Physical Activity Levels and Body Composition in Children living in Disadvantaged areas of Urban India
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Abstract:

Background: Recent studies on children attending private or governmental schools in India have reported increasing rates of obesity. The aim of this study was to examine body composition and activity levels of children attending non-formal schools both in the community and in sheltered care.

Methods: Sixty-five children were recruited. Anthropometric data was taken on all children. Activity levels of children residing in the community were assessed with accelerometers.[1] Activity levels of girls living in sheltered accommodation were assessed using a questionnaire.

Results: No child was obese. Thirty two percent were underweight. Higher rates of underweight were seen in the community children, and among females. Activity levels among those in sheltered accommodation were high, (mean of 15 hours a week). Less than half the community dwelling children achieved the recommendation of 60 minutes moderate activity a day. Activities carried out consisted mainly of informal play. Children reported having little access to organised sport and physical education.

Conclusions: Obesity was not seen in these subjects living in underprivileged areas in urban India. Children in sheltered accommodation reported meeting physical activity recommendations while objective results revealed that most children in the community did not. However, comparisons cannot be made between groups as methods of data collection differed.

Introduction

Rates of obesity and obesity related diseases are increasing worldwide. The USA, UK, and many other countries around the world have reported increasing levels of overweight, obesity and associated medical problems in children.[2] Much of the blame for this has been laid upon the "western lifestyle". Increased availability of processed food,[3] and the replacement of physical activity with television viewing and videogame use among children have been linked strongly with obesity and related diseases.[4] In developing countries rates of obesity are lower, but may be catching up.[5]

India is among the fastest growing economies in the world with an estimated GDP growth in 2009 of 6.1.[6] Its recent wealth has led to a phenomenon called the double burden disease (where a country has medical problems relating to obesity alongside malnutrition).[7] Due to the growing economy there is an increase in the availability of processed foods and sedentary occupations, both risk factors for obesity. Additionally, as an ethnic group, Asian Indians are more likely to manifest high adiposity, insulin resistance, metabolic perturbations, and lower muscle mass than Caucasian children.[8] For a given BMI Indians have a higher percentage of body fat

and more visceral fat than other populations.[9] This is present at birth and throughout childhood as well as into adulthood.

With the nutrition transition underway, Indian people are changing their food consumption habits to those of the western world. It is presumed that it may take longer to change activity behaviours. Asian Indians have been shown in several studies to have lower levels of physical activity than other races.[10,11] Even when living in the United Kingdom, Indian people have been shown to have significantly lower levels of activity than the general population. Levels of activity are particularly lower among Indian women.[12] Patterns of physical activity have also been shown to be different, with less participation in organised sport.[13]

The prevalence of overweight/obesity in urban children in Delhi rose from 16% in 2002 to 24% in 2006. Approximately 30% of Indian children in private schools in India have been reported to be overweight or obese, compared to 11% in government schools.[14] A recent review on obesity, overweight, and undernutrition in India reported that "the prevalence of overweight and obesity has increased slightly over the past decade, but in some urban and high socioeconomic status groups it reached a relatively high level".[15] It is also reported that "factors associated with under-nutrition need closer examination and prevention of obesity should be targeted at the high-risk groups simultaneously." Anthropometric data on children who regularly attend school are easily gathered. The challenge lies in documenting the anthropometrics of the most underprivileged children who are not enrolled in government schools, often due to their family travelling to cities to find work.

The lower socioeconomic classes in India traditionally display higher rates of malnutrition and tend to be underweight rather than overweight. However, there are several known risk factors for the development of obesity which lie with the underprivileged. These include: low levels of maternal education; poor access to health care; fewer opportunities for physical activity; and specific to those living in highly populated urban areas or in shelter homes, a lack of space in which to exercise.[16] Several studies have reported higher levels of cardiovascular disease among the illiterate and slum populations in India.[17] Despite all these risk factors however, obesity will only become a problem if sufficient food is available. With the nutrition transition underway, food is becoming more available to everyone in India.

Current evidence suggests that school-age youth should participate daily in 60 minutes or more of moderate to vigorous physical activity that is developmentally appropriate, enjoyable, and involves a variety of activities.[18] Aerobic exercise is recommended for all children for optimal health status, but despite these health recommendations, low activity and high inactivity levels among children has been reported in many countries around the world,[19] and is known to play a large part in the increased levels of paediatric obesity seen today. In the past there was a lack of objective measures to measure physical activity in children. Now new devices are avail-

able which are valid,[20] easy to use and provide accurate measures of activity levels in children.

The overall aim of this study was to measure the anthropometrics and physical activity levels of underprivileged urban children in India living in the community and in shelter homes. A secondary aim was to compare results with published activity level recommendations for children.

Methodology:

Subjects:

All children were recruited through a juvenile justice aid centre in South Delhi. Community dwelling males and females (CDM/CDF n=12, aged 7-14 years) were recruited from four non formal education centres in the slum area of one of India's oldest and largest unauthorised colonies. These children were enrolled in non formal education centres with the view to being mainstreamed into formal government school. Most would have worked from an early age with no previous education. Community dwelling children lived with their families, and although the area in which they live is densely populated with few open spaces, they were free to walk, play and exercise outside. All community children were recruited through a talk given by the principal investigator which was translated by the school teachers to parents and children.

Non-community dwelling females (NCDF, n=28, aged 7-15 years), were recruited from a shelter home. These girls were permitted to leave the shelter only to attend school and for special circumstances. They, therefore, carried out most of their activity in the grounds of the shelter itself which had space inside and out, including a garden, to exercise in. The girls followed a general timetable which incorporated school, bed time, homework and chores, and they were encouraged to spend three hours of leisure time outside each day.

Non community dwelling males (NCDM, n=25, aged 10-16 years), were recruited from a juvenile detention centre. They were not permitted to leave the grounds in which they lived and strictly followed a daily regime which included exercise time. They had access to a large open space in which they played various games, including sports.

Ethical approval:

Ethical approval was granted by the Trinity College, Faculty of Health Sciences, research ethics committee. This research was conducted in India, and specifically inner city Delhi as an area which is currently undergoing the nutrition transition, and where a lot of children live in densely populated areas. Additionally the principal investigator had previously worked with people in this area of Delhi.

Measures and Procedures:

Anthropometrics:

Height, weight and skinfold thickness of all children were recorded. Measurements were taken by a trained investigator in the presence of an unbiased observer. Height was measured to the nearest cm with a tape measure against a wall. Weight was measured to the nearest kg with digital scales. BMI was calculated as $kg.m^{-2}$. Skin fold measurements were taken as outlined by Gore et al 2000.[21] This involved lightly gripping a fold of skin and subcutaneous fat with a skinfold calliper, and reading the dial at 2 seconds. All skin fold sites were measured on the right hand side while the participant was standing, by the same individual with the same instrument, a Harpenden callipers ($10g\ mm^{-2}$ pressure). Skin fold thickness was measured at the biceps, triceps, subscapular and suprailiac sites. Body fat percentage was estimated through skinfold measurement using the Durnin Womersley equation as an indication of body composition.[22]

Assessment of activity levels:

There are a number of ways to measure the physical activity levels of children. In a free living situation, available objective measures include doubly labelled water,[23] heart rate monitoring, pedometers and accelerometers. Subjectively, questionnaires can be used. The ideal method of measuring activity levels in children is with accelerometry. However methods which would be considered most appropriate by the researcher cannot always be employed. As seen in this study, some of the logistics of monitoring activity are within the control of the researcher, others are not. Girls who were in shelter care were not permitted to wear activity monitors as their minders did not want them to feel different in any way from other children at school. Activity levels of the non-community dwelling boys were not recorded due to the strict confidentiality rules in operation in the detention centre in which they were residing.

Girls abiding in the shelter home completed the modifiable activity questionnaire for adolescents (MAQA[24]) through an interview with the principal investigator in the presence of a translator. The first question asked how many days in the preceding fourteen days did the child participate in at least twenty minutes of hard exercise. Hard exercise was explained to each child as exercise that resulted in heavy breathing and a faster heart beat. The second question asked how many days in the preceding fourteen days did the child carry out at least twenty minutes of light exercise. Light exercise was explained to each child as exercise that did not result in heave breathing or a fast heart beat. The next question asked how many hours a day during a normal week was spent watching television and videos, or playing computer or video games. Participation in any competitive sports, and how the children travelled to school were also recorded. The final questions involved reporting activity in the past year in terms of weekly frequency and usual duration of each session. The

number of months that each activity was performed over the past year and the average weekly time devoted to it.

The MAQA was chosen as its questions were straight forward and easy to translate. It was also suitable in terms of its results which can be reported in terms of energy expended in regular activity in MET hours per week, and results can be compared to other studies.[25] This questionnaire has been shown to be valid and reliable.[26] As the MAQA is designed for adolescents and the children in the shelter home were as young as 7 years, where children were unsure of the answers to questions their guardians were consulted.

Activity levels of the community dwelling children were objectively measured with an accelerometer, (the RT3 triaxial accelerometer). This is a noninvasive device which, similar to a pedometer, is clipped onto the participant's clothes at the level of the right hip. It measures acceleration in three planes, therefore giving accurate information on activity levels when worn. The RT3 accelerometer has been found to be valid in the measurement of physical activity among boys and men[27] and among children.[28] It's reliability has also been established.[29] The children recruited were asked to wear the accelerometer for a period of twenty four hours.

Statistical analysis:
Results were analysed by JMP Version 7.1 (SAS for Windows, NC, USA). Results are expressed as mean ±SD with $p < 0.05$ considered significant.

Results:
Anthropometrics
Twelve community dwelling children (6 male) and 53 non-community dwelling children (25 male) were recruited. Table I describes their anthropometrics. Children were aged 12.35 ± 2.42 years, BMI was $17.14 \pm 2.72 kg/m^2$ and body fat % was $14.87 \pm 5.32\%$.

Anthropometric results were compared to the WHO (World Health Organisation) international BMI for age z scores.[30] Although the WHO charts are designed to be used internationally, the use of one set of cut off points for all races has been disputed due to clear genetic differences in the growth of children.[31] Therefore population specific references were also employed to analyse anthropometric data gathered.[32]

According to the WHO guidelines, two non community dwelling (NCD) males were overweight (between 85th and 97th percentile). Three fell between the 3rd and 15th centiles. One NCD female was in the thinness category (below the 3rd percentile), nine were between the 3rd and 15th centiles and none were overweight (Table II). One community dwelling (CD) male, and two CD females were in the thinness category (below the 3rd percentile) while, one CD female and one CD male were in the severe thinness category. One CD female and two CD males were between the 3rd and 15th percentiles. No community dwelling child measured was overweight.

Using references specific to Indian children published by Khadikar et al,[33] no child was considered overweight, only two were below the 3rd percentile (those that were in the severe thinness category using the WHO cut off points). Twenty one of the NCD males were within the 25th to 75th percentiles. One was between the 75th and 85th, and three were between the 10th and 25th. Sixteen of the NCD females were within the 25th to 75th percentiles. Eleven were between the 10th and 25th and one girl was between the 3rd and 10th (Table II).

All community dwelling children were below the 50th percentile. Four lay between the 10th and 25th percentiles (all male), while four were between the 3rd and 10th percentile (one male). Two children fell below the 3rd percentile (one male). Table II represents the number of children in each of the centile categories. Differences between the two references are slight, as seen in the results.

	Age (years)		Height (cms)		Weight (kgs)		BMI (kg.m^{-2})		Body fat (%)	
ID	Mean	Std Dev	Mean	Std Dev	Mean	S t d Dev	Mean	Std Dev	Mean	Std Dev
All (N=65)	12.35	2.42	144.45	13.28	36.85	11.76	17.14	2.72	14.87	5.32
CDF	11.17	1.83	140.17	9.6	29.2	9.23	14.51	2.77	16.48	6.02
CDM	10.67	1.97	134.33	8.36	26.02	4.9	14.34	1.67	8.33	2.43
NCDF	11.18	2.09	136.39	8.54	30.48	6.76	16.16	1.79	19.14	3.58
NCDM	14.36*	1.52	156.92	9.32	48.41	8.03	19.54	1.76	11.28	2.47

Table I- Subject characteristics

* Age of two boys was estimated by their guardian. CDF, community dwelling females. CDM, community dwelling males. NCDF, non-community dwelling females. NCDM, non-community dwelling males.

	India specific reference percentiles (Khadilkar et al)					
Percentiles	< 3	3-10	10-25	25 - 50	50 - 75	75-85
CDF (N=6)	1	3	0	2	0	0
CDM (N=6)	1	1	4	0	0	0
NCDF (N=28)	0	1	11	13	3	0
NCDM (N=25)	0	0	3	9	12	1
ALL (N=65)	2 (3.1%)	5 (7.7%)	18 (27.7%)	24 (37%)	15 (23%)	1 (1.5%)
	WHO percentiles					
Percentiles	< 3	3-15	15 - 50	50 - 85	85 - 97	
CDF (N=6)	3	1	2	0	0	
CDM (N=6)	2	2	2	0	0	
NCDF (N=28)	1	9	14	4	0	
NCDM (N=25)	0	3	7	13	2	
ALL (N=65)	6 (9.2%)	15 (23%)	25 (38.5%)	17 (26.2%)	2 (3.1%)	

Table II – Number of participants, and percentage of total children, in reference centiles

Activity results:

Community dwelling children:

Twelve children (6 males) were provided with accelerometers to wear for a 24 hour period. The results are as shown in Table III. Cut off points for inactive, light, moderate and vigorous exercise were used as outlined by Rowlands et al.[34] Ten hours were deducted from the inactive minutes of each child's results as time spent asleep. This method has been used in similar studies and was done to give a more realistic idea of the time spent inactive during waking hours.[35] Children spent an average of 465.42 minutes being inactive, 303.25 minutes carrying out light activity, 65 minutes moderate and 5.83 minutes in vigorous activity in a 24 hour period. A significant difference between genders was found for inactive and light activity. On average the recommendations for activity levels in children as outlined by Strong et al[36] were reached. However of the twelve children assessed, seven did not accumulate the recommended 60 minutes moderate activity in a day.

Group	Inactive		Light		Moderate		Vigorous		Moderate + Vigorous	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
All (n=12)	465.42	192.52	303.25	151.48	65.00	66.24	5.83	9.86	70.83	75.16
CDF	535.00	229.39	234.17	165.46	63.00	87.62	7.67	13.69	70.67	100.87
CDM	395.83	131.51	372.33	107.93	67.00	44.36	4.00	4.29	71.00	47.48

Table III - Activity levels of community-dwelling children- Minutes in each intensity category

Activity levels of non-community dwelling girls (n=26):
Twenty six girls living in sheltered accommodation completed the MAQA. Results are presented in Table IV. Nine children (35%) reported carrying out at least 20 minutes of hard exercise in the last 14 days, and did so on an average of 2.69 days during that time. This consisted mainly of running races and tag. Of these nine children, four carried out hard exercise for at least 20 minutes everyday. Twenty four girls (92%) reported carrying out at least 20 minutes of light exercise in the past 14 days, and did so on an average of 12.54 days during this time. The average hours reported watching television in a week was 10.3 ± 04.12. Only one child reported not watching television in the last 7 days. Every girl walked to school everyday. Yoga classes were organised for all girls in the shelter home for two months during the summer. These classes were 90 minutes long, and ran 6 days a week. Some girls carried out self directed yoga when the classes were over. Other activities reported by the girls were dancing, school physical education, tag and skipping. No child was involved in organised competitive sports. Their reported play time out of doors was included in the calculation of their total activity hours and MET hours. No child had access to computer games or bicycles. Total hours spent being physically active in an average week in the year was calculated for each girl as per the questionnaire instructions,[37] and was 15.38 ± 4.98 hours. Using the compendium of physical activities[38] to attribute MET values to the activities reported, MET hours a week were calculated. The mean MET hours in a week were 72.15 ± 24.22. Strong et al[39] recommend 60 minutes of moderate activity on all days of the week, this would amount to approximately 49 MET hours a week (1 hour x 7 days x 7 METS). Twenty girls (77%) reported achieving this recommendation.

	Mean	Std Dev	Min	Max
Days in last 14 where 20 mins hard exercise was carried out	2.69	4.71	0	14
Days in last 14 where 20 mins light exercise was carried out	12.54	4.18	0	14
Hours of television viewing in average week	9.90	4.51	0	20
Total activity minutes in an average day	131.91	42.73	21.33	211.43
Total hours activity in an average week	15.39	4.99	2.49	24.67
MET hours in an average week	72.15	24.22	8.72	116.14

Table IV, Objectively measured activity levels of non-community dwelling girls, N= 26

Discussion:

The increasing rate of obesity and obesity related disease in adults and children in India in recent years has sparked a number of studies. Many of these however have failed to capture the anthropometric data of the most underprivileged children, for whom there are several additional risk factors including poor maternal education and lack of space and opportunity to exercise. This study measured the anthropometrics and activity levels of underprivileged children in urban India.

Anthropometrics:

Children's BMI for age in this study were compared with the WHO,[40] and population specific reference charts.[41] Although the WHO reference is internationally recognised, references specific to Indian children were also used as they are argued by some to be more relevant.[42] Only two children measured were overweight according to the WHO charts, none were overweight when using population specific charts. Although Khadilkar et al's reference values are derived from affluent Indian children ("mostly middle-class Hindu Bengalis who belonged to upper castes such as Brahmin, Baidya, and Kayastha and some lower castes."), they may be considered the standard, since populations on which references are based should not be subject to nutritional constraints and should have full access to health care, therefore reflecting true growth potential.[43] Thirty eight percent of children were below the 25th centile according to the India specific reference. Of these 40% were living in the community, and 64% were female. The low rates of overweight, alongside problems of

undernutrition seen among the lower socioeconomic classes support the results of a recent review by Wang et al[44] and other similar studies.[45] This would indicate that problems of excess weight among children have not yet begun to affect the least affluent.

Low BMI however does not always mean low body fat percentage, as BMI is simply weight adjusted for height. Skinfold thickness, although an indirect method of estimating body fat percentage, was employed as it is the most practical and appropriate for epidemiological studies where laboratory equipment is not available. In general Asians have a lower BMI for the same body fat percentage, age and sex than Caucasians.[46] Body fat percentage as measured using skin fold thickness was on average quite low (14.87%) among all children and below that measured in children in other studies.[47]

Activity levels:
Current recommendations for children are to carry out at least 60 minutes of moderate to vigorous activity daily.[48] Objectively measured activity data revealed that urban underprivileged community dwelling children are on average reaching this target. However minutes of moderate plus vigorous activity ranged from 8 to 270 minutes in 24 hours. Seven of the 12 children (over 58%), did not achieve the recommended cut off. Of these four were female, one boy and one girl were in the thinness category, and one boy was in the severe thinness category. Their low levels of activity may have been an energy conservation mechanism. Females spent more time inactive, and carried out less light activity than their male peers. There was no difference in moderate or vigorous activity between genders. This finding is different to similar studies who have reported girls as spending less time in moderate to vigorous activity than boys.[49] Although accelerometers are recommended to be worn for a minimum of four days[50] to get a good representation of a child's activities, one day's activity in this cohort is likely to represent a typical day's activity since the children did not participate in extracurricular activities, therefore each day was quite similar to the next. The duration of 24 hours was agreed upon with school teachers as the duration most likely to give worthwhile information while reducing the chances of the device being stolen or broken in the community, a genuine concern of the school teacher.

Thirty five percent of the non community dwelling girls who completed the survey carried out at least 20 minutes of hard activity in the 14 days preceding the administration of the questionnaire. This is low, but may be explained by the type of activities carried out, which were mainly informal playing. Natural child play is intermittent in nature and is unlikely to be high in intensity for 20 consecutive minutes. The children carried out hard activity on average 3 days in 14 and light activity over 12 days in 14. It is encouraging that all but two girls reported carrying out at least 20 minutes of light activity in the previous 14 days, and that they were active on most

days. Of concern however, only three girls reported carrying out physical education at school. Activity carried out by the girls consisted mainly of play time outside their shelter home, and through walking to school.

Girls living in the shelter home were active for an average of 2 hours a day. This is above the recommended 60 minutes.[51] The girls surveyed reported expending over 72 MET hours in an average week, however there was a large range. This highlights the role individual choice has to play in activity patterns, even at an early age. Although each girl was given the same opportunities for exercise, and all lived in the same environment, some reported spending as little as 2.5 hours being active in a week. A similar trend was seen with television viewing with some girls choosing to watch no television and others accumulating up to 20 hours viewing in a week.

Low numbers recruited, specifically in the community, mean that the results found may not be totally representative. Finally while the accelerometers and questionnaire used in this study attempt to measure the same thing, their results are not comparable.

Cultural differences impacted on the study at times. A translator was needed for all communication with parents, guardians and the children themselves. The voluntary nature of all aspects of the study had to be re-iterated as those recruited, and their guardians were not familiar with the voluntary nature of research. Skinfold measurements on girls were conducted out of view of any boys or men as this involved exposure of the abdomen. As noted above, the principal investigator was advised by school teachers to allow children to have accelerometers for a period of only 24 hours as they felt there was a high risk of the equipment being stolen or lost in the community.

Conclusion:

This paper provides a cross sectional view of the anthropometrics and activity levels of underprivileged children in urban India, living in both community and non community settings. Results show no obesity and little overweight. On the contrary, there is a high rate of underweight, in particular among those living in the community. Both objectively measured and subjectively reported activity levels were at or above recommended values on average. Of concern however was the fact that 58% of children living in the community did not achieve the recommended sixty minutes of moderate activity a day.
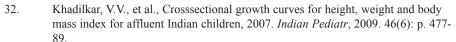
Acknowledgements:

NOTES

1.   A device used to measure activity levels.
2.   Chinn, S. and R.J. Rona, Prevalence and trends in overweight and obesity in three cross sectional studies of British Children, 1974-94. *BMJ*, 2001. 322(7277): p. 24-6. See also, Wang, Y., et al., Is obesity becoming a public health problem in India? Examine the shift from under- to overnutrition problems over time. *Obes Rev*, 2009. 10(4): p. 456-74.
3.   Popkin, B.M., The nutrition transition and obesity in the developing world. *J Nutr*, 2001. 131(3): p. 871S-873S.
4.   Vandewater, E.A., M.S. Shim, and A.G. Caplovitz, Linking obesity and activity level with children's television and video game use. *J Adolesc*, 2004. 27(1): p. 71-85. See also, Epstein, L.H., Integrating theoretical approaches to promote physical activity. *Am J Prev Med*, 1998. 15(4): p. 257-65.
5..   Popkin, B.M., Richards, M.K., Monteirro, C.A. , Stunted is associated with over weight in four nations that are undergoing the nutrition transition. *J Nutr*, 1996. 126(9): p. 8.
6.   Agency, C.I., ed. *The CIA World Factbook Vol. 2010*. 2010, Skyhorse Publishing.
7.   Bhardwaj, S.,et al., Childhood obesity in Asian Indians: a burgeoning cause of insulin resistence, diabetes and sub-clinical inflammation. *Asia Pac J Clin Nutr*, 2008. 17 Suppl 1: pp. 172-5.
8.   Ibid
9.   Yaajnik, C.S., Early life origins of insulin resistance and type 2 diabetes in India and other Asian countries. *J Nutr*, 2004. 134(1): pp. 205-10.
10.   Fischbacher, C.M., S. Hunt, and L. Alexander, How physically activeare South Asians in the United Kingdom? A literature review. *J Public Health* (Oxf), 2004. 26(3): pp.250-8.
11.   Sinnapah, S., S. Antoine-Jonville, and O. Hue, Is the leisure-time physical activity of Asian Indian Guadeloupean adolescents different from that of their island counter parts? *Ethn Health*, 2009. 14(3): p. 303-14.
12.   Hayes, L., et al., Patterns of physical activity and relationship with risk markers for cardiovascular disease and diabetes in Indian, Pakistani, Bangladeshi and European adults in a UK population. *J Public Health Med*, 2002. 24(3): p. 170-8.
13.   Ibid
14.   Bhardwaj, S., et al., Childhood obesity in Asian Indians: a burgeoning cause of insulin resistance, diabetes and sub-clinical inflammation. *Asia Pac J Clin Nutr*, 2008. 17 Suppl 1: p. 172-5.
15.   Wang, Y., et al., Is obesity becoming a public health problem in India? Examine the shift from under- to overnutrition problems over time. *Obes Rev*, 2009. 10(4): p. 456-74.
16.   Gupta, R., et al., Prevalence and determinants of coronary heart disease in a rural population of India. *J Clin Epidemiol*, 1997. 50(2): p. 203-9.
17.   Gupta, R., V.P. Gupta, and N.S. Ahluwalia, Educational status, coronary heart dis ease, and coronary risk factor prevaence in a rural population of India. *BMJ*, 1994. 309(6965): p. 1332-6; Misra, A., et al., Adverse profile of dietary nutrients, anthro-

pometry and lipids in urban slum dwellers of northern India. *Eur J Clin Nutr*, 2001. 55(9): p. 727-34; Pais, P., et al., Risk factors for acute myocardial infarction in Indians: a case-control study. Lancet, 1996. 348(9024): p. 358-63.

18.   Strong, W.B., et al., Evidence based physical activity for school-age youth. *J Pediatr*, 2005. 146(6): p. 732-7.

19.   Hussey, J., J. Gormley, and C. Bell, Physical activity in Dublin children aged 7-9 years. *Br J Sports Med*, 2001. 35(4): p. 268-72; discussion 273.

20.   Krishnaveni, G.V., et al., Accelerometers for measuring physical activity behavior in Indian children. *Indian Pediatr*, 2009. 46(12): p. 1055-62.

21.   Gore, C., ed. Physiological Tests for Elite Athletes, Human Kinetics ed. A.S. Commission. 2000: Champaign, IL.

22.   Reilly, J.J., J. Wilson, and J.V. Durnin, Determination of body composition from skinfold thickness: a validation study. *Arch Dis Child*, 1995. 73(4): p. 305-10.

23.   Doubly-labeled water method is used to measure energy expenditure. This is done by the subject ingesting a dose of doubly-labeled water, and then measureing the elimination rates of deuterium and Oxygen 18 over time, though the regular sam pling of urine blood or saliva.

24.   Aaron, D.J., et al., Reproducibility and validity of an epidemiologic questionnaire to assess past year physical activity in adolescents. *Am J Epidemiol*, 1995. 142(2): pp. 191-201.

25   Hussey, J., J. Gormley, and C. Bell, Physical activity in Dublin children aged 7-9 years. *Br J Sports Med*, 2001. 35(4): p. 268-72; discussion 273; Aaron, D.J., et al., The epidemiology of leisure physical activity in an adolescent population. *Med Sci Sports Exerc*, 1993. 25(7): p. 847-53.

26   Aaron, D.J., et al., Reproducibility and validity of an epidemiologic questionnaire to assess past year physical activity in adolescents. *Am J Epidemiol*, 1995. 142(2): pp. 191-201.

27.   Rowlands, A.V., et al., Validation of the RT3 triaxial accelerometer for the assess ment of physical activity. *Med Sci Sports Exerc*, 2004. 36(3): p. 518-24.

28.   Hussey, J., Bennett, K., O'Dwyer, J., Langford, S., Bell, C. and Gormley, J. , Validation of the RT3 in the measurement of physical activity in children. *Journal of Science and Medicine in Sport* (2007)

29.   Powell, S.M., and Rowlands, A.V., Intermonitor variability of the RT3 accelerome ter during typical physical activities. *Medicine and Science in Sports and Exercise* 2004. 36: p. 324-330

30   Group, W.M.G.R.S., *WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-forlength, weight-for-height and body mass index-for-age: methods and development. 2006*, World Health Organization: Geneva.

31.   Butte, N.F., C. Garza, and M. de Onis, Evaluation of the feasibility of international growth standards for school-aged children and adolescents. *J Nutr*, 2007. 137(1): p. 153-7.

32.   Khadilkar, V.V., et al., Crosssectional growth curves for height, weight and body mass index for affluent Indian children, 2007. *Indian Pediatr*, 2009. 46(6): p. 477-89.

33   Ibid

34   Rowlands, A.V., et al., Validation of the RT3 triaxial accelerometer for the assessment of physical activity. *Med Sci Sports Exerc*, 2004. 36(3): p. 518-24.

35   Masse, L.C., et al., Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. *Med Sci Sports Exerc*, 2005. 37(11 Suppl): p. S544-54.

36   Strong, W.B., et al., Evidence based physical activity for school-age youth. *J Pediatr*, 2005. 146(6): p. 732-7.

37   Aaron, D.J., et al., Reproducibility and validity of an epidemiologic questionnaire to assess past year physical activity in adolescents. *Am J Epidemiol*, 1995. 142(2): p. 191-201.

38   Ainsworth, B.E., et al., Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*, 2000. 32(9 Suppl): p. S498-504.

39   Strong, W.B., et al., Evidence based physical activity for school-age youth. *J Pediatr*, 2005. 146(6): p. 732-7.

40   Group, W.M.G.R.S., *WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-forlength, weight-for-height and body mass index-for-age: methods and development. 2006*, World Health Organization: Geneva.

41   Khadilkar, V.V., et al., Crosssectional growth curves for height, weight and body mass index for affluent Indian children, 2007. *Indian Pediatr*, 2009. 46(6): p. 477-89.

42   de Onis, M., et al., The National Center for Health Statistics reference and the growth of Indian adolescent boys. *Am J Clin Nutr*, 2001. 74(2): p. 248-53.

43   Assessment of differences in linear growth among populations in the *WHO Multicentre Growth Reference Study. Acta Paediatr Suppl, 2006*. 450: p. 56-65.

44   Wang, Y., et al., Is obesity becoming a public health problem in India? Examine the shift from under- to overnutrition problems over time. *Obes Rev*, 2009. 10(4): p. 456-74.

45   de Onis, M., et al., The National Center for Health Statistics reference and the growth of Indian adolescent boys. *Am J Clin Nutr*, 2001. 74(2): p. 248-53; Mukhopadhyay, D.K., et al., Anthropometric failure, a new approach to measure undernutrition: an experience from a rural community of West Bengal, *India. J Indian Med Assoc*, 2009. 107(4): p. 211-4, 236.

46   Yajnik, C.S., Early life origins of insulin resistance and type 2 diabetes in India and other Asian countries. *J Nutr*, 2004. 134(1): p. 205-10.

47   Tucker, L.A., G.T. Seljaas, and R.L. Hager, Body fat percentage of children varies according to their diet composition. J Am Diet Assoc, 1997. 97(9): p. 981-6.

48   Strong, W.B., et al., Evidence based physical activity for school-age youth. *J Pediatr*, 2005. 146(6): p. 732-7.

49   Hussey, J., et al., Relationship between the intensity of physical activity, inactivity, cardiorespiratory fitness and body composition in 7-10-year-old Dublin children. *Br J Sports Med*, 2007. 41(5): p. 311-6; Falgairette, G., et al., Evaluation of habitual physical activity from a week's heart rate monitoring in French school children. *Eur J Appl Physiol Occup Physiol*, 1996. 74(1-2): p. 153-61; Armstrong, N. and S. Bray, Physical activity patterns defined by continuous heart rate monitoring. *Arch Dis Child*, 1991. 66(2): p. 245-7.
50.   Trost, S.G., et al., Using objective physical activity measures with youth: how many days of monitoring are needed? *Med Sci Sports Exerc*, 2000. 32(2): p. 426-31.
51   Strong, W.B., et al., Evidence based physical activity for school-age youth. *J Pediatr*, 2005. 146(6): p. 732-7.