Dyspnoea, disability, and distance walked: comparison of estimates of exercise performance in respiratory disease

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Summary and conclusions

Forty-four patients with airway obstruction and 18 with pulmonary infiltration were studied in an attempt to correlate exercise tolerance, as assessed by a simple walking test, with basic respiratory function values and differing subjective assessments of exercise performance. The distance walked in 12 minutes was significantly correlated with the response to a structured questionnaire and with the patients' assessment of performance using an oxygen-cost diagram. The distance walked did not agree well with simple subjective estimates obtained in the clinical history. It was better correlated with forced vital capacity than with forced expiratory volume in one second in both groups of patients, and was well correlated with carbon monoxide transfer factor in those with pulmonary infiltration. The scatter of results, however, was such that exercise performance could not usefully be predicted from the respiratory function values or from subjective assessments.

Simple exercise tests are an essential part of assessing disability and response to treatment in patients with respiratory impairment.

Introduction

Breathlessness on effort is common among patients with respiratory disability, and its severity is initially assessed from the clinical history—that is, subjectively. Traditional physical examination usually adds little information; and help is often sought from basic pulmonary function tests, such as measurement of forced expiration in patients with airway obstruction, on the assumption that exercise tolerance is closely linked to lung mechanics. Informal exercise tests, such as climbing stairs, are sometimes used and can give useful information on, for example, the development of cyanosis, tachycardia, claudication, angina, or an abnormal breathing pattern. Formal exercise testing is usually the province of the respiratory laboratory and is confined to well-equipped centres. The response to treatment with such drugs as bronchodilators is often judged from the patient's own assessment and by changes in pulmonary function values.

We have shown[1] that in patients with chronic airway obstruction improvement in forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) after inhaling salbutamol does not accurately reflect improvement in exercise performance, and that subjective estimates of the benefit of training may be confirmed by objective measurements made during exercise in the absence of changes in FEV_1 and FVC.[2] We report here an attempt to assess the value of subjective symptoms and results of pulmonary function tests as guides to exercise performance.

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Patients and methods

We studied 62 patients aged 22-75 years (mean age 56); 21 were women. Forty-four had airway obstruction—mean FEV_1 1·2±SD 0·58 l (range 0·28-2·55 l) at body temperature and pressure, saturated (BTPS); mean FVC 2·64±1·05 l—and 18 radiological evidence of pulmonary parenchymal infiltration without airway obstruction—mean FVC 3·26±0·87 l; mean carbon monoxide transfer factor (T_LCO) 5·12±2·14 ml/min/kPa (17·07±7·13 ml/min/mm Hg).

The patients were first asked to estimate how far they could walk before breathlessness stopped them and how far they thought they could walk in 12 minutes. They then answered simple questions adapted from those used by Fletcher *et al*[3] to grade the severity of their breathlessness (table). Next they were shown an oxygen-cost diagram (fig 1). This consisted of a list of everyday activities positioned alongside a 100-mm vertical scale proportionally to their oxygen cost.

Grades of breathlessness (adapted from definitions of Fletcher et al[3]*)*

Breathless at rest or on minimal effort	5
Able to walk about 100 yards (91 m) on the level	4
Able to walk for 1 mile (1·6 km) on the level at own pace but unable to keep up with people of similar age	3
Able to keep up with people of similar age on level but not on hills or stairs	2
Otherwise	1

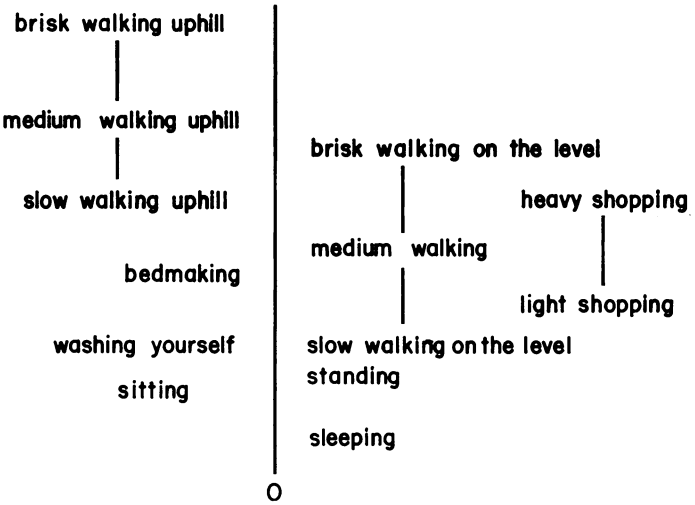

FIG 1—Oxygen-cost diagram. Vertical line is normally 100 mm long, and everyday activities listed are placed proportionately to their oxygen cost.[4] Patients were asked to indicate point above which they thought their breathlessness would not let them go.

Values for oxygen uptake during the activities were taken from those collected by Durnin and Passmore.[4] The patients marked the line at a point above which they thought their breathlessness would not allow them to go when at their best, and the result was expressed as the distance of the mark in millimetres above zero. After the walking test, patients were asked to assess the strain of the exercise using Borg's[5] rating of perceived exertion (RPE; fig 2). Guided by the printed

expressions of severity, the patients recorded the number that most accurately described the sense of effort during the test. The RPE scale has been used by others,[6 7] and the results correlate well with power output, oxygen intake, heart rate, expired ventilation, and blood lactate in normal people and patients with obstructive bronchitis.

Pulmonary function tests were performed before the exercise test. In all patients FEV_1 and FVC were measured with a water-filled spirometer,[8] the best of three technically satisfactory readings being used. T_LCO was measured by the single-breath technique[9] in the 18 patients with pulmonary infiltration. Exercise tolerance was measured by the distance in metres walked in 12 minutes (12MD). The patient was instructed to walk as far as he could in 12 minutes in a level hospital corridor, regardless of stops.[10] The test was performed twice with a rest of at least 20 minutes between attempts.

6	
7	VERY VERY LIGHT
8	
9	VERY LIGHT
10	
11	FAIRLY LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD
16	
17	VERY HARD
18	
19	VERY VERY HARD
20	

FIG 2—Scale of rating of perceived exertion (devised by Borg[5]).

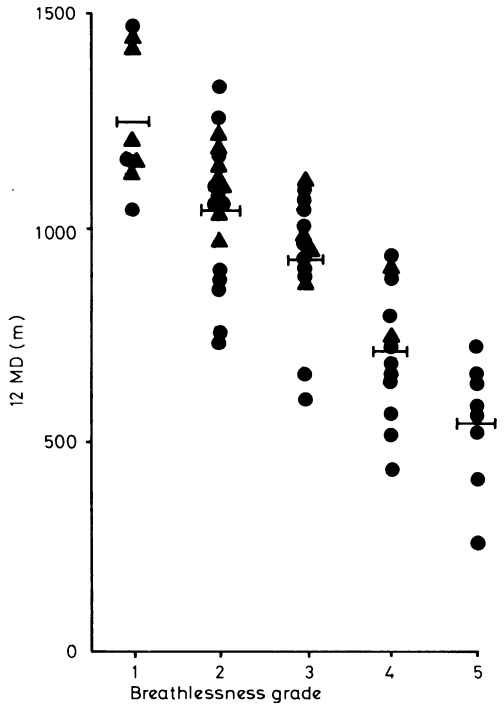

FIG 3—Relation between distance walked in twelve minutes (12MD) and grade of breathlessness.[3] ● = Patients with airway obstruction. ▲ = Patients with pulmonary infiltration. Bars represent means.

Results

WALKING TEST

The mean distance covered in 12 minutes by the 62 patients at the first attempt was 877±SD 272 m; at the second attempt the mean distance was 915±262 m. The correlation between the two attempts in individual patients was high ($r=0{\cdot}97$; $P<0{\cdot}001$) but the distance walked on the second occasion was significantly greater (paired t test: $t=4{\cdot}41$; $P<0{\cdot}001$). Thus the distance walked at the second attempt was used for the remainder of the analysis. Fifteen patients rested at least once during their second attempt. In these patients the distance to the first stop correlated well with the total distance covered in 12 minutes ($r=0{\cdot}73$; $P<0{\cdot}001$), but the total distance covered by those who stopped was often greater than that covered by other patients who walked more slowly and did not need to stop.

CORRELATIONS OF 12MD

In the group as a whole we found no significant correlation between the distance actually covered in 12 minutes and the patients' own estimates of how far they could walk either before breathlessness stopped them or in 12 minutes. A better relation was found between the distance walked and the grading of breathlessness[3] (fig 3), though in each grade there was wide variation in the distance. No significant difference in 12 MD was found in any grade between patients with airway obstruction and those with pulmonary infiltration. The distance walked also correlated well with the point marked on the oxygen-cost diagram ($r=0{\cdot}68$; $P<0{\cdot}001$) and with the RPE ($r=-0{\cdot}59$; $P<0{\cdot}001$), the negative correlation indicating that those who walked least far found the test most arduous.

Fig 4 shows the correlation between the distance covered in 12 minutes and other estimates of respiratory disability. In the 44 patients with airway obstruction a significant correlation was found between 12MD and both FEV_1 and FVC. The individual results (fig 5), however, illustrate the wide scatter of exercise performance observed at any given FEV_1 or FVC. Multiple regression analysis was performed to assess the separate effects of age and body weight as predictors, with FEV_1 or FVC, of the distance walked in 12 minutes. Age proved to be of no significance in either analysis; the change in 12MD

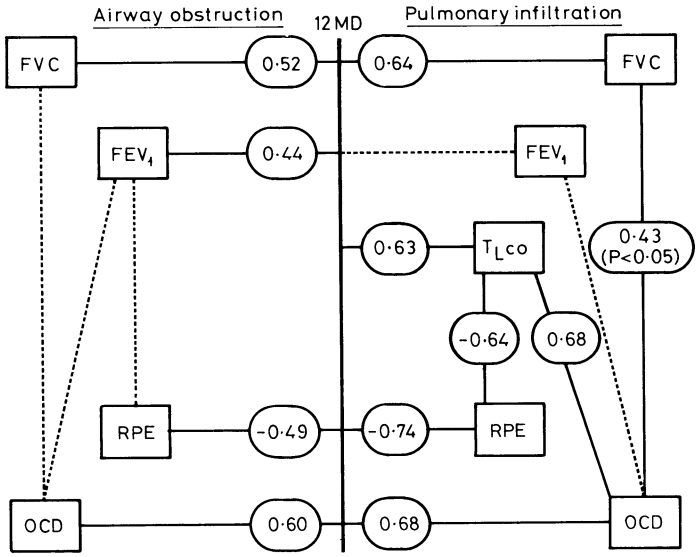

FIG 4—Correlation between distance walked in 12 minutes (12MD) and other estimates of respiratory disability in 44 patients with airway obstruction and 18 with pulmonary infiltration. RPE = Rating of perceived exertion[5] (fig 2). OCD = Distance marked on oxygen-cost diagram (fig 1). Correlation coefficients significant at $P<0{\cdot}01$ except where shown. Dashed lines indicate no significant correlation.

attributable to weight was slight and allowing for it did not usefully improve prediction of 12MD from FEV_1 or FVC. The distance walked was also well correlated with the rating of perceived exertion and the point marked on the oxygen-cost diagram, but we found no significant correlation between either FEV_1 or FVC and these subjective assessments.

In the 18 patients with pulmonary infiltration we found highly significant correlations between the distance covered in 12 minutes and T_LCO, rating of perceived exertion, and the point on the oxygen-cost diagram (fig 4). FVC was significantly correlated with 12MD and, at a lower level of probability, the oxygen-cost diagram (fig 4);

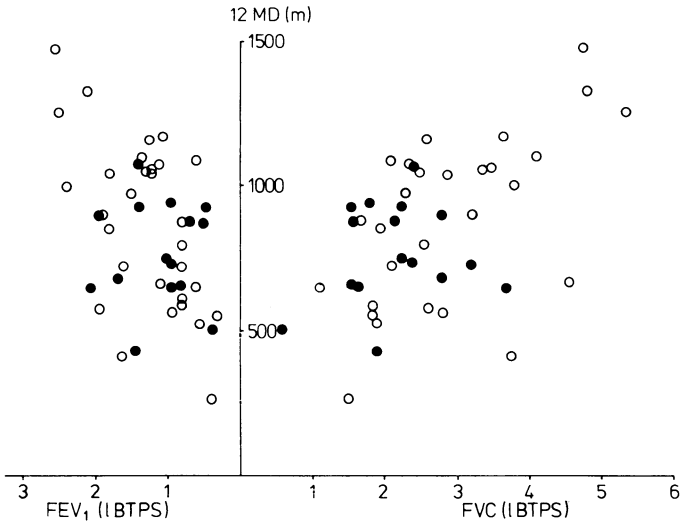

FIG 5—Relation between distance walked in 12 minutes (12MD) and FEV_1 and FVC in 44 patients with airway obstruction. ○ = Men. ● = Women. Standard deviation from regression for relation between FEV_1 and 12MD ± 238 m, and between FVC and 12MD ± 227 m.

but FEV_1 was not significantly correlated with either. T_LCO was also significantly correlated with the rating of perceived exertion and the point on the oxygen-cost diagram in these patients.

Throughout the analysis we found that when FEV_1, FVC, and T_LCO were expressed as percentages of the predicted normal values for individual patients[9] the correlation coefficients between them and the other quantities were invariably less than when the actual values were used.

Discussion

In this study we used the distance walked in 12 minutes as an estimate of exercise performance in place of the results of tests carried out in the laboratory on the step, bicycle ergometer, or treadmill.[11] All formal exercise tests are unnatural in requiring the subject to exercise in a way different from his everyday activities. The walking test has the advantages that it is based on a universally familiar activity (in contrast to the bicycle ergometer) and that the subject can adjust his pace during the test (in contrast to tests on the treadmill and step). The test may be criticised as being more dependent on effort and motivation than, for example, the FEV_1; but our results show that it is highly reproducible, and others[12] have also found it of value.

If the distance covered in 12 minutes is accepted as a reasonable measure of exercise performance the more structured subjective assessments should be better guides to exercise performance than are simple, traditional clinical questions, and, of the standard spirometric measurements, FVC is a better guide than FEV_1 both in patients with airway obstruction and in those with pulmonary infiltration. The scatter of results made exercise performance difficult to predict accurately from either the subjective assessments or the simple respiratory function tests, despite the significant correlation. Similar conclusions were reached by Gilbert *et al*,[11] who used the treadmill, although in their studies the better correlation of exercise tolerance was with FEV_1. The scatter of results was also reflected in the lack of correlation between spirometric measurements and subjective assessment of symptoms in the patients with airway obstruction.

The value of history taking when assessing respiratory disability could therefore be greatly strengthened if the patient answered standard questions on dyspnoea and recorded his score on the oxygen-cost diagram. If further information is sought from respiratory function tests we believe that more attention should be given to FVC as a predictor of exercise performance than to FEV_1. Exercise tolerance can be measured simply and safely with a corridor and a clock; thus there are good reasons for advocating the use of this type of test as an addition to the clinical history and spirometric measurements when assessing disability and response to treatment in patients with respiratory impairment.

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ONE HUNDRED YEARS AGO A rare and curious case is related by Dr Studsgaard of the Communal Hospital in Copenhagen, in a recent number of the *Hospitals-Tidende*. A man, aged 35, introduced into the rectum, with the open end uppermost, a preserve-bottle nearly seven inches long, for the purpose of stopping a diarrhœa. The next morning, he complained of pain in the abdomen; chloroform was given, and the bottle, which could before this be felt in the rectum, passed higher up, and he was brought to the hospital (January 10th). The bottle could be felt through the abdominal wall, lying in the middle line, with the bottom close to the horizontal ramus of the pubic bone. In the afternoon he was deeply narcotised, and posterior linear rectotomy was performed, and an attempt was made to reach the bottle, but without success. Abdominal section was therefore performed, under antiseptic precautions, in the linea alba. An incision having been carried four inches downwards from the umbilicus, a loop of intestine, apparently a portion of the sigmoid flexure, was protruded with the neck of the bottle. The bowel was then divided over the mouth of the bottle and a little way down the neck, and removal was effected slowly. The neighbouring parts were protected by sponges and compresses from the escape of fæces; and, after the bowel had been cleaned, twelve or fourteen catgut sutures were applied to it, each being, for safety, tied with three knots. The bowel having been replaced, the wound in the abdominal wall was united by eight silk sutures. The operation lasted an hour. Recovery was slow, and the prognosis was for a time doubtful in consequence of local peritonitis and the formation of abscesses, which opened partly through the incision in the abdominal wall and partly through the rectum; the patient was, however, discharged quite cured on April 16th—less than fourteen weeks after the operation. The bottle was 17 *centimètres* (6.8 inches) long, 5 *centimètres* (2 inches) in diameter at the lower end, and 3 *centimètres* (1.2 inches) at the upper end. In commenting on this case, Dr Studsgaard refers to three others of a similar character; one related by Ogle, in which recovery followed spontaneous discharge of the foreign body (a stick); one by Closmadeuc, where the patient died of peritonitis, without operation; and one in which laparo-enterotomy was successfully performed in 1849 by Reali of Orvieto. (*British Medical Journal*, 1878.)