Ambulatory oxygen therapy assessment: A comparative study of incremental shuttle and six-minute walking tests

Running title: Walking tests in assessment of ambulatory oxygen therapy

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ABSTRACT:

Walking tests, such as Incremental Shuttle (ISWT) and Six Minute (6MWT) Walk Tests, are recommended in the assessment of ambulatory oxygen for patients with Chronic Obstructive Pulmonary Disease (COPD). However, there is no evidence that these tests can be used interchangeably.

Objectives: To compare ISWT and 6MWT in COPD patients with respect to indication for ambulatory oxygen therapy. **Design:** Cross over design. **Setting:** Patients attended as out-patients. **Participants:** 50 patients with stable COPD (31 male; age 67(43 - 83) yrs; mean (SD) FEV_1 1.24 (0.62) l and 48.6(23.4) % predicted). **Intervention:** Patients performed both ISWT and 6MWT whilst breathing air. Breathlessness (Borg Scale), percutaneous arterial oxygen saturation (SpO_2) and heart rate were measured before and after both tests. **Main outcome measures:** Post test SpO_2 and change from baseline. **Results:** The mean change in saturation (SD) was -4.6 (6.2) % and **-**2.8 (5.3) % after the ISW and 6WM tests respectively. Using Bland and Altman plots the limits of agreement for difference in change in SpO_2 (%) between the two tests were wide (-8.1 to 11.6) and clinically relevant. Sixteen patients (32%) met the criteria for ambulatory oxygen with ISWT and 13 (26%) with 6MWT (p=0.32).

Conclusions: In this study there was a wide variation between differences in exercise oxygen desaturation after ISWT compared with 6MWT supporting the premise that these tests should not be used interchangeably in the assessment of ambulatory oxygen for COPD patients.

INTRODUCTION:

Chronic Obstructive Pulmonary Disease (COPD) is a disease characterised by airflow obstruction, which is usually progressive and non-reversible. Increasing severity of airflow obstruction, alveolar wall destruction and impairment in diffusing capacity leads to arterial hypoxaemia. Initially, hypoxaemia is experienced during physical activities (1) which may, in the advanced disease stage, progress into chronic type two respiratory failure. For these patients the provision of long-term oxygen therapy is a vital component of management (2-4). However, COPD is a heterogeneous disease, in many patients desaturation and arterial hypoxaemia occurs only on exercise. The provision of oxygen during exercise and activities of daily living, known as an ambulatory oxygen therapy may be beneficial for these patients. Ambulatory oxygen is recommended in order to allow the patient to spend longer periods outside the home, to increase daily activities (5;6) and to improve health related quality of life (7). However, in order to maximise effectiveness, titration and usage of oxygen, accurate and appropriate assessment of ambulatory oxygen is required.

Currently, according to British Thoracic Society guidelines (6), when oxygen desaturation of 4% to a value < 90% is demonstrated after either a maximal or endurance field walking test, further assessment with ambulatory oxygen is recommended. Assuming these patients show clinical benefit with oxygen, ambulatory oxygen prescription is advised (5;6). However, current guidelines do not specify whether endurance tests or maximal tests should be used in the evaluation of exercise induced desaturation nor do they stipulate walking rather than cycle ergometry. Field walking tests have been found to be more sensitive to blood oxygen changes than cycle-ergometry suggesting walking tests are appropriate for the assessment of ambulatory oxygen (8). However, two measures often used interchangeably, the Incremental Shuttle (ISWT) and the Six Minute (6MWT) Walking Tests induce different physiological responses. The ISWT demonstrates a strong correlation with maximal oxygen consumption (VO_2 max) (9;10). Whilst data suggests that 6MWT demonstrates maximal sustainable activity levels (11) and a review of the two tests purports the 6MWT to be a better assessment of daily function in COPD (12). The 6MWT is self paced as opposed to the externally paced measure that stresses the patient to a symptom-limited maximum (13). Other comparative studies show that 6MWT and ISWT provoke different physiological responses in COPD

patients. The ISWT demonstrates a linear increment in heart rate, similar to that of incremental cycle-ergometry, in contrast 6MWT shows a plateau effect (8). However, the two walking tests result in similar mean end values for oxygen saturation, dyspnoea score and heart rate (14;15). Whilst this would suggest a similar performance in both tests, there is no clear evidence that the tests can be used interchangeably in assessment of ambulatory oxygen. Physiotherapists, positioned as they are in pulmonary rehabilitation, are at the forefront of exercise assessment in COPD. Thus it is imperative that the implications of the effects of different exercise tests on oxygen desaturation are explored.

The purpose of this study therefore is to compare change in oxygen saturation, dyspnoea score and heart rate in COPD between ISWT and 6MWT. Additionally, we will identify numbers of COPD patients meeting the criteria for ambulatory oxygen assessment with each test.

MATERIAL AND METHODS:

Patients

Patients were recruited from the chest clinic at St. George's Hospital, London. Fifty patients were included in the study with mild-to-severe COPD and had had no exacerbation in previous 6 weeks as defined by the National Institute for Health and Clinical Excellence (NICE) guidelines (16). All patients had limited exercise tolerance due to dyspnoea and were referred to the study by their general practitioner, hospital consultant, respiratory nurse or physiotherapist. All provided written informed consent. Exclusion criteria consisted of recent exacerbation, unstable angina, significant co-morbidities such as stroke or carcinoma, psychiatric disorders, intermittent claudication or other mobility limiting conditions. Full ethical consent was obtained from Wandsworth Local Research Ethics Committee and the study was conducted according to the Helsinki good practice declaration.

Assessments

At the initial assessment session demographic data (age, gender); height (cm) and weight (kg) were recorded. Body Mass Index (BMI) was calculated from weight (kg) divided by square of the height (m) (kg/m^2). Spirometry; Forced Expiratory Volume in one second (FEV_1) and Forced Expiratory Capacity and (FVC), were measured using Vmax 29c; SensorMedics (Yorba Linda, CA, USA) Cardiopulmonary Exercise Testing Instrument and in accordance with British Thoracic Society Guidelines. All patients performed both Shuttle Walk and 6 Minute Walk Tests whilst breathing air. The walking tests were performed on separate days over a period of one week in random order.

Incremental Shuttle Walking Test, an incremental, externally paced exercise capacity test was conducted according to standardised procedure (17). Patients were asked to walk around two cones placed at either end of a 9 meter course. The walking speed was indicated by signals played from the cassette and increased every minute. The test was terminated when the patient was either too breathless to continue or could no longer keep up with required speed. The standardised tape instruction was played to the patient prior the test. Patients performed two ISWT with a break of 30 minutes between them. The results of the best test were recorded as actual values.

Six Minute Walking Test, a submaximal, self-paced exercise capacity test was conducted according to American Thoracic Society (ATS) guidelines (12). Patients were required to walk for six minutes at their own pace along a 30 meter corridor. The patient was permitted to slow down, stop or rest if necessary. Standardised instruction was given prior to testing. Two repeatable tests were taken (repeatability was defined as a difference between walks of less than 50 m), we have used this conservative estimate based on the mean minimal clinically important difference for 6MWT (18). Results of the best test were recorded as actual values and patients rested for 30 minutes between tests.

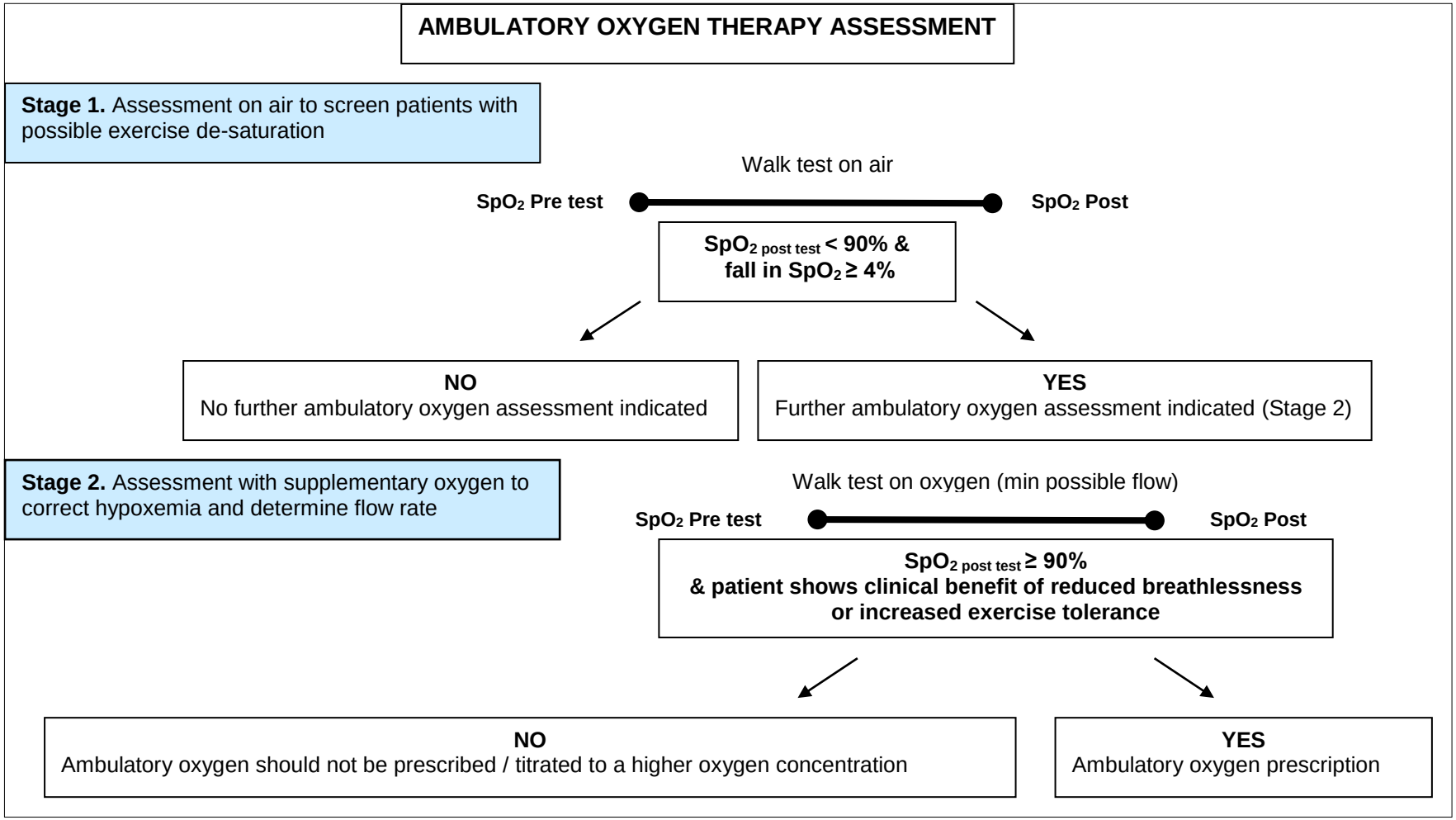
Measures were taken by the same investigator before and after each walking test to examine physiological responses to the exercise. Breathlessness was assessed with Borg CR 10 Scale (Dyspnoea assessment)(19). Percutaneous arterial oxygen saturation (SpO_2) and heart rate were measured using a pulse oximeter (Pulsox-3i-Konika Minolta, Osaka, Japan) applied to the finger.

Statistical Analysis:

All data are expressed as mean and standard deviation (SD). Change (Δ) in variables was calculated by end value minus resting value. All change data were normally distributed, except change in oxygen saturation after 6MWT and ISWT. Data for these variables were log transformed to achieve a normal curve. The Bland and Altman method for assessing agreement between two clinical measurements was used for comparison of changes in oxygen saturation between the walking tests and limits of agreement were calculated as described (20). The Spearman's correlation was used to assess relationship between changes in SpO_2 with both tests.

Patients who showed desaturation of 4% or more to below 90% were defined as appropriate for stage 2 assessment (Figure 1 shows the stages of ambulatory therapy as outlined by BTS guidance, only stage 1 was performed in this study). Using Wilcoxon Signed Ranks Test, the number of patients qualifying for stage 2 ambulatory oxygen assessment was compared according to the walk test. Significance was accepted as $p < 0.05$. Data were analysed using SPSS 12.0 for Windows.

Figure 1. Assessment for ambulatory oxygen therapy for patients demonstrating exercise desaturation (not prescribed Long Term Oxygen Therapy) adapted from the BTS guidelines 2006 for England and Wales



RESULTS

Patient Details

Fifty patients entered the study of whom thirty-one were male. Six Minute Walk Distance data was unavailable for one subject. All had a diagnosis of COPD, mean FEV_1 (SD) 1.24(0.62) l. Baseline characteristics are shown in table 1.

Physiological response measures

There was a significant difference in the walking distance between both tests mean (SD) ISWT 216 (149) m and 6MWT 365 (157) m ($p< 0.001$). Prior to the walking tests mean baseline SpO_2 levels were similar; 6MWT 94.5 (2.4) % compared with SpO_2 levels prior to ISWT 95.2 (2.0) %. Table 2 shows mean end values and changes in oxygen saturation, heart rate and dyspnoea score between the two tests.

Figure 2 represents the Bland and Altman plot showing the difference in the change in oxygen saturation between the two tests and the mean change between paired scores. The mean difference between the tests was 1.74 % with 95% confidence interval 0.34 to 3.14 %. The limits of agreement for difference in change in SpO_2 (%) between the two tests were wide (-8.1 to 11.6) and clinically relevant. These data tell us that the fall in SpO_2 after 6MWT may be as much as 8.1% greater than fall in SpO_2 after ISWT, or that the fall in SpO_2 post ISWT may be as much as 11.6 % greater than fall after 6MWT. As expected, change in SpO_2 after ISWT was correlated with change in SpO_2 after 6MWT, however this correlation was weak and showed a large degree of scatter ($r=0.49$, $p<0.001$) (Figure 3).

The number of patients with oxygen saturation below 90% after either walk was similar ($p = 0.26$). Overall 19 (38%) of our patients met the criteria for ambulatory oxygen assessment (6) using either test but the tests agreed in only 10 of these patients.

Table 1. Baseline characteristics.

*BMI = Body Mass Index (weight kg /height m ^{2})

	N	Mean	SD
Age (years)	50	67.0	10.5
BMI* (kg/m^2)	50	26.7	5.7
FEV_1 (l)	49	1.24	0.62
FEV_1 % predicted	49	48.6	23.4
FVC (l)	49	2.2	0.76

Table 2. Mean (SD) end values and changes in oxygen saturation, heart rate and dyspnoea for both walking tests.
6MWT = Six Minute Walk Test, ISWT = Incremental Shuttle Walking Test

	N	6MWT Mean (SD)	ISWT Mean (SD)	Mean difference (SD)
Arterial oxygen saturation post walk (%SpO_2)	50	91.7 (6.1)	90.6 (6.9)	1.0 (4.5)
Change in arterial oxygen saturation (Δ%SpO_2)	50	-2.8 (5.3)	-4.6 (6.2)	1.7 (5.0)
End heart rate (bpm)	49	97.4 (20.0)	103.0 (16.2)	-5.6 (22.2)
Change in heart rate (Δbpm)	49	11.4(14.5)	19.9(16.3)	-8.5(2.8)
Dyspnoea score (Borg)	49	3.9 (1.5)	4.1 (1.6)	-0.2 (1.1)
Change in CR10 Borg (Δ Borg)	49	3.2(1.3)	3.1(1.4)	0.6(1.1)

Figure 2. Bland and Altman plot for change in oxygen saturation (%SpO_2)

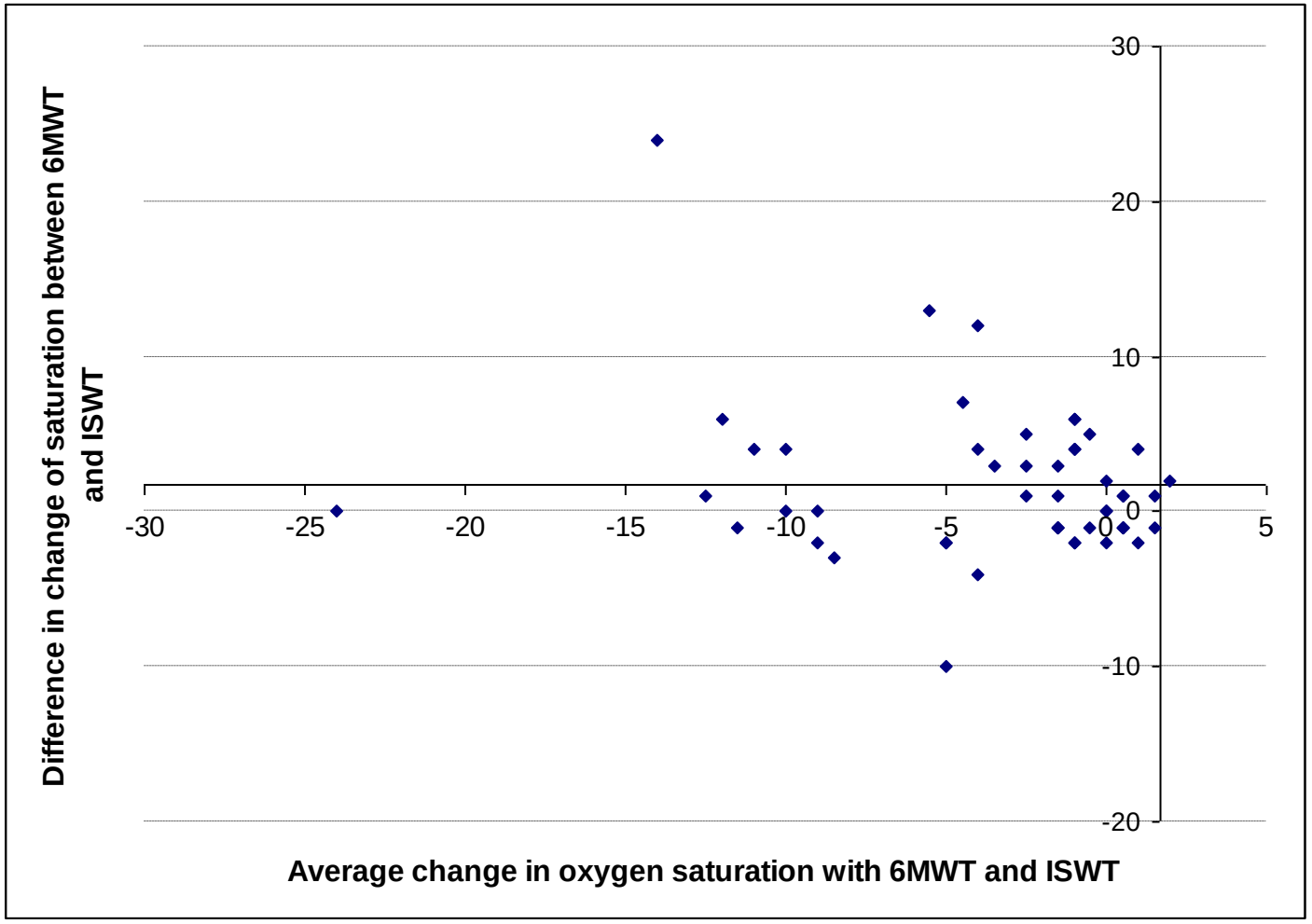
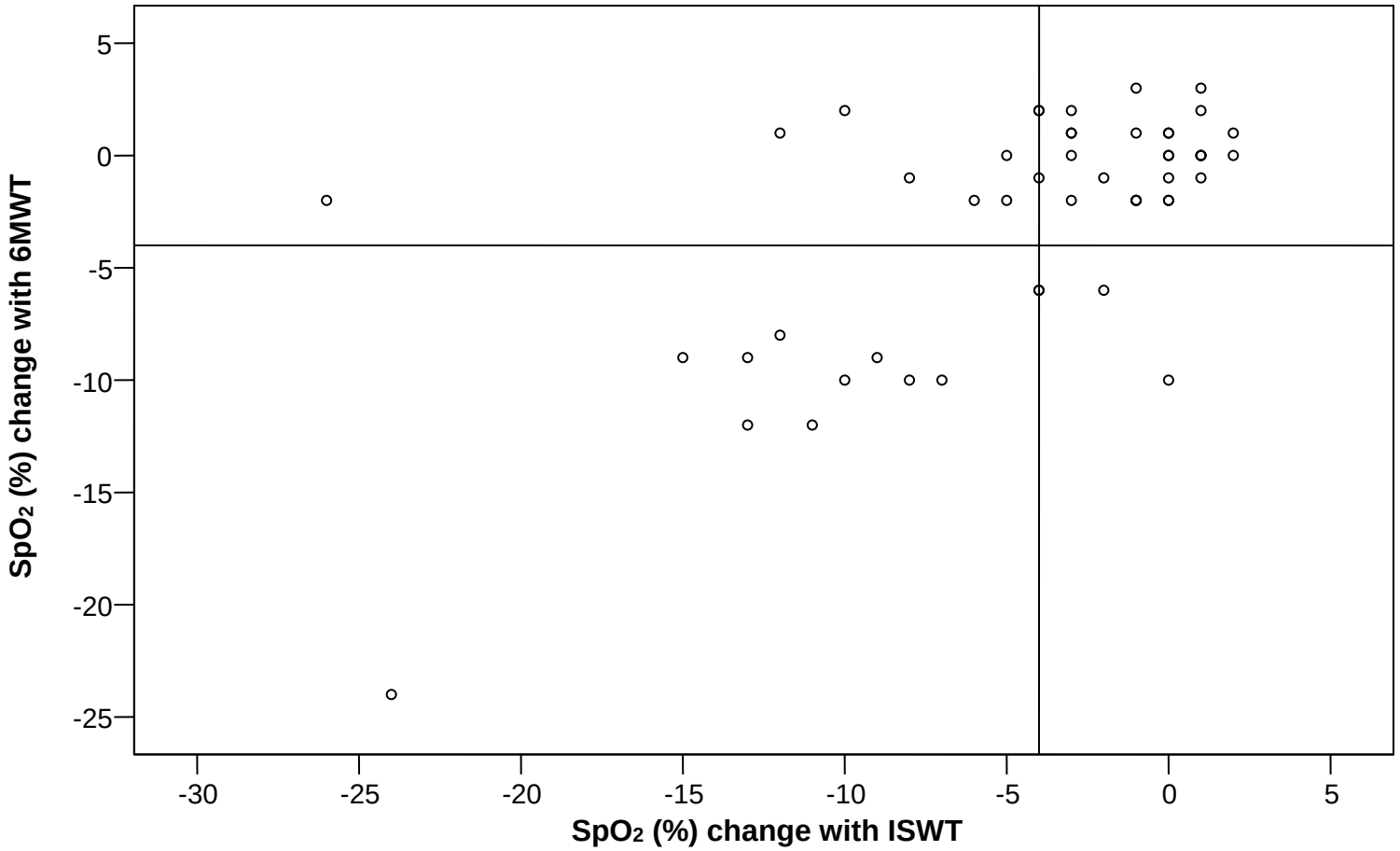


Figure 3. Relationship between change in arterial oxygen saturation (SpO_2) with 6MWT and ISWT (r=0.49). The reference lines represent fall in oxygen saturation by 4%; 6MWT- Six Minute Walk Test, ISWT- Incremental Shuttle Walking Test



DISCUSSION

This study provides comparative data concerning the use of the Incremental Shuttle and Six Minute Walk Tests and relative exercise induced desaturation. These data confirm previous work showing different physiological responses according to the two tests but that heart rate and arterial oxygen saturation end point levels do not differ between tests. However, analysis of the change in variables show that the ISWT had a greater impact on the cardio-respiratory response to exercise and induced greater exercise hypoxaemia compared with the 6MWT. The mean difference in oxygen desaturation between the tests was small. However, further analysis reveals that the limits of agreement between levels of desaturation with these two tests are too wide to enable us to confidently use the tests interchangeably for clinical purpose. These findings show that, when change in exercise desaturation is a critical factor for treatment prescription, the 6MWT or the ISWT only must be used. The number of patients meeting criteria for further assessment for ambulatory oxygen differs according to the walking test used.

Vagaggini and colleagues (15), showed no difference between these walking tests in terms of oxygen saturation or heart rate in COPD patients recovering from an acute exacerbation. The patients in our study, however, were clinically stable, which could explain the different physiological responses between studies. Assessment for ambulatory and long term oxygen therapy should only be performed in stable COPD patients suggesting that our data is more robust when considering this purpose. However, in our study we performed the walking tests on separate days and therefore variations in patient condition may have influenced the results. In clinical practice tests are likely to be performed on the same day which may provide more robust data.

The prescription of ambulatory oxygen per se remains controversial. One recent review of long term evaluation of ambulatory oxygen suggests there is insufficient evidence to demonstrate efficacy of the addition of ambulatory oxygen to daily life compared with placebo (21). Although, a review of the short term benefit, based on response from acute exercise tests, demonstrates significant increases in exercise tolerance and breathlessness (5). However, assuming, short term benefit in some patients translates into longer term efficacy (and studies are required to show this) then accurate assessment of ambulatory oxygen therapy becomes paramount.

Evaluation of appropriate assessment for ambulatory oxygen requires standardisation. However, it is not clear which test or which measure is a better indicator of a patient's requirement for ambulatory oxygen therapy.

In a recent study by Morante and colleagues (22) ambulatory oxygen therapy was assessed according to Spanish guidelines. This method considered the mean oxygen saturation value throughout the test rather than the end point. Using this method the 6MWT was effective in the detection of desaturation during daily activities and for establishing the correct oxygen level to overcome desaturation. However, they did not compare 6MWT with any another test. Unfortunately, in our study we did not assess activities of daily living and therefore cannot make comparisons of the relative value of ISWT or 6MWT in this respect. Furthermore we have only considered the assessment for ambulatory oxygen at stage 1 and cannot determine from our data which test would most useful for titration of oxygen concentration. We suggest that future studies considering comparison of walking tests in the evaluation of oxygen desaturation should apply the methods described by Morante. This is of particular relevance when considering that patients may stop walking during the 6MWT which in turn could affect end SpO_2.

Assessment tests should be linked to appropriate provision of treatment in concordance with patient goals. The concept of ambulatory oxygen therapy is such that oxygen is administered during exercise or daily activity and, as such the amount of activity an individual performs will influence choice of delivery. In COPD patients a fall in oxygen saturation is reported mainly during walking, washing and eating (1;23). The purpose of provision of ambulatory oxygen requires consideration when choosing the assessment method. If assessment is performed to evaluate oxygen requirements during maximal exercise a robust maximal test such as ISWT may be most appropriate. However, ambulatory oxygen is associated with the inconvenience of using a supplementary device and oxygen itself can be hazardous (24) and assessment is required that minimises over prescription of oxygen but maximises potential use. Clinicians should be aware that choice of walking test will influence the numbers of patients deemed to require oxygen (although not statistically significant in this study) and as demand increases the choice of assessment test will have greater impact on the numbers of patients receiving oxygen. As yet, there is no evidence that long-term benefit is determined from any short-term assessment. In conclusion, our data shows wide variation between differences in exercise desaturation after ISWT

compared with 6MWT supporting the premise that these tests should not be used interchangeably.

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