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Reproducibility of walking test results in chronic obstructive airways disease

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ABSTRACT Thirty six patients with chronic airflow obstruction were studied to examine (1) the reproducibility and order effect of repeated walking tests when performed over consecutive days or consecutive weeks; (2) the correlation between walking distance and spirometric measurements; and (3) the effect of static visual clues on performance. In study 1, where 12 patients performed 12 walks over three consecutive days, five minute walking distance increased by 33% between walks 1 and 12, half of the increase occurring after the first three walks. In study 2, where 24 patients performed 12 walks over four consecutive weeks, five minute walking distance increased by 8·5% between walks 1 and 12. A learning effect was seen over the first nine walks. Static visual clues to performance did not affect the distance walked. Spirometric measurements showed no order effect in either study. Although walking distance correlated significantly with FEV_1, forced vital capacity, and peak expiratory flow, these measurements were poor predictors of exercise performance. The learning effects seen on repeated performance of walking tests over short intervals should be considered when an individual's response to treatment is being interpreted. When walking tests are used in clinical trials a placebo group or randomised crossover design is essential.

Since its introduction in 1976 by McGavin *et al* [1] the corridor walking test has been used increasingly to evaluate different forms of treatment in respiratory medicine,[2–12] and more recently in cardiology.[13] Various factors are known to affect performance, including encouragement, the timing of the test in relation to meals, and subjective attitudes and beliefs.[14–17] Early workers noted a learning effect with repeated testing and suggested that this was confined to the first two or three walks.[1 18] There has, however, been a suggestion from a recent study by Swinburn *et al* [19] that the learning effect may be more prolonged, these authors suggesting that a 3% improvement with each subsequent walk should be expected. We set out to examine the learning effect more closely by looking at the reproducibility of the results of 12 walking tests performed over either three consecutive days or four consecutive weeks. We also assessed whether the reproducibility of walking distances is affected by visual clues—that is, whether patients tend to walk up to or beyond a fixed point if walks are repeated along the same track. For this purpose we compared walking distances achieved from fixed or randomly varied starting points on the hospital corridor. We used five minutes as the walk time as Butland *et al* [20] have shown that equally useful information can be obtained from walks ranging from two to 12 minutes.

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Methods

SUBJECTS

We studied 36 patients meeting the Medical Research Council criteria for chronic bronchitis, all with evidence of airflow obstruction (forced expiratory volume in one second (FEV_1) < 70% predicted). They were being treated with either inhaled β agonists or inhaled anticholinergic drugs, and one was taking oral theophylline. Their mean age was 63 (range 50–75) years, 22 were male, none was atopic, and all were clinically stable. Mean (SD) FEV_1 was 0·75 (0·34) l and forced vital capacity (FVC) 1·9 (0·40) l.

DESIGN OF THE STUDY

Walks were performed on a continuous rectangular hospital corridor according to the method described by McGavin *et al*.[1] Encouragement was standardised, one of three encouraging phrases being used every 30

seconds as recommended by Guyatt *et al.*[14] Before each walk spirometric measurements were made with a bellows spirometer (Vitalograph) and peak expiratory flow (PEF) with a Wright mini peak flow meter (best of three attempts). After each walk breathlessness was assessed on a 10 cm visual analogue scale with "not breathless at all" at one end of the scale and "as breathless as you could ever imagine" at the other end.[21] Bronchodilators were withheld for 12 hours before the first walk of each study day.

Study 1: Reproducibility over three consecutive days and the effect of visual clues
Twelve patients performed four walking tests of five minutes each on three consecutive days, a total of 12 walks for each subject. Walks consisted of fixed starting point walks, where subjects walked from the same starting point on the circuit, and random point walks, where the starting point was randomised for each walk. Randomising the starting point minimised the effect of static visual clues on performance. On day 1 two fixed point walks were performed followed by one fixed point and one random point walk in random order. On days 2 and 3 two fixed point and two random point walks were performed in random order.

Study 2: Reproducibility over four consecutive weeks
Twenty four subjects performed three five minute walks a day on four separate days at intervals of one week, again a total of 12 walks for each subject.

STATISTICAL ANALYSIS
For study 1 the effect of day, walk number and walk type (fixed versus random point) on five minute walking distance, spirometric results, and visual analogue scale score were assessed by an analysis of variance of repeated measures (BMDP 2V).[22] In study 2 the effects of day and walk number on each variable were assessed by linear regression analysis (GLIM).[23] Pearson correlation coefficients were calculated for the relationship between five minute walk distance, spirometric measurements and visual analogue scale score on the basis of mean data from walks 4, 5, and 6 for all 36 patients.

Results

STUDY 1
Visual clues
The two fixed point and two random point walks on days 2 and 3 were compared for each patient. The mean (SEM) distance walked for all 12 patients was 249 (30·9) m for the fixed point and 247 (30·6) m for the random point walk. Walk type did not affect distance walked ($p = 0·74$). In view of this result all walks were considered together in subsequent analyses.

Reproducibility over three consecutive days
Mean (SEM) distance walked increased both with day ($p < 0·001$) and with walk number ($p < 0·001$), from 192 (29·3) m for day 1 walk 1 to 254 (32·3) m for day 3 walk 12 (fig 1). The mean increase in distance walked over the 12 walks was 33%, individual changes ranging from zero to 270%. Although the greatest increase per walk was seen over the first three walks, there was a further 17% increase in mean distance walked after this time (table 1). Five of the 12 subjects had a 20% or greater improvement between walks 3 and 12.

Mean visual analogue scale scores diminished significantly with day ($p = 0·012$), from 67·9 mm on day 1 to 58·1 mm on day 3 (mean of four values on each day for 12 subjects). FEV_1, FVC, and PEF did not vary significantly either with day or with walk number (table 2).

Study 2: Reproducibility over four consecutive weeks
Mean (SEM) distance walked increased significantly with walk number ($p < 0·05$) and with day ($p < 0·05$), from 248 (14·2) m for day 1 walk 1 to 269 (14·3) m for day 4 walk 12 (fig 2). Most of this 8·5% increase occurred between walks 3 and 12 (table 1); seven of the 24 subjects improved by 20% or more between walks 3

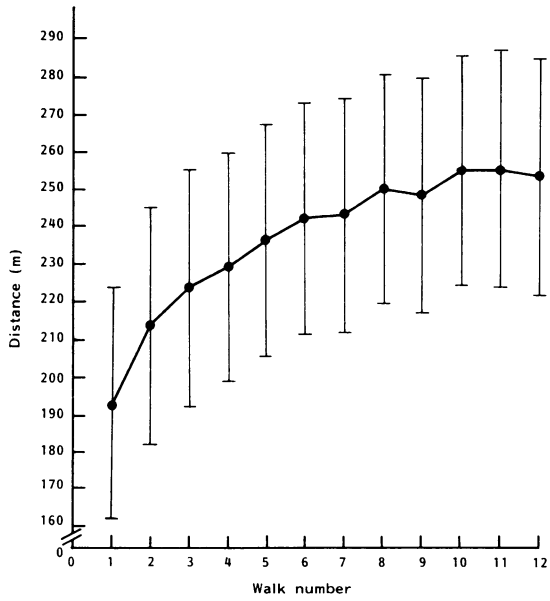

Fig 1 *Mean (SEM) distance walked by 12 subjects performing 12 walks over three days in study 1.*

Table 1 *Cumulative percentage improvement in distance walked after 2, 3, and 12 walks over three days (study 1)*

	% Improvement after:		
	Walk 2	*Walk 3*	*Walk 12*
Study 1	11·4	16·1	33·0
Study 2	−1·3	−2·9	8·5

and 12. Individual change over the 12 walks ranged from −21% to +81%.

Spirometric values and visual analogue scale scores did not vary with either day or walk number.

Correlations between five minute walk and other assessments

Five minute walk distance correlated with all spirometric assessments, the strongest correlation being with FEV_1 ($r = 0{\cdot}46$, $p = 0{\cdot}005$). Correlation coefficients between walk distance and FVC and PEF were 0·45 and 0·44. There was no correlation between five minute distance and visual analogue scale scores.

Discussion

In this study we attempted to eliminate the role played by visual clues by comparing walks from random and fixed starting points on the circuit. Although visual clues might not be eliminated completely, their effect should be minimised. The lack of difference between the results from the two types of walk suggests that these patients are not using visual clues to monitor their performance to any appreciable extent.

Table 2 *Effect of day and walk number on different variables in study 1*

Variable	*Day effect (p)*	*Walk number effect (p)*	*Interaction effect (p)*
VAS score	0·012	0·88, NS	0·019
PEF	0·72, NS	0·26, NS	0·75, NS
FEV_1	0·51, NS	0·40, NS	0·40, NS
FVC	0·51, NS	0·84, NS	0·40, NS
Distance	<0·001	<0·001	<0·001

VAS, visual analogue scale; PEF, peak expiratory flow; FVC, forced vital capacity.

Previous studies have acknowledged the existence of a learning effect on repeated testing both with walking tests and with other exercise tests,[1 18–20] but none has investigated it fully. Our data suggest that the learning effect is more pronounced when repeated walks are carried out over short intervals (33% improvement in study 1), and that it continues for at least nine walks. Although this increase is greater than the increases found by McGavin *et al*[1] and Butland *et al*,[20] the increase after the third walk was less than the 3% per walk predicted by Swinburn *et al*.[19] When repeated walks were carried out over consecutive weeks in study 2 the learning effect was less pronounced (8·5% overall), most of the increase occurring after the third walk. Another feature of both study 1 and study 2 was that the largest increase on any day occurred between the first two walks (figs 1 and 2).

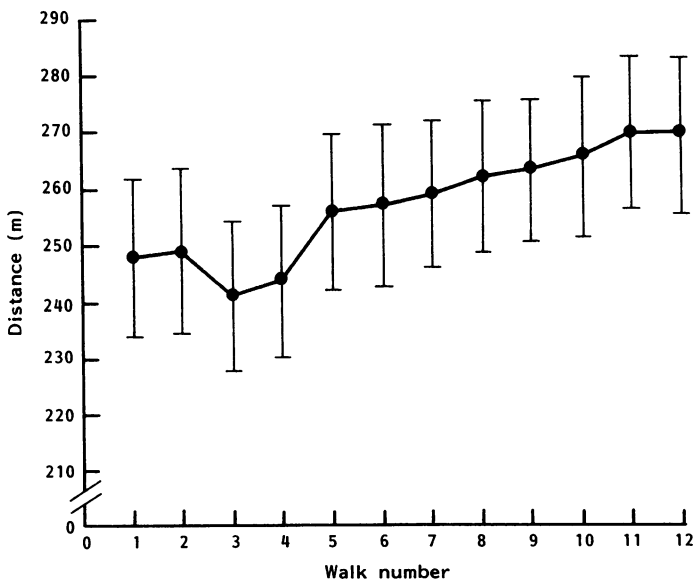

Fig 2 *Mean (SEM) distance walked by 24 subjects performing 12 walks over four weeks in study 2.*

There was a significant increase in distance walked after the third walk in our study. This was not seen in some previous studies and may be due to the larger number of walks, which increased the chance of detecting a significant difference. In addition, earlier workers used the coefficient of variation as an index of reproducibility,[4 18] a measurement which, unlike analysis of variance, cannot detect improvement on repeated testing.[24]

The reason for these learning effects is not fully understood but, as other authors have shown, attitudes and beliefs are strong predictors of exercise performance.[16 17] The improvement seen on repeated testing may represent alterations in the patient's motivation, at least in the short term. In the longer term exercise training may be contributing. Some studies on the effects of various treatments on walking distance have shown a placebo effect[4 7 12] and others have not.[5 6] The studies in which fewer tests were performed at longer intervals[5 6] have tended to show less placebo effect. This supports the findings of our study, where the learning effect was greater when several tests were performed over a short interval.

None of the spirometric indices we measured showed a learning effect. The visual analogue scale score showed significant improvement over three days but not over four weeks.

We found significant but fairly weak correlations between walking distance and spirometric values, the strongest correlation ($r = 0{\cdot}46$) being with FEV_1. Other authors have shown either no correlation[4 18] or a weak correlation, which in the study of McGavin *et al* was greater for FVC.[1] Thus spirometric indices alone appear to be poor predictors of exercise capacity in these patients. We found no correlation between visual analogue scale scores and distance walked, which suggests either that the subjective appreciation of breathlessness differs considerably between subjects for a given disability or that subjects use the visual analogue scale in different ways.

In conclusion, our data suggest that the learning effect with walking tests is not confined to the first three walks and is more pronounced when repeated tests are performed over short intervals. Walking tests are a useful guide to exercise disability, but it is important that learning effects are considered when walking tests are used to assess the response of an individual to treatment in the everyday clinical setting. When walking tests are to be performed over consecutive days, our data suggest that patients should have at least five practice walks to familiarise them with the test. This would take them close to the plateau seen in figure 1. When repeated tests are to be performed over consecutive weeks then four practice attempts would probably suffice as the magnitude of the learning effect is less. A further practice walk on each study day containing walking tests would also seem advisable before the study tests if within day comparisons are to be made. When walking tests are used in research studies, it is important to incorporate several practice walks and a placebo group or randomised crossover structure into the study design. Several studies in recent years have not fulfilled these criteria.[4 9 10 25]

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