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The Six-Minute Step Test as an Exercise Outcome in COPD

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To the Editor:

Exercise capacity predicts adverse outcomes, identifies exercise-induced oxygen desaturation, and facilitates exercise prescription in COPD. Established tests of exercise capacity such as cardiopulmonary exercise testing (CPET) or field walking tests (six-minute walking test: 6MWT; incremental shuttle walking test: ISWT) can be limited by equipment, time or space, and are not feasible in some settings, for example the home. Field walking tests also require a practice walk to account for learning effect.

The six-minute step test (6MST) is a simple functional test adapted from the 6MWT.[1] It is reproducible in COPD,[2] correlates with 6MWT distance,[3] is responsive to a physical training programme,[4] and identifies exercise-induced desaturation in interstitial lung disease.[5] However, it remains unclear whether the 6MST generates a similar cardiorespiratory response to more established maximal tests of exercise capacity, identifies exercise-induced desaturation in COPD or can be used for exercise prescription.

We aimed to: 1) determine the association between 6MST with ISWT and CPET; 2) compare cardiorespiratory responses between 6MST, ISWT and CPET; 3) generate equations based on 6MST for exercise prescription; 4) compare responsiveness of 6MST and ISWT to pulmonary rehabilitation (PR).

Methods

Participants were prospectively recruited from those attending PR assessment clinics. Inclusion criteria were: a diagnosis of COPD, Medical Research Council (MRC) Dyspnoea Score ≥2, and able to walk 5m independently. The study was approved by the London Riverside Research Ethics Committee (reference 17/LO/1830). All participants provided informed consent.

CPET, ISWT and 6MST were performed in random order, with the assessor blinded to the order and to the results of the other assessments. For all tests, heart rate, oxygen saturation (SpO_2), and breathlessness scores using a modified Borg CR-10 scale were measured at baseline, one-minute intervals during exercise and at end exercise.

The 6MST was self-paced and performed using a 20cm-high, single-step platform as previously described.[5] Standardised encouragement was given at the end of each minute as per 6MWT technical standards. The total number of steps achieved in six minutes was recorded. The ISWT was performed as previously described.[6] The CPET was performed using a cycle ergometer (ergoselect 200, ergoline GmbH, Germany) with a metabolic cart (Ultima™ $Cardio_2$® gas exchange analysis system, MCG Diagnostics, Saint Paul MN, USA).[7] Participants attended an eight week, twice-weekly, supervised PR programme conducted according to British Thoracic Society Quality Standards.[8]

To demonstrate a strong correlation (r>0.7) between 6MST with ISWT distance, peak oxygen consumption ($\dot{V}O_{2peak}$) and peak workload against the null hypothesis (r=0) with 95% power at a p-value threshold of 0.05 required a minimum of 20 participants.

The relationship between variables were analysed using Pearson's correlation co-efficient or Spearman's rank correlation depending on distribution of data. Changes between baseline and peak heart rate, SpO_2 nadir and peak Borg scores were compared between 6MST, ISWT and CPET using paired sample t-tests, or Wilcoxon matched-pairs signed-rank tests. Responses of the 6MST and ISWT to PR were assessed using a paired t-test, and the standardised mean responses calculated.

Based on the ISWT and CPET, we calculated exercise intensity prescription for walking speed (75% of peak walking speed) and cycling work rate (60% of peak cycle work rate) as per the Lung Foundation Australia Pulmonary Rehabilitation Toolkit.[9]

Multivariable regression was performed to generate predictive equations for walking speed and cycling work rate prescriptions based on 6MST step count. Bland-Altman plots were constructed to demonstrate agreement between predictive equation derived and actual prescribed walking speed and cycling work rate by plotting the mean difference between the two measures against the mean of the two measures.

Results

Twenty-four participants (Table 1) completed 6MST and ISWT, with 23 also performing CPET. 6MST correlated with ISWT distance, $\dot{V}O_{2peak}$ and peak work rate (r=0.90, 0.77 and 0.72 respectively; all $p<0.05$).

Median (25th, 75th centile) change in SpO_2 during 6MST was at least similar or more pronounced to that seen during ISWT or CPET (Figure 1). Changes in heart rate and Borg were also similar across tests (Figure 1).

Multivariable linear regression equations incorporating 6MST to predict prescribed walking speed (75% of maximum walking speed, taken from ISWT) and cycling work rate (60% of peak cycle work rate from CPET) prescriptions were:

Initial walking speed prescription(km/h) = 1.866+(0.028*6MST)

Initial work rate prescription(W) = -4.388+((0.707*BMI)+(-3.204*MRC)+(0.430*6MST))

These correlated strongly with actual prescribed walking speed and cycling work rate (r=0.876 and 0.773 respectively). Bland-Altman plots showed good agreement between the predicted and prescribed walking speeds and cycling work rates, with data scatter lying primarily within the limits of agreement (Figure 2).

Following pulmonary rehabilitation, mean(SD) 6MST increased from 56(30) steps to 69(28) steps, with a mean(95% CI) change of 12(5 to 19) steps, and a standardised mean response of 1.22. The ISWT showed a trend towards improvement (mean(95% confidence interval) change of 21(-5 to 48m)) with a standardised mean response of 0.38.

Discussion

Simple functional tests require little space or equipment, and may be particularly helpful for home-based assessments for PR.[10] Although functional tests such as sit-to-stand and gait speed have been shown to be responsive to exercise-based intervention in COPD,[11, 12] they are not maximal tests, nor been shown to be appropriate for exercise prescription.[13]

Climbing steps or stairs is a familiar physical activity to patients with chronic respiratory disease, and the use of the 6MST has been previously described in COPD, ILD and post-COVID-19.[2-5, 14] We have demonstrated that the 6MST correlates strongly with ISWT distance, $\dot{V}O_{2peak}$, and peak work rate with similar cardiorespiratory responses, providing evidence that the 6MST is a near maximal test. Furthermore, we have generated equations based on the 6MST to help exercise practitioners prescribe initial exercise intensity (walking speed, or cycling work rate) for a PR programme. We also demonstrate that the 6MST is as responsive to PR as the ISWT.

Despite adequate power, this was a single centre study in a cohort of symptomatic but stable patients referred for PR, so our data require corroboration in larger cohorts and in other patients with COPD (for example, less symptomatic or those unwell with an acute exacerbation). The exercise-testing was also supervised at a PR centre, and so our data cannot necessarily be extrapolated to the home setting, nor for remotely supervised tests. Future work should include the validation and safety testing of remotely supervised step tests in patients with COPD, as has been demonstrated in a small feasibility study of adults with cystic fibrosis.[15]

We propose that the 6MST is a simple field functional test that could be used as a surrogate of exercise capacity, to identify oxygen desaturation and determine responsiveness to exercise-training in patients with COPD, particularly when more established exercise tests are not possible, for example during a home-based assessment.

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Table 1: Baseline characteristics

Variable (n=24)		Mean (SD) or Median (25^{th}, 75^{th} centiles)
Age (years)		72.5 (70, 74.75)
Gender (male n (%))		8 (33)
BMI (kgm^{-2})		28.7 (6.7)
MRC Dyspnoea score		4 (2, 4)
FEV_1 (%predicted)		54.0 (19.8)
FVC (%predicted)		91.7 (19.8)
Resting SpO_2 (%)		98 (98, 99)
Resting heart rate (beats/min)		79(10)
ISWT (metres)		330 (140)
	Change SpO_2	-5 (-8, -3)
	Change HR	37 (17)
	Change Borg	5 (2)
6MST (steps)		70 (23)
	Change SpO_2	-5 (4)
	Change HR	29 (2)
	Change Borg	4 (2)
CPET (n=23)	$\dot{V}O_2$peak ml/kg/min	12.9 (3.4)
	Peak watts	60.5 (23)
	Change SpO_2	-2 (-4, -2)
	Change HR	32 (20)
	Change Borg	4 (2)

Data expressed as n, mean (SD: standard deviation) or median (25^{th} and 75^{th} centiles). Abbreviations: BMI: Body Mass Index; MRC: Medical Research Council Dyspnoea score; FEV_1: Forced Expiratory Volume in 1 second; FVC: Forced Vital Capacity; SpO_2: oxygen saturation; ISWT: Incremental Shuttle Walk Test; HR: heart rate; 6MST: 6-minute step test; CPET: Cardiopulmonary Exercise Test

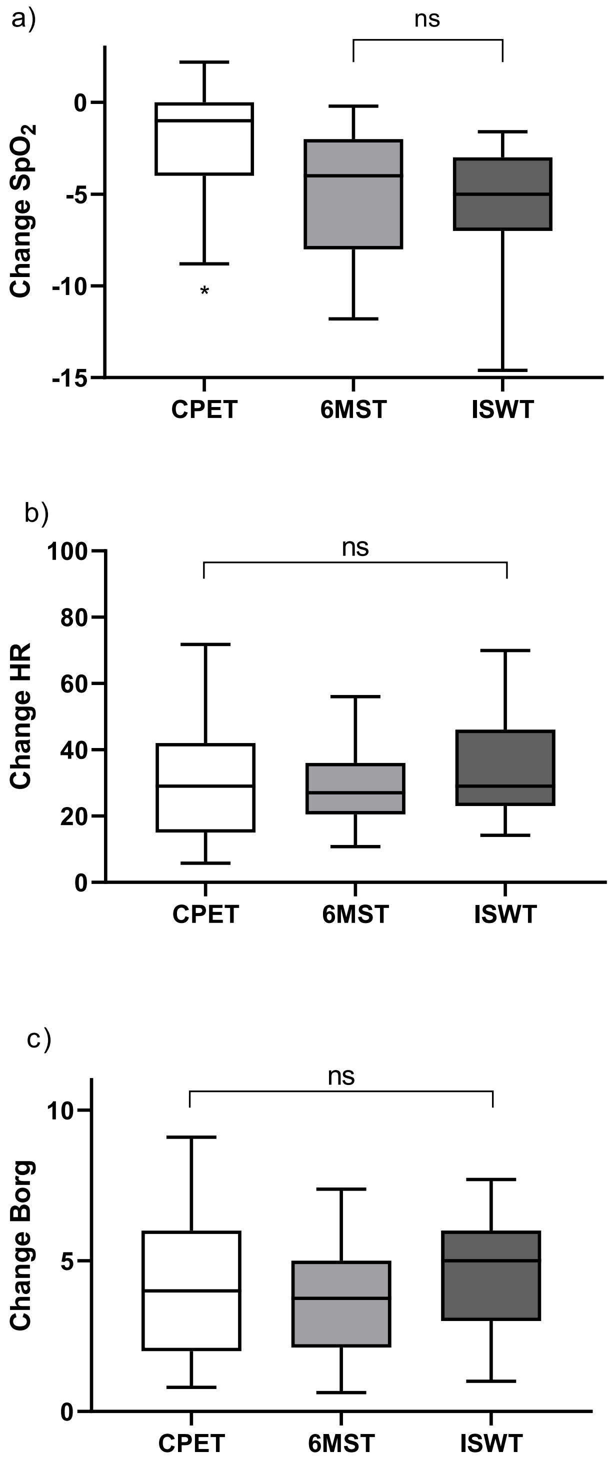

Figure 1: Box and whisker plots to show change in a) SpO2 b) heart rate c) Borg dyspnoea score during each test: cardiopulmonary exercise test (CPET), 6-minute step test (6MST), and incremental shuttle walk test (ISWT). Error bars show 95% confidence intervals.

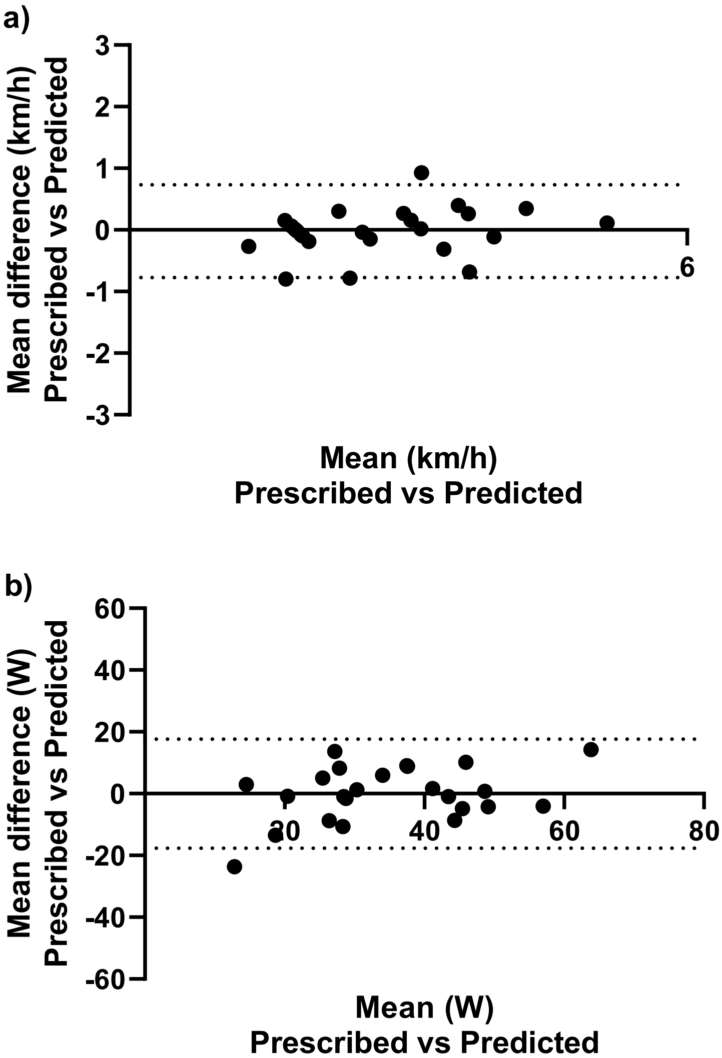

Figure 2: Bland-Altman plot of mean difference against mean of predicted prescribed speed/watts from 6MST vs prescribed speed/watts from a) ISWT, and b) CPET