Patients over 65 years are assigned lower ECOG PS scores than younger patients, although objectively measured physical activity is no different

Julie M. Broderick[a,*], Juliette Hussey[a], M.J. Kennedy[b], Dearbhaile M. O' Donnell[b]

[a]School of Medicine, Trinity Centre for Health Science, St. James's Hospital, St. James's Street, Dublin 8, Ireland
[b]Department of Medical Oncology, St. James's Hospital, St. James's Street, Dublin 8, Ireland

Abstract

Objectives: The Eastern Cooperative Group Performance Status (ECOG PS) is a widely used standard functional classification in oncology practice, the verbal descriptors of which refer to physical activity (PA). Little is known about the cut-off points of this scale and measured PA levels. This research investigated the relationship between PS assigned, objectively measured PA, and patient age.

Materials and Methods: One hundred ambulatory patients with treatment-naive cancer wore an accelerometer (RT3) for a mean (SD) of 5.6 (1.1) days before initial oncology evaluation and ECOG PS assignment.

Results: Seventy five participants (75%) were < 65 years and 25 were ≥ 65 years. Eighty nine (89%) were assigned an ECOG PS of 0 or 1 and 11% a PS of 2 or 3. A weak but significant inverse association was found between objectively measured PA and PS (rho = − 0.26, p = 0.01). Seventy one participants (80%) with a PS of 0 or 1 spent more than 50% of waking hours resting. Participants assigned a PS of 2–3 spent significantly more time resting than those assigned a PS of 0 (p = 0.01). Age ≥ 65 years was significantly related to PS assigned (p = 0.04), although the older cohort were no less sedentary than younger patients.

Conclusion: PA levels were low, but PS scoring reflected relative PA levels and differentiated between patients of PS 0 and 2–3. Chronological age was not predictive of activity levels, but older patients were assigned lower PS scores. Incorporation of objective PA measures may merit further investigation especially in the geriatric oncology setting.

Keywords Eastern Co-operative Oncology Group; Performance status; Physical activity; Accelerometer; Geriatric assessment

1. Introduction

Performance status (PS), a numerical quantification of a patient's actual physical function and capacity for independent living and self-care is widely used in oncology practice. It is assessed by interview with a health care professional[1] using a scoring system such as the Eastern Cooperative Oncology Group Performance Status (ECOG PS) scale[2] (Fig. 1). The verbal descriptors of the ECOG scale relate to physical activity (PA).

Performance status (PS) scoring tends to be lower in older patients with cancer.[3] This may be related to the decrement in PA which occurs with advancing age,[4] which in turn has been linked with functional disability and an increased number of co-morbidities.[5–7] Lower PS scoring may impact negatively on treatment decisions as the cut-off points between ECOG PS 1 and 2 or between ECOG PS 2 and 3 are routinely used to select patients for clinical trial entry.[8–10] Good PS (ECOG 0 and 1) is associated with better response to treatment[11] and quality of life[12,13]. Poor PS (ECOG PS 2, 3, and 4) has been linked to fatigue[14,15] and increased risk of treatment-related toxicity[16–18].

The challenges of PS scoring are well documented. Doctors[19,20] and health care providers[21] have been reported to "over-estimate" PS in clinical practice, when compared with PS estimated by the patient.[1,19,20,22] A recently published study[23] details a Chemotherapy Risk Assessment Scale for High-Age Patients (CRASH) score to assess the risk of severe toxicity in elderly patients. The CRASH scale was shown to differentiate between different risk levels of severe toxicity. However, no difference in toxicity risk emerged between patients who were assigned an ECOG PS of 1 compared to those assigned a PS of 2, highlighting the limitations of PS scoring in elderly patients with cancer.

Indeed, self-reported PA – which influences PS scoring – is notoriously prone to bias,[24] as it is difficult to quantify volume and intensity of activity and patients often struggle to recall how much of the day they spend in bed or chair or "up and about". This raises the question whether objective PA measurement, using new accelerometry technology might be useful. Little is known about the relationship between PS and objectively measured PA in heterogeneous cancer populations or PA in older patients with cancer.

The aim of this study was to compare physician-assigned ECOG PS to objectively measured PA assessed by an accelerometer (RT3 accelerometer Stayhealthy Inc., Monrovia, CA), and to see whether ECOG PS assigned and/or PA had any relationship to patient age. A secondary objective was to compare these measures to subjective PA as estimated by a questionnaire (International Physical Activity Questionnaire).

2. Materials and Methods

2.1. *Setting and Participants*

One hundred patients were recruited consecutively from a single cancer centre in St. James's Hospital, Dublin, Ireland over a 16-month period. All participants gave written informed consent. Patients were eligible if they had a recent diagnosis of a non-haematological malignancy (all stages included), were not hospitalised, were treatment naive and were being considered for initial chemotherapy and/or radiotherapy. Patients had to be at least 18 years of age and be capable of completing the questionnaire. Exclusion criteria included significant chronic lung disease or cardiovascular disease which interfered with mobility or any other co-morbid condition which significantly impaired functional ability.

2.2. *Study Procedures*

Potential participants were sourced through oncology multidisciplinary meetings or via communication with relevant medical/nursing personnel. Eligible participants were subsequently approached in the hospital environment, generally during their inpatient stay for surgical removal of their tumour and given study information. If interest was indicated, participants were supplied with an RT3 accelerometer and an activity diary. Patients were instructed to wear the monitor for up to 7 days in the home environment during the immediate lead-up to the initial evaluation appointment with the medical or radiation oncology team. The activity diary recorded daily

Grade	ECOG
0	Fully active, able to carry on all pre-disease performance without restriction
1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light house work, office work
2	Ambulatory and capable of all self-care but unable to carry out any work activities. Up and about more than 50% of waking hours
3	Capable of only limited self-care, confined to bed or chair more than 50% of waking hours
4	Completely disabled. Cannot carry on any self-care. Totally confined to bed or chair
5	Dead

Fig. 1 – The Eastern Cooperative Oncology Group Performance Status (ECOG PS).

wearing time of the monitor and documented the time the monitor was put on in the morning and taken off at night, as well as any period when the activity monitor was not worn and the reasons for this.

Participants were instructed to wear an RT3 accelerometer continuously during waking hours, except during water-based activities such as showering. They were instructed not to alter daily routines and to record on and off monitor wearing time. Printed material given to each participant also reiterated verbal instructions given, and a phone call was made by the study personnel on the first morning of monitor wearing in order to re-confirm instructions to the participants and trouble-shoot any problems. Contact details were also provided should questions arise. At the initial evaluation appointment with the medical or radiation oncology team, the accelerometer was removed. At that visit, the ECOG PS was assigned by the physician as part of the routine evaluation and the patient completed the International Physical Activity Questionnaire (IPAQ)[25] with one of the study personnel. During analysis of the accelerometer data, the investigator was unaware of which PS had been assigned.

Institutional ethical board approval was granted for this study.

2.3. *Study Measures*

An accelerometer is a motion sensor which measures acceleration of the limbs and trunk. The RT3 accelerometer has previously been shown to be a valid and reliable measure of PA in adults.[26] It is worn on the waistband and is about the size of a pager (dimensions 7.1 × 5.6 × 2.8 cm, weight 65.2 g including AAA battery). When the subject moves, a sensor within the monitor registers acceleration or deceleration in three axes: vertical (x), anteroposterior (y), and mediolateral (z) which are converted to a series of numbers called "activity counts" which were set as accumulated vector magnitude ($[x^2 + y^2 + z^2]^{0.5}$) activity over a one-minute epoch (Mode 4). The activity counts correspond to time spent in light, moderate and vigorous domains of activity based on accumulated vector-magnitude cut-off points previously described.[26] Subjects in this study were required to provide at least 3 days valid monitoring as this is considered the minimum number of days to assess PA in daily life.[27]

The International Physical Activity Questionnaire (IPAQ) (long version) was used for subjective assessment of habitual PA participation during the previous 7 days. Acceptable validity and reliability across 12 countries been previously described.[25] The full questionnaire and data-processing guidelines are available from www.ipaq.ki.se and a description of this questionnaire is presented in Table 1.

The Charlson co-morbidity index scores were calculated according to pre-determined recommendations.[28] This index takes into account the number and the seriousness of co-morbid diseases and predicts related mortality rates. Information about co-morbidities was extracted from patient medical charts.

2.4. *Statistical Analysis*

Normality of distribution was tested using a 1-sample Kolmogorov–Smirnof test. Analysis of variance (ANOVA) was used to compare ECOG PS to age with age entered as the dependent variable and ECOG PS as the factor. Similarly, ANOVA was also used to compare the Charlson co-morbidity index to age. Post hoc tests (LSD) were used to identify which means were significantly different to each other. The Kruskal–Wallis test was used to compare the ECOG PS and Charlson co-morbidity index. Associations between domains of activity and the ECOG PS were evaluated using a Spearman's rank correlation coefficient (rho). All reported p values were two-tailed and p values <0.05 were considered statistically significant. Data were analysed using SPSS (SPSS16.0 Inc., Chicago, IL).

3. Results

The progress of patients through the study is shown in Fig. 2. The mean (SD) number of days monitored before ECOG PS assignment was 5.6 (1.1) days (range 3–8 days). Sixty-eight percent (n = 68) of patients had breast cancer, 10% (n = 10) lung/thoracic cancer, 9% (n = 9) colorectal cancer, 10% (n = 10) gynaecological cancer and 3% (n = 3) prostate cancer. The majority (n = 98) had undergone surgical removal of their tumour within the previous month prior to oncology out-patient assessment when ECOG PS was graded. Patient characteristics are listed in Table 2. Fourteen consultant or registrar grade physicians in medical or radiation oncology assessed patients and assigned ECOG PS in the course of the study.

The majority (89%) of these ambulatory patients were assigned a good PS (ECOG PS 0 or 1). Twenty-eight patients were assigned an ECOG PS of 0, 61 patients a PS of 1, 6 patients a PS of 2, and 5 patients a PS of 3. Due to small numbers in ECOG categories 2 and 3, these categories were collapsed for further analysis. Two participants were ≥80 years and the

Table 1 – Summary of the IPAQ (International Physical Activity Questionnaire).

Description	Self-report physical activity (PA) questionnaire
Version used	Long-form (can be downloaded from www.ipaq.ki.se)
Domains assessed	Leisure-time PA, transport-related PA, domestic and gardening (yard) activities, work-related PA, time spent setting
Unit score	MET-min week^{-1}
METs (metabolic equivalents)	METs are multiples of the resting metabolic rate and a total physical activity score (MET-min week^{-1}) is computed by multiplying the MET-score of an activity by the minutes performed per week
Computation of score	Following the scoring protocol (www.ipaq.ki.se), time spent in vigorous, moderate and walking in each of the activity domains was calculated per day Energy expenditure estimate measures were produced by weighting the reported minutes per week for each activity category by an estimated MET energy expenditure equivalent nominated for each activity category (3.3 METs walking, 4.0 METs moderate, 8.0 METs vigorous)

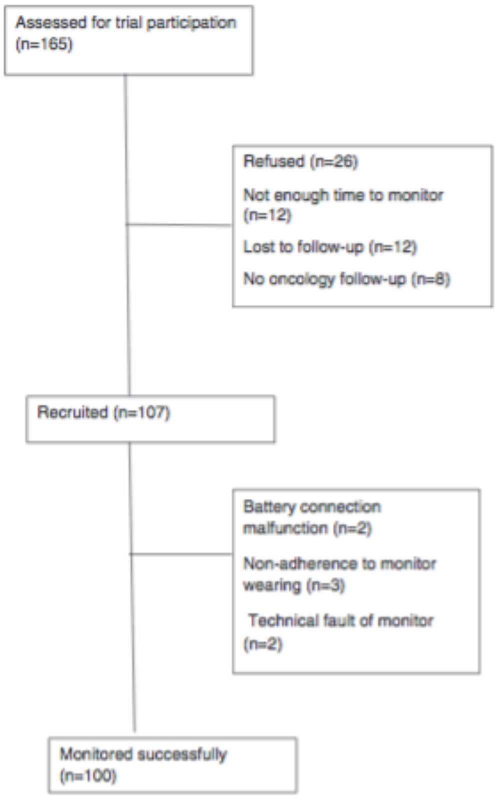

Fig. 2 – Flow diagram of participants through the study.

majority of participants (98%) were <80 years. Seventy-five (75%) of participants were aged <65 years (67 females, 8 males), while 25 were aged ≥65 years (22 females, 3 males). Age was significantly related to ECOG PS assigned (between groups p = 0.04) with differences identified between ECOG 0 and ECOG 2–3 categories (p = 0.02). The older cohort displayed significantly higher Charlson co-morbidity scores compared to the younger cohort (p < 0.001) (Table 2).

Analysis of accelerometry data showed that among participants of all ages a large proportion of waking hours were spent resting, which increased with worsening PS assigned (PS 0: 7.5 (2.5) h, PS 1: 8.2 (2.0) h, PS 2–3: 9.2 (1.2) h) (Table 3). ANOVA testing showed that ECOG PS was significantly related to percentage time spent resting as measured by an accelerometer (p = 0.04). Post-hoc testing revealed the difference was between time spent resting by participants assigned a PS of 0 and a PS of 2–3 (p = 0.02). There was a significant inverse correlation between "percentage time in activity" as measured by the accelerometer and ECOG PS assigned (rho = −0.26, p = 0.01). The mean (SD) percentage time spent in any activity per day was 42.9% (17.9) for PS 0, 36.9% (15.1) for ECOG 1, and 28.9% (10.7) for ECOG 2–3. Within each PS category a small number of participants were very active and spent minimal time resting (Fig. 3). However, only 17 of the 100 patients spent more than 50% of waking hours in any activity, however light. All 17 were assigned an ECOG PS of 0 or 1; 4 of these were ≥65 years while 13 were <65 years. No patient who was assigned an ECOG PS of 2 or 3 met this cut-off.

There was no difference between percentage time spent resting of those patients <65 years (n = 75) compared to ≥65 years (n = 25) (mean (SD)) 61.5% (15.5) versus 64.9% (17.3). When time spent sedentary for the older and younger cohorts was considered in terms of PS assigned, there was a trend for the elderly cohort of PS 0 to be less sedentary (5.9 (1.8) h per day) than patients of PS 0 in the younger group (7.7 (2.6) h per day), although the numbers were small and this difference did not reach statistical significance.

Subjective PA data (IPAQ) is presented in Table 3. ECOG PS was not significantly related to total estimated PA levels or average hours spent sitting. Associations between ECOG and subjectively measured PA are presented in Table 4.

4. Discussion

To our knowledge, this is the first study to compare ECOG PS assigned to objectively measured PA in patients with newly-diagnosed cancer, and to consider the PA levels of older patients with cancer in relation to ECOG PS assigned. Our striking finding was the time most patients of all ages, even those assigned a good PS, spent at rest. Very few patients, even those assigned PS 0, spent less than 50% of waking hours at rest. In fact, nearly all our subjects spent >50% of the day at rest (whether "confined" or not), which would appear to correspond to an ECOG PS of 3. Within ECOG PS categories 0 and 1, however, a small number of participants were very active, confirming that the accelerometer technology did indeed capture all activity.

Even though relative activity levels were much lower than verbal descriptors of the ECOG PS scale for all PS assigned, participants were still sub-classified appropriately according to relative PA levels. We found that chronological age was not predictive of activity levels, as, despite higher co-morbidity scores, the older cohort was no less active than the younger cohort. However, this was not reflected in the PS scoring; in fact, there was a trend within the group assigned a PS of 0, for the patients ≥65 years to be less sedentary than the younger patients.

The first question is whether the PS scores assigned by our participating physicians were simply "wrong". This is likely to be an over-simplification — the explanation may be more related to the fact that PS measures something different from PA as evidenced by the low correlation between these variables. PS may be considered more a measure of what you could potentially do and PA is a measure of what you are doing. PS scoring also encompasses the subtle concept of physician judgement, which may be important as despite the dichotomy between PS assigned and objectively measured physical activity, PS has been shown to be a strong predictor of toxicity and prognosis.

Health care professionals may expect higher levels of PA in younger patients (<65 years) and those with fewer co-morbidities, and therefore assign them better PS scores, even though we did not find them to be more active than the older patients. The meanings of the verbal descriptors of the ECOG PS scale are likely to have shifted as the population has become more sedentary over the 50 years since the scale was devised. The vocabulary and phrasing of the ECOG PS scale appear based on the premise that periods spent at rest reflect disease-related restriction rather than habitual inactivity. In our automated society, patients can be very sedentary, yet maintain

Table 2 – Demographic characteristics of participants and Charlson co-morbidity index score (n = 100).

	Combined group	ECOG 0	ECOG 1	ECOG 2–3
Age				
Mean (SD)	54.7 (12.5)	50.2 (12.5)	55.8 (11.8)	60.7 (14.0)
Range	24–82	24–77	30–82	37–79
≥65 years				
Percentage (n)	25 (25)	16 (4)	64 (16)	20 (5)
Age (mean (SD))	71.3(5.0)	70.8 (4.7)	71.1 (5.3)	72.6 (4.9)
<65 years				
Percentage	75 (75)	32 (24)	60 (45)	8 (6)
Age (mean (SD))	49.2 (8.8)	46.8 (9.6)	50.6 (8.2)	50.7 (10.4)
Gender (% female (n))	89 (89)	100 (28)	85.3 (52)	81.8 (9)
≥65 years (%(n))	88 (22)	100 (4)	87.5 (14)	80 (4)
<65 years (%(n))	89.3 (62)	100 (28)	85.2 (52)	81.8 (9)

Co-morbidity index score (%(n))	0	1	2	≥3	p value
Overall	58 (58)	28 (28)	9 (9)	5 (5)	
Separated by age ≥65/<65					< 0.001[a]
≥65 years	24 (6)	40 (10)	24 (6)	12 (3)	
<65 years	69.3 (52)	24.0 (18)	4.0 (3)	2.7 (2)	
Separated by ECOG					0.49[b]
ECOG 0	67.9 (19)	25.0 (7)	7.1 (2)	0 (0)	
ECOG 1	55.7 (34)	29.5 (18)	8.2 (5)	6.6 (4)	
ECOG 2–3	45.5 (5)	27.3 (3)	18.2 (2)	9.2 (1)	

Abbreviations; n = number, SD = standard deviation, % = percentage.
[a] Groups compared using 1 way ANOVA.
[b] Groups compared using Kruskall–Wallis test.

the ability to be fully functioning and feel unrestricted. Sitting awake, completely immobile, could be described as time spent "up and about" rather than "at rest" by those habitually inactive.

The impact of such low PA levels on toxicity and treatment tolerability is not fully known at this time, as PA has not been evaluated against these end-points. This underlines the need to measure PA and record subsequent treatment tolerability and toxicity. Only then can the case for integration of PA measurement as part of an assessment for patients with cancer can be made. Of note, given the low PA levels observed in this study, an

Table 3 – Physical activity results (objective (RT3) and self-report (IPAQ)) per ECOG PS level assigned.

ECOG PS assigned	0	1	2–3	p value	Difference between groups[a]
RT3 (mean (95% CI))					
Sedentary (h/day)					
Overall	7.5 (6.5–8.5)	8.2 (7.7–8.7)	9.2 (8.4–10.0)	0.04*	PS 0–PS 2–3
≥65 years	5.9 (3.1–8.7)	8.4(6.9–9.5)	8.8 (7.4–10.1)	0.05*	PS 0–PS 1 and, PS 0–PS 2–3
<65 years	7.7(6.7–8.8)	8.1(7.6–8.7)	9.5 (8.3–10.8)	0.05*	PS 0–PS 2–3
Light (h/day)					
Overall	4.7 (4.0–5.5)	4.3 (3.8–4.7)	3.7 (2.5–5.0)	0.28	–
≥65 years	4.7 (1.8–7.6)	3.8 (2.9–5.0)	3.6 (1.5–5.7)	0.63	–
<65 years	4.7 (3.9–5.6)	4.5 (3.9–4.9)	3.8 (1.6–6.1)	0.55	–
Moderate/vigorous (h/day)					
Overall	0.9 (0.4–1.3)	0.6(0.4–0.8)	0.2 (0.7–0.3)	0.09	–
≥65 years	1.1 (−1.3-3.4)	0.6(0.02–1.2)	0.1 (−0.1–0.3)	0.42	–
<65 years	0.9 (0.4–1.3)	0.6(0.3–0.8)	0.2 (0.1–0.4)	0.27	–
IPAQ (mean (95% CI))					
Total PA per week (MET-min)					
Overall	2861.2 (1999.9–3722.5)	2515.8 (1637–3394.5)	759.0 (42.5–1560.5)	0.10	–
≥65 years	3154.5 (715.5–7024.5)	2552.9 (63.2–5042.6)	155.1 (219.2–529.4)	0.38	–
<65 years	2812.3 (260.4–2784.9)	2502.8 (1604.7–3400.9)	1262.3 (260.4–2894.9)	0.42	–
Time spent sitting per day (h)					
Overall	5.7 (4.8–6.7)	7.2 (6.4–7.9)	7.2 (6.4–7.9)	0.07	–
≥65 years	5.2 (4.1–6.3)	7.1 (5.2–8.9)	8.0 (3.7–12.4)	0.34	–
<65 years	5.8 (4.7–6.9)	7.2 (6.3–8.1)	6.6 (3.0–10.2)	0.15	–

Abbreviations: IPAQ, International Physical Activity Questionnaire; SD, standard deviation; 95% CI, 95% confidence interval.
[a] If there was a difference in the ANOVA test, to determine which groups were significantly different, multiple comparisons were made using the least significant difference (LSD) test.
* $p \leq 0.05$.

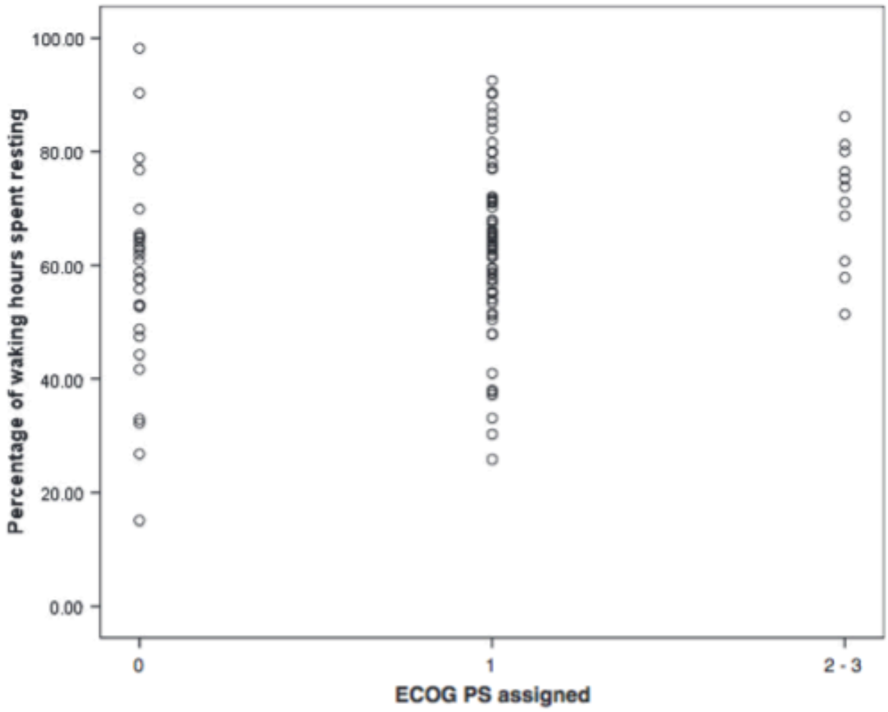

Fig. 3 – Dot-plot of percentage time resting and ECOG PS assigned.

important consideration would be the sensitivity of the PA measurement tool to detect very low levels of activity. The RT3 accelerometer used in this study has shown good levels of reliability among sedentary groups.[26,29,30]

There was no significant correlation between patients' own estimation of physical activity (from IPAQ) and ECOG PS, but a moderate association between IPAQ and accelerometer data. That suggests that a patient's estimation of his or her own activity levels using the recall questionnaire may reflect PA more accurately than the ECOG PS.

We acknowledge the difficulty of comparing ECOG PS, an ordinal scale, to PA, a continuous multidimensional measure, and that the ECOG PS scale was devised based on physician–patient interaction, not objective assessment to reflect physical function including "self-care" and occupational activity as well as absolute PA levels. As accelerometers measure all activity, however slight, we feel they are a reasonable proxy measure to explore comparison with the ECOG PS and clearly an excellent way to measure true activity levels in patients with cancer, including those ≥65.

Strengths of the current study were a heterogeneous population of treatment-naive, ambulatory patients, each measured at first treatment decision, and the assignment of PS in the course of the initial cancer consultation by medical or radiation oncology physicians who regularly selected patients for clinical trials. A limitation of this study was that participants ≥65 years only comprised 25% of the group. Our recruitment of elderly patients and the composition of that cohort may have been influenced by the exclusion of those with cognitive difficulties and significant mobility restrictions. A further limitation is that there were very few males included in this study which may have consequences for the general applicability of this study.

Nonetheless, this study raises interesting questions about how we assess fitness for cancer therapy in a sedentary society and whether physician expectations that PA levels will be lower in older patients might influence PS scoring. We found that the ECOG PS score did not reflect objective activity levels but it still differentiated between the activity levels of patient groups. Despite higher co-morbidity levels, elderly patients were no less active than the younger cohort. There is a need for longitudinal data linking PA levels to toxicity and prognosis in order to advance the case for the integration of objective PA tools as an adjunct to clinical assessment. Objective PA measures might also help select fit elderly patients who may tolerate intensive treatment well.

Funding

This work was supported by the Health Research Board, Ireland [CTPF/2008/12, 2008].

Disclosures and Conflict of Interest Statements

There is no conflict of interest to report.

Author Contributions

Concept and design: JM Broderick, DM O' Donnell, J Hussey.
Data collection: JM Broderick, MJ Kennedy, DM O' Donnell.
Analysis and interpretation of data: JM Broderick, J Hussey, DM O' Donnell, MJ Kennedy.

Table 4 – Correlation (Spearman's rho) of objective time (RT3) in activity (summation of time in light, moderate and vigorous domains of activity) and ECOG PS score by self-report total PA (from IPAQ) and time spent sitting per day (from IPAQ).

	Total physical activity (MET-min week^{-1})	Hours spent sitting (per day)
RT3 % time in activity		
Correlation coefficient	0.59	−0.48
Significance (two-tailed)	<0.001**	<0.001**
ECOG PS		
Correlation coefficient	−0.34	0.023
Significance (two-tailed)	0.001**	0.03*

Abbreviations: IPAQ, International Physical Activity Questionnaire; MET, metabolic equivalent.
* Correlation is significant at 0.05 level.
** Correlation is significant at 0.01 level.

Manuscript writing and approval: JM Broderick, J Hussey, DM O' Donnell, MJ Kennedy.

Acknowledgements

We gratefully acknowledge all the patients who participated in this study as well as Dr. Kathleen Bennett for her statistical advice and Ms. Niamh Murphy and Ms. Emer Guinan for their support as well as the medical, nursing and administrative staff of the Medical Oncology Unit of St. James's Hospital, Dublin.

REFERENCES

1. Ando M, Ando Y, Hasegawa Y. Prognostic value of performance status assessed by patients themselves, nurses, oncologists in advanced non-small cell lung cancer. *Br J Cancer* 2001;**85**:1634–1639.
2. Oken MM, Creech RH, Tormey DC, Horton J, Davis T, Mc Fadden ET, et al. Toxicity and response criteria and the Eastern Cooperative Oncology Group. *Am J Clin Oncol* 1982;5:649–655.
3. Chen H, Cantor A, Meyer J. Can older patients tolerate chemotherapy? A prospective pilot study. *Cancer* 2003;**97**: 1107–1114.
4. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, Mc Dowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc* 2008;**40**:181–188.
5. Extermann M, Overcash J, Lyman GH, Parr J, Balducci L. Comorbidity and functional status are independent in older cancer patients. *J Clin Oncol* 1988;**16**:1582–1587.
6. Repetto L, Fratino L, Audisio RA. Comprehensive geriatric assessment adds information to Eastern Cooperative Oncology Group performance status in elderly cancer patients: an Italian Group for Geriatric Oncology Study. *J Clin Oncol* 2002;**20**:494–502.
7. Balducci L, Colloca G, Cesari M, Gambassi G. Assessment and treatment of elderly patients with cancer. *Surg Oncol* 2010;**19**: 117–123.
8. Deans DAC, Wigmore SJ, de Beaux AC, Paterson-Brown S, Garden OJ, Fearon KCH. Clinical prognostic scoring system to aid decision-making in gastro-oesophageal cancer. *Br J Surg* 2007;**95**:1501–1508.
9. Albain KS, Crowley JJ, LeBlanc M, Livingston RB. Survival determinants in extensive-stage non-small cell lung cancer: the south west Oncology Group experience. *J Clin Oncol* 1991;**9**: 1618–1626.
10. Motzer RJ, Mazumdar K, Bacik J, Amsterdam A, Ferrara J. Survival and prognostic stratification of 670 patients with advanced renal cell carcinoma. *J Clin Oncol* 1999;**17**: 2530–2540.
11. Sengelov L, Kamby C, Geertsen P, Anderson L, von der Maase H. Predictive factors of response to cisplatin-based chemotherapy and the relation of response to survival in patients with metastatic urothelial cancer. *Cancer Chemother Pharmacol* 2000;**46**:357–364.
12. Jordhoy MS, Fayers P, Loge JH, Saltnes T, Ahlner-Elmqvist M, Kassa S. Quality-of-life in advanced cancer patients: the impact of sociodemographic and medical characteristics. *Br J Cancer* 2001;**85**:1478–1485.
13. Schaafsma J, Osoba D. The Karnofsky performance status scale re-examined: a cross validation with the EORTC-C30. *Qual Life Res* 1994;3(6):413–424.
14. Brown D, Mc Milan D, Milroy R. The correlation between fatigue, physical function, the systemic inflammatory response, and psychological distress in patients with advanced cancer. *Cancer* 2004;**103**:377–382.
15. Scott HR, Mc Millan DC, Forrest LM, Brown DJ, Mc Ardle CS, Milroy R. The systemic inflammatory response, weight loss, performance status and survival in patients with inoperable non-small cell lung cancer. *Br J Cancer* 2002;**87**:264–267.
16. Akechi T, Okuyama T, Sugawara Y. Major depression, adjustment disorders, and post-traumatic stress disorder in terminally ill cancer patients: associated and predictive factors. *J Clin Oncol* 2004;**22**:1957–1965.
17. LLoyd-Williams M, Dennis M, Taylor F. A prospective study to determine the association between physical symptoms and depression in patients with advanced cancer. *Palliat Med* 2004;**18**:558–563.
18. Dimeo F, Schmittel A, Fietz T. Physical performance, depression, immune status and fatigue in patients with hematological malignancies. *Ann Oncol* 2004;**15**:1237–1242.
19. Blagden SP, Charman SC, Sharples LD, Magee LR, Gilligan D. Performance status score: do patients and their oncologists agree? *Br J Cancer* 2003;**89**(6):1022–1027.
20. Loprinzi CL, Laurie JA, Wieand HS, Krook JE, Novoyny PJ, Kugler JW, et al. Prospective evaluation of prognostic variables from patient-completed questionnaires. North Cancer Treatment Group. *J Clin Oncol* 1994;**12**:601–607.
21. Lilenbaum RC, Cashy J, Hensing TA, Young S, Cella D. Prevalence of poor performance status in lung cancer patients. *J Thorac Oncol* 2008;3(2):125–129.
22. Buccheri G, Ferrigno D, Tamburini M. Karnofsky and ECOG performance status scoring in lung cancer: a prospective, longitudinal study of 536 patients from a single institution. *Eur J Cancer* 1996;7:1135–1141.

23. Extermann M, Boler I, Reich RR, Lyman GH, Brown RH, DeFelice J, et al. Predicting the risk of chemotherapy toxicity in older patients: the Chemotherapy Risk Assessment Scale for High-Age Patients (CRASH) score. *Cancer* 2012;**118**(13):3377–3386.
24. Sallis JF, Saelens BE. Assessment of physical activity by self-report: status, limitations, and future directions. *Res Q Exerc Sport* 2000;**71**(2 Suppl):S1–S14.
25. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003;**35**: 1381–1395.
26. Rowlands AV, Thomas PWM, Eston RG, Topping R. Validation of the RT3 triaxial accelerometer for the assessment of physical activity. *Med Sci Sports Exerc* 2004;**36**(3):518–524.
27. Pitta F, Troosters T, Spruit MA, Probst VS, Gosselink R. Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2005;**171**:972–977.
28. Charlson ME, Pompei P, Ales K. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;**40**:373–383.
29. Sumukadas D, Laidlaw S, Witham MD. Using the RT3 accelerometer to measure everyday activity in functionally impaired older people. *Aging Clin Exp Res* 2008;**20**(1):15–18.
30. Hale L, Pal J, Becker I. Measuring free-living physical activity in adults with or without neurologic dysfunction with a triaxial accelerometer. *Arch Phys Med Rehabil* 2008;**89**: 1765–1771.