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Relationship between lung function and Modified Shuttle Test performance in adult patients with cystic fibrosis: a cross-sectional, retrospective study

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Abstract

Objectives To investigate the relationship between lung function and exercise capacity in adults with cystic fibrosis (CF), and to develop a CF-specific equation to predict Modified Shuttle Test (MST) performance from baseline data.

Design Cross-sectional, retrospective study.

Setting Adult CF centre.

Participants One hundred and twenty-seven patients with CF [61 male; mean age 25 years (range 17 to 52 years), mean forced expiratory volume in 1 second (FEV_1) 56% predicted (range 15 to 124%)].

Main outcome measures MST and FEV_1.

Results Overall, a moderate-to-good relationship was found between lung function and MST performance (walking distance vs FEV_1% predicted: $r = 0.64$, $P = 0.01$). This relationship between FEV_1 and MST shows an obvious threshold at an FEV_1 of 67% predicted. Above this threshold, no significant association was observed between FEV_1 and MST performance. However, a strong relationship (MST vs FEV_1% predicted: $r \geq 0.74$, $P < 0.01$ for men and $r = 0.79$, $P < 0.01$ for women) was found below an FEV_1 of 67% predicted.

Conclusions This study suggests that a strong association exists between lung function (FEV_1% predicted) and MST (walking distance) in adult patients with moderate-to-severe CF ($FEV_1 < 67$% predicted). A reference equation for MST performance was developed for those patients with $FEV_1 \leq 67$% predicted, providing a tool to make an a-priori prediction of MST walking distance.

Keywords: Modified Shuttle Test; Cystic fibrosis; Exercise; Exercise test

Introduction

Both lung function and exercise capacity are described as predictors of prognosis and survival in patients with cystic fibrosis (CF) [1]. Both are also used as instruments to evaluate treatment [2–5].

The gold standard to measure exercise capacity is to use formal laboratory tests with analysis of expired air, but this type of testing is not commonly applied within CF centres [6]. In general, exercise testing seems to be underused in CF centres [6–8]. A survey of the provision of exercise testing and training in UK CF clinics showed that only 28% of adult patients with CF had performed an exercise test in the preceding year [6]. However, healthcare professionals have reported the importance of exercise testing to be high [8]. A survey among German CF centres showed that only 30% of the responding centres had adopted exercise testing as part of

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their diagnostic routine [8]. Formal laboratory exercise tests such as cycle ergometry might be experienced as stressful by many patients with CF, and therefore they may display an aversion to perform such tests on a routine basis [4]. An alternative is to measure exercise capacity by using a clinic-based test such as the Modified Shuttle Test (MST) [9,10].

The MST is a clinic-based walk/run test for adult patients with CF, and has proven reliability, repeatability and responsiveness in this patient group [3–5]. The MST was developed to provide a disease-specific, sensitive measure of exercise capacity in adult patients with CF [5]. The modification was based upon the Shuttle Walking Test (SWT); a standardised and externally paced clinic-based walking test, incorporating an incremental and progressive structure, to assess functional exercise capacity in patients with chronic airways obstruction [3]. The SWT was established to provide an objective measurement of disability, and allows direct comparison of a patient's performance.

A validation study by Bradley *et al.* showed that there is a strong relationship between MST performance and peak oxygen uptake in adults with CF, thus providing a good alternative for a formal laboratory exercise test with analysis of expired air [4].

Several studies have shown that peak oxygen uptake in patients with CF is associated with lung function [11–15]. It is generally assumed that the pulmonary system has an over-capacity of approximately 30% [16], and that small impairments may not lead to functional loss. Versteegh *et al.* reported that desaturation during exercise and sleep was only found in patients with forced expiratory volume in 1 second (FEV_1) <65% of predicted [17], suggesting that a decrease in lung function of 30% to 35% is a threshold for normal function of the respiratory system.

Based on the literature, the authors hypothesised that there is a strong association between lung function and exercise capacity in adult patients with CF with severe ventilatory limitations (FEV_1 <65% predicted). As such, this study aimed to investigate the relationship between lung function and exercise capacity measured with the MST in adults with CF, and to develop a CF-specific equation to predict MST performance from baseline data.

Methods

Subjects

From October 2000 to February 2010, all patients with CF attending the study outpatient clinic on a yearly basis were monitored systematically by the same physical therapist (WD). One hundred and twenty-seven adult patients with CF were included in this retrospective cross-sectional cohort study. Sixty-six were female and sixty-one were male. Mean age was 25 [standard deviation (SD) 8] years (range 17 to 52 years). Patients who had been diagnosed with a different disease that also affected exercise capacity or was associated with disturbances of the motor system (e.g. arthralgia, rheumatoid arthritis) were excluded from this study. Repeated measurements were not included in this analysis. All patients provided written informed consent for storage and use of their data for scientific purposes, as approved by the ethical board of the University Medical Centre Utrecht. Researchers had full access to all relevant patient data, and took responsibility for the integrity of the data and the accuracy of the analyses.

Modified Shuttle Test

The MST was used to measure exercise capacity. The test is a 15-level, externally paced test that requires patients to walk/run at increasing speeds back and forth on a 10-m course. The test protocol starts with an average speed of 1.8 km/hour (Level 1), followed by an increment of 0.6 km/hour at each successive level. The test ends when patients become unable to maintain the required speed, fail to complete a shuttle in the time allowed, or attain the maximal distance of 1500 m (Level 15) [4,5]. During the test, heart rate (Polar Electro, OY, Finland) and oxygen saturation (SpO_2%) at the fingertip (Nonin Avant 4000, Nonin Medical Inc, Plymouth, MN, USA) were measured. The tests were supervised by the same physical therapist (WD), with a physician immediately available in the vicinity of the testing area. Total MST distance was used for further analysis. To avoid the ceiling effect of the MST, measurements were only used when patients were unable to complete the entire MST protocol (i.e. MST distance <1500 m).

Feelings of post-exercise dyspnoea and fatigue

Before and immediately after the MST, patients were asked to rate subjective feelings of dyspnoea and fatigue on a 10-point Borg scale [18].

Lung function

FEV_1, forced vital capacity (FVC) and FEV_1/FVC ratio were determined by spirometry (ZAN, Oberthulba, Germany). All variables were expressed as a percentage of the value for healthy subjects, according to the standards of the European Respiratory Society [19].

Statistical analysis

Numerical data are expressed as mean (SD), absolute values or percentage of predicted values. The relationship between lung function and MST performance was investigated using locally weighted scatterplot smoothing.

Correlations between variables were assessed using Pearson's correlation coefficient. Values from 0.00 to 0.25 indicate little or no relationship, values from 0.25 to 0.50 indicate a fair relationship, values from 0.50 to 0.75 indicate a moderate to good relationship, and values >0.75 indicate a good to excellent relationship [20].

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