the weekend ($P$=0.002), 13.6g ± 15.1g vs. 26.1 ± 27.7g respectively. This observation held true when nutrient intakes between WD and WE within the sexes were compared, with the average amount of alcohol consumed on WE, being double that on WD, for both men and women. There were no significant differences in the proportions of total energy from protein, fat and total sugars between WD and WE. The mean daily proportions of

total energy from carbohydrate ($P$=0.005) and starch ($P$=0.025) were higher on WD compared to WE and this observation was demonstrated in men only. The proportion of energy from alcohol was higher on WE ($P$=0.002) than WD and this was seen within both men and women. On excluding energy from alcohol, there were no significant differences in the proportions of food energy from macronutrients between WD and WE.

Men had higher mean daily energy intakes than women on both WD and WE ($P$<0.001) and consequently higher intakes of all macro-nutrients ($P$<0.05). There were no significant differences between men and women, in the contribution of macronutrients to energy including or excluding alcohol, on WD or WE.

The characteristics of the total study sample, including mean anthropometric data and mean daily nutrient intake data, are fully described as part of the results section in Chapter 2 and presented in Table 2.2 of Chapter 2. The socio-demographic and lifestyle characteristics of men, women and the total sample have also been fully described in Chapter 2 (Table 2.5).

### 7.3.4 Temporal pattern of macronutrient intakes during eating occasions

The temporal pattern of mean energy intakes (MJ), absolute intakes of macronutients (g) and macronutrient intakes expressed as percentages of total energy and food energy during eating occasions (>0MJ) at each hour, by individuals on WD and WE, are presented in Figures 7.1, 7.2, 7.3 and 7.4 respectively. The *n* values at each hour are presented in Table 7.3. The *n* value at each hour refers to the number of subjects included in the calculation of the mean at the hour i.e. those who ate at least once at that hour during the 5 (WD) or 2 (WE) days of recording.

The mean energy content (MJ) of eating occasions increased over the course of the day with comparable patterns on WD and WE (Figure 7.1). Mean energy intakes of eating occasions consumed at each hour were lowest in the morning hours, with peaks occurring at 13.00 - 14.00 hours and 18.00 - 19.00 hours, on both WD and WE. These time points are equivalent to lunch time and evening meal times. The mean energy content of eating occasions at each hour was somewhat higher on WE compared to WD, at almost all hours. Hours 13.00, 18.00

and 23.00 were the exception, when energy intakes on WD were 0.2MJ higher than those on WE. Eating occasions in the morning hours on WE were 0.3 - 0.6MJ greater in energy than eating occasions on WD, with large differences of 0.9 - 1.1MJ of energy between WD and WE, during eating occasions at 15.00 - 16.00 hours.

The mean macronutrient composition (% total and food energy) of eating occasions at each hour, on WD and WE, is presented in Figure 7.3 and 7.4. When macronutrient intakes during eating occasions were expressed as percentages of food energy, as opposed to total energy, there was little difference in the temporal pattern of nutrient intake between WD and WE. There were no remarkable differences in the mean macronutrient composition of eating occasions between WD and WE at each hour, with few exceptions (e.g. % energy from carbohydrate at 12.00, 15.00 and 16.00 hours). In addition, the mean macronutrient composition (% energy) of eating occasions between each hour over the course of the day was similar on both WD and WE. The percentage of energy from fat in eating occasions was lowest in the morning hours on both WD (23-35% of food energy) and WE (19-32% of food energy), with 27-39% of food energy from fat during eating occasions over the course of the day thereafter, on both WD and WE. The mean percentage of food energy from carbohydrate in eating occasions was highest in the morning hours, on both WD (51-61% of food energy) and WE (55-61% of food energy), with 42-61% of food energy from carbohydrate during eating occasions over the course of the day thereafter. The protein content of eating occasions was similar over the course of the day, on WD (9-16% of food energy) and WE (10-19% of food energy), with slightly higher intakes at 13.00 – 14 hours and 18.00 – 19.00 hours (16% of food energy). The alcohol content of eating occasions was higher on the WE, at each hour and it increased gradually over the course of the day with peaks at 17.00 hours and 22.00 hours on both WD and WE.

## 7.4 DISCUSSION

The validity of the reported energy intakes of the total study sample was examined and described in Chapter 2. The dietary data of the total sample were considered acceptable and valid, with little evidence of under-reporting.

**Mean daily nutrient intakes**

The findings of this study reveal very interesting results and for the first time present a most comprehensive description of the differences in average energy and macronutrient intakes between WD and WE, in a group of free-living Irish adults. The difference in energy and macronutrient intakes between WD and WE was thoroughly investigated by firstly examining the day-of-the-week effect on energy and macronutrient intakes (both absolute intakes and proportions of total energy and food energy) and secondly by comparing intakes on WD (Monday through Friday) vs. WE (Saturday & Sunday).

The day-of-the-week effect on energy intakes, in the present study, was no longer observed when energy from alcohol was excluded. The higher energy intake on Friday and Saturday was due to the increase in alcohol intake on these two days. Similar results were observed by Thomson *et al.*, (1988a; 1988b), in a study of Scottish middle-aged men and by McBride *et al.*, (1990), in a study of male British students. In the present study, there was no day-of-the-week effect on absolute intakes of protein, fat or carbohydrate and the day-of-the-week effects on proportions of total energy from protein and carbohydrate were no longer observed when protein and carbohydrate intakes were expressed as proportions of food energy.

This particular study sample was a group of office workers whose working week dictated working Monday through to Friday, which meant that Saturday and Sunday were generally understood to represent the weekend. In contrast to the day-of-the-week effect observed, when Monday through to Friday were considered together and Saturday and Sunday were considered together, to represent WD and WE respectively, the average energy intakes in the present study did not differ between WD and WE. There were no differences in macronutrient intakes between WD and WE when expressed in terms of proportions of food energy, which was also observed with the day-of-the-week effect.

A review of the studies in the literature, which demonstrated a day-of-the-week effect on energy and macronutrient intakes, revealed inconsistent results. It was therefore difficult to make comparisons between the present study and the literature and to interpret the findings in the literature for a number of reasons, which are subsequently discussed.

The studies in the literature, that reported higher nutrient intakes on WE compared to WD, varied widely in the particular days of the week considered to represent the WE. Unlike the present study, those studies in which Saturday and Sunday collectively represented the WE found higher energy intakes on WE compared to WD (De Boer *et al.*, 1987; Post *et al.*, 1987; Tarasuk & Beaton, 1992). Other studies have reported higher energy intakes on Saturday and Sunday (Maisey *et al.*, 1995; Löwik *et al.*, 1998), on Friday and Saturday (Basiotis *et al.*, 1989; McBride *et al.*, 1990; Briefel *et al.*, 1995) and on Friday, Saturday and Sunday (Thomson *et al*, 1988a, De Castro, 1991, Briefel *et al.*, 1995; Jula *et al*, 1999) than on other days of the week. Energy intakes were also reported to be highest on WE, when Sunday was the only weekend day included in the study (Beaton *et al.*, 1979; 1983; Nicklas *et al.*, 1997). Beaton *et al.*, (1979; 1983), in one of the most commonly quoted studies in the literature, on the differences between WD and WE, observed higher energy intakes on Sundays compared to Tuesdays and Wednesdays/Thursdays in a study of Canadian adults. Nicklas *et al.*, (1997) compared intakes on Sunday to those on Monday through Thursday, in 10 year old American children and observed no day-of-the-week effect in energy intakes, but acknowledged that intakes on Sunday may not truly reflect mean intakes on WE. Only one study commented on differences in energy intakes excluding alcohol energy, between WD and WE (Thomson *et al.*, 1988a), and found an increase in alcohol at the WE to explain the higher energy intakes observed on WE, as demonstrated in the present study.

In previously published studies, differences in macronutrient intakes between WD and WE, particularly protein, fat and carbohydrate intakes, are extremely difficult to interpret as these intakes are presented differently across studies. Intakes are presented as absolute intakes, proportions of total energy or proportions of food energy. Comparisons between studies are also confounded by differences in the dietary assessment methods used, in the sample sizes and the ages and nationality of the study samples.

Overall, the most noteworthy difference in mean daily macronutrient intakes between WD and WE, in the present study, was the higher alcohol intakes (g and % energy) on WE. This finding of higher alcohol intakes on WE, has been the most consistent observation between

WD and WE in studies to date (Post *et al.*, 1987; Thomson *et al.*, 1988a; Basiotis *et al.*, 1989; McBride *et al.*, 1990; De Castro, 1991; Jula *et al*, 1999).

No other significant differences in mean daily macronutrient intakes were identified between WD and WE. Surprisingly, the fat intake of this population was not higher on WE. Average daily fat intakes (% energy), were higher than the current recommendations for fat of 35% of food energy (Food Advisory Committee, 1987), on both WD and WE. Higher fat intakes on WE have been reported in many previous studies (Post *et al.*, 1987; De Boer *et al.*, 1987; Thomson *et al.*, 1988a; De Castro, 1991; Tarasuk & Beaton, 1992). Higher fat intakes on WE was also observed more recently (Maisey *et al.*, 1995; Nicklas *et al.*, 1997; Löwik *et al.*, 1998; Jula *et al.*, 1999). The fat intakes in these studies were not presented in the same way however. Intakes in some studies were presented as absolute fat intakes (Post *et al.*, 1987; De Boer *et al.*, 1987; De Castro 1991; Tarasuk & Beaton, 1992; Nicklas *et al.*,1997; Löwik *et al.*, 1998), with no details of the proportions of total energy or proportions of food energy derived from fat. In other studies, the observation of higher absolute fat intakes on WE, disappeared when intakes were expressed as percentages of energy (Maisey *et al.*, 1995). The converse was also observed, with non-significant differences in absolute fat intakes on WE and WD being significantly different when expressed as a percentage of energy (Jula *et al.*, 1999).

The findings of the present study highlight the importance of using two methods of analysis to assess differences in nutrient intakes between weekdays and weekend days i.e. to assess differences across the individual days of the week in addition to comparing nutrient intake on WD (Monday through Friday) and WE (Saturday & Sunday). These results also highlight the importance of presenting macronutrient intakes as absolute intakes and as percentages of total energy and food energy, when comparing the effect of day-of-the-week and differences in nutrient intake between WD and WE. Furthermore, differences in macronutrient intakes may simply be a consequence of increased alcohol intakes, as observed in the present study. Presenting macronutrient intakes in these ways will allow meaningful comparisons between studies and correct interpretation of findings.

**Temporal pattern of nutrient intake during eating occasions throughout the day**

A further aim of this study was to characterise the temporal pattern of macronutrient intake during eating occasions on WD and WE. No other studies were found in the published literature to explore these differences. A clearly identifiable temporal eating pattern was observed on WD and WE. The nutrient composition of eating occasions throughout the day was not consistent, on both WD and WE. Although comparable temporal patterns were observed with eating occasions lowest in energy in the morning hours and highest at two later time points, 13.00 – 14.00 hours and 18.00 – 19.00 hours, during the day, some differences were also observed. The average energy content of eating occasions at each hour was generally higher on WE compared to WD, which did not reflect the comparable mean daily energy intakes of WD and WE. Fewer eating occasions occurred on WE vs. WD (5.33 ± 1.4 vs. 5.97 ± 1.1 respectively, $P<0.001$). The fact that more (energy) was eaten during the fewer number of eating occasions per day on WE than on WD, explains why there was no difference observed in the mean daily energy intakes between WD and WE. When mean daily energy intake was divided by the mean daily eating frequency for WE and WD, there was a higher energy intake per eating occasion on WE than on WD (2.05MJ ± 0.8 vs. 1.76 ± 0.5, respectively, $P<0.001$). The eating occasions in the morning hours and afternoon (15.00 – 16.00 hours) seem to contribute largely to these differences. The greater energy content of eating occasions in the morning and afternoon hours may be attributed to the less formal eating pattern of WE. Unlike WE days, the times of eating during the week, particularly lunch eating occasions, are controlled by defined breaks at work. More food may be eaten during eating occasions on the WE morning hours, than during the week, as the amount of time available may be greater.

On examining the nutrient composition of eating occasions throughout the day expressed as proportions of energy, it was interesting that the nutrient composition of eating occasions were remarkably comparable on WD and WE. The most notable difference between WD and WE was in alcohol intakes. The proportion of energy from alcohol in eating occasions was higher on WE and this reflected the difference observed in mean daily nutrient intakes. In the present study the fat content (% energy) of eating occasions on WE was not different to those on WD, irrespective of the time of the day. In contrast, De Castro, (1991) observed an increase in

absolute intakes of all macronutrients during WE eating occasions. It is important to note that De Castro's (1991) findings were based on calculations, which compared the average of, all eating occasions of each day, on each day of the week. As explained in chapter 3, such calculations, which aggregate the nutrient content of all the eating occasions of a day into one mean value, conceal details of the actual temporal pattern of nutrient intake during eating occasions throughout the day. Furthermore, De Castro, (1991) also did not present macronutrient intakes in terms of proportions of energy.

Unexpectedly, the findings of this study did not identify any major differences in mean daily macronutrient intakes or the macronutrient quality of eating occasions throughout the day, between WD and WE, with the exception of alcohol intakes. The results of this study suggest that it is therefore not appropriate to target particular days of the week or specific times of the day during WD or WE, with regard to the dietary recommendations for fat and carbohydrate. Whilst, this study sample was not a random sample of the Irish population, nor is it representative of other populations of other countries. The results are however based on a large free-living cohort and provide useful information for the development of FBDG. For example, identifying the times of the day at which alcohol is taken may help in the development of public health campaigns that encourage moderation in alcohol intake. On both WD and WE, alcohol was not only consumed in the late evening as expected, but also during the lunchtime hours of 12.00 – 14.00 hours and the hours immediately after work (16.00 – 19.00 hours), which may be associated with social events after work or leisure pursuits. An inaccurate perception of personal nutrient intake has been observed to be a contributory factor to people failing to adhere to the dietary recommendations and this is particularly true for fat (Mela, 1993). Therefore the development of practical strategies, which assist populations in evaluating personal fat intakes and recognising high fat intakes, has been recommended as part of dietary fat reduction strategies (Mela, 1995; Kearney *et al.*, 1997). Similarly, the use of such strategies may be useful for creating awareness of high alcohol intakes. Prompting people as to the usual times of consumption of alcohol, in such an evaluation concerned with alcohol, may assist people in determining a more accurate estimate of personal alcohol intakes and consequently make people aware of their high personal alcohol intakes. Personalising nutritional issues may improve the attainment of dietary targets for the

population as a whole, since it has been suggested that health promotion strategies which are based on the actual behaviours of the population are more effective (McLeroy *et al.*, 1993).

In conclusion, the results of the present study show that the day of the week has the most notable effect on alcohol intakes in this group of free-living healthy Irish adults. Differences in energy intakes were actually due to an increase in alcohol intakes on Saturdays and Sundays. There were no differences in energy intakes between WD and WE, when Monday through to Friday represented WD and Saturday and Sunday represented WE. The differences in macronutrient intakes between WD and WE disappeared when intakes were expressed as proportions of food energy. Generally, the temporal pattern of macronutrient intakes during eating occasions on WD, was almost identical to that on WE. The temporal pattern of alcohol intake during eating occasions throughout the day has implications for the development of health promotion strategies to reduce alcohol intakes.

Determination of the temporal pattern of nutrient intake during eating occasions throughout the day in this free-living population of adults has allowed a number of important public health nutrition issues to be addressed. The issues of whether differences exist in the eating patterns of, high-fat and low-fat eaters and of those with different periodicities of eating and whether differences exist in nutrient intakes between different days of the week were addressed in Chapters 5, 6 and 7 respectively. The issue of whether test meals used in postprandial lipaemic studies reflects everyday eating occasions, was also addressed (Chapter 4). These investigations demonstrated the importance and value of studying data at the level of eating occasions. A database of the nutrient intakes of eating occasions of free-living adults allowed these issues to be clarified. This could not have been done using data on total daily intakes. The cohort of office workers surveyed in the present study was not, however, representative of the full population. Clearly, it is limited because of its small sample size. Food and nutrient intake findings of a small non-random population in a country must also be observed in a random and representative sample of the population, before recommendations can be formulated. When the Irish Universities Nutrition Alliance (a formal association of nutrition departments in University College Cork, Trinity College Dublin & University of

Ulster) were planning a food consumption survey to be carried out in an adult population, on the island of Ireland between 1997-1999, specific attention was paid to ensuring the methodology would allow data to be collected at the level of individual eating occasions. The following chapter (Chapter 8) details the methodology used to collect the food consumption data in the North/South Ireland Food Consumption Survey (NSIFCS). Chapter 9 describes the macronutrient intakes and food sources of this adult population.

**Table 7.1: The day-of-the-week effect on energy and macronutrient intakes : mean and standard deviation (SD) values**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | | Saturday | | Sunday | | *P†* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | |
| Kcals | 2343.3 | (765.1) | 2415.6 | (753.4) | 2451.2 | (904.0) | 2492.6 | (868.7) | 2649.2 | (960.4) | 2648.7 | (1014.3) | 2378.3 | (886.6) | * |
| MJ | 9.89 | (3.3) | 10.19 | (3.2) | 10.33 | (3.9) | 10.50 | (3.8) | 11.20 | (4.2) | 11.08 | (4.2) | 9.96 | (3.7) | * |
| Protein (g) | 86.1 | (29.0) | 86.1 | (26.5) | 83.5 | (27.3) | 86.4 | (31.8) | 87.0 | (29.1) | 86.1 | (30.0) | 85.2 | (32.5) | ns |
| Fat (g) | 94.1 | (39.7) | 97.4 | (41.2) | 99.7 | (49.9) | 101.6 | (45.6) | 105.2 | (46.5) | 105.8 | (52.0) | 93.3 | (40.9) | ns |
| Carbohydrate (g) | 288.7 | (98.1) | 303.2 | (98.4) | 305.1 | (115.0) | 303.8 | (111.1) | 309.8 | (121.7) | 303.1 | (120.7) | 280.6 | (118.0) | ns |
| Total sugars (g) | 118.3 | (61.8) | 124.0 | (57.2) | 124.1 | (63.5) | 123.0 | (55.0) | 131.1 | (74.9) | 127.8 | (72.4) | 127.4 | (148.1) | ns |
| Alcohol (g) | 9.7 | (29.2) | 8.3 | (19.2) | 10.3 | (21.7) | 12.7 | (24.0) | 26.9 | (41.2) | 31.5 | (43.2) | 20.7 | (30.4) | *** |
| % TE from protein | 15.1 | (3.9) | 14.6 | (3.2) | 14.1 | (3.2) | 14.2 | (3.9) | 13.7 | (3.8) | 13.5 | (3.7) | 14.9 | (4.2) | ** |
| % TE from fat | 35.6 | (8.2) | 35.6 | (8.2) | 35.9 | (8.1) | 36.2 | (7.4) | 35.5 | (7.7) | 35.6 | (8.7) | 35.2 | (8.9) | ns |
| % TE from carbohydrate | 46.7 | (7.5) | 47.4 | (7.0) | 46.8 | (6.9) | 46.0 | (6.9) | 44.1 | (7.4) | 43.4 | (8.5) | 44.4 | (9.1) | *** |
| % TE from alcohol | 2.5 | (6.5) | 2.4 | (5.2) | 3.0 | (6.1) | 3.3 | (6.0) | 6.6 | (9.2) | 7.7 | (8.7) | 5.5 | (7.9) | *** |
| Total kcals minus alcohol kcals | 2275.2 | (732.7) | 2357.4 | (743.8) | 2378.8 | (885.7) | 2403.4 | (840.3) | 2460.6 | (894.2) | 2428.5 | (911.5) | 2233.5 | (819.1) | ns |
| % FE from protein | 15.5 | (4.0) | 15.0 | (3.3) | 14.7 | (3.5) | 14.7 | (3.9) | 14.7 | (3.6) | 14.7 | (4.1) | 15.8 | (4.6) | ns |
| % FE from fat | 36.4 | (7.8) | 36.4 | (7.8) | 36.8 | (7.6) | 37.4 | (7.3) | 37.9 | (7.1) | 38.4 | (8.3) | 37.2 | (8.8) | ns |
| % FE from carbohydrate | 47.9 | (7.6) | 48.6 | (7.3) | 48.3 | (6.9) | 47.6 | (6.7) | 47.3 | (7.4) | 47.1 | (8.2) | 46.9 | (8.7) | ns |

† Comparison of means between the individual days of the week: * P<0.05, ** P<0.01, ***P<0.001, ns not significant P>0.05.
TE - total energy, FE - food energy

**Table 7.2: *Mean and standard deviation (SD) values of total daily energy and macronutrient intakes of Irish adults on weekdays and weekend days***

| | Weekdays | | | | | | | Weekend days | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All (n=133) † | | Males (n=55) | | Females (n=78) | | P‡ | All (n=133) | | Males (n=55) | | Females (n=78) | | P‡ |
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | *P* | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* | |
| Kcal | 2470.4 NS | (717.1) | 2999.7 | (699.3) | 2097.1 | (444.4) | *** | 2513.5 | (840.9) | 3055.8 | (862.6) | 2131.1 | (576.4) | *** |
| MJ | 10.4 NS | (3139.6) | 12718.6 | (3153.6) | 8791.4 | (1860.6) | *** | 10519.1 | (3520.0) | 12793 | (3599.2) | 8915.8 | (2420.5) | *** |
| Protein (g) | 85.8 NS | (21.9) | 102.2 | (19.5) | 74.2 | (15.1) | *** | 85.6 | (26.5) | 102 | (27.8) | 74.1 | (18.3) | *** |
| Carbohydrate (g) | 302.1 NS | (93.2) | 366.8 | (93.3) | 256.5 | (60.8) | *** | 291.9 | (107.0) | 351.4 | (115.1) | 249.9 | (77.7) | *** |
| Fat (g) | 99.6 NS | (36.1) | 121.2 | (39.0) | 84.3 | (24.3) | *** | 99.6 | (40.6) | 120 | (42.7) | 85.1 | (32.3) | *** |
| Sugars (g) | 124.1 NS | (52.2) | 147.1 | (60.2) | 107.9 | (38.5) | *** | 127.6 | (96.1) | 162.5 | (131.9) | 103 | (46.4) | *** |
| Alcohol (g) | 13.6 *** | (15.1) | 17.6 | (15.5) | 10.8 | (14.2) | ** | 26.1 | (27.7) | 36 | (34.0) | 19.1 | (19.4) | *** |
| % energy from protein | 14.1 NS | (2.1) | 13.9 | (1.8) | 14.4 | (2.3) | NS | 14.0 | (3.0) | 13.5 | (2.3) | 14.3 | (3.3) | NS |
| % energy from carbohydrate | 45.9 ** | (5.2) | 45.9 | (5.5) | 45.9 | (5.0) | NS | 43.7 | (7.4) | 43.1 | (7.2) | 44.1 | (7.6) | NS |
| % energy from starch | 27.1 * | (4.9) | 27.6 | (4.6) | 26.7 | (5.1) | NS | 25.1 | (8.7) | 23.8 | (10.5) | 26.1 | (7.1) | NS |
| % energy from total sugars | 18.8 NS | (5.3) | 18.3 | (5.6) | 19.1 | (5.1) | NS | 18.5 | (9.3) | 19.3 | (12.6) | 18 | (5.8) | NS |
| % energy from fat | 35.9 NS | (5.2) | 35.9 | (5.4) | 35.8 | (5.0) | NS | 35.4 | (7.2) | 35.5 | (7.3) | 35.3 | (7.1) | NS |
| % energy from alcohol | 4 *** | (4.4) | 4.3 | (3.7) | 3.7 | (4.8) | NS | 7 | (6.9) | 8 | (7.4) | 6.4 | (6.5) | NS |
| % food energy from carbohydra | 47.8 NS | (4.9) | 47.9 | (5.3) | 47.7 | (4.6) | NS | 46.9 | (6.7) | 46.8 | (6.9) | 46.9 | (6.6) | NS |
| % food energy from fat | 37.3 NS | (5.0) | 37.5 | (5.5) | 37.2 | (4.7) | NS | 38.1 | (7.1) | 38.4 | (6.8) | 37.8 | (7.3) | NS |
| % food energy from protein | 14.8 NS | (2.3) | 14.5 | (2.0) | 15.5 | (2.6) | NS | 15.4 | (3.5) | 14.8 | (2.9) | 15.4 | (3.9) | NS |

† Comparison of mean daily nutrient intakes between weekdays and weekend days for the full population

‡ Comparison of mean daily nutrient intakes between men and women within weekdays and weekend days, * P<0.05, ** P<0.01, ***P<0.001, NS, not signi

**Table 7.3: The number (n) of values per hour ***

| hour | Weekdays (WD) | Weekend days (WE) |
|---|---|---|
| | *n* | *n* |
| 1.00 | 8 | 10 |
| 2.00 | 2 | 11 |
| 3.00 | 2 | 3 |
| 6.00 | 3 | 1 |
| 7.00 | 45 | 8 |
| 8.00 | 93 | 17 |
| 9.00 | 74 | 48 |
| 10.00 | 85 | 65 |
| 11.00 | 102 | 70 |
| 12.00 | 39 | 69 |
| 13.00 | 122 | 72 |
| 14.00 | 97 | 90 |
| 15.00 | 53 | 71 |
| 16.00 | 82 | 62 |
| 17.00 | 75 | 65 |
| 18.00 | 113 | 84 |
| 19.00 | 119 | 79 |
| 20.00 | 101 | 70 |
| 21.00 | 106 | 68 |
| 22.00 | 123 | 78 |
| 23.00 | 85 | 60 |
| 24.00 | 52 | 27 |

* the number of subjects who ate at an hour, having taken into consideration the no. of times during the 5 days (WD) or 2 days (WE) an individual ate at the hour

**Figure 7.1: Temporal pattern of mean energy intake (MJ) during eating occasions/hour on weekdays (WD) and weekend days (WE)**

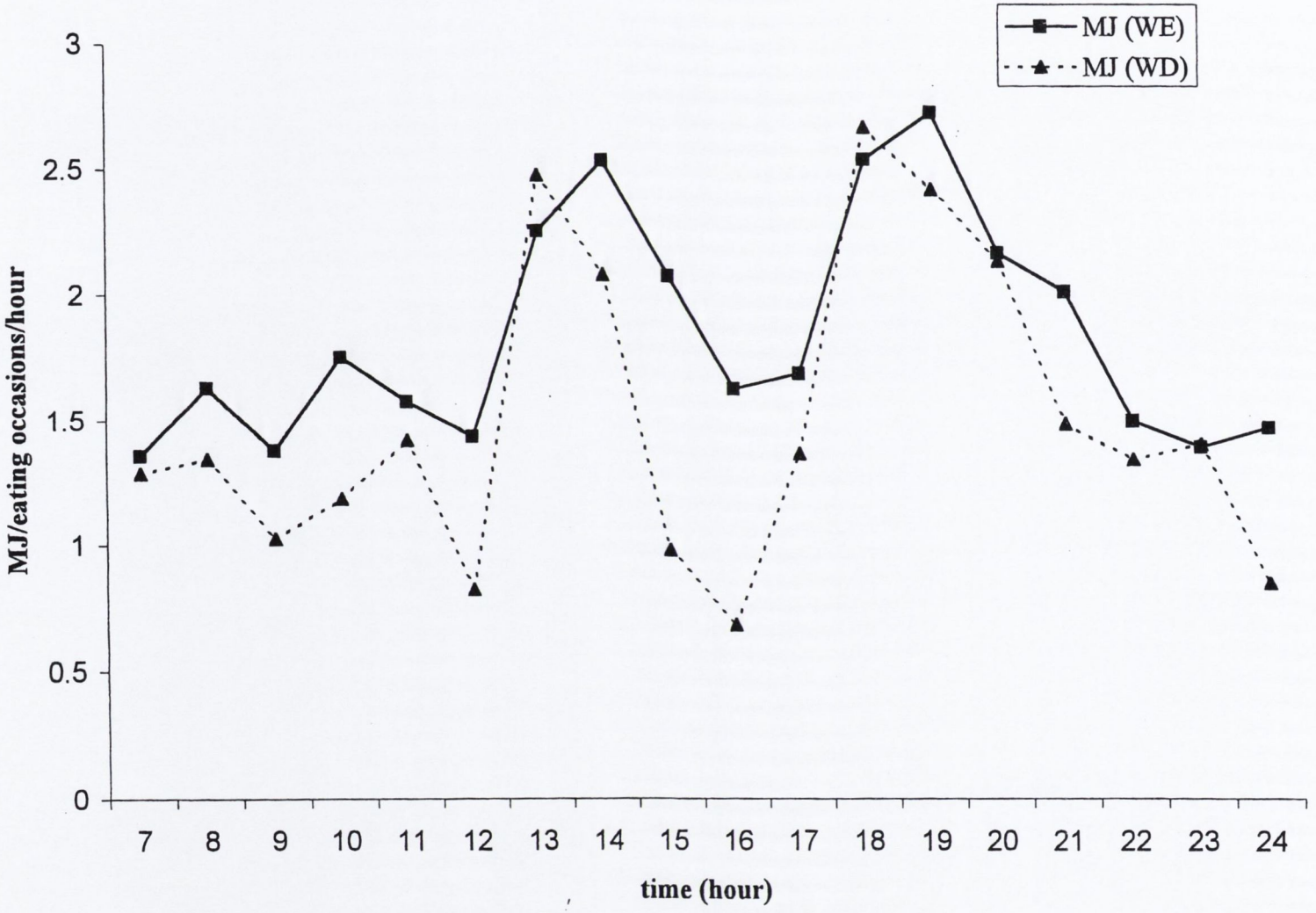


**Figure 7.2a: Temporal pattern of mean carbohydrate and fat intake (g) during eating occasions/hour on weekdays (WD) and weekend days (WE)**

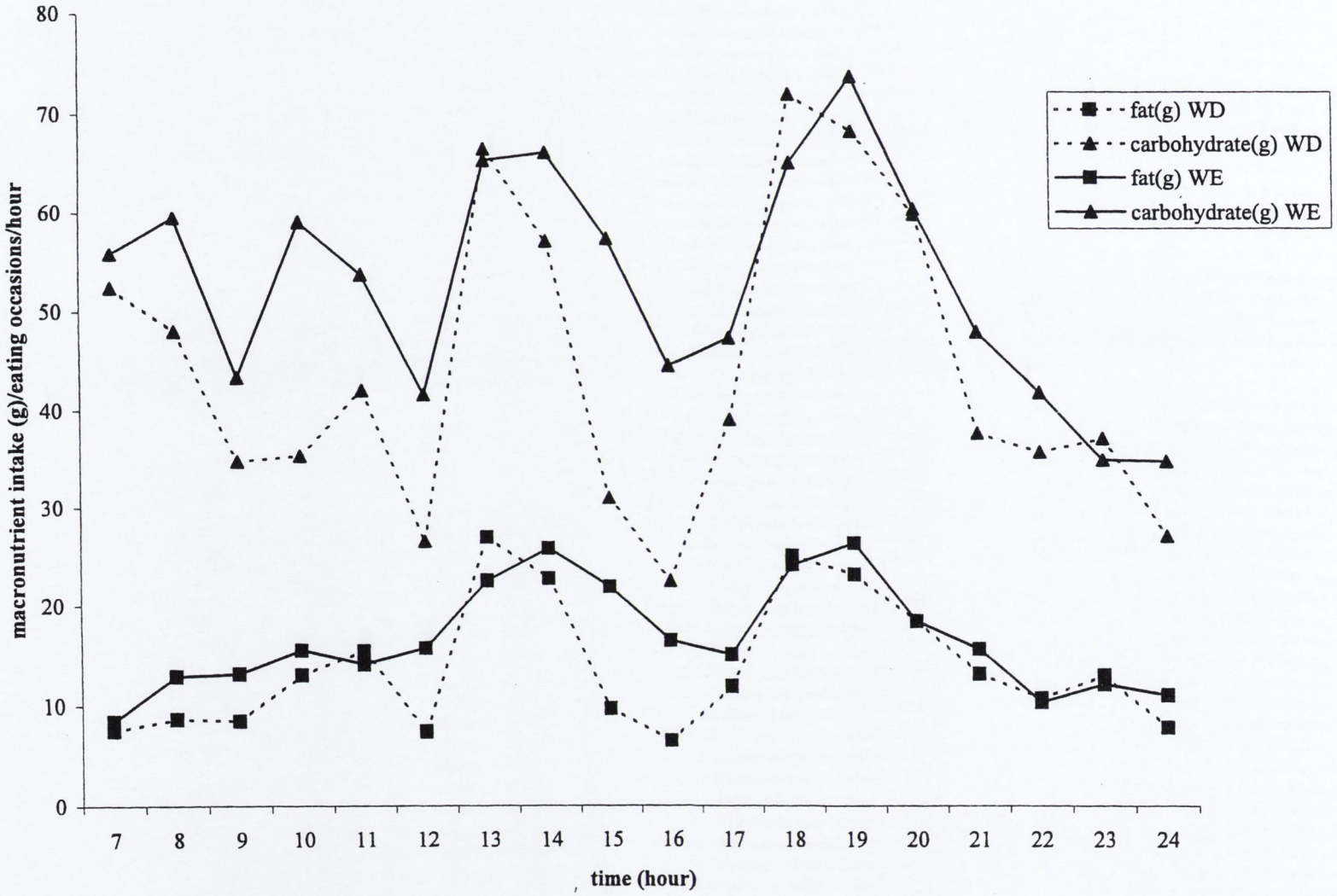


**Figure 7.2b: Temporal pattern of mean protein and alcohol intake (g) during eating occasions/hour on weekdays (WD) and weekend days (WE)**

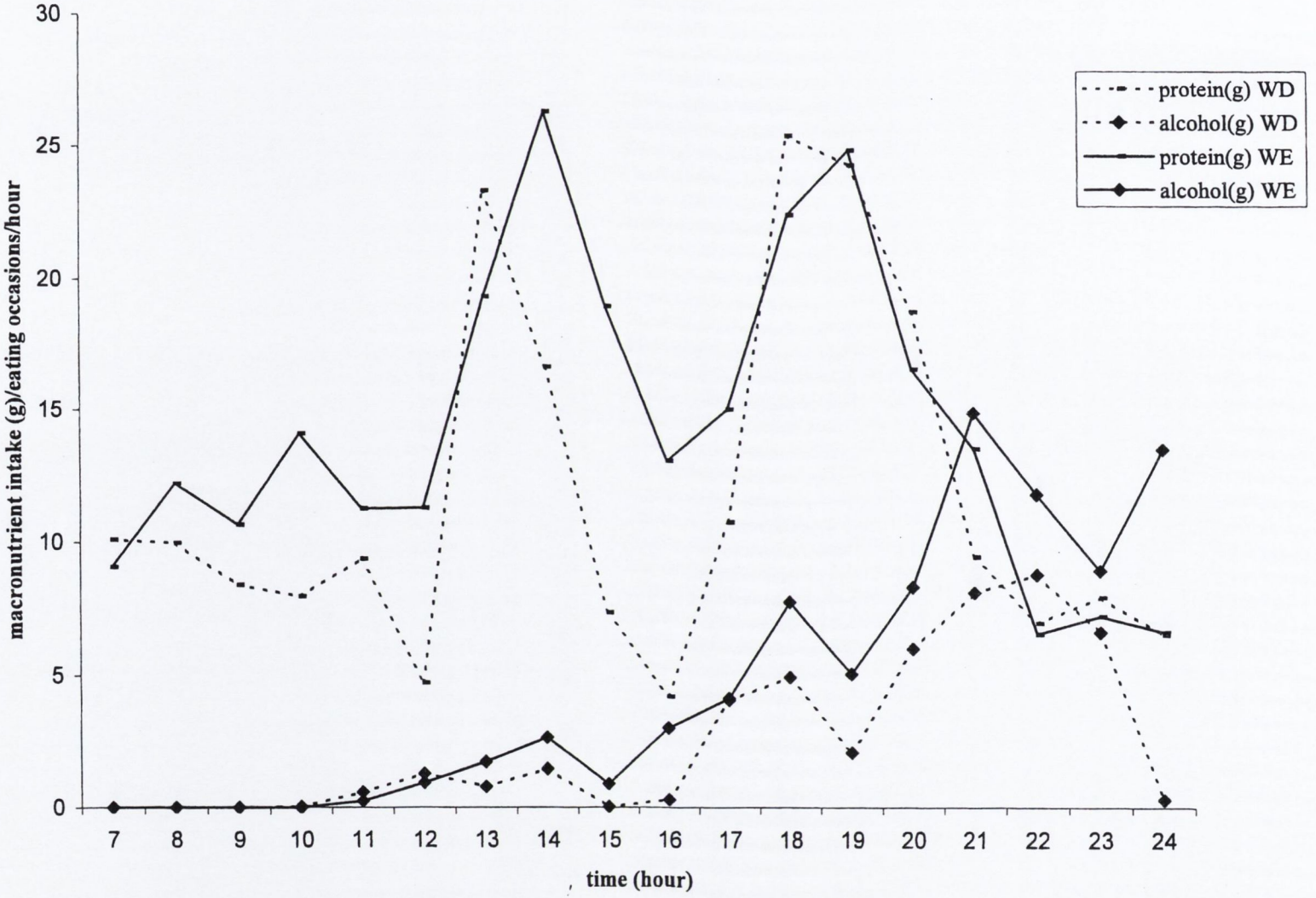


**Figure 7.3: Temporal pattern of mean proportions of total energy from macronutrients during eating occasions/hour on weekdays (WD) and weekend days (WE)**

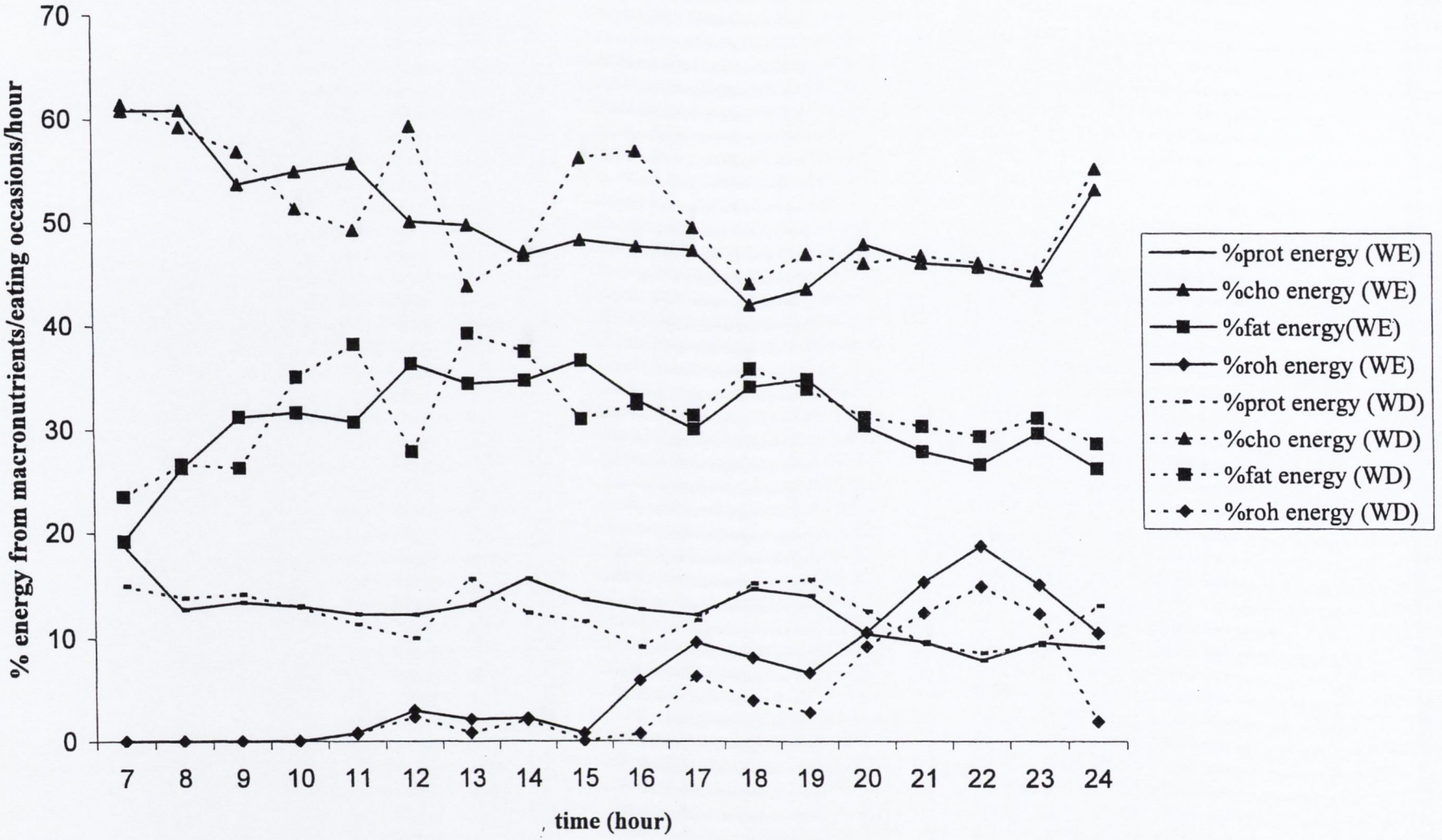
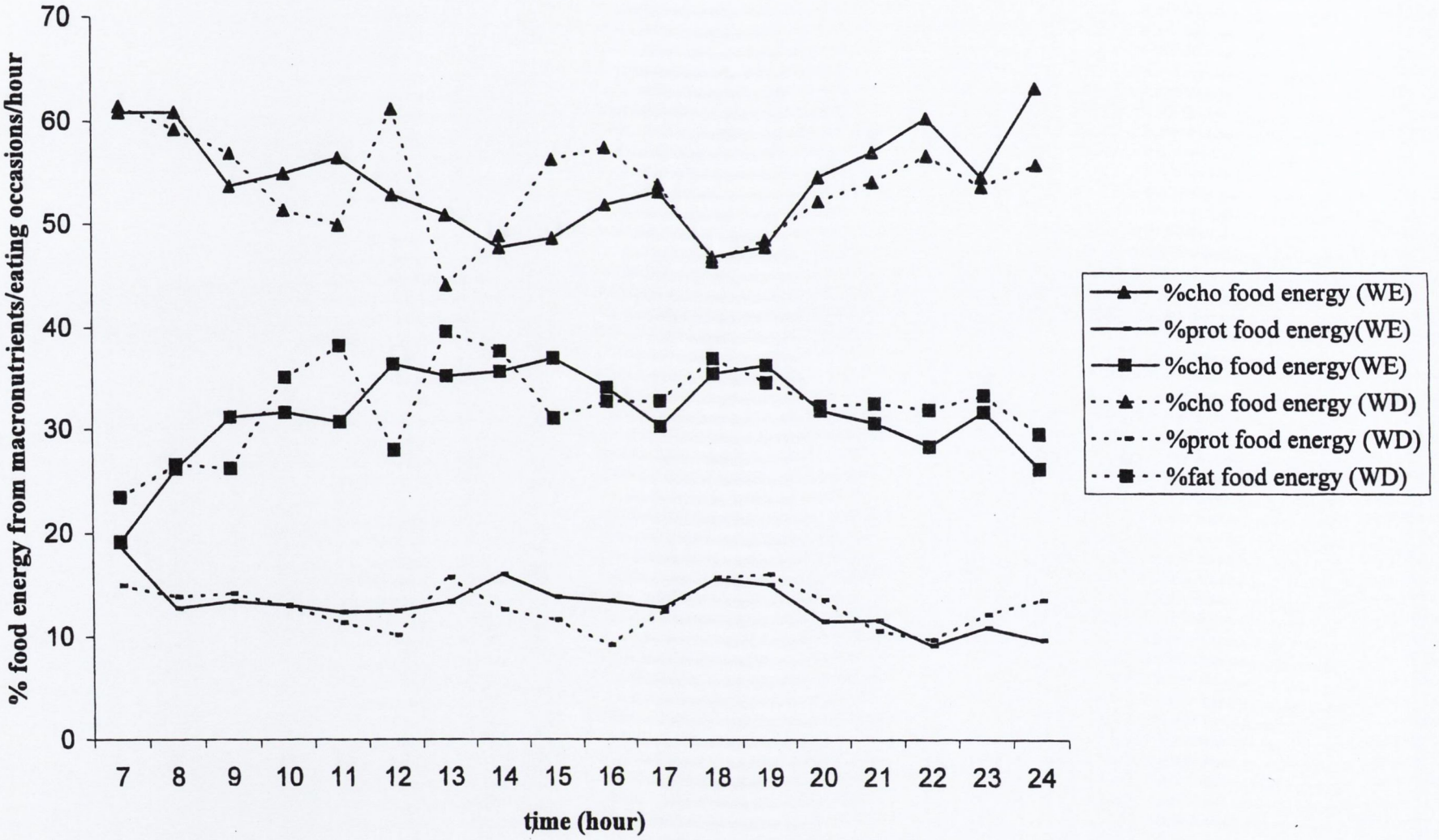


**Figure 7.4: Temporal pattern of mean proportions of food energy from macronutrients during eating occasions/hour on weekdays (WD) and weekend days (WE)**



## 7.5 REFERENCES


Acheson, K.L., Campbell, I.T., Edholm, O.G., & Miller, D.S. (1980). The measurement of food and energy intake in men: An evaluation of some techniques. *American Journal of Clinical Nutrition, 33,* 1147-1154.

Basiotis, P.P., Thomas, R.G., Kelsay, J.L., & Mertz, W. (1989). Sources of variation in energy intake by men and women as determined from one year's daily dietary records. *American Journal of Clinical Nutrition, 50,* 448-453.

Beaton, G.H., Milner, J., Corey, P., McGuire, V., Cousins, M., Stewart, E., de Ramos, M., Hewitt, D., Grambsch, P.V., Kassim, N., & Little, J.A. (1979). Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. *American Journal of Clinical Nutrition, 32,* 2456-2559.

Beaton, G.H., Milner, J., McGuire, V., Feather, T.E., & Little, J.A. (1983). Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. Carbohydrate sources, vitamins, and minerals. *American Journal of Clinical Nutrition, 37,* 986-995.

Briefel, R.R., McDowell, M.A., Alaimo, K., Caughman, C.R., Bischof, A.L., Carroll, M.D., & Johnson, C.L. (1995). Total energy intake of the US population: the third National Health and Nutrition Examination Survey, 1988-1991. *American Journal of Clinical Nutrition, 62(suppl),* S1072-S1080.

Chalmers, F.W., Clayton, M.M., & Gates, L.O. *et al.* (1952). The dietary record - how many and which days. *Journal of the American Dietetic Association, 28,* 711-716.

De Boer, J.O., Knuiman, J.T., West, C.E., Burema, J., Rasanen, L., Scaccini, C., Villavieja, G.M., & Lokko, P. (1987). Within-person variation in daily dietary intake of boys from

Finland, The Netherlands, The Philippines and Ghana. *Human Nutrition: Applied Nutrition, 41A,* 225-232.

De Castro, J.M. (1991). Weekly rhythms of spontaneous nutrient intake and meal pattern of humans. *Physiology & Behaviour, 50,* 729-738.

Food Advisory Committee. (1987). *Guidelines for Preparing Information and Advice to the General Public on Healthy Eating.* Dublin, Ireland: Department of Health.

Goldberg, G.R., Black, A.E., Jebb, S.A., Cole, T.J., Murgatroyd, P.R., Coward, W.A., & Prentice, A.M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off values to identify under-recording. *European Journal of Clinical Nutrition, 45,* 569-581.

Hulshof, K.A.M., Löwik, M.R.H., Kistemaker, C., Hermus, R.J.J., ten Hoor, F., & Ockhuizen, T. (1993). Comparison of dietary intake data with guidelines: some potential pitfalls (Dutch Nutrition Surveillance System). *Journal of the American College of Nutrition, 12,* 176-185.

Jula, A., Seppanen, R., & Alanen, E. (1999). Influence of days of the week on reported food, macronutrient and alcohol intake among an adult population in south western Finland. *European Journal of Clinical Nutrition, 52,* 808-812.

Kearney, M., Gibney, M.J., Martinez, J.A., de Almeida, M.D.V., Friebe, D., Zunft, H.J.F., Widhalm, K., & Kearney, J.M. (1997). Perceived need to alter eating habits among representative samples of adults from all member states of the European Union. *European Journal of Clinical Nutrition, 51,* S30-S35.

Krebs-Smith, S.M., Cleveland, L.E., Ballard-Barbash, R., Cook, D.A., & Kahle, L.L. (1997). Characterizing food intake patterns of American adults. *American Journal of Clinical Nutrition, 65,* S1264-S1268.

Löwik, M.R.H., Hulshof, K.F.A.M., van der Heijden, L.J.M., Brussard, J.H., Burema, J., Kistemaker, C., & de Vries, P.J.F. (1998). Changes in the diet in The Netherlands: 1987-88 to 1992. *International Journal of Food Sciences and Nutrition , 49 (Supplement 1),* S1-S64.

Maisey, S., Loughridge, J., Southon, S., & Fulcher, R. (1995). Variation in food group and nutrient intake with day of the week in an elderly population. *British Journal of Nutrition, 73,* 359-373.

McElroy, K.R., Steckler,A.B., Simons-Morton, B., Goodman, R.M., Gottlieb, N., & Burdine,J.N. (1993). Social science theory in health education: Time for a new model? Health Education Research, 8, 305-312.

McBride, A., Wise, A., McNeill, G., & James, W.P.T. (1990). The pattern of food consumption related to energy intake. *Journal of Human Nutrition and Dietetics, 3,* 27-32.

McGee, D., Rhoads, G., Hankin, J., Yano, K., & Thillotson, J. (1982). Within-person variability of nutrient intake in a group of Hawaiian men of Japanese ancestry. *American Journal of Clinical Nutrition, 36,* 657-663.

Mela, D.J. (1993). Consumer estimates of the percent energy from fat in common foods. *European Journal of Clinical Nutrition, 47,* 735-740.

Mela, D.J. (1995). Understanding fat preference and consumption: applications of behavioural sciences to a nutritional problem. *Proceedings of The Nutrition Society, 54,* 453-464.

Ministry of Agriculture, Fisheries and Food (MAFF). (1994). *The Dietary and Nutritional Survey of British Adults - Further Analysis.* London: HMSO.

Nicklas, T.A., Farris, R.P., Bao, W., Webber, L.S., & Berenson, G.S. (1997). Differences in reported dietary intake of 10-year-old children on weekdays compared to Sunday: the Bogalusa Heart Study. *Nutrition Research, 17,* 31-40.

Post, B., Kemper, H.C.G., & Storm-Van Essen, L. (1987). Longitudinal changes in nutritional habits of teenagers: differences in intake between schooldays and weekend days. *British Journal of Nutrition, 57,* 161-176.

St.Jeor, S.T., Guthrie, H.A., & Jones, M.B. (1983). Variability in nutrient intake in a 28-day period. *Journal of the American Dietetic Association, 83,* 155-162.

Tarasuk, V., & Beaton, G.H. (1992). Statistical estimation of dietary parameters: implication of patterns in within-subject variation - a case study of sampling strategies. *American Journal of Clinical Nutrition, 55,* 22-27.

Thomson, M., Elton, R.A., Fulton, M., Brown, S., Wood, D.A., & Oliver, M.F. (1988a). Individual variation in the dietary intake of a group of Scottish men. *Journal of Human Nutrition and Dietetics, 1,* 47-57.

Thomson, M., Fulton, M., Elton, R.A., Brown, S., Wood, D.A., & Oliver, M.F. (1988b). Alcohol consumption and nutrient intake in middle-aged Scottish men. *American Journal of Clinical Nutrition, 47,* 139-145.

# CHAPTER 8

## The North/South Ireland Food Consumption Survey: Survey Design and Methodology

*Public Health Nutrition, submitted April, 2001*

## 8.1 INTRODUCTION

The last major nutrition surveys carried out in the Republic of Ireland and Northern Ireland were the Irish National Nutrition Survey (Lee & Cunningham, 1990) in 1988/1989 and the Diet, Lifestyle and Health in Northern Ireland survey (Barker *et al.*, 1989) in 1986/1987 respectively. Changing social and demographic circumstances, the growing choice of pre-packed convenience foods, the influence of ethnic foods, the greater availability of low and reduced fat foods as well as an increasing awareness of 'healthy eating' messages suggest that food consumption patterns in adults are likely to have modified substantially over the intervening decade since these surveys were undertaken. Thus, new information is required. Data concerning current food consumption in Ireland are also necessary in order to fulfil the requirements of three European Union (EU) directives which require member states to establish systems to monitor intakes of sweeteners, colours and food additives (other than colours and sweeteners) (European Parliament and Council Directives 94/35/EC, 94/36/EC, 95/2/EC). The existing databases, in addition to being over 10 years old, are unsuitable for this purpose as they were designed mainly to assess nutrient intakes.

The primary objective of the North/South Ireland Food Consumption Survey was to establish a database of habitual food and beverage consumption in a representative sample of Irish adults aged 18 to 64 years. The survey was carried out by the Irish Universities Nutrition Alliance (IUNA). The IUNA is a formal association of the nutrition units at University College Cork, Trinity College Dublin and the University of Ulster at Coleraine, committed to joint initiatives in education and research. The survey team was based at the nutrition departments of the three universities with a co-ordinating nutritionist in each department. It is anticipated that the data obtained from the present (all Ireland) study will facilitate (i) the determination of food and nutrient intakes against which current dietary guidelines can be evaluated and future changes monitored (ii) an assessment of adult intakes of food chemicals in order to fulfil EU Directives and (iii) an evaluation of lifestyle factors influencing food and nutrient intakes. The aim of the present paper is to describe the design and methods used in collecting data for the North/South Ireland Food Consumption Survey.

## 8.2 SAMPLING

Ethical permission was obtained from the Federated Dublin Voluntary Hospitals and St. James's Hospital Joint Research Ethics Committee for the Republic of Ireland and from the Research Ethical Committee of the University of Ulster for Northern Ireland. Fieldwork was completed over a two-year period between October 1997 and October 1999 with each year divided into two seasons, winter (September – February inclusive) and summer (March – August inclusive). Nationally representative samples were randomly selected for both the Republic of Ireland and Northern Ireland using the 1997 Electoral Register and the 1997 - 1999 Register of Electors respectively. A two-stage sampling procedure was employed where district electoral divisions (DEDs) in the Republic of Ireland or electoral wards in Northern Ireland were randomly selected followed by the random selection of individuals within these areas. Eligible respondents were adults between the ages of 18 and 64 years inclusive who were not pregnant or breast-feeding. A detailed description of the sampling procedure has been provided by Kiely *et al.*, (2001). A response rate of 63% was obtained (Kiely *et al.*, 2001).

## 8.3 RESPONDENT RECRUITMENT

An introductory letter and information about the study were posted to all selected individuals in an area. One week later a survey fieldworker called to explain the survey in more detail, determine eligibility and invite participation. Four visits were made to each respondent's address before they were deemed to be non-contactable. People who declined to participate were asked to provide information concerning age, education, occupation and a reason for non-participation in an attempt to characterise groups of people who declined to participate in the survey. Characteristics of this group have been reported by Kiely *et al.*, (2001). If a potential respondent agreed to participate, they were asked to sign a consent form and the survey commenced.

## 8.4 SURVEY PROCEDURES

### 8.4.1 Food Intake Data Collection

Each respondent kept a written record of all food and drink consumed for 7 days using a 7-day food diary. The choice of the 7-day food diary was governed by the objective of the study,

which was to measure food consumption with a view to determining nutrient and food chemical intakes. Respondents were instructed, encouraged and motivated to complete the diary using a protocol called the Food Diary Instruction Model by the survey team. Using this model, the same fieldworker made four visits (of on average 30mins duration per visit) to the respondent during the recording period: a training session; a visit on day 2; a third visit on day 4 or 5; and a final visit on day 8 (at the end of the recording period). Each respondent was visited in his/her home or place of work. During the training session the fieldworker explained how the food diary should be completed. As an example the respondent was instructed to record his/her previous eating occasions, thus reducing the chance of the fieldworker influencing the respondent's reporting of food consumption. Respondents were asked to provide detailed information regarding the types and amounts of all foods, beverages and nutritional supplements consumed over the seven day period, the time and location of each 'eating occasion', method of cooking and brand name (where appropriate), leftovers, recipe details and a definition of the 'eating occasion' as the subject perceived it, as either a meal or a snack. Detailed instructions were given on the recording of recipes and food/drink eaten out. It was stressed to respondents that they should not attempt to change or 'improve' their diet during the recording period. During visits on days 2, 4 or 5, and 8 the fieldworker reviewed the diary recording, checked for completeness, clarified the quantities of food/drink consumed and obtained any further information required. The food diary was an A6 sized booklet chosen for its compact size with the anticipation that respondents would be more likely to carry it with them. The diary included guidelines on how to record food and drink intake, recording pages, recipe pages and a table for the fieldworker to note usual food used e.g. milk type. Each eating occasion was filled in on a separate page (with 15-20 pages/diary) and the respondent was provided with a new food diary at each visit and the old food diary was collected.

### 8.4.2 Quantification of Food Diaries

As there is a paucity of clear information on the validity and usefulness of different portion size measuring aids, there is little consensus of opinion regarding the most effective tools to use (Cypel *et al.*, 1997). Although comparative studies are lacking, it is likely that all foods and beverages cannot and should not be quantified in the same way. Therefore the ethos of

the North/South Ireland Food Consumption survey was to obtain the best estimates possible using a combination of food quantification methods. It is generally accepted that direct weighing is the most precise method of determining amounts of food eaten. However it is also recognised that for a survey of this size it is not feasible to provide all respondents with dietary scales on the grounds of cost and to weigh all foods would be unduly invasive and could reduce compliance. On this basis, a hierarchical approach to quantification was developed. Foods and drinks were quantified by eight specific methods according to a quantification protocol. If it was not possible to quantify a food or drink with a method on the 1st level of the hierarchy, a subsequent method was used. Each fieldworker was responsible for quantification of each food diary they collected.

(1) *Direct weighing.* Fieldworkers obtained the weights of certain foods in the respondents' homes using a portable food scales (Soehnle Vita 8020 food scales (2000g x 1g) and Acculab (4000g x 1g), CMS Weighing Equipment Ltd., London, U.K.). The foods chosen for this approach were those, which are (i) difficult to estimate using other methods and (ii) thought to be unlikely to be subject to substantial intra-individual variation. Foods weighed by the fieldworker included breakfast cereals, milk on cereal and milk added to tea and coffee, spreading fats used on bread, slices of breads and beverages used such as tea, coffee, juices and alcohol. Food weights were obtained only once for a particular food or when the same cup or glass was used and amounts were assumed to be the same on subsequent occasions. If a respondent subsequently requested dietary scales to weigh other foods over the 7-day period, these were provided. The scales were verified for weighing accuracy at the beginning of each fieldwork session by fieldworkers. A plastic measuring jug (mls) was also left with respondents for measuring milk in cereal, if requested.

(2) *Photographic Food Atlas.* The second approach was to ask respondents to describe food quantities that they had eaten in terms of fractions or multiples of the amounts of food shown in the appropriate photograph in an album of food photographs specifically designed for this survey (Robson, 1997). Photographs are an attractive quantification aid as they are portable, capable of portraying a wide range of foods and relatively easy to reproduce (Lucas *et al.*, 1995). There is however little consensus of opinion concerning the nature of food

photographs suitable for use as quantification aids in dietary surveys. The foods selected for inclusion in the album for use in the North/South Ireland Food Consumption Survey were foods consumed commonly in Ireland. Those foods that could easily be described in terms of natural units such as biscuits, eggs and commercially sliced bread were not included, as various studies have suggested that these can be adequately described without the use of portion size aids (Young *et al.*, 1952; Guthrie, 1984; Haraldsdóttir *et al.*, 1985; Wein *et al.*, 1989)

Two types of food photographs were produced; reference photographs (RP) and single food photographs (SFP). The RP showed several different types of a particular food in one picture and were intended mainly for identification purposes. Due to the wide range of breads eaten in Ireland, a major difficulty in Ireland concerns identification of, and nomenclature used, for different types of bread other than standard sliced loaves. Thus 14 reference photographs were taken solely of different types of bread from different regions throughout Ireland. The SFP showed only one portion of one type of food. The majority of the food weights shown in these photographs were derived from UK average portion weight data (MAFF, 1997). The resulting album contained 61 colour prints (18.0cm x 12.5cm).

(3) *Manufacturers' Information.* For some foods, it was possible to obtain the amounts eaten by deriving them from weights printed on food packaging. These included confectionery, savoury snacks, chilled and frozen foods, franchised fast foods, canned or bottled goods and packaged bakery goods. To facilitate collection of such data, fieldworkers asked respondents to collect all packaging of food and beverages consumed in a storage box/bag provided. Manufacturers' information was then added to an Extended Menu Search (EMS©) facility on the nutritional analysis program (WISP©, Tinuviel Software, Warrington, U.K.), which interfaced with the food diary data entry system (WISP-DES©, Tinuviel Software, Warrington, U.K.) enabling fieldworkers to quickly code and quantify food and drink consumed.

(4) *IUNA Information.* Average portions were ascertained for certain foods by the survey team. These foods included fruits, vegetables, processed meats, meat products, cakes, breads, bread rolls and take-away foods on sale in Ireland.

(5) *Data collected as part of previous UK studies* included weights on cereals, meat dishes, egg and egg dishes, desserts/puddings, vegetables, sauces, others (Livingstone, 1997).

(6) *Food Portion Sizes* was consulted if none of the previous methods provided quantities for foods or drinks (MAFF, 1997)

(7) *Household measures* were also used to quantify foods eaten. When respondents recorded quantities in household measures e.g. half a pint, one tablespoon, these amounts were then clarified by the fieldworker and weighed where necessary.

(8) *Estimated.* Food quantities were defined as 'estimated' if the fieldworker made an assessment of the amount likely to have been consumed, based on their knowledge of the respondent's general eating habits observed during the recording period. It also referred to food/drink quantities derived from estimates of items previously weighed.

In order to quantify cooked foods and recipes for which raw weights were available, the cooked food weights were derived from the raw weights and adjusted for weight gain or loss on cooking according to McCance and Widdowson guidelines (Holland *et al.*, 1995; Chan *et al.*, 1995; Chan *et al.*, 1996).

### 8.4.3 Coding, Data Entry and Analysis of Food Diaries

Food diaries were coded and data were entered by fieldworkers using a customised computer program called the Weighed Intake Software Package - Data Entry System (WISP-DES©) Version 1.25C (Tinuviel Software, Warrington, U.K.), installed on laptop computers. This program allowed entry of all data collected in the food diary (day, time, location, definition of an eating occasion, amount, food/drink, quantification method, fieldworker identification code and the season in which the food diary was completed) but had no facility for nutritional analysis. Completed food diaries were then exported from fieldworkers' laptops and imported by the co-ordinators into a customized nutritional analysis program called the Weighed Intake Software Package (WISP©) (Tinuviel Software, Warrington, U.K.). WISP-DES© was a derivative of WISP© with all the data entry functions of the main program. WISP© included a

recipe analyser for nutrient analysis of recipes created by fieldworkers in WISP-DES©. The food diaries were analysed for nutrient data and all food and nutrient data were imported into the statistical package for social sciences (SPSS®) (SPSS Inc., Chicago, U.S.A.).

### 8.4.4 Quality Control of Food Diary Data

Health science professionals, nutritionists and dietitians were employed as fieldworkers and each was responsible for the collection, quantification, coding and data entry of their own food diaries. Nutritionists reviewed diaries in each centre. One in every eight diaries was checked on a line-by-line basis by a trained nutritionist in the Republic of Ireland. This entailed a review of every entry from a food diary for accuracy of quantification, food code used and data entry. In the North, the co-ordinating nutritionist checked every diary in this way.

Having all fieldworkers use the quantification protocol described above also ensured quality control. WISP-DES© also incorporated over-range checks for portion sizes by generating a warning if a portion size was entered as five times a large portion size. During the coding and data entry of foods into WISP-DES©, an Extended Menu Search (EMS©) function developed specifically for the present survey was used (Tinuviel Software, Warrington, U.K.). EMS© is a database that uses the food group framework of the McCance and Widdowson's Composition of Foods (Holland *et al.*, 1988; Holland *et al.*, 1989; Holland *et al.*, 1991; Holland *et al.*, 1992a; Holland *et al.*, 1992b; Holland *et al.*, 1993; Chan *et al.*, 1994; Holland *et al.*, 1995; Chan *et al.*, 1995; Chan *et al.*, 1996) and links a food code to details on specific foods that are represented by that food code. This data includes manufacturer specific food portion sizes and product descriptions. Data in EMS© were managed and continually reviewed centrally by a co-ordinating nutritionist. The data included in EMS© were collected by respondents collecting packaging using the storage box, manufacturer's information supplied by manufacturers, and fieldworkers noting product data in the supermarket. A list of default codes was also compiled to assist the coding of food and drink that was poorly described in the food diary.

Fieldworkers completed training workshops to: (1) learn interview techniques, respondent recruitment procedures and dietary assessment training of respondents. Role-playing was

undertaken with nutritionists (who were trained in diet survey methodology) using closed circuit televisions. (2) assess each fieldworkers competency in the quantification and coding of food diaries. This included fieldworker familiarization with the range of products currently available on supermarket shelves and the collection of average portion size data (as described above under the quantification of food diaries under IUNA portion sizes). (3) train fieldworkers in the collection of anthropometric measurements using standardized procedures.

### 8.4.5 Food Composition Database

The food composition database used by WISP-DES© and WISP© contains data from the 5th edition of the 'Composition of Foods' (Holland *et al.*, 1995) and all nine supplements (Holland *et al.*, 1988; Holland *et al.*, 1989; Holland *et al.*, 1991; Holland *et al.*, 1992a; Holland *et al.*, 1992b; Holland *et al.*, 1993; Chan *et al.*, 1994; Chan *et al.*, 1995; Chan *et al.*, 1996). This food composition database was expanded to include generic Irish products and new products on the market, to allocate brand codes to specific products, to enable analysis of recipes and to include nutritional supplements. Fieldworker queries on coding and the generation of new food codes were managed centrally by a co-ordinating nutritionist. The decision to create a new food code was based on the following criteria: (i) the food was not present or was different from other foods in the existing nutrient database, (ii) the food was a diet product with little nutrient content but contained sugar substitutes (artificial sweeteners), (iii) the food was present in the database but the nutrient content was very different to existing codes. In this case the creation of a new food code depended on the number of respondents the food was consumed by and its frequency of consumption. Foods were assigned a new food code under the food group categories defined by the McCance and Widdowson database (Holland *et al.*, 1988; Holland *et al.*, 1989; Holland *et al.*, 1991; Holland *et al.*, 1992a; Holland *et al.*, 1992b; Holland *et al.*, 1993; Chan *et al.*, 1994; Holland *et al.*, 1995; Chan *et al.*, 1995; Chan *et al.*, 1996). The nutrient composition of new food codes was obtained from manufacturer's nutritional information and nutrient analysis of recipes. Mean values of nutrients were calculated for food products that were similar, from the manufacturer's information. Micronutrient values not obtained from the food manufacturer were obtained from the nearest food match in the existing database, where possible. Recipes were provided by respondents and for dishes eaten out were created by fieldworkers in WISP-DES© (Tinuviel Software,

Warrington, U.K.) with the assistance of recipe books. Recipes were reviewed during importation to WISP© (Tinuviel Software, Warrington, U.K.) by the co-ordinator. The decision was made by the co-ordinator to replace the recipe with a local food code or to assign it to a new food code and add it to the food composition database. 1010 new food codes (including 148 nutritional supplements) were created and added to the food composition database.

### 8.4.6 Anthropometric measurements

Five measurements were taken in this survey: weight, height, waist and hip circumferences and body composition using bioelectrical impedance analysis. The procedures used in taking the anthropometric measurements are described in detail by McCarthy *et al.*, (2001). All measurements except height and body composition were performed in duplicate. Body mass index (BMI) was derived from weight and height measurements. Body weight was measured on day 0 (usually the training visit) and on day 8 (or the final visit on completion of diary recording). Weight on day 0 was used for all calculations. Height was generally measured on day 0 and waist and hip circumferences and body composition were measured on day 4/5 or day 8. Each fieldworker judged the most appropriate time for taking measurements. The Seca Alpha 770 digital personal weighing scales (200kg x 0.1kg) (CMS Weighing Equipment Ltd, London) used in the Republic of Ireland were verified for accuracy of weighing up to 180kg by the Legal Metrology Service, Dublin and up to 100kg by technicians of the Northern Ireland Centre for Diet and Health (NICHE) prior to and on completion of the survey, without the need for adjustment. The bioelectrical impedance analyser (Bodystat 1500; Bodystat Ltd, Douglas, Isle of Man) used to measure body composition automatically performs its own calibration check each time a measurement is taken. Periodically, fieldworkers also checked the calibration separately according to the manufacturer's instructions.

### 8.4.7 Questionnaire Design

Respondents were asked to complete six questionnaires: a Health, Lifestyle and Socio-demographic Questionnaire, a Physical Activity Questionnaire, a Dutch Eating Behaviour Questionnaire (DEBQ) (van Strien *et al.*, 1986; van Strien, 1997), an Attitudinal

Questionnaire, a Meat Questionnaire and an Evaluation Questionnaire. All questionnaires were self-administered.

The *Health, Lifestyle and Socio-demographic Questionnaire* was used to allow an assessment of the influences of social and lifestyle factors on food choice and/or nutrient intake. The first section of the questionnaire was designed to provide background information on sex, age, smoking habits, usual alcohol consumption, medical conditions, weight changes in the past 5 years and changes in dietary habits in the past year. The second section was used to describe the socio-economic status and educational achievements of each respondent.

The *physical activity questionnaire* measured habitual physical activity. This questionnaire was developed by and provided by kind permission of the Institute of Public Health, University of Cambridge, U.K. The questionnaire was divided into three sections: (i) physical activity patterns in and around the home, (ii) work related activity patterns and travel and (iii) recreational activity. The data were analysed by the Institute of Public Health, Cambridge to produce variables that expressed the energy cost of all self-reported activity in household, work and recreational activities as an activity metabolic equivalent (MET) index by assigning a multiple of resting metabolic rate (MET score) to each activity (Livingstone *et al.*, 2001).

The validity of energy intakes in large-scale food intake surveys such as this is frequently questioned. Assuming that, on average the population is in energy balance, it can therefore be assumed that energy intake should equal energy expenditure. The measurement of energy expenditure by the doubly labelled water method is one of the best means of independently validating self-reported food intakes in free-living individuals (Black *et al.*, 1993). However, due to constraints on resources, it was not feasible to implement this method in the present survey. Therefore, anthropometric data (height and weight) were used to predict basal metabolic rate (BMR) using the equations derived by Schofield *et al.*, (1985) and those equations used in the 1991 UK Dietary Reference Values for those aged 60 years or more (Department of Health 1991). The physical activity questionnaire data was collected also to allow determination of the activity levels of individual respondents as light, moderate or heavy. This information can then be combined with predicted BMR and used to determine

predicted energy expenditure levels, which in turn, can be compared with reported energy intakes.

Recent studies have indicated that the prevalence of under-reporting of food intake is high, particularly among obese adults (Black *et al.*, 1993). Thus it has been recommended that a means of identifying weight-conscious individuals should be included in food surveys, as these individuals in particular may be prone to misrepresentation of food intakes (Black *et al.*, 1993). The *Dutch Eating Behaviour Questionnaire* was used in the present survey for this purpose (van Strien *et al.*, 1986; van Strien, 1997). This is a short multi-choice self-administered questionnaire that measures three eating behaviour scales – restraint, emotional and external eating.

Respondents were also asked to complete an *attitudinal questionnaire* designed to assess attitudes to diet and health and a *meat questionnaire* that assessed respondents' understanding of 'red meat', meat food choices and cooking practices. An *evaluation questionnaire* was used to assess reasons for participation and how respondents felt about participation.

To avoid an excessive burden on respondents, questionnaires were given a priority ranking with the Health, Lifestyle and Socio-demographic Questionnaire, Physical Activity Questionnaire and the Dutch Eating Behaviour Questionnaire ranked as the most important to be completed by respondents. The Health and Lifestyle Questionnaire and the Physical Activity Questionnaire were generally left with respondents at the training visit for completion before the end of the survey. It may be more appropriate to issue questionnaires such as the DEBQ and the Attitudinal Questionnaire at a time independent of the dietary assessment period. As this was not feasible in the present survey it was deemed appropriate to leave these questionnaires with respondents on day 4/5, with instructions for completion when diary recording was finished.

### 8.4.8 Questionnaire Data Management

All questionnaire data were entered into a customised Questionnaire - Data Entry Program - QDES© (Tinuviel Software, Warrington, U.K.). This program validated the data entry by

requiring dual-data entry and rules-based validation processes where only certain answers were permitted. Validated questionnaires were then imported into the customised questionnaire data collection system called the Questionnaire Consolidator program (QCON©) Version 1.1D (Tinuviel Software, Warrington, U.K.). This allowed collected data to be consolidated into a master output file before import into SPSS® (SPSS Inc., Chicago, U.S.A.) to produce a database for statistical analysis. Further quality control was executed on all questionnaires at the SPSS® stage. This entailed the review of all questionnaire data by co-ordinators to ensure only permissible answers were included.

All food, nutrient and questionnaire data were imported into SPSS® (SPSS Inc., Chicago, U.S.A.). These were compiled into a fully integrated relational database, which means that each respondent's ID number links every piece of information that is collected on that respondent.

## CONCLUSION

The North/South Ireland Food Consumption Survey is unique in being the first survey ever to be carried out in the Republic of Ireland and Northern Ireland concurrently using the same methodology. It provides an up-to-date database of habitual food and drink consumption in conjunction with data on socio-demographic status, physical activity levels, anthropometry, attitudes and restrained eating patterns in a representative sample of Irish adults. This database is an invaluable asset to government departments, regulatory authorities, nutrition scientists and educators, food and drink industries and consumers. This is in respect of many aspects of food and nutrition policy, including food additive usage levels and food contaminant issues. This database will also provide a resource for the development of dietary guidelines (both quantitative and qualitative) that may be attainable by the population. Furthermore, the provision of up-to-date information concerning eating habits of the population will assist regulatory authorities to draft policy on such issues as fortification, food and nutrition labelling and the nutritional impact of novel foods.

## 8.5 REFERENCES


Barker ME, McClean SI, McKenna PG, et al. (1988) *Diet, Lifestyle and Health in Northern Ireland.* Coleraine: University of Ulster.

Black AE, Prentice AM, Goldberg GR, Jebb SA, Bingham SA, Livingstone MBE. (1993) Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. *Journal of the American Dietetic Association* 90:572-9.

Chan W, Brown J, Buss DH. (1994) *Miscellaneous Foods. Fourth supplement to the fifth edition of McCance & Widdowson's The Composition of Foods.* The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Chan W, Brown J, Church SM, Buss DH. (1996) *Meat Products and Dishes. Sixth supplement to the fifth edition of McCance & Widdowson's The Composition of Foods.* The Royal College of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Chan W, Brown J, Lee SM, Buss DH. (1995) *Meat, Poultry and Game. Fifth supplement to the fifth edition of McCance & Widdowson's The Composition of Foods.* The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Cypel YS, Guenther PM, Petot GJ. (1997) Validity of portion-size measurement aids: a review. *Journal of the American Dietetic Association* 97(3):289-92.

Department of Health (1991) *Dietary reference values for food energy and nutrients for the United Kingdom. Report of the panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy.* London: HMSO.

European Parliament and Council Directive 94/35/EC on sweeteners for use in foodstuffs

European Parliament and Council Directive 94/36/EC on colours for use in foodstuffs

European Parliament and Council Directive 95/2/EC on food additives other than colours and sweeteners for use in foodstuffs

Guthrie HA. (1984) Selection and quantification of typical food portions by young adults. *Journal of the American Dietetic Association* 84:1440-4.

Haraldsdóttir J, Holm L, From og Lone V, Nielsen S. (1985) Estimering af portionsstorrelser ved hjaelp af modeller (Estimation of portion sizes with the help of models). *Naringsforskning* (29):59-65.

Holland B, Brown J, Buss DH. (1993) *Fish and Fish Products. Third supplement to the fifth edition of McCance & Widdowson's The Composition of Foods.* The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Holland B, Unwin ID, Buss DH. (1988) *Cereal and Cereal Products. The third supplement to McCance & Widdowson's The Composition of Foods (4th edition).* Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Holland B, Unwin ID, Buss DH. (1992a) *Fruit and Nuts. First supplement to the fifth edition of McCance & Widdowson's The Composition of Foods.* The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Holland B, Unwin ID, Buss DH. (1989) *Milk Products and Eggs. The fourth supplement to McCance & Widdowson's The Composition of Foods (4th edition).* Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Holland B, Unwin ID, Buss DH. (1991) *Vegetables, Herbs and Spices. The fifth supplement to McCance & Widdowson's The Composition of Foods (4th edition).* The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Holland B, Welch AA, Buss DH. (1992b) *Vegetable Dishes. Second supplement to the fifth edition of McCance & Widdowson's The Composition of Foods.* The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Holland B, Welch AA, Unwin ID, Buss DH, Paul AA, Southgate DAT. (1995) *McCance & Widdowson's The Composition of Foods. Fifth edition.* The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO.

Kiely M, Harrington KE, Robson PJ, Cran GW, Flynn A. (2001) Sampling description and procedures used to conduct the North/South Ireland Food Consumption Survey. *Public Health Nutrition* In Press

Lee P, Cunningham K. (1990) *The Irish National Nutrition Survey.* Dublin: Irish Nutrition and Dietetic Institute.

Livingstone MBE, Robson PJ, McCarthy SN, Kiely M, Harrington KE, Galvin M, Wareham NJ, Rennie KL. (2001) Physical activity patterns in a nationally representative sample of adults in Ireland. *Public Health Nutrition* In Press

Livingstone, M.B.E. (1997) Portion sizes of food and drink collected as part of UK studies. (unpublished data)

Lucas F, Niravong M, Villeminot S, Kaaks R, Clavel-Chapelon F. (1995) Estimation of food portion sizes using photographs: validity, strengths, weaknesses and recommendations. *Journal of Human Nutrition and Dietetics* 8:65-74.

MAFF. (1997) *Food Portion Sizes.* London: The Stationery Office.

McCarthy SN, Livingstone MBE, Harrington KE, Kiely M, Robson PJ, Gibney MJ. (2001) Analyses of anthropometric data from the North/South Ireland Food Consumption Survey. *Public Health Nutrition* In Press

Robson, PJ (1997) Photographic Food Atlas for the North/South Ireland Food Consumption Survey (NSIFCS).

Schofield WN, Schofield C, James WPT. (1985) Basal metabolic rate-review and prediction. *Human Nutrition and Clinical Nutrition* 39 (Suppl):S1-S96.

van Strien T, Frijters JER, Bergers GPA, Defares PB. (1986) The Dutch Eating Behaviour Questionnaire (DEBQ) for assessment of restrained, emotional and external eating behaviour. *International Journal of Eating Disorders* 5:295-315.

van Strien T. (1997) The concurrent validity of a classification of dieters with low versus high susceptibility toward failure of restraint. *Addictive Behaviour* 22:587-97.

Wein EE, Sabry JH, Evers FT. (1989) Recalled estimates of food portion size. *Journal of the American Dietetic Association* 89(7):962-4.

Young CM, Chalmers FW, Church HN, Clayton MM, Hagan GC, Steele BF, Tucker RE, Foster WD. (1952) Subject's ability to estimate food portions. *Massachusetts Experiment Station Bulletin* (469):63-77.

# CHAPTER 9

## Macronutrient Intakes and Food Sources in Irish Adults: Findings of the North/South Ireland Food Consumption Survey

*Public Health Nutrition, submitted April, 2001*

## 9.1 INTRODUCTION

The significance of diet to health and disease has been much debated in devising dietary recommendations and guidelines for the improvement of health and prevention of disease in a population (WHO, 1990; European Heart Network, 1998; Department of Health, 1991; Department of Health 1994; FAO/WHO, 1998; Scientific Committee for Food, 1993; FAO, 1994). Nutrition and diet are considered important to the underlying risk factors for cardiovascular disease and cancer, the primary causes of pre-mature mortality in most developed countries (WHO, 1990; European Heart Network, 1998; Department of Health, 1991; Department of Health, 1994; FAO/WHO, 1998; FAO, 1994; World Cancer Research Fund, 1997; Department of Health, 1998a; Sugimura, 2000; Reddy, 2000; Giovannucci, 1999). Cardiovascular disease and cancer accounted for 41% and 24% respectively of all deaths in the Republic of Ireland in 1999 (Central Statistics Office, 2000) and 43% and 25% respectively of all deaths in Northern Ireland in 1997 (British Heart Foundation, 1999). The distribution of energy between macronutrients is a priority in devising dietary recommendations to reduce the risk of these diseases. A reduction in dietary fat intake is currently the main focus of dietary recommendations in Europe (European Heart Network, 1998; Department of Health, 1991; Department of Health 1994; Trichopoulou & Vassilakou, 1990; Food Advisory Committee, 1987; Department of Health and Children, 1995; Department of Health, 1992; Department of Health, 1998b; Deutsche Gesellschaft für Ernahrung, 1991; Nationale raad voor de Voeding, 1997; Nordiska Ministerraadet, 1996; Netherlands Food and Nutrition Council, 1992; Valtion ravitesemusneuvottelunta, 1998). In addition, an increase in carbohydrate intake, an adequate protein intake and a reduction in the number of people exceeding guidelines for alcohol intake (Department of Health, 1995; Department of Health, 1996) are also advocated.

Dietary recommendations for the UK population include Dietary Reference Values (DRVs) (Department of Health, 1991) for nutrients, Health of the Nation dietary targets (Department of Health and Children, 1992; Department of Health, 1998b) and qualitative healthy eating guidelines (HEA/MAFF/Department of Health, 1997). In the Republic of Ireland quantitative dietary guidelines (Food Advisory Committee, 1987) exist and in 1995 the Nutrition Advisory Group (NAG) of the Department of Health set qualitative guidelines for the general population and subgroups of the population (Nutrition Advisory Group, 1995). NAG also made recommendations for a food and nutrition policy for Ireland (Nutrition Advisory Group, 1995). Quantitative targets for population intakes of

macronutrients were to be set, but a lack of up-to-date information on food and nutrient intakes of the population at that time was a deterring factor. NAG also recommended that national food consumption surveys be conducted every five years and encouraged collaboration with Northern Ireland in such research (Nutrition Advisory Group, 1995). In 1999 Recommended Dietary Allowances for Ireland were revised (FSAI Nutrition Subcommittee, 1999).

The North/South Ireland Food Consumption Survey (NSIFCS) was conducted between 1997-1999 to establish an up-to-date database of habitual food and drink consumption of Irish adults. This is the first large survey of its kind to be concurrently conducted on the populations of Northern Ireland and the Republic of Ireland using the same methodology. The aim of this paper is to describe current estimates of macronutrient intakes of adult men and women and to identify the primary food sources of macronutrients in the Irish diet. A further aim is to assess adherence of the population to current dietary recommendations for health promotion and disease prevention (Department of Health, 1991; Scientific Committee for Food, 1993; Food Advisory Committee, 1987; Department of Health and Children, 1995; Department of Health, 1992; Department of Health, 1998b; Department of Health, 1995; Department of Health, 1996).

## 9.2 METHODS

The North/South Ireland Food Consumption Survey was a cross-sectional study of the food and nutrient intakes of a representative sample of adults in the Republic of Ireland and Northern Ireland. Fieldwork was carried out between October 1997 and October 1999. Ethical permission was obtained from the Federated Dublin Voluntary Hospitals and St. James's Hospital Joint Research Ethics Committee for the Republic of Ireland and from the Research Ethical Committee of the University of Ulster for Northern Ireland. A detailed description of the sampling procedure is presented elsewhere in this supplement (Kiely *et al.*, 2001). Subjects were contacted by letter and then visited by a fieldworker. Eligible subjects who were between the ages of 18-64years and neither pregnant nor breast-feeding were invited to participate. In all, 1379 subjects completed the full dietary survey, with a response rate of 63% (Kiely *et al.*, 2001). In addition to food intake data, information on health and lifestyle practices and socio-demographic, attitudinal, restrained eating, physical activity and anthropometric data were collected.

### 9.2.1 Dietary Assessment

A food diary was used to collect food and nutrient intakes over a period of 7 days. Harrington *et al.* (2001) have described the methods used in detail. Each day of the week was represented. Subjects recorded each item of food and drink consumed (including vitamin and mineral supplements), the amount, brand name (where possible), method of cooking, location and subject's perception of the eating event as a meal, snack or beverage. Details of recipes used, including ingredients, were requested and food or drinks eaten out were recorded. Subjects were asked to continue their normal eating habits, to carry the diary with them at all times and were encouraged to record in the food diary immediately after eating or drinking. The subjects were visited 4 times by the fieldworker according to the food diary instruction model. Food and drink consumed were quantified by eight specific methods according to a quantification protocol (Harrington *et al.*, 2001). A photographic food atlas (Robson, 1997) was developed specifically for the survey. The fieldworker weighed specific items of food and drink consumed. Weights of all manufactured food and fluid were obtained from manufacturer's data. 'Fast food' portion sizes were derived from product data or from weights compiled by the survey team. Household measures were also used and standard portion sizes (Harrington *et al.*, 2001; MAFF, 1997) were used when quantification by other methods was not possible.

### 9.2.2 Nutrient analysis

Food and nutrient analysis was conducted using WISP (Weighed Intake Software Package), a nutrient analysis program customised for data entry for this survey (Tinuviel Software, Warrington, UK). WISP uses McCance and Widdowson's food tables (Holland *et al.*, 1991a) and published supplements (Holland *et al.*, 1988; Holland *et al.*, 1989; Holland *et al.*, 1991b; Holland *et al.*, 1992a; Holland *et al.*, 1992b; Holland *et al.*, 1993; Chan *et al.*, 1994; Chan *et al.*, 1995; Chan *et al.*, 1996) to generate nutrient data. 1010 new food codes were added to the existing databank to include food composition data of manufactured foods or fluids not present, to enable the analysis of recipes and to include nutritional supplements (Harrington *et al.*, 2001). The mean daily nutrient intake was analysed for each individual. Food codes used were also categorised into 19 major food groups and the contribution of these 19 food groups to mean daily protein, fat and carbohydrate intake was calculated.

### 9.2.3 Comparison with Dietary Recommendations

The mean daily intakes of macronutrients of men and women of the NSIFCS were compared to existing dietary guidelines and recommended intakes (Department of Health, 1991; Scientific Committee for Food, 1993; Food Advisory Committee, 1987; Department of Health and Children, 1995; Department of Health, 1992; Department of Health, 1998b; Department of Health, 1995; Department of Health, 1996). Two different calculations were used in evaluating the attainment of dietary recommendations. Approach 1 calculated the percentage of *individuals* in the population who met the dietary target for a macronutrient, for men and women and in each of three age categories for men and women. Dietary targets and recommendations however are set as average intakes for the population and not as individual targets. Approach 2 takes this into account by calculating the maximum size of a *subgroup of the population* known as *'compliers'*, whose mean intake equals the population dietary recommendation. Both approaches were used for fat and carbohydrate (Table 9.2). Approach 2 was described by both Wearne *et al.*, (1999) and MAFF (1994). For fat (% of total energy and food energy from fat), the mean intakes for each individual were ranked in ascending order from lowest to highest. The mean intake of the compliers group (to equal the fat targets of 33% of total energy from fat or 35% of food energy from fat) was then calculated by starting with the individual with the lowest mean fat intake and including subsequent individuals in the calculation of a group mean intake until the addition of the one more individual caused the group mean to exceed the fat target (Department of Health, 1991; Food Advisory Committee, 1987). For carbohydrate (% of total energy and food energy from carbohydrate) the same approach was used, except that mean intakes for each individual were ranked in descending order from highest to lowest. Successive individuals were then added until the addition of the next individual caused the group mean to fall below a target of 47% of total energy and 50% of food energy from carbohydrate (Department of Health, 1991). For comparative purposes, the Irish National Nutrition Survey (INNS) database was used to calculate the proportion of individuals attaining recommendations, using approaches 1 and 2, in 1988/89 in adults aged 18-64years taking part in the INNS (Irish Nutrition and Dietetic Institute, 2000).

### 9.2.4 Statistical Analysis

Statistical analysis was performed using SPSS® (V. 9.0.1, SPSS Inc., Chicago, U.S.A.). Mean ± standard deviation was calculated for daily intakes of macronutrients by gender

and age. The contribution of 19 food groups to protein, fat and carbohydrate intake was calculated by gender and age. Differences in mean intakes between men and women were assessed using independent t-tests. Differences between age groups within each sex were evaluated using one-way analysis of variance (ANOVA) for multiple comparisons. When statistically significant effects were encountered ($P<0.05$), comparisons of means were made using Scheffe post hoc multiple comparisons to ascertain which specific means differed. For variables which did not follow a normal distribution, as in the case of alcohol and some food groups, the Mann-Whitney and Kruskal-Wallis non-parametric tests were used for comparison of two or more groups, respectively. Post-hoc comparisons of mean daily intakes of alcohol or % energy from alcohol across age groups in women was not possible as the data did not satisfy the assumptions of homogeneity of variance (Coakes & Steed, 1999). Values of $P<0.05$ were taken as statistically significant. Tables were created using Microsoft® Excel spreadsheets (V. 1997 SR-2, Microsoft Corporation, Redmond, Washington, U.S.A.).

## 9.3 RESULTS

### 9.3.1 Mean daily energy and macronutrient intakes

Table 9.1 presents mean daily energy and macronutrient intakes of all men and women and according to age group. Men had higher energy intakes than women and consequently higher intakes of all macronutrients ($P<0.001$). When energy from alcohol was excluded, the contribution of fat and carbohydrate to energy did not differ between men and women. A small but statistically significant difference between men and women in the proportion of food energy from protein was observed ($P=0.021$). When alcohol energy was included however, women had greater proportions of energy from fat (35.6%) than men (34.8%) ($P=0.005$). It is noteworthy that women aged 18-35years ($P=0.022$) and 51-64years ($P=0.042$) reported greater proportions of total energy from fat than the men of those age groups, with no differences between the men and women aged 36-50years. Similarly when energy from alcohol was included women (18-64years) had greater proportions of total energy from carbohydrate than men ($P<0.001$) but intakes of total energy from protein did not differ between men and women.

With increasing age, fat intakes (% food energy) decreased, with 51-64year old men and women having lower fat intakes than the other two age groups ($P<0.001$). Carbohydrate

intakes (% food energy) increased with age in men ($P<0.01$) but not in women. Protein intakes (% food energy) increased with age in both men and women ($P<0.001$). The distribution of alcohol intake (as g/d) reported was skewed with median intakes of 13g and 4g for men and women respectively (data not shown). Mean daily alcohol intake (g) in men was 2.5 times that in women ($P<0.001$). A trend of decreasing alcohol intake with increasing age was observed in both men and women.

### 9.3.2 Mean daily macronutrient intakes compared to dietary recommendations

When compared to existing recommendations, protein intake in adults was found to be more than adequate. Mean daily protein intakes of men and women of all age groups were much higher than the Population Reference Intake (PRI) (Scientific Committee for Food, 1993; FSAI Nutrition Subcommittee, 1999) of 56g for males and 47g for females (Table 9.1). As many as 93% of men and 86% of women had protein intakes above the PRI (expressed as 0.75g of protein/kg body weight/day) (Scientific Committee for Food, 1993; FSAI Nutrition Subcommittee, 1999) with mean daily protein intakes of 1.2g and 1.1g/kg body weight/day for men and women respectively (data not shown). Some 2% of men and 4% of women consumed mean daily protein intakes less than or equal to the Average Requirement (AR expressed as 0.6g of protein/kg body weight/day) (Scientific Committee for Food, 1993; FSAI Nutrition Subcommittee, 1999). Only 1% of both men and women had protein intakes less than or equal to the Lower Threshold Intake (LTI expressed as 0.45g/kg body weight/day) (Scientific Committee for Food, 1993; FSAI Nutrition Subcommittee, 1999).

Table 9.2 presents a comparison of the proportions of men and women in each age group that had total fat and carbohydrate intakes (% energy) that were compatible with current dietary recommendations (Department of Health, 1991; Food Advisory Committee, 1987) using approaches 1 and 2 as described in the methods section. Results are discussed in the context of food energy as well as total energy.

The mean daily percentages of total energy and food energy from fat for men and women exceeded current recommendations (Department of Health, 1991; Food Advisory Committee, 1987) of 33% and 35% respectively (Table 9.2). Men and women aged 51-64years were the only subgroup of this population with mean intakes close to the food energy target for fat. When energy from alcohol was included, only men aged 51-64years

had mean intakes close to the total energy target for fat. The proportions of men and women in the population achieving fat recommendations for food energy using approach 1 were 33% of men and 34% of women and for total energy were 35% of men and 30% of women. Using approach 2, the maximum size of the 'compliers' group with a group mean equal to the food energy target was 78% for men and 80% for women and with a group mean equal to the total energy target was 82% for men and 71% for women.

Carbohydrate intakes were lower than the Dietary Reference Values (DRVs) (Department of Health, 1991) for all age groups of men and women (Table 9.2). Using approach 1, 23% of men and 27% of women met the food energy target for carbohydrate and 29% of men and 37% of women met the total energy target. Using approach 2, the maximum size of the 'compliers' group with a group mean equal to the food energy target for carbohydrate was 56% for men and 62% for women and with a group mean equal to the total energy target was 67% for men and 82% for women.

The proportion of individuals in the population and the proportion of individuals in the 'compliers' group who met these fat or carbohydrate recommendations (% total energy or % food energy) showed a tendency of increasing proportions of both men and women attaining targets with increasing age. The highest proportions of individuals in both the population and in the 'compliers' group, who met recommendations for fat or carbohydrate, were seen in men and women aged 51-64years.

### 9.3.3 % contribution of foods to mean daily macronutrient intakes

Tables 9.3, 9.4 and 9.5 show the main food sources of protein, fat and carbohydrate intakes by gender and age respectively. In each table, food groups are ranked according to their percentage contribution to mean daily macronutrient intakes for all adults (18-64years). Each table has been limited to include food groups that contribute greater than 1% of total mean daily nutrient intake for all adults. The food sources of each macronutrient were similar within the various age-sex groupings in terms of both the percent contribution and the ranking of the food group, with a few exceptions.

Table 9.3 presents the food groups contributing to protein intake. 'Meat and meat products' were the main source of protein (37%) followed by 'breads and rolls' (14%) and 'milk and yogurt' (11%). Men obtained a greater proportion of their protein from 'meat

and meat products' and 'potatoes and potato products' than did women ($P<0.001$). Women derived more protein from 'milk and yogurt' ($P<0.001$). The contribution of 'breads and rolls' to protein intake increased with increasing age in men ($P<0.001$). Both men ($P=0.001$) and women ($P<0.001$) derived more protein from 'fish and fish products' with increasing age. The contribution of 'milk and yogurt' to protein intake increased with increasing age in women ($P=0.008$) but it decreased with increasing age in men ($P=0.025$).

Table 9.4 presents the food groups contributing to fat intake in the Irish diet. 'Meat and meat products' and 'butter, spreading fats and oils' provided 40% of total fat intake. 'Biscuits, cakes, pastries and puddings' and 'milk and yogurt' each provided 9%. 'Potatoes and potato products' contributed 7% to fat intake most likely by the inclusion of chipped potatoes in this food group category. Men had greater intakes of fat from 'meat and meat products' ($P<0.001$), 'butter, spreading fats and oils' ($P=0.001$) and 'potatoes and potato products' ($P<0.001$) than women. Women derived more fat from 'biscuits, cakes, pastries and puddings' and 'vegetables and vegetable dishes' than men ($P<0.001$). With increasing age the contribution of the 'butter, spreading fats and oils' and 'biscuits, cakes, pastries and puddings' to fat intake increased in both males and females ($P<0.001$). Fat intakes from 'potatoes and potato products' and 'sugars, preserves, confectionery and savoury snacks' decreased with increasing age in both men and women ($P<0.001$).

Table 9.5 lists the food groups contributing to carbohydrate intake. 'Breads and rolls' and 'potatoes and potato products' provided 42% of carbohydrate intake. 'Biscuits, cakes, pastries and puddings' and 'sugars, preserves, confectionery and savoury snacks' together provided 20% of carbohydrate intake. Breakfast cereals, the fruit and fruit juices group and 'milk and yogurt' each contributed 6%. Men derived more carbohydrate from 'potatoes and potato products' than women ($P<0.001$) and women obtained more carbohydrate than men from 'biscuits, cakes, pastries and puddings' and the fruit group ($P<0.001$). As age increased, 'breads and rolls' contributed more to the carbohydrate intakes of men ($P<0.001$). Women derived more carbohydrate from 'milk and yogurt' ($P=0.001$) with increasing age but men derived less ($P=0.015$). The contribution of 'biscuits, cakes, pastries and puddings' ($P<0.001$) and the fruit group ($P<0.05$) to carbohydrates intakes increased with increasing age, with greater contributions to the intakes of women than men in all age groups.

## 9.4 DISCUSSION

This survey is a comprehensive investigation of the food and nutrient intakes of a representative sample of adults in the Republic of Ireland and Northern Ireland. The mean ratio of energy intakes to estimated basal metabolic rate ($EI/BMR_{est}$) was used to assess the validity of reported energy intakes (Black *et al.*, 1991; Goldberg *et al.*, 1991; Livingstone, 1995; Bingham, 1994) and was 1.38 in this population (McGowan *et al.*, 2001). While lower than the expected mean $EI/BMR_{est}$ of 1.53 proposed by Goldberg *et al.*, (1991) for a population of this size with 7 days of food intake data, this $EI/BMR_{est}$ is comparable to that reported in other large food intake surveys (Black *et al.*, 1991; Becker, 1999; Hermann-Kunz & Thamm, 1999; Price *et al.*, 1997).

Table 9.6 compares macronutrient intakes of men and women in the NSIFCS to the mean intakes observed in previous large food intake surveys in Ireland (Irish Nutrition and Dietetic Institute, 2000), Northern Ireland (Barker *et al.*, 1988) and Great Britain (Gregory *et al.*, 1990). It is of interest to compare current results with such studies in order to assess trends in macronutrient intakes over time. An analysis of the NSIFCS data for the North and South of Ireland separately, revealed comparable macronutrient intakes expressed as either percentages of total or food energy ($P>0.01$, data not shown). These similarities between data from the North and South permit comparisons of the NSIFCS data as a whole with previous food surveys. It should be noted that the study was not designed to compare nutrient intakes in different regions of the island of Ireland.

The energy intakes of men of the NSIFCS were not remarkably different (0.4 – 1.2MJ) to the men of the INNS (Irish Nutrition and Dietetic Institute, 2000) and those of men in Northern Ireland (Barker *et al.*, 1988) and Great Britain (Gregory *et al.*, 1990) (Table 9.6). The energy intakes of women showed a similar trend to men between surveys although differences were not as marked (0.2 – 0.6MJ). The most notable difference was a 1.5 fold increase in reported alcohol intake in men and a 2 fold increase in alcohol intake in women since the INNS (Irish Nutrition and Dietetic Institute, 2000) and the Diet Lifestyle and Health in Northern Ireland (DLHNI) (Barker *et al.*, 1988) survey. Carbohydrate intakes (% total and food energy) were lower in the NSIFCS than those observed in the INNS (Irish Nutrition and Dietetic Institute, 2000) but were slightly higher than those of the DLHNI (Barker *et al.*, 1988) survey and the Diet and Nutrition Survey in British Adults (DNSBA) (Gregory *et al.*, 1990). Intakes of energy from protein were somewhat higher

than those observed in previous surveys (Table 9.6). Intakes of energy from fat were comparable to those of the INNS (Irish Nutrition and Dietetic Institute, 2000) but were somewhat lower than those observed in the DLHNI (Barker *et al.*, 1988) survey and the DNSBA (Gregory *et al.*, 1990). Despite the difficulties inherent in comparing data from surveys using different methodologies (Margetts & Nelson, 1997) there were clearly no outstanding differences in energy intakes or macronutrient intakes between surveys.

To evaluate adherence to dietary guidelines, two approaches were used in this paper (Table 9.2). Many investigators (Ministry of Agriculture Fisheries and Food, 1994; Hulshof *et al.*, 1993, Millen *et al.*, 1997; Murphy *et al.*, 1992; Cade & Booth, 1990; Cade & Margetts, 1989; Nelson, 1985) have used approach 1 addressing the proportion of *individuals* in the population attaining to current dietary recommendations. Wearne *et al.*, (1999) and Ministry of Agriculture, Fisheries and Food (1994) have used approach 2 identifying a *sub-group of the population* (*'compliers'*) with a group mean intake corresponding to the dietary target in the evaluation of data from Great Britain. Approach 2 would seem markedly more appropriate when evaluating the attainment of population-based nutrition targets such as DRVs (Department of Health, 1991). The former approach is obviously more suitable when evaluating the attainment of individual-based targets e.g. folic acid. The results of evaluating adherence to fat intake (% total energy) in the NSIFCS data were comparable to results obtained from re-analysis of the INNS data, using approaches 1 and 2 (unpublished data) (Irish Nutrition and Dietetic Institute, 2000). 33% of all adults in the NSIFCS met the target for fat (% total energy) compared to 35% of all adults in the INNS (Irish Nutrition and Dietetic Institute, 2000) (approach 1). The proportion of individuals comprising the maximum size of the 'compliers' group, with a group mean equivalent to the fat target (33% total energy), was 82% for men and 71% for women of the NSIFCS and 78% for men and 77% for women of the INNS (Irish Nutrition and Dietetic Institute, 2000) (approach 2). The proportion of the population adhering to dietary fat recommendations in Great Britain in 1986/1987 was lower: 14% of all adults met the target for total fat and 41% of men and 31% of women comprised the 'compliers' group (Ministry of Agriculture, Fisheries and Food, 1994).

Recommendations for dietary fat intakes, being devised to reduce the risk of cardiovascular disease and cancer, the major causes of pre-mature mortality, are the most frequently assessed dietary guidelines (WHO, 1990; European Heart Network, 1998;

Department of Health, 1991; Department of Health 1994; FAO/WHO, 1998; FAO, 1994; World Cancer Research Fund, 1997; Department of Health, 1998a; Trichopoulou & Vassilakou, 1990; Food Advisory Committee, 1987; Department of Health and Children, 1995; Department of Health, 1992; Department of Health, 1998b; Deutsche Gesellschaft für Ernahrung, 1991; Nationale raad voor de Voeding, 1997; Nordiska Ministerraadet, 1996; Netherlands Food and Nutrition Council, 1992; Valtion ravitesemusneuvottelunta, 1998). Recommendations advise dietary fat intake in the region of 33% of total energy or 35% of food energy (Department of Health, 1991; Food Advisory Committee, 1987). Our findings show that irrespective of the approaches used in evaluating the fat intakes of men and women of the NSIFCS, intakes are higher than recommended targets and a reduction in fat intake is still warranted.

The trend of decreasing fat intake with increasing age requires further investigation before the men and women aged 51-64years can be excluded from future targeting of advice on dietary fat reduction. Although men and women in this age group had mean daily fat intakes close to current recommendations (% food energy from fat) and had the greatest proportions meeting fat targets using both approaches 1 and 2, these data may be confounded by a number of factors. Mean $EI/BMR_{est}$ values in this age group were lower than those reported in younger age groups suggesting that under-reporting of energy intake may have occurred (McGowan *et al.*, 2001). Furthermore, Body Mass Index (BMI) and the prevalence of obesity were highest in this age group of adults (McCarthy *et al.*, 2001) and indeed it has been well documented that the overweight and obese are more likely to under-report energy intakes than those of normal weight (Briefel *et al.*, 1997; Schoeller, 1990; Pryer *et al.*, 1997). These trends of an increasing BMI and prevalence of obesity with increasing age were continous through the age groups in women but men aged 36-50 and 51-64years showed no differences in BMI or prevalence of obesity (McCarthy *et al.*, 2001). The influence of under-reporting on macronutrient intakes (% energy) is somewhat unclear. Diets lower in fat (expressed as % of total energy) have been reported in under-reporters compared to acceptable reporters (Price *et al.*, 1997; Briefel *et al.*, 1997; Pryer *et al.*, 1997). Some investigators however have reported that the contribution of macronutrients to energy (% total energy) does not appear to be grossly different between under-reporters and acceptable reporters (Margetts & Nelson, 1997; Becker *et al.*, 1999; Hirvonen *et al.*, 1997). This latter finding would suggest that the lower fat intakes reported by those aged 51-64years are valid even with evidence of under-reporting. Lower energy

intakes in those consuming low-fat diets compared to those consuming high-fat diets have been reported (Haraldsdóttir, 1999; De Henauw & De Backer, 1999; Valsta, 1999; Löwik *et al.*, 1999) and this was also observed in the present study, with lower mean daily energy intakes in this group of 51-64 year olds (Table 9.1). When interpreting the influence of under-reporting on the proportions of energy from macronutrients however, consideration must also be given to the different cut-off criteria used to define under-reporters. While more investigative research is needed to understand and interpret the relationship between under-reporting, the prevalence of obesity and dietary fat intake, it remains the case that dietary fat intake in Ireland needs to be further reduced. All age groups of men and women need to be targeted considering the lower fat targets of WHO (1990) and the European Heart Network (1998) who recommend a population average of 30% of energy intake as an upper limit for total fat intake, which is of course lower than the recommendations evaluated in this paper.

The marked increase in alcohol intake reported over the past decade is an important public health concern that also needs to be addressed. Alcohol recommendations are set for individuals, unlike recommendations for other macronutrients that are population-based (Department of Health, 1995; Department of Health, 1996). Mean daily alcohol intake underestimates the quantity of alcohol consumed by alcohol drinking adults, as non-drinkers are included in this mean value. Furthermore, alcohol intake (g/d) collected using the 7-day food diary refers to alcohol intake during this period only. It has been estimated that 20-50 days of assessment are required to get an estimate of usual alcohol intake for individuals (FAO/WHO, 1998). 65% of this population reported to consume alcohol using the food diary data (70% of all men and 61% of all women) (McGowan *et al.*, 2001). Questionnaire data from this population included estimates of usual alcohol intake and found that 80% of the population was consuming alcohol (81% of all men and 79% of all women), with 36% of these men and 20% of these women consuming greater than recommended limits of alcohol intake, of 21 units for men and 14 units for women (expressed as units of alcohol per week) (Department of Health, 1996). These results were higher for men but comparable for women, to those reported in a recent health and lifestyle survey in the Republic of Ireland where 27% of men and 21% of women (n=approx. 3500) consumed greater than recommended alcohol intakes using questionnaire data (National Nutrition Surveillance Centre, 1999). Alcohol must continue to be included in future strategies to improve health and prevent the problems associated with excessive alcohol

consumption that are detrimental to health (Thakker, 1998; Ahlawat & Siwach, 1994, Steinberg *et al.*, 1991).

Dietary recommendations must explicitly state whether energy derived from alcohol is included. The proportion of energy from carbohydrate, protein, and fat in this population increased, when energy from alcohol was excluded (Table 9.1). Hulshof *et al.*, 1993) have expressed concern when using energy-related recommendations. Including alcohol, 23% of Dutch men had fat intakes less than or equal to 35% of total energy and excluding alcohol 13% of Dutch men had fat intakes less than or equal to 35% of food energy. These results demonstrated that the prevalence of a high dietary fat intake in a population is affected by the method of calculation (Hulshof *et al.*, 1993). Clarification of whether energy derived from alcohol is included or not is essential to correctly interpret findings and allow comparisons with other data. Indeed many existing reports have not clearly stated whether dietary recommendations for fat refer to percentage of total energy or food energy (European Heart Network, 1998; Department of Health and Children, 1995; Health Promotion Unit Department of Health, 1991).

Nonetheless all men and women should increase carbohydrate intakes as only 25% of all individuals met the carbohydrate recommendations (% food energy) and only 59% of all adults were included to comprise the maximum size of the 'compliers' group with a group mean meeting this population target (Table 9.2). Protein intakes were adequate for nearly all individuals (93% of men and 86% of women had protein intakes above the PRI (Scientific Committee for Food, 1993)) and have increased somewhat in the past decade. Some 21% of men and 8% of women of the NSIFCS had intakes greater than or equal to 1.5g/kg body weight/day, twice the PRI (Scientific Committee for Food, 1993) (data not shown). Although twice the PRI (Scientific Committee for Food, 1993) has been used as a guideline threshold for high protein intakes, Millward (1999) has recently proposed re-evaluation of this value as it can easily be exceeded by individuals with a high energy expenditure (Millward, 1999). Indeed, the scientific case for excessive protein intakes being a risk to renal function and bone health (Department of Health, 1991; Scientific Committee for Food, 1993) remains uncertain and has recently been reported to be weak (Millward, 1999).

After evaluating the attainment of macronutrient guidelines in a population and identifying the nutrient(s) to be targeted, for example fat in the NSIFCS, the food sources of the target nutrient must be determined (FAO/WHO, 1998). The foods to be included in food based dietary guidelines can then be identified so as to enable modification of the target nutrient(s) intake. Tables 9.3, 9.4 and 9.5 present the food sources of protein, fat and carbohydrate respectively. These results are also useful for assessing changes in the main food sources of a nutrient in a population over time. In general, the results were consistent with previous reports on diets in Ireland (INNS) (Lee & Cunningham, 1990) and Great Britain (DNSBA) (Gregory *et al.*, 1990). It is not correct however to advocate changes in the consumption of a food group without investigating the contribution of individual foods within a food group to the nutrient of concern (FAO/WHO, 1998). This facilitates more specific targeting as the individual foods in a food group can contribute to the intake of a nutrient by different amounts. The contribution of the food group to the intake of other nutrients must also be evaluated (FAO/WHO, 1998). These issues arise in examining the sources of dietary fat for this population with a view to targeting dietary fat reduction (Table 9.4).

Meat and meat products were the greatest source of fat in the NSIFCS and the contribution of this group to fat intake (23%) has changed little since previous surveys (INNS 25% (Lee & Cunningham, 1990), DNSBA 26% (Gregory *et al.*, 1990)). This food group however was also the greatest source of protein for men and women (Table 9.3) and the second largest source of iron for men (20%) and women (16%) (Hannon *et al.*, 2001). A reduction in the consumption of this food group cannot be advised without investigation of the contribution of individual foods within this group to total dietary fat intake. The practice of trimming visible fat from meat and the cooking methods used must also be determined.

The 'milk and yogurt' group was also important as a source of total dietary fat and is targeted in healthy eating guidelines in order to reduce dietary fat intakes, with advice to choose lower fat varieties (Food Advisory Committee, 1987; HEA/MAFF/Department of Health, 1997). This food group is an important source of calcium however. The contribution of 'milk and yogurt' to both the fat (9%) and calcium (35%) (Hannon *et al.*, 2001) intakes of adults in the NSIFCS was lower than observed previously. Contributions of 17% and 15% from milk to fat intake were observed in the INNS (Lee & Cunningham, 1990) and DNSBA (Gregory *et al.*, 1990) respectively together with contributions of 44%

(Lee & Cunningham, 1990) and 48% (Gregory *et al.*, 1990) to calcium intakes respectively. Mean daily calcium intakes of men and women of the NSIFCS (Hannon *et al.*, 2001) (949mg and 742mg respectively) were also lower than those observed in men and women aged 18-64years in the INNS (1227mg and 869mg respectively, unpublished data) (Irish Nutrition and Dietetic Institute, 2000). Although the food groupings used in each study was not identical, these findings must be considered in the formulation of food-based dietary guidelines with respect to reducing fat intakes. Further analysis is required to determine whether advice to reduce dietary fat intake has resulted in decreased consumption of all milks (full-fat and lower fat varieties) to the point that calcium intakes are compromised. This is of great concern given reports of the increasing incidence of osteoporosis in Europe (European Commission, 1998; National Osteoporosis Society, 2000). Lower than recommended calcium intakes were previously observed in adolescent females (12-18 years) of the INNS (1990) (Lee & Cunningham, 1990) and more recently even lower calcium intakes have been observed in adolescents (Crawley, 1997; Strain *et al.*, 1994). If the trend of reduced calcium intakes in adults observed in this survey since the INNS (Irish Nutrition and Dietetic Institute, 2000) has also ensued in Irish adolescents, achievement of maximal adult peak bone mass could be impaired.

Interpretation of such complex relationships between foods and nutrients is essential in the evaluation of adherence to current dietary recommendations and to the subsequent amendment of existing nutrient and food-based recommendations. A number of other issues should also be considered. The fact that under-reporters of energy intake under-report foods and that this is not constant across all foods should be borne in mind in the context of revising dietary recommendations (Pryer *et al.*, 1997; Becker *et al.*, 1999; Krebs-Smith *et al.*, 2000). Notwithstanding reports of little difference in the macronutrient balance between under-reporters and acceptable reporters of energy intake (Margetts & Nelson, 1997, Becker *et al.*, 1999; Hirvonen *et al.*, 1997), the under-reporting of food intake poses challenges when defining food intake patterns to devise food-based dietary guidelines (Becker *et al.*, 1999). Consideration must also be given to consumer attitudes towards and beliefs about food and nutrition. Lack of knowledge has been suggested (Gibney *et al.*, 1997) as a reason for the limited success (less than 1%) reported in achieving all dietary guidelines by adults (British (Ministry of Agriculture, Fisheries and Food, 1994) and Dutch (Hulshof *et al.*, 1993)). Indeed, it is of particular concern that 52% of the NSIFCS population believed (agreed or strongly agreed) that they do not need to

make changes to their diet as it is already healthy enough (Kearney *et al.*, 2001). It has been previously suggested that individuals may not consider recommendations personally relevant as they may not be equipped to correctly evaluate their own eating patterns and thus may not realise the changes required (Kearney *et al.*, 1997). The food and nutrient characteristics of those achieving and not achieving current recommendations for the target nutrient should be determined (FAO/WHO, 1998). In addition, a more detailed investigation of the temporal pattern of food intake, nutrient intakes and meal types, and the meal patterns and meal compositions that differentiate people with high or low nutrient intakes would be valuable to the development of targeted food-based dietary guidelines.

In conclusion, a reduction in dietary fat intake remains an important public health issue in the Republic of Ireland and Northern Ireland. Attempts to increase dietary carbohydrate intake should also continue to be included in future recommendations so as to replace the energy deficit from reduced fat intakes. Attention must also be given to the rise in alcohol intake. A challenge still exists for all involved in the promotion of public health to devise focused strategies to increase the proportion of the population in the Republic of Ireland and Northern Ireland who adhere to current macronutrient recommendations.

**Table 9.1: Mean daily energy and macro-nutrient intakes and standard deviations (SD) in Irish adults according to sex and age group**

| | Targets[§] | Men | | | | | | | | Women | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18-64yrs[†] n=662 | | 18-35yrs n=253 | | 36-50yrs n=236 | | 51-64yrs n=173 | $P^{\ddagger}$ | 18-64yrs n=717 | | 18-35yrs n=269 | | 36-50yrs n=286 | | 51-64yrs n=162 | $P^{\ddagger}$ |
| | | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | *Mean* | *(SD)* | |
| Energy (MJ) | | 11.0 | (3.1)*** | $11.6^{a}$ | (3.3) | $11.0^{a}$ | (3.0) | $10.1^{b}$ | (2.7) | *** | 7.6 | (2.0) | $7.7^{ab}$ | (2.0) | $7.8^{b}$ | (2.1) | $7.3^{a}$ | (2.0) | * |
| Energy (kcal) | | 2632 | (730)*** | $2776^{a}$ | (750) | $2632^{a}$ | (728) | $2421^{b}$ | (653) | *** | 1826 | (484) | $1848^{ab}$ | (473) | $1858^{b}$ | (492) | $1735^{a}$ | (479) | * |
| Protein (g) | | 100.2 | (26.6)*** | $100.8^{ab}$ | (26.8) | $102.8^{b}$ | (28.8) | $95.8^{a}$ | (22.2) | * | 69.8 | (17.2) | $66.5^{a}$ | (17.5) | $72.4^{b}$ | (16.6) | $70.7^{bc}$ | (16.9) | *** |
| Fat (g) | | 102.2 | (34.3)*** | $108.3^{a}$ | (34.5) | $104.5^{a}$ | (34.7) | $90.3^{b}$ | (30.6) | *** | 73.1 | (24.9) | $74.8^{a}$ | (24.2) | $74.5^{a}$ | (24.7) | $67.9^{b}$ | (25.9) | * |
| Carbohydrate (g) | | 305.1 | (96.0)*** | $315.5^{a}$ | (97.8) | $303.7^{ab}$ | (97.1) | $291.7^{b}$ | (90.6) | * | 218.6 | (62.3) | $217.9^{a}$ | (59.9) | $220.9^{a}$ | (64.4) | $215.6^{a}$ | (62.4) | NS |
| Total sugars (g) | | 113.3 | (50.9)*** | $120.6^{a}$ | (55.0) | $111.2^{ab}$ | (50.1) | $105.4^{b}$ | (44.3) | ** | 84.6 | (35.5) | $83.9^{a}$ | (33.9) | $83.9^{a}$ | (37.7) | $87.0^{a}$ | (34.4) | NS |
| Starch (g) | | 187.8 | (60.1)*** | $190.2^{a}$ | (59.6) | $188.7^{a}$ | (60.1) | $183.1^{a}$ | (61.0) | NS | 130.1 | (36.4) | $129.6^{a}$ | (35.2) | $133.0^{a}$ | (35.7) | $125.6^{a}$ | (39.2) | NS |
| Alcohol (g) | | 22.9 | (29.8)*** | $29.6^{a}$ | (34.0) | $19.4^{b}$ | (24.3) | $17.9^{b}$ | (28.2) | *** | 9.3 | (13.0) | 12.9 | (15.2) | 9.0 | (12.0) | 3.9 | (7.9) | *** |
| % total energy from protein | | 15.5 | (2.7) [NS] | $14.8^{a}$ | (2.6) | $15.9^{b}$ | (2.6) | $16.2^{b}$ | (2.7) | *** | 15.6 | (2.9) | $14.7^{a}$ | (3.0) | $15.9^{b}$ | (2.6) | $16.7^{c}$ | (2.8) | *** |
| % total energy from fat | ≤ 33% | 34.8 | (5.7)** | $35.0^{a}$ | (5.5) | $35.5^{a}$ | (5.7) | $33.3^{b}$ | (5.9) | *** | 35.6 | (5.8) | $36.1^{a}$ | (5.4) | $35.7^{a}$ | (5.8) | $34.7^{a}$ | (6.5) | NS |
| % total energy from carbohydrate | ≥ 47% | 43.5 | (6.4)*** | $42.7^{a}$ | (6.1) | $43.3^{a}$ | (6.3) | $45.1^{b}$ | (6.8) | *** | 45.1 | (6.1) | $44.4^{a}$ | (5.7) | $44.7^{a}$ | (6.1) | $46.8^{b}$ | (6.4) | *** |
| % total energy from alcohol | | 5.9 | (7.2)*** | $7.2^{a}$ | (7.8) | $5.1^{b}$ | (6.2) | $5.1^{b}$ | (7.2) | ** | 3.5 | (4.6) | 4.8 | (5.3) | 3.3 | (4.2) | 1.5 | (2.9) | *** |
| % food energy from protein | | 16.6 | (2.8)* | $16.0^{a}$ | (2.7) | $16.8^{b}$ | (2.8) | $17.1^{b}$ | (3.0) | *** | 16.2 | (3.0) | $15.5^{a}$ | (3.2) | $16.5^{b}$ | (2.7) | $16.9^{b}$ | (2.9) | *** |
| % food energy from fat | ≤ 35% | 37.0 | (5.4) [NS] | $37.7^{a}$ | (4.9) | $37.5^{a}$ | (5.6) | $35.1^{b}$ | (5.7) | *** | 36.9 | (6.0) | $38.0^{a}$ | (5.4) | $37.0^{a}$ | (6.1) | $35.2^{b}$ | (6.6) | *** |
| % food energy from carbohydrate | ≥ 50% | 46.2 | (5.4) [NS] | $46.0^{a}$ | (5.0) | $45.6^{a}$ | (5.5) | $47.5^{b}$ | (5.7) | ** | 46.6 | (5.6) | $46.6^{a}$ | (5.1) | $46.2^{a}$ | (5.7) | $47.5^{a}$ | (6.2) | NS |

§ Dietary Reference Values (Department of Health, UK, 1991)

† Comparison of means between all men and all women: * P<0.05, ** P<0.01, ***P<0.001, NS not significant P>0.05.

‡ One-way ANOVA for comparison of mean nutrient intakes between age groups within each sex, significant differences: * P<0.05, ** P<0.01, *** P<0.001, NS not significant P>0.05.

[a-c] Different superscripts are significantly different (P<0.05) between age groups within each sex (Scheffe post-hoc ANOVA contrasts)

**Table 9.2: Percentage (%) of Irish adults adhering to current dietary recommendations for total fat and carbohydrate intakes according to sex and age group**

| | ALL | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 18-64yrs n=1379 | 18-64yrs n=662 | 18-35yrs n=253 | 36-50yrs n=236 | 51-64yrs n=173 | 18-64yrs n=717 | 18-35yrs n=269 | 36-50yrs n=286 | 51-64yrs n=162 |
| *% food energy from fat (target ≤ 35%)* †‡ | | | | | | | | | |
| mean daily % food energy from fat | 36.9 | 37.0 | 37.7 | 37.5 | 35.1 | 36.9 | 38.0 | 37.0 | 35.2 |
| Approach 1: proportion of individuals who met target (%) | 34 | 33 | 26 | 29 | 48 | 34 | 26 | 34 | 49 |
| Approach 2: proportion of individuals in 'compliers' group (%) | 79 | 78 | 64 | 72 | 99 | 80 | 65 | 80 | 99 |
| *% total energy from fat (target ≤ 33%)* † | | | | | | | | | |
| mean daily % total energy from fat | 35.2 | 34.8 | 35.0 | 35.5 | 33.3 | 35.6 | 36.1 | 35.7 | 34.7 |
| Approach 1: proportion of individuals who met target (%) | 33 | 35 | 34 | 27 | 48 | 30 | 25 | 31 | 40 |
| Approach 2: proportion of individuals in 'compliers' group (%) | 76 | 82 | 78 | 72 | 98 | 71 | 63 | 71 | 85 |
| *% food energy from carbohydrate (target ≥ 50%)* † | | | | | | | | | |
| mean daily % food energy from carbohydrate | 46.5 | 46.2 | 46.0 | 45.6 | 47.5 | 46.6 | 46.6 | 46.2 | 47.5 |
| Approach 1: proportion of individuals who met target (%) | 25 | 23 | 21 | 18 | 32 | 27 | 24 | 25 | 34 |
| Approach 2: proportion of individuals in 'compliers' group (%) | 59 | 56 | 49 | 50 | 75 | 62 | 58 | 58 | 75 |
| *% total energy from carbohydrate (target ≥ 47%)* † | | | | | | | | | |
| mean daily % total energy from carbohydrate | 44.3 | 43.5 | 42.7 | 43.3 | 45.1 | 45.1 | 44.4 | 44.7 | 46.8 |
| Approach 1: proportion of individuals who met target (%) | 33 | 29 | 21 | 28 | 41 | 37 | 30 | 38 | 46 |
| Approach 2: proportion of individuals in 'compliers' group (%) | 75 | 67 | 56 | 63 | 86 | 82 | 72 | 80 | 99 |

† Dietary Reference Values (Department of Health, UK, 1991)

‡ Nutrient Recommendations of the Food Advisory Committee (Department of Health, Republic of Ireland, 1987)

**Table 9.3: Percentage (%) contribution of food groups to mean daily protein intake of Irish adults according to sex and age group**

| *Food Groups* | ALL | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 18-64yrs (n=1379) % | 18-64yrs† (n=662) % | 18-35yrs (n=253) % | 36-50yrs (n=236) % | 51-64yrs (n=173) % | 18-64yrs (n=717) % | 18-35yrs (n=269) % | 36-50yrs (n=286) % | 51-64yrs (n=162) % |
| Meat & meat products | 37 | 39 *** | 40 | 39 | 39 | 35 | 35 | 36 | 35 |
| Breads & rolls | 14 | 14 NS | 13 | 15 | 15 | 14 | 14 | 14 | 15 |
| Milk & yogurt | 11 | 10 *** | 11 | 10 | 9 | 12 | 11 | 12 | 13 |
| Potatoes & potato products | 6 | 7 *** | 7 | 6 | 7 | 5 | 6 | 5 | 5 |
| Fish & fish dishes | 5 | 5 NS | 4 | 5 | 6 | 5 | 4 | 5 | 6 |
| Biscuits, cakes, pastries & puddings | 4 | 3 *** | 3 | 3 | 4 | 4 | 4 | 5 | 5 |
| Vegetables & vegetable dishes including pulses | 4 | 4 *** | 4 | 4 | 4 | 4 | 5 | 4 | 4 |
| Breakfast cereals | 3 | 2 ** | 2 | 3 | 3 | 3 | 3 | 3 | 4 |
| Cheese | 3 | 3 NS | 4 | 3 | 3 | 4 | 4 | 3 | 3 |
| Eggs & egg dishes | 3 | 3 * | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| Flours, grains, starches, rice, pasta & savouries | 3 | 2 *** | 4 | 2 | 1 | 3 | 4 | 3 | 2 |
| Alcoholic beverages | 2 | 2 *** | 2 | 1 | 1 | 2 | 3 | 2 | 1 |
| Others‡ | 5 | 6 | 4 | 6 | 5 | 6 | 4 | 5 | 4 |
| Total % contribution of food groups to protein | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total mean daily protein intake (g) | 84.4 | 100.2 | 100.8 | 102.8 | 95.8 | 69.8 | 66.5 | 72.4 | 70.7 |

† Comparison of means between all men and all women: * P<0.05; ** P<0.01, ***P<0.001, NS not significant P>0.05.

‡ food groups contributing

**Table 9.4: Percentage (%) contribution of food groups to mean daily fat intake of Irish adults according to sex and age group**

| *Food Groups* | ALL | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 18-64yrs (n=1379) % | 18-64yrs† (n=662) % | 18-35yrs (n=253) % | 36-50yrs (n=236) % | 51-64yrs (n=173) % | 18-64yrs (n=717) % | 18-35yrs (n=269) % | 36-50yrs (n=286) % | 51-64yrs (n=162) % |
| Meat & meat products | 23 | 25 *** | 26 | 24 | 25 | 21 | 20 | 21 | 21 |
| Butter, spreading fats & oils | 17 | 18 ** | 15 | 19 | 21 | 16 | 14 | 17 | 19 |
| Biscuits, cakes, pastries & puddings | 9 | 8 *** | 7 | 9 | 9 | 10 | 8 | 11 | 12 |
| Milk & yogurt | 9 | 9 NS | 9 | 10 | 9 | 9 | 9 | 9 | 11 |
| Potatoes & potato products | 7 | 8 *** | 10 | 7 | 6 | 6 | 8 | 6 | 4 |
| Sugars, preserves, confectionery & savoury snacks | 5 | 5 ** | 8 | 4 | 2 | 6 | 8 | 5 | 3 |
| Vegetables & vegetable dishes including pulses | 5 | 4 *** | 4 | 4 | 4 | 6 | 7 | 6 | 5 |
| Breads & rolls | 4 | 4 NS | 3 | 4 | 5 | 4 | 4 | 4 | 5 |
| Cheese | 4 | 4 NS | 4 | 4 | 3 | 4 | 5 | 4 | 4 |
| Eggs & egg dishes | 3 | 3 NS | 3 | 3 | 4 | 3 | 3 | 3 | 3 |
| Fish & fish dishes | 3 | 3 NS | 2 | 3 | 3 | 3 | 2 | 3 | 4 |
| Flours, grains, starches, rice, pasta & savouries | 3 | 3 *** | 3 | 2 | 1 | 3 | 4 | 3 | 2 |
| Soups, sauces & miscellaneous foods | 3 | 3 *** | 3 | 2 | 2 | 4 | 4 | 4 | 3 |
| Creams, ice creams & chilled desserts | 2 | 2 ** | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Others‡ | 3 | 3 | 2 | 3 | 4 | 3 | 2 | 2 | 2 |
| Total % contribution of food groups to fat | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total mean daily fat intake (g) | 87.1 | 102.2 | 108.3 | 104.5 | 90.3 | 73.1 | 74.8 | 74.5 | 67.9 |

† Comparison of means between all men and all women: * P<0.05; ** P<0.01, ***P<0.001, NS not significant P>0.05.

‡ food groups contributing ≤1% to mean daily fat intake (Breakfast cereals, fruit group, non-alcoholic beverages, alcoholic beverages, nutritional supplements)

**Table 9.5: Percentage (%) contribution of food groups to mean daily carbohydrate intake of Irish adults according to sex and age group**

| | ALL | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Food Groups* | 18-64yrs (n=1379) % | 18-64yrs† (n=662) % | 18-35yrs (n=253) % | 36-50yrs (n=236) % | 51-64yrs (n=173) % | 18-64yrs (n=717) % | 18-35yrs (n=269) % | 36-50yrs (n=286) % | 51-64yrs (n=162) % |
| Breads & rolls | 25 | 25 NS | 22 | 26 | 28 | 24 | 24 | 25 | 25 |
| Potatoes & potato products | 17 | 19 *** | 19 | 19 | 20 | 15 | 16 | 14 | 15 |
| Biscuits, cakes, pastries & puddings | 10 | 9 *** | 7 | 10 | 10 | 11 | 9 | 12 | 13 |
| Sugars, preserves, confectionery & savoury snacks | 10 | 11 * | 11 | 10 | 11 | 10 | 10 | 9 | 10 |
| Breakfast cereals | 6 | 6 * | 6 | 6 | 6 | 7 | 6 | 7 | 8 |
| Fruit, fruit juice, nuts & seeds, herbs & spices | 6 | 5 *** | 4 | 5 | 5 | 7 | 6 | 7 | 8 |
| Milk & yogurt | 6 | 5 *** | 6 | 5 | 5 | 6 | 6 | 6 | 7 |
| Flours, grains, starches, rice, pasta & savouries | 4 | 4 ** | 5 | 3 | 2 | 4 | 5 | 5 | 2 |
| Meat & meat products | 4 | 4 NS | 5 | 3 | 3 | 4 | 4 | 4 | 3 |
| Non-alcoholic beverages | 4 | 4 NS | 7 | 2 | 1 | 3 | 6 | 2 | 2 |
| Vegetables & vegetable dishes including pulses | 4 | 4 *** | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Others‡ | 4 | 4 | 4 | 7 | 5 | 5 | 4 | 5 | 3 |
| Total % contribution of food groups to carbohydrate | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total mean daily carbohydrate intake (g) | 260.1 | 305.1 | 315.5 | 303.7 | 291.7 | 218.6 | 217.9 | 220.9 | 215.6 |

† Comparison of means between all men and all women: * P<0.05; ** P<0.01, ***P<0.001, NS not significant P>0.05.

‡ food groups contributing ≤1% to mean daily carbohydrate intake (alcoholic beverages, soups & sauces, cream & icecream group, fish & fish products, eggs & egg dishes, butter & spreading fats, cheese)

**Table 9.6: Comparison of mean daily macronutrient intakes of men and women in the present study (NSIFCS) with other large scale food and nutrition surveys in Ireland (INNS) and the UK (DLHNI & DNSBA).**

| | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|
| | NSIFCS 2000§ 18-64yrs (n=662) | INNS 1990† 18-64yrs (n=256) | DLHNI 1988‡ 16-64yrs (n=258) | DNSBA 1990‡ 16-64yrs (n=1087) | NSIFCS 2000§ 18-64yrs (n=717) | INNS 1990† 18-64yrs (n=334) | DLHNI 1988‡ 16-64yrs (n=344) | DNSBA 1990‡ 16-64yrs (n=1110) |
| Energy (MJ) | 11.0 | 12.2 | 10.6 | 10.3 | 7.6 | 7.8 | 7.1 | 7 |
| Energy (kcal) | 2632 | 2899 | 2526 | 2450 | 1826 | 1872 | 1670 | 1680 |
| Protein (g) | 100.2 | 104.6 | 85 | 84.7 | 69.8 | 71 | 59.7 | 62 |
| Fat (g) | 102.2 | 115.4 | 108.8 | 102.3 | 73.1 | 75.1 | 75.5 | 76.5 |
| Carbohydrate (g) | 305.1 | 354.9 | 292.2 | 272 | 218.6 | 234.9 | 198.7 | 193 |
| Total sugars (g) | 113.3 | 95.7 | - | 115 | 84.6 | 71.8 | - | 86 |
| Starch (g) | 187.8 | 193.9 | - | 156 | 130.1 | 124.1 | - | 106 |
| Alcohol (g) | 22.9 | 15.6 | 15.3 | 25 | 9.3 | 4.4 | 4.8 | 6.9 |
| % total energy from protein | 15.6 | 14.6 | 13.7 | 14.1 | 15.6 | 15.7 | 14.4 | 15.2 |
| % total energy from fat | 34.8 | 35.2 | 38.7 | 37.6 | 35.6 | 35.4 | 39.6 | 39.2 |
| % total energy from carbohydrate | 43.5 | 46.1 | 43.4 | 41.6 | 45.1 | 47.1 | 43.9 | 43 |
| % total energy from alcohol | 5.9 | 3.9 | 4.1 | 6.9 | 3.5 | 1.7 | 1.9 | 2.8 |
| % food energy from protein | 16.6 | 14.8 | 14.3 | 14.9 | 16.2 | 15.7 | 14.7 | 15.2 |
| % food energy from fat | 37.0 | 37.1 | 40.3 | 40.4 | 36.9 | 36.9 | 40.4 | 40.3 |
| % food energy from carbohydrate | 46.2 | 48 | 45.3 | 44.8 | 46.6 | 47.4 | 44.7 | 44.4 |

§ 7 day food diary
† 7 day diet history
‡ 7 day weighed intake

## 9.5 REFERENCES


Ahlawat, S.K., & Siwach, S.B. (1994). Alcohol and coronary artery disease. *International Journal of Cardiology, 44,* 157-162.

Barker, M.E., McClean, S.I., McKenna, P.G., Reid, N.G., Strain, J.J., Thompson, K.A., Williamson, A.P., & Wright, M.E. (1988). *Diet, Lifestyle and Health in Northern Ireland.* Coleraine: University of Ulster.

Becker, W. (1999). Dietary guidelines and patterns of food and nutrient intake in Sweden. *British Journal of Nutrition, 81,* S113-S117.

Becker, W., Foley, S., Shelly, E., & Gibney, M. (1999). Energy under-reporting in Swedish and Irish dietary surveys: implications for food-based dietary guidelines. *British Journal of Nutrition, 81,* S127-S131.

Bingham SA. (1994). The use of 24-h urine samples and energy expenditure to validate dietary assessments. *American Journal of Clinical Nutrition, 59,* 227S-231S.

Black AE, Goldberg GR, Jebb SA, Livingstone MBE, Cole, T.J., & Prentice AM. (1991). Critical Evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *European Journal of Clinical Nutrition, 45,* 583-599.

Briefel RR, Sempos CT, McDowell MA, Chien S, & Alaimo K. (1997). Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *American Journal of Clinical Nutrition, 65 (suppl),* 1203S-1209S.

British Heart Foundation. (1999). *Coronary Heart Disease Statistics . British Heart Foundation Statisitics 1999.* London: British Heart Foundation.

Cade, J., & Booth, S. (1990). What can people eat to meet the dietary goals: and how much does it cost? *Journal of Human Nutrition and Dietetics, 3,* 199-207.

Cade, J.E., & Margetts, B.M. (1989). Dietary patterns in three English towns in relation to dietary goals and RDAs. *Journal of Human Nutrition and Dietetics, 2,* 49-54.

Central Statistics Office. (2000). *Vital Statistics 4th Quarter and Yearly Summary 1999.* Dublin: CSO.

Chan, W., Brown, J., & Buss, D.H. (1994). *Miscellaneous Foods. Fourth Supplement to the Fifth Edition of McCance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Chan, W., Brown, J., Church, S.M., & Buss, D.H. (1996). *Meat products and dishes. Sixth supplement to the fifth edition of McCance & Widdowson's The Composition of Foods. The Royal College of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: H.M.S.O.

Chan, W., Brown, J., Lee, S.M., & Buss, D.H. (1995). *Meat, Poultry and Game. Fifth Supplement to the Fifth Edition of McCance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Coakes, S.J., & Steed, L.G. (1999). *SPSS Analysis without Anguish Versions 7.0, 7.5, 8.0 for Windows.* Brisbane: John Wiley & Sons.

Crawley, H. (1997). Dietary and lifestyle differences between Scottish teenagers and those living in England and Wales. *European Journal of Clinical Nutrition, 51,* 87-91.

De Henauw, S., & De Backer, G. (1999). Nutrient and food intakes in selected subgroups of Belgian adults. *British Journal of Nutrition, 81,* S37-S42.

Department of Health. (1991). *Dietary Reference Values for food energy and nutrients for the United Kingdom: Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy.* London: HMSO.

Department of Health. (1992). *The Health of the Nation: A Strategy for Health in England. Cm1986.* London: HMSO.

Department of Health. (1994). *Nutritional Aspects of Cardiovascular Disease: Report of the Cardiovascular Review Group of the Committee on Medical Aspects of Food Policy.* London: HMSO.

Department of Health and Children. (1995). *A Health Promotion Strategy: making the healthier choice the easier choice.* Dublin: Department of Health and Children.

Department of Health. (1995). *Sensible Drinking. The Report of an Inter-Governmental Working Group.* London: Department of Health.

Department of Health. (1996). *National Alcohol Policy Ireland.* Dublin: Stationery Office.

Department of Health. (1998a). *Our Healthier Nation: A Contract for Health. Cm3852.* London: Stationery Office.

Department of Health. (1998b). *Nutritional Aspects of the Development of Cancer. Report of the Working Group on Diet and Cancer of the Committee on Medical Aspects of Food and Nutrition Policy.* London: HMSO.

Deutsche Gesellschaft fur Ernahrung (German Society of Nutrition). (1991). *Empfehlungen fur dir wunschenswerte Nahrstoffzufuhr.* Frankfurt am Main: Umschau Verlag.

European Commission. (1998). *Report on Osteoporosis in the European Community: Action for Prevention.* Luxembourg: European Commission.

European Heart Network. (1998). *Food, Nutrition and Cardiovascular Prevention in the European Union.* Luxembourg: European Heart Network.

FAO. (1994). *Fats and Oils in Human Nutrition. Report of a joint expert consultation.* Rome: FAO.

FAO/WHO. (1998). *Preparation and Use of Food-based Dietary Guidelines. WHO Technical Report Series 880.* Geneva: WHO.

Food Advisory Committee. (1987). *Guidelines for Preparing Information and Advice to the General Public on Healthy Eating.* Dublin, Ireland: Department of Health.

FSAI, Nutrition Subcommittee. (1999). Protein Requirements. In FSAI, *Recommended Dietary Allowances for Ireland.* (pp. 16-17). Dublin: Food Safety Authority of Ireland.

Gibney, M.J., Kearney, M., & Kearney, J.M. (1997). Introduction. IEFS pan-EU survey of consumer attitudes to food, nutrition and health. *European Journal of Clinical Nutrition, 51,* S2

Giovannucci, E. (1999). Nutritional factors in human cancers. *Adv Exp Med Biol, 472,* 29-42.

Goldberg GR, Black AE, Jebb SA, Cole, T.J., Murgatroyd PR, Coward WA, & Prentice AM. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *European Journal of Clinical Nutrition, 45,* 569-581.

Gregory, J., Foster, K., Tyler, H., & Wiseman, M. (1990). *The Dietary and Nutritional Survey of British Adults.* London: HMSO.

Hannon, E., Kiely, M., Harrington, K.E., Robson, P., Strain, J.J., & Flynn, A. (2001). Mineral Intakes of Irish Adults of the North/South Ireland Food Consumption Survey. *Public Health Nutrition, (in press)*

Haraldsdóttir, J. (1999). Dietary guidelines and patterns of intake in Denmark. *British Journal of Nutrition, 81,* S43-S48.

Harrington, K.E., Robson, P., Kiely, M., Livingstone, M.B.E., Lambe, J., Cran, G., & Gibney, M.J. (2001). The North/South Ireland Food Consumption Survey: Survey Design and Methodology. *Public Health Nutrition, (in press)*

HEA/MAFF/DoH. (1997). *Eight Guidelines for A Healthy Diet.* London: Health Education Authority.

Health Promotion Unit Department of Health. (1991). *Nutrition Health Promotion Framework for Action.* Dublin: Department of Health.

Hermann-Kunz E, & Thamm M. (1999). Dietary recommendations and prevailing food and nutrient intakes in Germany. *British Journal of Nutrition, 81,* S61-S69.

Hirvonen, T., Mannisto, S., Roos, E., & Pietinen, P. (1997). Increasing prevalence of under-reporting does not necessarily distort dietary surveys. *European Journal of Clinical Nutrition, 51,* 297-301.

Holland, B., Brown, J., & Buss, D.H. (1993). *Fish and Fish Products. Third Supplement to the Fifth Edition of McCance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1988). *Cereal and Cereal Products. Third Supplement to McCance & Widdowson's The Composition of Foods ( 4th edition). Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1989). *Milk Products and Eggs. Fourth Supplement to McCance & Widdowson's The Composition of Foods (4th edition). Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1992a). *Fruit and Nuts. First Supplement to McCance & Widdowson's The Composition of Foods (5th Edition). The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Welch, A.A., Unwin, I.D., Buss, D.H., Paul, A.A., & Southgate, D.A.T. (1991a). *McCance & Widdowson's The Composition of Foods. Fifth revised and extended edition. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Unwin, I.D., & Buss, D.H. (1991b). *Vegetables, Herbs and Spices. Fifth Supplement to McCance & Widdowson's The Composition of Foods (4th edition). The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: HMSO.

Holland, B., Welch, A.A., & Buss, D.H. (1992b). *Vegetable Dishes. Second Supplement to the Fifth Edition of Mc Cance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.* London: H.M.S.O.

Huslhof, K.F.A.M., Löwik, M.R.H., Kistemaker, C., Hermus, R.J.J., ten Hoor, F., & Ockuizen, T. (1993). Comparison of Dietary Intake Data with Guidelines: Some Potential Pitfalls (Dutch Nutrition Surveillance System). *Journal of the American College of Nutrition, 12,* 176-185.

Irish Nutrition and Dietetic Institute. (2000). Unpublished data from the database of the Irish National Nutrition Survey (INNS) 1990.

Kearney, J., Harrington, K., Kiely, M., Robson, P., Livingstone, M.B.E., & Gibney, M.J.G. (2001). Attitudes towards and beliefs about nutrition and health among a representative sample of adults in the Republic of Ireland and Northern Ireland. *Public Health Nutrition, (in press)*

Kearney, M., Gibney, M.J., Martinez, J.A., de Almeida, M.D.V., Friebe, D., Zunft, H.J.F., Widhalm, K., & Kearney, J.M. (1997). Perceived need to alter eating habits among representative samples of adults from all member states of the European Union. *European Journal of Clinical Nutrition, 51,* S30-S35.

Kiely, M., Harrington, K.E., Robson, P., Cran, G., & Flynn, A. (2001). Survey Design and Sample Description. *Public Health Nutrition, (in press)*

Krebs-Smith SM, Graubard BI, Kahle LL, Subar AF, Cleveland LE, & Ballard-Barbash R. (2000). Low energy reporters vs others: a comparison of reported food intakes. *European Journal of Clinical Nutrition, 54,* 281-287.

Lee, P., & Cunningham, K. (1990). *The Irish National Nutrition Survey.* Dublin: Irish Nutrition and Dietetic Institute.

Livingstone MBE. (1995). Assessment of food intakes: are we measuring what people eat? *British Journal of Biomedical Science, 52,* 58-67.

Löwik, M.R.H., Huslhof, K.F.A.M., & Brussard, J.H. (1999). Food-based dietary guidelines: some assumptions tested for the Netherlands. *British Journal of Nutrition, 81,* S143-S149.

MAFF. (1997). *Food Portion Sizes.* London: HMSO.

Margetts, B.M., & Nelson, M. (1997). *Design Concepts in Nutritional Epidemiology.* Oxford: Oxford University Press.

McCarthy, S.M., Livingstone, M.B.E., Harrington, K.E., Kiely, M., Robson, P., & Gibney, M.J.G. (2001). Analyses of anthropometric data from the North/South Ireland Food Consumption Survey. *Public Health Nutrition, (in press)*

McGowan, M., Harrington, K.E., Kiely, M., Robson, P., Livingstone, M.B.E., & Gibney, M.J.G. (2001). An Evaluation of Energy Intakes and the ratio of energy intake to basal metabolic rate (EI/BMRest) in the North/South Ireland Food Consumption Survey. *Public Health Nutrition, (in press)*

Millen, B.E., Quatromoni, P.A., Franz, M.M., Epstein, B.E., Cupples, A., & Copenhafer, D.L. (1997). Population nutrient intake approaches dietary recommendations: 1991 to 1995 Framingham Nutrition Studies. *Journal of the American Dietetic Association, 97,* 742-749.

Millward, D.J. (1999). Optimal protein intakes in the human diet. *Proceedings of the Nutrition Society, 58,* 403-413.

Ministry of Agriculture, Fisheries and Food. (1994). *The Dietary and Nutritional Survey of British Adults - Further Analysis.* London: HMSO.

Murphy, S.P., Rose, D., Hudes, M., & Viteri, F.E. (1992). Demographic and economic factors associated with dietary quality for adults in the 1987-88 Nationwide Food Consumption Survey. *Journal of the American Dietetic Association, 92,* 1352-1357.

National Nutrition Surveillance Centre. (1999). *Annual Report 1999: Dietary habits of the Irish population: results from SLAN.* Galway: Centre for Health Promotion Studies.

National Osteoporosis Society. (2000). Facts and Figures on Osteoporosis.

Nationale raad voor de Voeding (National Council on Nutrition). (1997). *Dietary Recommendations for Belgium (Voedingsaanbevelingen voor Belgie)* D/1996/7995/12. Brussels: Ministry of Social Affairs.

Nelson, M. (1985). Nutritional Goals from COMA and NACNE: How can they be achieved? *Human Nutrition: Applied Nutrition, 39A,* 456-464.

Netherlands Food and Nutrition Council. (1992). *Nederlandse voedingsnormen 1989.* The Hague: Voorlichtingsbureau voor de voeding.

Nordiska Ministerraadet (Nordic Council of Ministers). (1996). *Nordiska naringsrekommendationer 1996.* Copenhagen: Nordisk Ministerraad.

Nutrition Advisory Group. (1995). *Recommendations for a Food and Nutrition Policy for Ireland.* Dublin: Stationary Office.

Price, G.M., Paul, A.A., Cole, T.J., & Wadsworth, M.E.J. (1997). Characteristics of the low-energy reporters in a longitudinal national dietary survey. *British Journal of Nutrition, 77,* 833-851.

Pryer JA, Vrijheid M, Nichols R, Kiggins M, & Elliott P. (1997). Who are the 'low energy reporters' in the Dietary and Nutritional Survey of British Adults? *International Journal of Epidemiology, 26,* 146-153.

Reddy, B.S. (2000). The Fourth DeWitt S. Goodman lecture. Novel approaches to the prevention of colon cancer by nutritional manipulation and chemoprevention. *Cancer Epidemiology Biomarkers Previews, 9,* 239-247.

Robson, P. (1997). *Photographic food atlas for the North/South Ireland Food Consumption Survey.*

Schoeller DA. (1990). How accurate is self-reported dietary energy intake? *Nutrition Reviews, 48,* 373-379.

Scientific Committee for Food. (1993). Protein. In Scientific Committee for Food *Reports of the Scientific Committee for Food (31st series) Nutrient and Energy Intakes for the European Community.* Luxembourg: Office for Official Publications of the European Communities.

Steinberg, D., Pearson, T.A., & Kuller, L.H. (1991). Alcohol and atherosclerosis. *Annals of Internal Medicine, 1,* 967-976.

Strain, J.J., Robson, P.J., Livingstone, M.B.E., Primose, E.D., Savage, J.M., Cran, G.W., & Boreham, C.A.G. (1994). Estimates of food and macronutrient intake in a random sample of Northern Ireland adolescents. *British Journal of Nutrition, 72,* 343-352.

Sugimura, T. (2000). Nutrition and dietary carcinogens. *Carconogenesis, 21,* 387-395.

Thakker, K.D. (1998). An overview of health risks and benefits of alchol consumption. *Alcohol Clin Exp Res, 22,* 285S-298S.

Trichopoulou, A., & Vassilakou, T. (1990). Recommended dietary intakes in the European Community member states: an overview. *European Journal of Clinical Nutrition, 44,* 51-125.

Valsta, L.M. (1999). Food-based dietary guidelines for Finland - a staged approach. *British Journal of Nutrition, 81,* S49-S55.

Valtion ravitesemusneuvottelunta. (1998). *Suomalaiset ravitsemussuositukset. Komiteamietinto 1998:7.* Helsinki: Oy Edita Ab.

Wearne, S.J., & Day, M.J.L. (1999). Clues for the development of food-based dietary guidelines: how are dietary targets being achieved by UK consumers? *British Journal of Nutrition, 81,* S119-S126.

WHO. (1990). *Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series No. 797.* Geneva: WHO.

World Cancer Research Fund. (1997). *Food, Nutrition and the Prevention of Cancer: a global perspective.* World Cancer Research Fund/American Institute for Cancer Research.

# CHAPTER 10

## General Discussion

The purpose of this discussion is to reflect on the overall subject of periodicity of eating which has been very poorly studied and badly defined, rather than to repeat discussions of the work undertaken in this thesis, which has already been done in previous chapters. There is a general lack of research in the area of periodicity of eating. This, together with the methodological challenges that one faces when studying the area of periodicity of eating, has made it difficult to be conclusive about whether there are health benefits with an increased frequency of eating. It is clear, at this time however, that it remains incorrect to advocate a particular periodicity of eating for specific dietary or health benefits. Clearly more work is needed. The establishment of the Committee on Food Habits, by the International Union of Nutritional Sciences (IUNS) in 1994, 'to review the impact of changing food choice and habits on nutritional status' has been an important step to stimulate more research in this area of the science of nutrition (Oltersdorf *et al.*, 1999). This committee of the IUNS has given priority to reviewing the methodological issues related to identifying and assessing eating patterns as these are significant limiting factors in the interpretation of associations between eating patterns and aspects of diet or health. A number of important points have emerged from the research undertaken in this thesis, which warrant mention as they are relevant when looking to future research in the area of periodicity of eating.

Firstly, in order to obtain a greater understanding of periodicity of eating in free-living populations, it is essential that, in national food and nutrition surveys, data are collected at the level of the individual eating occasions of the day. Nutrient intakes are almost exclusively presented as mean daily nutrient intakes for populations and food intakes are generally presented as mean intakes of the population or as mean intakes among consumers of specific foods in the population. Food consumption surveys strive to obtain data on the food and nutrient intakes of a population, in order to assess the nutritional status of the population and to direct future public health nutrition strategies in a country to maintain and improve the health of the population. Without a thorough understanding of a population's eating patterns, in terms of frequency of eating, food choice, food combinations and locations of eating, strategies to improve the nutritional status of a population will, however, be limited by not being completely evidence-based. The current consensus on the most practical way of reaching the nutritional goals of a population is by developing food-based dietary guidelines

(FBDGs) rather than numerical goals (FAO/WHO, 1996). FBDG for a population must be practical, comprehensible, culturally acceptable and based on the food patterns and eating patterns of the population. Those responsible for conducting food and nutrition surveys must be encouraged to obtain data on both the total daily food and nutrient intakes of a population and data at the eating occasion level.

Secondly, given the cost implications of conducting national food and nutrition surveys it is essential that nutrition scientists work together in defining and establishing the most effective methods to obtain food and nutrient data at the level of eating occasions. If a clear understanding of the relevance of periodicity of eating in a population is to be obtained, the choice of method used to collect the dietary data and the criteria used to define eating occasions must be standardised and consistent between investigators. Attention must also be paid to the assessment of the validity of the dietary data collected, especially with evidence of under-reporting of specific eating occasions (Livingstone *et al.*, 1990; Heitmann & Lissner, 1995; Macdiarmid & Blundell, 1997; Poppitt *et al.*, 1998). In assessing the validity of the dietary data, consideration must be given to addressing the weight status of the population, the dieters in a population, the restrained eating habits and the physical activity level of the population. Investigators should provide full details of whether these issues were addressed, in any way, as part of future studies of periodicity of eating. Such measures will allow for a clearer understanding of the results and allow for more meaningful comparisons of results between studies.

Thirdly, having collected dietary data at the level of eating occasions, challenges exist in choosing the most appropriate calculation method to determine the food and nutrient intakes of the eating occasions of a population during the day. Individuals differ in the number of times they eat or drink during the day, in the times of the day at which they eat or drink and in the terms used to define the different eating occasions of the day e.g. meal, snack, breakfast, light lunch. Such facts make analysis of the data especially challenging. As part of this thesis, the mean nutrient intakes of eating occasions were determined using the temporal pattern of nutrient intake during the eating occasions at each hour of the day. This method is not dependent on the subjective terms used to describe eating occasions. Exploration of the use of

four different calculation methods demonstrated that very different results were obtained by each method, which of course has significant implications for the interpretation of the data. Again, nutrition scientists must collaborate in the study of this area by providing clear details of the calculation methods used in their work. Furthermore, the study of periodicity of eating represents a significant statistical challenge due to the differences in eating patterns between individuals. Future work must involve collaboration with statisticians to define the most appropriate statistical tests to be used. Only then can definitive conclusions be made regarding associations between periodicity of eating and health or dietary benefits.

Fourthly, the results of the research undertaken in this thesis encourage and support the move towards the study of food and nutrient intakes in its most dis-aggregated form. A dis-agggregated database is one which includes each item of food or drink consumed during an eating occasion, for all eating occasions on the day, as in the North/South Ireland Food Consumption Survey (NSIFCS). Aggregated databases, which present data as total daily intakes of food or nutrients, clearly mask valuable data on the eating patterns of the population. The study of the temporal pattern of nutrient intake during eating occasions throughout the day, in this thesis, provided data to allow a number of public health nutrition issues to be addressed. These were whether differences exist in the eating patterns of, high-fat and low-fat eaters and of those with different periodicities of eating and whether differences exist in nutrient intakes between different days of the week. The issue of whether test meals used in postprandial lipaemic studies reflect everyday eating occasions was also addressed. These investigations demonstrated the importance and value of studying data at the level of eating occasions. Data on the nutrient intakes of the eating occasions of free-living adults allowed these issues to be clarified. This could not be done using data on total daily intakes. The database of the NSIFCS will allow such issues to be addressed in a representative sample of the population as the cohort of office workers, in the present study, is not representative of the full population. Future studies of periodicity of eating must involve investigations of both the nutrient intakes of the eating occasions of a population and the food content of eating occasions. Such an approach, as presented in this thesis, means that data can be obtained on both the type and amount of each food or nutrient consumed at each eating occasion. In addition, a comprehensive understanding of free-living eating patterns can be obtained using

this approach, as full details of the other foods consumed as part of the eating occasion can be determined using such a database. It is clear that such databases are the way forward to address many public health nutrition issues for a population. Disaggregated databases, which allow the study of periodicity of eating, are invaluable to establishing a comprehensive understanding of the nutrition issues of a population.

Finally, it is very clear that further study of periodicity of eating must be encouraged among nutrition scientists. The potential health and the dietary implications of different periodicities of eating remains unclear and needs definition. The IUNS and the Committee of Food Habits will have a major role in stimulating more research in this neglected area. As part of future research to increase our knowledge of periodicity of eating as nutrition scientists we must strive to ensure that national food and nutrition surveys collect data at the level of individual eating occasions and store this data in disaggregated databases. We must also work together in establishing the most effective methods of collecting and analyzing food and nutrient intake data at the level of individual eating occasions. Investigation of the temporal patterns of food and nutrient intake during eating occasions throughout the day is valuable to many areas of nutrition research. Such investigations offer enormous potential however to improving our understanding of the role of diet to promoting health and preventing disease through the provision of baseline data. Food and nutrient data at the level of individual eating occasions is essential to the establishment of evidence-based and targeted public health nutrition policies and campaigns for a population.

**References**

Food and Agriculture Organization/World Health Organisation of the United Nations. Preparation and use of Food-Based-Dietary-Guidelines. Report of a joint FAO/WHO consultation Nicosia, Cyprus. WHO. (1996). WHO/NUT/96.6.

Heitmann, B.L., & Lissner, L. (1995). Dietary underreporting by obese individuals - is it specific or non-specific? *British Medical Journal, 311,* 986-989.

Livingstone, M.B.E., Prentice, A.M., Strain, J.J., Coward, W.A., Black, A., Barker, M.E., McKenna, P.G., & Whitehead, R.G. (1990). Accuracy of weighed dietary records in studies of diet and health. *British Medical Journal, 300,* 708-712.

Macdiarmid, J.I., & Blundell, J.E. (1997). Dietary under-reporting: what people say about recording their food intake. *European Journal of Clinical Nutrition, 51,* 199-200.

Oltersdorf, U., Schlettwein-Gsell, D., & Winkler, G. (1999). Assessing eating patterns - an emerging research topic in nutritional sciences: Introduction to the symposium. *Appetite, 32,* 1-7.

Poppit, D., Swann, D., Black, A., & Prentice, A.M. (1998). Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *International Journal of Obesity, 22,* 303-311.

# APPENDIX I

## 7-day food record diary &
## Guidelines for completion of the diary

# Food Diary

**ADDRESS QUERIES:**

**Karen Harrington,**
**Unit of Nutrition and Dietetic Studies,**
**Department of Clinical Medicine,**
**Trinity Centre for Health Sciences,**
**St. James's Hospital,**
**Dublin 8.**

**Telephone: 7022478(w) /4932480(h)**

**NAME:** _____

**DATE COMMENCED:** _____

**DATE COMPLETED:** _____

## FOOD RECORD DIARY

The purpose of this food diary is to know exactly what you eat and drink for the next seven days. An example of how to keep this diary is shown on the next page.

**For the success of this study, there are a number of important points I would ask you to remember:**

* **Please follow your normal eating pattern and food choices. It is vital that you do not change how often you eat/drink or the amounts of food you eat, while keeping this diary.**
* **Please CARRY the diary with you at all times.**
* **Please make note of all food and drink consumed immediately after eating/drinking.**
* **Remember to include between meal snacks, fruit, crisps, nuts, sweets, etc.; nibbles while cooking, all cups of tea and coffee, all drinks including water, milk, soft drinks, diet drinks, juices and alcohol.**

Start each day on a new page of your food diary. Use as many pages as you need.

## I NEED YOU TO RECORD THE FOLLOWING:

- **TIME** - record at what time you eat or drink anything even if it something small e.g. a few sweets
- **NAME of food or drink** - please specify the brand of food/drink e.g. cornflakes, aero bar, diet coke
- **AMOUNT of food or drink** - e.g. large bowl of cereal, 4 small potatoes, 1 cup of rice
- **METHOD OF COOKING** for all cooked foods e.g. boiled, fried, deep fried. It is not enough to say meat, please note the type and method of cooking e.g. fried lean mincemeat.

**Thank You.**

| TIME | AMOUNT | FOOD/DRINK | Method of Cooking | BRAND | LOCATION |
|---|---|---|---|---|---|
| 7.30am | Small bowl | Cornflakes | | Kelloggs | Home |
| | Large glass | Milk, no sugar | | Low-fat | |
| | 2 slices | White toast | | Brennans | |
| | Thickly | Butter | | Kerry | |
| | Mug | Tea with milk | | Low-fat | |
| 10am | 1 | Fruit scone | | | Work canteen |
| | 1 pat | butter | | | |
| | 1 glass | milk | | | |
| 1.00pm | 2 slices | Brown bread | | | Work |
| | | Margarine | | | |
| | 2 dessertsp | Tuna and mayo | | | |
| | 3 slices | Tomato | | | |
| | 1 can | Diet coke | | | |
| 5.00pm | 1 | Packet crisps – cheese/onion | | Tayto | Bus |
| 7.00pm | 2 small | Potatoes | Boiled | | Home |
| | 2 dessertsp. | Carrots | boiled | | |
| | | Breaded fish | Grilled | Findus | |
| 9.00pm | 4 | Chocolate biscuits | | Jacobs | Home |
| | 1 mug | Tea and milke | | Low-fat | |
| 11.00pm | 2 pints | Guinness | | | Pub |

**DAY:** _____ **DATE:** _____

| TIME | AMOUNT | FOOD/DRINK | Method of Cooking | BRAND | LOCATION |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

DATE: _____

| TIME | AMOUNT | FOOD/DRINK | Method of Cooking | BRAND | LOCATION |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## RECIPE SHEET

**Please note the ingredients of your recipe on this page:** _____

## GUIDELINES FOR FOLLOWING THE 7-DAY FOOD RECORD DIARY

Thank you for agreeing to participate in this study on meal patterns and nutrient intakes.

For the success of this study it is essential that we know exactly what you eat and drink for the next seven days.

It is very important that you carry the food diary with you at all times so that you can write down everything immediately after eating/drinking.

It is essential to follow your normal dietary pattern during the 7 day recording period.

Start each day on a new page and use as many lines as you need. Use as many pages as you need - I have provided you with 2 food diaries.

**I need you to record the following:**

**1) TIME**
Record at what time you eat the food even if it is something small e.g. a few sweets

**2) AMOUNT**
Please estimate the food portion consumed
e.g. 2 slices of brown bread, small/large bowl of cereal (cornflakes), 2 dessertspoons of boiled carrots, 2 cups of boiled white rice.
Record food eaten only, do not include leftovers.

**3) NAME OF FOOD OR DRINK**
Include all food and drink consumed during the seven days.
Remember to include between meal snacks, fruit, crisps, nuts, sweets etc. Nibbles while cooking. All cups of tea and coffee and whether you added milk and/or sugar or sweetener. All drinks, including water, juices, soft drinks (including diet drinks) and alcohol.

**4) METHOD OF COOKING**
State whether boiled, fried, stewed, grilled, baked, steamed or microwaved. If fat is used when cooking, please note the type and amount of cooking fat or oil used. e.g. egg fried in lard or cooking oil. Please note the type of cooking oil used e.g. vegetable, olive oil, mazola, flora.

**5) BRAND**
Please state the brand name of the food e.g. Kelloggs cornflakes, Aero bar, Uncle Ben's sauce, Yoplait yogurt.

**6) LOCATION**

Please note the location of the eating occasion e.g. home, work canteen, friend's house, restaurant, shop, coffee shop, pub.

**DESCRIPTION & QUANTIFICATION OF FOOD AND DRINK:**

Give as much detail as you can about each food.
List each item on a separate line.

**Bread:** State type: brown, white, wholemeal, plain or soda, sliced or cut from loaf, small or large slice, thick or thinly cut.

**Milk:** Whole/full-fat, low-fat/light, super, skimmed.

**Cheese:** State type e.g. cheddar, edam, cottage cheese, soft cheese, low fat, etc.

**Fruit:** Peeled or unpeeled, whole fruit or fruit juice, fresh or tinned.

**Meat:** State cut and if fat is eaten e.g. fat on chops, rind on bacon.

**Fish:** Type e.g. fresh/breaded cod, plaice, herring, smoked, whether fresh, frozen or tinned.

**Chicken:** leg, wing, breast; whether skin was eaten or not.

**Butter/Dairy Spread:** State brand, whether low fat or butter.

**Biscuits:** State brand name, state if chocolate covered.

**Sweets/Chocolate:** Brand name and size. Please note weight.

**Cereal:** Brand name.

**Vegetables:** note amounts as large or small, use standard kitchen serving spoons or dessertspoons. Note whether fresh, frozen, tinned, dried, etc. Note amounts of mashed potatoes in spoons or scoops or small or large portions. Note whether oil or lard was added with roast potatoes and whether butter or spread was added to vegetables or potatoes and/or milk in mashed vegetables.

**Stews, casseroles and other mixed dishes**:
Please give the recipe if known, listing ingredients on sheet provided.

**Sauces/Gravies:** If a homemade sauce please list each ingredient used in the sauce. If packet sauce, please note the brand used. Record amount eaten on meal in tablespoons or dessertspoons.

**Soft Drinks:** State brand name and if low calorie or diet.

**Ready Prepared Meals:** State brand name and weight e.g. Lean Cuisine, Lasagne, Marks and Spencer Chicken Kiev.

**Sandwiches:** note if spread eaten or not, mayo or dressing on fillings, note portions in dessertsp. for fillings (tuna, coleslaw, potato salad).

# APPENDIX II

## Advice Pamphlet

**Remember .....**

Being healthy is your choice and your responsibility. For most of us there are likely to be some things we need to try and change. If there is more than one area in your life where you feel the need to take action, it is probably best to make small changes gradually and tackle them one area at a time. Example: eat more bread, cereal and potatoes, take the stairs at work or get off the bus a stop early, and take a few minutes each day to relax both mind and body.

**Your summary for Healthy Living - The Choice is yours**

- Enjoy your food
- Eat a variety of different foods from the Food Pyramid
- Eat plenty of foods rich in starch and fibre
- Avoid eating too much fat
- If you drink, keep within sensible limits
- Be active: take part in three sessions of physical activity each week
- Don't smoke
- Keep to a healthy weight by eating the most nutritious foods in the right amounts.



---

**MEAL PATTERNS & NUTRIENT INTAKES STUDY 1995**
**D.I.T. Kevin Street and Trinity College Dublin.**

Thank you for taking the time and effort to participate in this study.

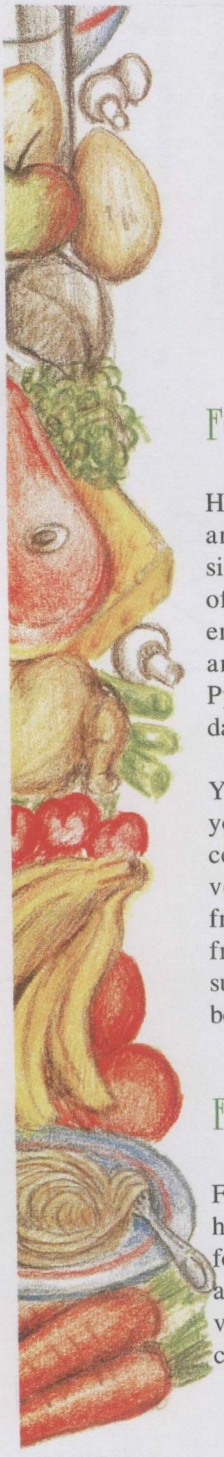
# HEALTHY EATING
# for
# Healthy Living

## Your Health Profile 1995

**NAME:** _____

# APPENDIX III

## 'A Guide to Healthy Food Choices' Leaflet



A GUIDE TO EATING

# HEALTHY Food CHOICES

## FOOD PYRAMID

Healthy eating is important for you and your family. Healthy eating simply means eating a wide variety of food, in the correct amounts, to ensure that you get all the energy and vitality you need. The Food Pyramid will help you plan your daily food choices.

You can see at a glance that most of your food intake should come from cereals and cereal foods, fruit and vegetables, with smaller amounts from milk and milk products, and from meat and alternatives. Fats, sugars and confectionery foods should be eaten in very small quantities.

## FOOD GROUPS

Foods provide different nutrients to help the body stay healthy. No single food contains all the nutrients in the amounts needed, so you have to eat a variety of different foods to get the correct amount.

Foods which contain simila nutrients are grouped into foo groups - this allows you variety an flexibility in your choices from eac group. Choosing food servings fror the four main food groups provide you with the balance of nutrients yo need daily - extra energy should b obtained from cereals, bread an potatoes as required. Variety come from not always selecting the sam foods from each group. Dependin on your age, you need a particula number of servings from each c these food groups every day. Chec the table opposite for individua serving needs.

## How to use the Food Pyramid

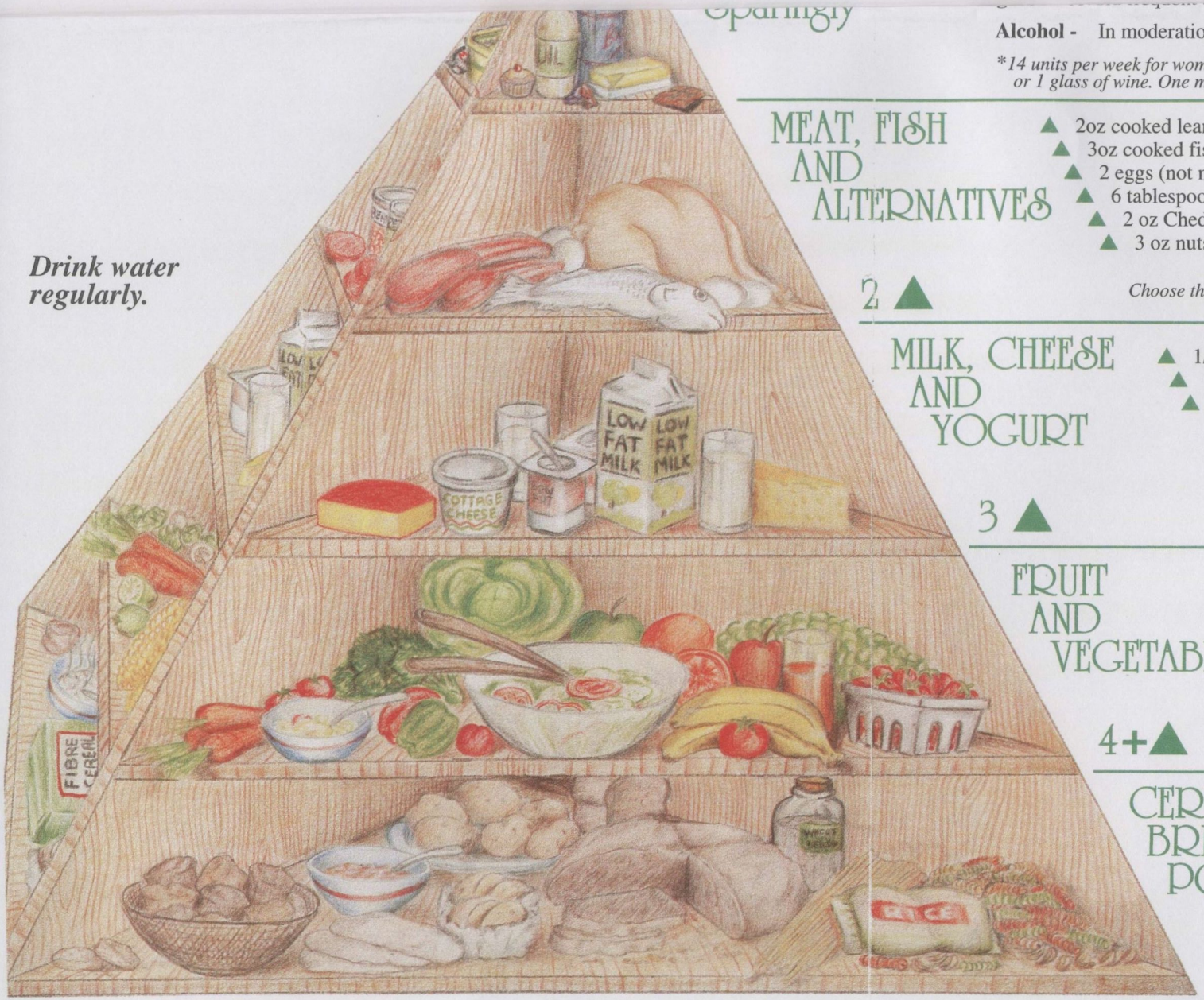
Each ▲ represents one serving an the number of servings needed eac day is indicated on the Foo Pyramid. Start at the base of th Pyramid choosing more of thes foods and less of those from the top Servings indicated are for adults an children.

sparingly

**Alcohol -** In moderation,* preferably taken with meals - with some alcohol free days.

**14 units per week for women. 21 units per week for men. 1 unit is equivalent to ½ pint beer or 1 glass of wine. One measure of spirits is 1½ units.*

***Drink water regularly.***




## MEAT, FISH AND ALTERNATIVES

2 ▲

- ▲ 2oz cooked lean meat or poultry
- ▲ 3oz cooked fish
- ▲ 2 eggs (not more than 7 per week)
- ▲ 6 tablespoons cooked peas/beans
- ▲ 2 oz Cheddar type cheese (preferably low fat)
- ▲ 3 oz nuts

*Choose three servings during pregnancy.*

## MILK, CHEESE AND YOGURT

3 ▲

- ▲ 1/3 pint of milk
- ▲ 1 carton of yogurt
- ▲ 1oz Cheddar cheese or Blarney/Edam

**Choose low fat choices frequently**

*Choose at least four servings for teenagers.*
*Choose five servings for pregnant and breast feeding women.*

## FRUIT AND VEGETABLES

4+▲

- ▲ 1/2 glass fruit juice
- ▲ 2 tablespoons cooked vegetables or salad (minimum)
- ▲ Small bowl of homemade vegetable soup
- ▲ 1 medium sized fresh fruit
- ▲ 2 tablespoons cooked fruit

## CEREALS, BREAD AND POTATOES

6+▲

- ▲ 1oz wholegrain or bran type breakfast cereal
- ▲ 1oz slice wholemeal bread
- ▲ 2 tablespoons cooked pasta/rice
- ▲ 1 medium potato -boiled or baked

*If physical activity is high up to 12 servings may be necessary.*