

SHORT COMMUNICATION

Within and between day repeatability of the incremental shuttle walking test in patients with thoracic cancer

Andrew Wilcock^{a,*}, Sim Koon^b, Cathann Manderson^b, Vicky Taylor^{b,c}, Matthew Maddocks^{b,c}

^a*Department of Clinical Oncology, Nottingham University Hospitals NHS Trust, Nottingham, NG5 1PB, UK*

^b*Department of Palliative Care, Nottingham University Hospitals NHS Trust, Nottingham, NG5 1PB, UK*

^c*Present address: John Eastwood Hospice, Sutton-in-Ashfield, Nottinghamshire, NG17 4HJ, UK*

^d*Present address: Cicely Sanders Institute, King's College Hospital, London, SE5 9PJ, UK*

*Corresponding author at:

Department of Clinical Oncology
Nottingham University Hospitals NHS Trust
Nottingham, NG5 1PB, UK.

Fax: (+44) (0)115 962 7779

E-mail: andrew.wilcock@nottingham.ac.uk

Word count: 1059

ABSTRACT

Background: Breathlessness is common in patients with thoracic cancer but difficult to manage. The Incremental Shuttle Walking Test (ISWT) can help assess new treatments, but its repeatability has not been described in this group.

Aim: To examine within and between day repeatability of the ISWT in this setting.

Methods: Patients with incurable thoracic cancer were recruited from outpatient clinics at a University Hospital. Two ISWTs were completed one hour apart on two consecutive days, with the first test for familiarisation purposes only. Repeatability of distance walked was examined using Bland and Altman plots and assessed as the single determination (within subject) standard deviation of the difference between tests and its 95% range.

Results: Forty-one patients participated and completed all tests. Mean (SD) distance walked was 333 (134), 349 (129) and 353 (130) m over the three tests, with the mean difference significantly different from zero between days (16 m, 95% CI 8 to 24 m, $P=0.043$) but not within days (5 m, 95% CI -2 to 12 m, $P=0.47$). Within and between day single determination SD and 95% ranges were 30 (-31 to 91) m and 36 (-37 to 109) m respectively.

Conclusions: These data help inform the design of studies making use of the ISWT and the interpretation of their findings.

Key words: exercise; incremental shuttle walking test; lung cancer; mesothelioma; non-small cell lung cancer; small cell lung cancer.

1. Introduction

Breathlessness on exertion is common in patients with incurable thoracic cancer, reducing exercise capacity and impacting negatively on levels of physical activity, independence and quality of life [1]. It remains difficult to manage, and the assessment of new treatments and approaches will be aided by reliable, objective measures of exercise capacity. The Incremental shuttle walking test (ISWT) is a field-based exercise test that is used to assess functional exercise capacity in a variety of settings [2, 3]. Although criterion and construct validity of the ISWT have been examined in patients with thoracic cancer, data on repeatability are lacking [4]; these would help inform clinical assessment protocols, intervention effect interpretation and study sample size requirements. We determined the within and between day repeatability of the distance walked in the ISWT, as part of a study examining factors limiting exercise capacity in this group [5].

2. Participants and methods

Patients with incurable thoracic cancer and an Eastern Cooperative Oncology Group (ECOG) performance status of 0–2 reporting a reduction in their ability to undertake usual daily activities were recruited from outpatient clinics at Nottingham University Hospitals NHS Trust. Patients were excluded if they had received chemotherapy or radiotherapy within the last 4 weeks, or when their symptoms were amenable to a palliative intervention, e.g. drainage of a pleural effusion. Patients with chronic obstructive pulmonary disease (COPD) were included if this was not considered responsible for their decline in exercise capacity. All provided written informed consent and the study was approved by the Hospital Ethics Committee (EC99/45).

The ISWT was undertaken twice on two consecutive days at the same time of day. This involved walking up and down a 10 m course marked by two cones at a speed dictated by pre-recorded bleeps on a tape cassette, which increased every minute until a symptom-limited maximum was reached (with breathlessness and leg fatigue rated using the modified Borg scale), and the total distance walked noted [2]. Patients received written instructions to avoid caffeinated drinks within one hour, large meals within two hours and excess alcohol the night before the test. They were advised to take their usual medication, wear comfortable shoes and to walk but not run. For each test, the patient wore a facemask, secured by a net cap, connected to a portable, lightweight, telemetric COSMED K4 b² system (COSMED, Rome, Italy), fastened in a harness [6]. This permitted ventilation, oxygen uptake and heart rate to be measured [5]. On the first day, an initial ISWT was undertaken for familiarisation purposes as recommended by the developers [2]; this was followed, after 1h of rest, by Test 1. On the second day, Tests 2 and 3 were undertaken with a 1h rest period between.

Within (Test 2 vs Test 3) and between day (Test 1 vs. Test 2) repeatability of distance walked was examined using Bland and Altman plots and assessed as the single determination (within subject) standard deviation of the difference between tests and its 95% range, corrected for a sample size <100, as described by Chinn [7]. The latter were also assessed for the difference between the familiarization test and Test 1 to determine its contribution.

3. Results and discussion

Forty-one eligible patients (21 male) were recruited and completed the study, with a mean (SD) age of 64 (8) years and a median (range) ECOG performance status of 1 (0–2). Twenty six had non-small cell lung cancer, 11 mesothelioma and four small cell lung cancer. For full details see online supplementary table. All have since died with a median [IQR] survival of 39 [24–61] weeks. Symptoms limiting exercise were breathlessness alone (n=28), breathlessness and leg fatigue equally (n=9), leg fatigue alone (n=3) and general fatigue (n=1). Based on the best distance walked, patients achieved a median [IQR] of 51 [41–66] % of the age-related mean distance walked by healthy volunteers [8].

Figure. 1 shows Bland and Altman plots, and Table 1 repeatability outcomes of interest. The mean difference between tests was significantly different from zero between days (16 m, 95% CI 8 to 24 m, P=0.043) but not within days (5 m, 95% CI –2 to 12 m, P=0.47). The mean difference between the familiarization test and Test 1 was not significant (14 m, 95% CI -4 to 32 m, P=0.14).

To our knowledge, this is the first formal exploration of the repeatability of the ISWT in patients with incurable thoracic cancer, with data presented as recommended by Chinn [7]. Comparison with findings in other patient groups is limited because of differing methodology, e.g. repeatability described as an intraclass correlation coefficient, lack of the recommend familiarization test [2], and none used the COSMED K4 b² [3]. Nonetheless, more favourable between day data than ours has been reported in patients with COPD, with a mean (95% CI) difference of –2 m (–22 to 18 m) between tests [2]. Wearing a

mask may be a relevant factor, although only two patients reported feeling impeded by this.

Repeatability was poorer between day as compared to within day. Although not unexpected, because of the order in which the tests were done, a learning effect may have contributed to this difference; others have also reported first and second tests to differ significantly in patients with COPD, despite the use of a familiarization test [3]. Although the familiarization test was not significantly different from Test 1, its inclusion appears to improve subsequent repeatability.

Strengths include a relatively large, well described group, representative of those most likely suitable for drug and non-drug treatments for breathlessness, including exercise. Our use of the COSMED K4 b² permits additional data of relevance to be collected in future studies. A weakness is that between day testing was limited to consecutive days only.

4. Conclusions

We have described within and between day repeatability for the ISWT in patients with thoracic cancer. These data can help inform the design of studies making use of the ISWT and the interpretation of their findings. For example, although the minimum important difference of the ISWT has not been determined in thoracic cancer, applying our between day repeatability data to standard sample size calculations, suggests that to reliably detect the minimum important difference of 48 m reported in COPD [3], a within or between group comparison requires a sample size of 12 participants or 16 participants per group respectively (power 80%, P=0.05).

Declarations

Conflicts of interest

None.

Funding

This research was supported by funding from the University of Nottingham and League of Friends at Nottingham University Hospitals NHS Trust.

Acknowledgements

We would like to thank the patients who took part, Jacky Frisby and other colleagues who assisted with the original study, and Dr Tricia McKeever for statistical advice.

References

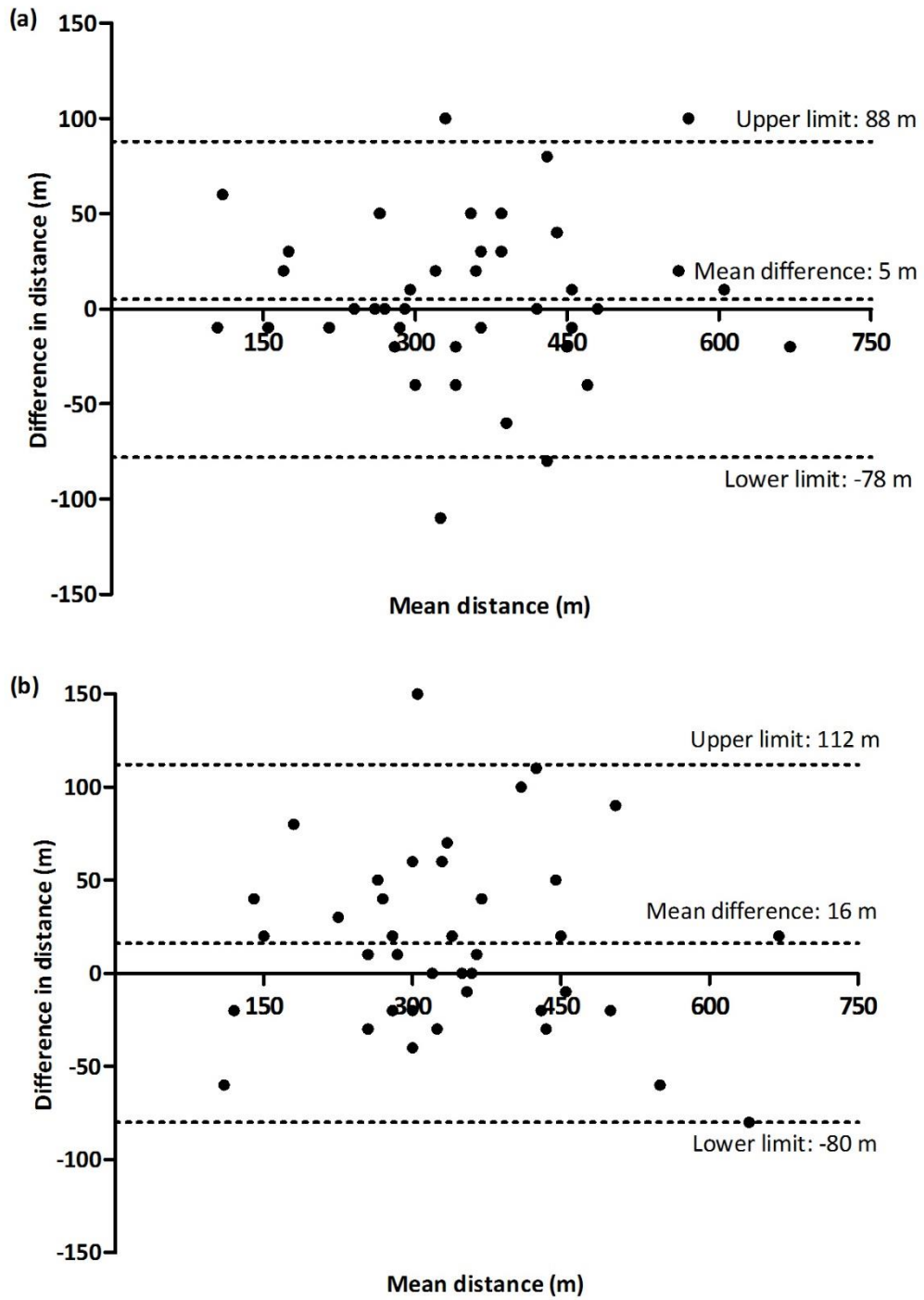
- [1] Weingaertner V, Oek G, Scheve C, Gerdes V, Schwarz-Eywill M, Prenzel R *et al.* Breathlessness, functional status, distress, and palliative care needs over time in patients with advanced chronic obstructive pulmonary disease or lung cancer: a cohort study. *Journal of pain and Symptom Management.* 2014;48:569–81.
- [2] Singh S, Morgan MD, Scott S, Walters D, Hardman AE. Development of a shuttle walking test of disability in patients with chronic airways obstruction. *Thorax* 1992;47:1019–24.
- [3] Parreira VF, Janaudis-Ferreira T, Evans RA, Mathur S, Goldstein RS, Brooks D. Measurement properties of the incremental shuttle walk test. *Chest* 2014;145:1357–69.

- [4] Granger CL, Denehy L, Parry SM, Martin J, Dimitriadis, T, Sorohan M *et al.* Which field walking test should be used to assess functional exercise capacity in lung cancer? An observational study. *BMC Pulmonary Medicine* 2015;15:89.
- [5] England R, Maddocks M, Manderson C, Wilcock A. Factors influencing exercise performance in thoracic cancer. *Respir Med* 2012;106:294–9.
- [6] McLaughlin JE, King GA, Bassett DR, Ainsworth BE. Validation of the COSMED K4b2 portable metabolic system. *Int J Sports Med* 2001;22:280–4.
- [7] Chinn S. Repeatability and method comparison. *Thorax* 1991;46:454–56.
- [8] Harrison SL, Greening NJ, Houchen-Wolloff L, Bankart J, Morgan MD, Steiner MC *et al.* Age-specific normal values for the incremental shuttle walking test in a healthy British population. *J Cardiopulm Rehabil Prev* 2013;33:309–13.

Table 1 Repeatability of the incremental shuttle walking test

<i>Outcome</i>	<i>Day 1</i>		<i>Day 2</i>	
	<i>Familiarization</i>	<i>Test 1</i>	<i>Test 2</i>	<i>Test 3</i>
<i>Distance walked (metres)</i>				
Mean (SD)	320 (128)	333 (134)	349 (129)	353 (130)
Range	70–630	130–680	80–680	100–620
<i>Borg score (median, IQR) at discontinuation</i>				
Breathlessness	3, 2–4	3, 2–4	3, 2–4	3, 2–4
Leg fatigue	0.5, 0–2	0, 0–2	0, 0–2	0, 0–3
<i>Within day difference in distance walked</i>				
Mean (SD) difference	14 (58)		5 (43)	
95% CI for mean difference	–5 to 22		–2 to 12	
Single determination (within subject) SD	42		30	
Single determination 95% range	–43 to 127		–31 to 91	
<i>Between day difference in distance walked</i>				
Mean (SD) difference		16 (49)		
95% CI for mean difference		8 to 24		
Single determination (within subject) SD		36		
Single determination 95% range		–37 to 109		

Figure 1. Bland and Altman plots of mean distance and difference in distance walked between incremental shuttle walk tests repeated (a) within and (b) between days. Mean difference and 95% limits shown.



Online supplementary table. Patient details. Mean (SD) or number of group unless specified otherwise.

Age, years	64 (8)
Gender, male:female	21:20
<i>Diagnosis</i>	
non-small cell/mesothelioma/small cell	26/11/4
<i>ECOG performance status</i>	
0/1/2	16/21/4
<i>Disease extent</i>	
local/advanced	21/20
<i>Metastases</i>	
lymph nodes/lung/bone/liver/adrenal	12/6/4/2/1
<i>Previous treatments</i>	
palliative chemotherapy	26
palliative radiotherapy	10
radical radiotherapy	1
<i>Cigarette smoking status</i>	
ex smoker/current/never	27/7/7
<i>Relevant co-morbidities</i>	
COPD	5
osteoarthritis	3
hypertension	4
diabetes	4
recent pulmonary embolism	1
<i>Current medication</i>	
inhaled corticosteroid	5
inhaled bronchodilator	2
oral corticosteroid	2
diuretic	2
low molecular weight heparin	1
<i>Anthropometry</i>	
height, cm	169 (10)
weight, kg	73 (14)
body mass index, kg.m ²	25.4 (3.8)
<i>Inspiratory muscle strength</i>	
actual, cmH ₂ O	58 (32)
% predicted	63 (32)
<i>Leg extensor power</i>	
watts	90 (43)
watts / kg	1.23 (0.52)
<i>Spirometry</i>	
FEV ₁ , L	1.62 (0.59)
FEV ₁ % predicted	60 (19)
FVC, L	2.15 (0.73)
FVC % predicted	64 (18)
FEV ₁ :FVC%	75 (11)
<70%	25
≥70%	16