

Comparison of Physiological Responses to Six Minute Walk Test and Incremental Shuttle Walk Test Among COPD Patients in UKMMC

(Perbandingan Respons Fisiologi Kepada Ujian Jalan Enam Minit dan Ujian Jalan Ulang-Alik Meningkatkan di Kalangan Pesakit COPD di PPUKM)

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ABSTRACT

The objective of the study was to compare the physiological responses among COPD patient to Six Minute Walk Test (6MWT) and Incremental Shuttle Walk Test (ISWT). Twenty subjects were recruited for both 6MWT and ISWT that was carried out randomly. The readings of oxygen saturation (SpO_2), heart rate (HR) and Modified Borg's Score (MBS) were being taken before, during (each minute) and after each test. There were no significant difference observed in the peak HR and MBS between 6MWT and ISWT. There was no significant difference observed in the end SpO_2 after both tests. In the two tests, HR and MBS increased linearly and were proportionate with time. However, our results showed that the distance walked in both test were significantly different and strongly related with more distance covered in 6MWT, with $p < 0.05$ ($p = 0.01$) and $R = 0.58$. Both 6MWT and ISWT elicited similar peak HRs and MBS suggesting both tests could be used to challenge patient to certain levels of cardiovascular and respiratory stress. There was no significant difference found in this study between the two tests. The two field tests could produce similar physiological responses in COPD patient.

Keywords: COPD; ISWT; 6MWT

ABSTRAK

Objektif kajian ini ialah untuk membandingkan perubahan fisiologi di kalangan pesakit COPD kepada Ujian Jalan Enam Minit (6MWT) dan Ujian Jalan Ulang-Alik Meningkatkan (ISWT). Sejumlah 20 subjek telah direkrut untuk 6MWT dan ISWT yang dilakukan secara rawak. Bacaan ketepuan oksigen (SpO_2), kadar denyutan jantung (HR) dan O_2 Skor Borg's Termodifikasi (MBS) telah diambil sebelum, semasa (setiap minit) dan selepas ujian. Tiada perbezaan yang tekak diperolehi dalam peak HR dan MBS antara ujian 6MWT dan ISWT yang di lakukan. Tiada perubahan yang tekak diperolehi dalam SpO_2 akhir setelah menjalani kedua-dua ujian. Dalam kedua-dua ujian, HR dan MBS meningkat secara linear dan berkadar langsung dengan masa. Namun kajian menunjukkan jarak berjalan dalam kedua-dua ujian mempunyai perbezaan yang bererti dan hubungan yang agak kuat berkait dengan pertambahan jarak di dalam 6MWT, dengan $p < 0.05$ ($p = 0.01$) dan $R = 0.58$. Ujian 6MWT dan ISWT menghasilkan peak HR dan MBS yang bersamaan menunjukkan ujian-ujian tersebut boleh digunakan untuk menguji tahap keupayaan kardiovaskular dan tekanan respiratori. Kajian ini menunjukkan tiada perbezaan yang bererti di antara kedua-dua ujian. Kedua-dua ujian boleh menghasilkan respons fisiologi yang sama di kalangan pesakit COPD.

Kata kunci: COPD; ISWT; 6MWT

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is characterised by airflow limitation and respiratory symptoms with subsequently deteriorating health (Pauwels et al. 2001). Health status is defined as the impact of health on a person's ability to perform and derive fulfillment from the activities of daily life (Curtin & Patrick 2003; Leidy 1995) which includes health-related quality of life (HRQoL) and functional status. Functional status focuses on the capacity to perform activities of daily living (ADL) while HRQoL reflects how the patients feel when their daily life and well-being are affected by the disease (Curtis et al. 1997). A withdrawal from everyday tasks will often be accepted by the patients as unavoidable adjustments

to a chronic disease. This lower level of performance in ADL may lead to a decline in related symptoms. Thus, we may record an apparent improvement in self-reported HRQoL while the patients' functional status is obviously worsened.

Limited exercise tolerance is one of the main complaints in patients with chronic obstructive pulmonary disease (COPD). Exercise capacity has become an important outcome measure in COPD, as many patients complain of exercise intolerance and exertional dyspnea, and because it is a major determinant of an impaired health status (Jones 2001). Exercise capacity tests vary from laboratory-based exercise tests to field walking tests. Laboratory-based tests, such as the Incremental Cycle Ergometer Test (CET)

or Treadmill Test, are mostly constructed to measure peak exercise capacity (W peak), and/or peak oxygen uptake (VO_2 peak) whereas field walking tests are considered as tools to reflect functional capacity (ATS 1999). Although the laboratory-based tests are the gold standard for the exercise testing, they require advanced technical equipment and maybe difficult to access. However, the field walking tests such as the six minute walk test (6MWT) and incremental shuttle walk test (ISWT) are usually used in pulmonary rehabilitation as both assessment tools as well as outcome measures (Cooper 2001; Steele 1996) in pulmonary rehabilitation program.

The protocol for 6MWT and ISWT are different respectively. The 6MWT is a self-paced walking test, in which it depends whether the subject rest during the test or walks continuously throughout the 6 minutes. As for the ISWT, it is an externally-paced test where by subjects are to increase their walking speed each minute progressively to a point at which the test is terminated due to breathlessness or unable to maintain the required walking speed (Singh et al. 1992). A study done by Turner et al. (2004) showed that similar peak exercise responses were achieved in the 6MWT, ISWT and CET, with greater oxygen desaturation observed during the field walking tests (Turner et al. 2004). Studies comparing the 6MWT and ISWT suggested that the peak exercise responses are similar between each test in subjects with moderate-to-severe COPD (Servino et al. 2000; Casas et al. 2002) while other study indicated that they are lower in the 6MWT in population with mild COPD (Singh et al. 1992).

Previous study suggested there are no significant differences in the changes of systolic blood pressure, heart rate, respiratory rate, oxygen saturation and dyspnea score among 6MWT and ISWT, with significant correlation between the distances walked in both tests (Vagaggini 2003). Recent study found that there are wide variation in oxygen saturation between the two walking tests (Lewko et al. 2007).

The aims of this study were to examine and compare the physiological responses in cardiorespiratory performance during the walking tests using the 6MWT and ISWT that was used in assessing the exercise capacity of COPD patients in the Malaysian population. Our hypothesis was significant difference in the cardiorespiratory performance, as measured through peak heart rate and dyspnea score, among the two walking tests in patients with COPD.

MATERIALS AND METHODS

SUBJECTS

This study was a cross-sectional quantitative study in which the within-subject design was used. Twenty subjects (14 males and 6 females, mean age 66.2 ± 6.7 years) were recruited for this study. These subjects were taken among COPD patients that were newly referred for pulmonary rehabilitation at the Universiti Kebangsaan Malaysia Medical Center (UKMMC), diagnosed by the

respiratory physician with COPD. Ethical approval was obtained from the Ethical Board of University Kebangsaan Malaysia Medical Centre. Inclusion criterion was forced expiratory volume in one second (FEV_1) $< 60\%$ of predicted value whilst exclusion criteria includes ischemic heart disease, diseases that compromise the exercise tolerance, musculoskeletal problems, unstable vitals signs, inability to understand written or spoken English, Malay or Chinese, impaired hearing or vision which affect subjects' ability to complete the required tests.

PROCEDURE

The subjects were required to complete the 6MWT and ISWT within 2-weeks duration with each test done less than 24 hours apart. The order of the exercise tests was randomized, and the time of day at which tests were conducted was maintained at a constant time. Subjects were explained the procedure of the study as well as the protocols of the two tests. They were also familiarized with the Modified Borg's Score prior to both test in order to minimize the interference when obtaining the score during the tests. HR and SpO₂ were taken before, during (each minute) and at the end of each tests with a portable pulse oxymeter. Also, the dyspnea score as measured from Modified Borg's Score were obtained from subject prior to, during (each minute) and at the end of each tests.

EXERCISE PROTOCOL

The Six Minute Walk Test (6MWT) was performed over a 30 m hospital corridor with cone placed at both ends of the course. It was performed according to the protocol provided by The Pulmonary Rehabilitation Toolkit initiated by the Australian Lung Foundation and Australia Physiotherapy Association (2007). Prior to the test, subjects were being issued a standard instructions and demonstrated as when to turn and walk back at the starting position. A standardized verbal encouragement was issued at the start of each minute throughout the test. Subjects were allowed to rest or stop anytime and anywhere if they are breathless and until they had rested enough to start walking again when they felt appropriate.

Incremental Shuttle Walk Test (ISWT) was performed according to the standard guidelines described by Singh et al. (1992). The subjects were required to walk up and down a 10 m course marked by cones placed 9m apart, allowing 0.5 m for turning at each ends. The speed was regulated by an audio signal played on a tape cassette. Each minute, the speed of walking was increased by 0.17 m/s. Standardised instructions and verbal encouragement were issued prior to and during the test. The test was terminated either: (1) when subject was too breathless to maintain the required speed; (2) if the subject failed to complete a shuttle in the time allowed (i.e. when he was farther than 0.5 m from the cone at the time when the beep sounded), or (3) the subject attained 85% of predicted maximum heart rate derived from formula $220 - \text{age}$.

DATA ANALYSIS

All indices are expressed as means \pm SD. ANOVA and Student's *t*-test were calculated for paired comparisons. The patterns of changes of the data from baseline were analysed using linear regression. Scatter plots were made for comparison of estimated and measured values. A *p* value < 0.05 was considered significant.

RESULTS

PEAK HR, PEAK DYSPNOEA SCORE AND END-OXYGEN SATURATION IN BOTH TESTS

Analysis demonstrated that the mean values for peak HR in 6MWT and ISWT were 117.1 ± 16.3 bpm and 113.3 ± 13.1 bpm, respectively. The difference in the peak HR between both tests was not significant ($p = 0.27$). As for peak dyspnea score, the mean values are 7.0 ± 2.2 and 6.6 ± 1.9 , in 6MWT and ISWT, respectively. There was no significant difference of the peak dyspnea score between both test, with $p = 0.36$. The results also showed no significant difference in the end-oxygen saturation between 6MWT and ISWT with $p = 0.85$. The respective mean values of oxygen saturation were 89.3 ± 11.4 and 89.2 ± 10.5 .

TABLE 1. Dyspnoea score during 6MWT and ISWT

Peak Dyspnoea score	Mean	SD	range	<i>p</i>
6MWT	7.0	2.2	2 - 9	0.36
ISWT	6.6	1.9	2 8	

PATTERN OF CHANGES OF HEART R IN BOTH TESTS

In the analysis of the pattern of changes of HR, the time at which a measurement was taken was expressed as a

percentage of the maximum time taken for that test (% of time) whilst measurements of HR were expressed as a percentage of the change from baseline to maximum values (% of HR). The mean values for % of HR in 6MWT and ISWT are $27.2 \pm 17.3\%$ and $25.2 \pm 23.6\%$, respectively. Linear regression suggested that there were significant relationship between the % of HR and % of time in both tests, with $p = 0.02$ and $p = 0.05$ respectively. The effect size in 6MWT was small ($R = 0.21$), but moderate in ISWT ($R = 0.36$). The HR increase linearly with time in both 6MWT and ISWT. (Figures 1 & 2)

PATTERN OF CHANGES OF DYSPNOEA SCORE IN BOTH TESTS

In the analysis of the pattern of changes of dyspnea score, the time at which a measurement was taken was expressed as a percentage of the maximum time taken for that test (% of time) whilst measurements of dyspnea score was expressed as a percentage of the change from baseline to maximum values (% of dyspnea). Findings showed that there was a significant relationship between the % of dyspnea and % of time in 6MWT and ISWT ($p < 0.001$ for both). The mean values for the % of dyspnea are $28.8 \pm 15.9\%$ in 6MWT and $23.9 \pm 15.8\%$ in ISWT. These were strong relationships with $R = 0.64$ and $R = 0.67$ respectively (Figures 3 & 4).

DISTANCE WALKED IN BOTH TESTS

The mean value for the distance walked was 6MWT is 427.4 ± 66.6 m and 312.0 ± 88.8 m in ISWT. During ISWT, 9 of the subjects, i.e. 45%, stopped the test because they felt breathless. The rest of the subjects stopped the test because of leg fatigue and 5 of them cannot cope with the pace of the tape recorder instruction. Results showed significant differences and there was a strong relationship between distance walked in both tests, with $p = 0.01$. The $R=0.58$ demonstrate moderate to large effect size. The distance

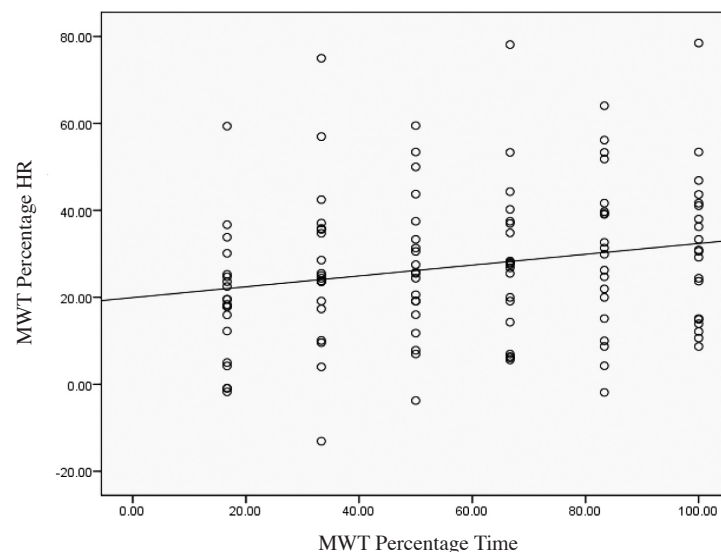


FIGURE 1. Changes of heart rate with time in 6MWT

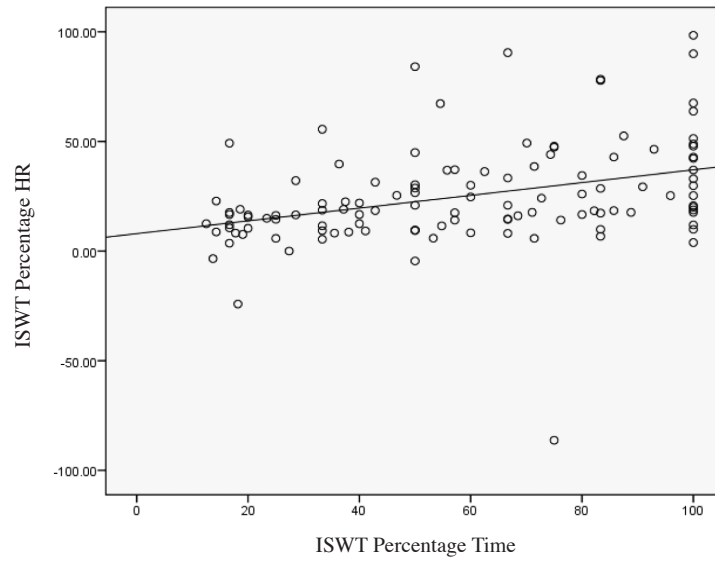


FIGURE 2. Changes of heart rate with time in ISWT

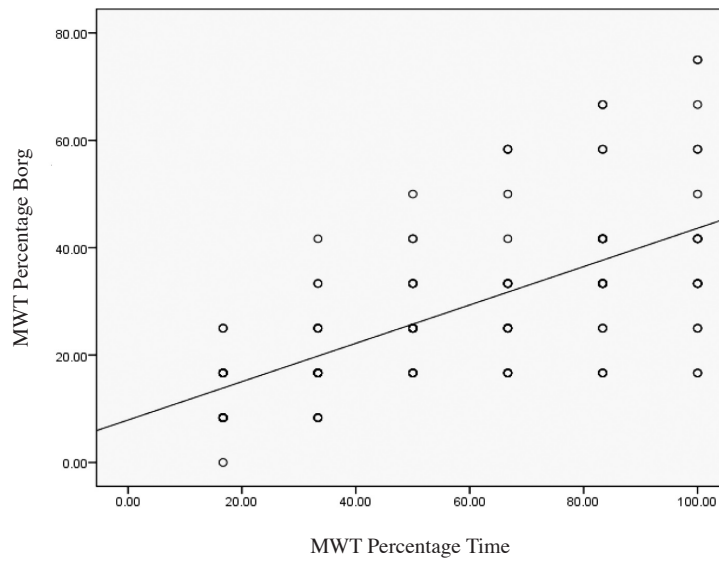


FIGURE 3. Changes of dyspnea score with time in 6MWT

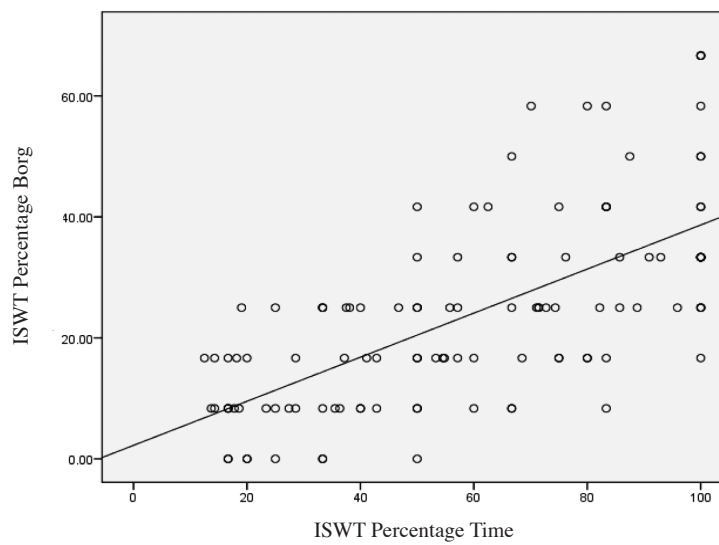


FIGURE 4. Changes of dyspnea score with time in ISWT

walked in 6MWT correlated with the age group and BMI category, but no significant difference was observed in both tests.

DISCUSSION

Heart rate is one of the objective parameters in determining the physiological responses of cardiorespiratory system. In these study, it was observed that both the walking tests could elicit HR responses with mean value of 117.1 ± 16.3 bpm in 6MWT and 113.3 ± 13.1 bpm in ISWT. Dyspnea score is a tool that is widely used in assessing the exertion level subjectively among COPD patients. In this study, both 6MWT and ISWT produced consistent dyspnea score with mean values of 7 ± 2.2 and 6.6 ± 1.9 , respectively.

The finding of this study is consistent with previous studies (Casas et al. 2002; Turner et al. 2004; Vagaggini et al. 2003) but it contravenes with the study by Singh et al. (1992) that showed HR and dyspnea score was significantly lower in 6MWT compared to ISWT. This difference might be due to the adoption of different protocols of 6MWT. In this study standardized instructions and encouragements for each minutes of walk was done thus such encouragements will motivate the subjects and hence improve their performance. There was also no significant difference of the peak HR between both tests, as well as in peak dyspnea score. The confidence level of 95% might be reduced if the number of subject was to increase and would then produce a statistically significant difference.

The pattern of changes of HR and dyspnea score are important in determining the level achieved at the end of exercise training. Although HR changes linearly with time in both 6MWT and ISWT, but the relationship in 6MWT was less strong than in ISWT. These findings were also different from that produced by Turner et al. (2004) where HR changes a linearly in 6MWT but linearly in ISWT. Their study showed that HR had a fast increase in the first few minutes of 6MWT and maintain a lower increment after that. The effect size of this relationship in 6MWT was smaller than normal ($R = 0.21$) compared to ISWT which is normal ($R = 0.36$). It could also be observed from the graph that the distribution of the changes of HR in 6MWT was quite consistent in each minute, as the distribution was rather focus and near to the linear line in ISWT. This suggested that the relationship of change of HR in 6MWT was less strong than in ISWT. According to the previous studies, the magnitude of load-associated stress in individual is titrated and self-paced to an end point that represents their maximum (Killian et al. 1992; Swinburn et al. 1985).

Regardless of what type of exercise activities, most of the subject terminated the exercise at an intensity which is sub-maximal. This was suggested in previous studies (Palange et al. 2000; Turner et al. 2004).

All studies showed that only a small portion of patient with COPD were ready to exercise themselves to a level at which the intensity of the symptoms were maximal. On the contrary, most of the individuals would choose to

terminate the exercise when the intensity was high enough to the level they tolerated in prior exercises (Killian et al. 1992).

This study suggests that the relationship between dyspnea score and time, and relationship between HR and time had their own significant level respectively. It was found that the relationships of HR with time were strong and significant in both tests. The distributions of dyspnea score were quite consistent with a steady increase at each minute. The changes of dyspnea score with time were linear and proportionate in both tests, which was different from Turner et al. (2004). Their study indicated that dyspnea score changes linearly in 6MWT but a linearly in ISWT.

Findings suggested significant lowered oxygen saturation at the end of each tests were parallel and consistent with previous studies (Palange et al. 2000; Poulain et al. 2003). These studies recorded that individuals with COPD were found to have incidents of large desaturation after walking exercises either walking at a constant speed and resistance or walking with increment, as compared to bicycle exercises, though not similar to all the cases. The reasons for this was still unexplainable. It could be related with conditions such as increase in ventilation/perfusion mismatch while walking compared to while cycling, as a result of differences in body posture, functional residual capacity, and/or pulmonary hemodynamic; effects from reflex impulse to the respiratory center which was stimulated by the arm muscles where by the upper limbs were more active while walking than in cycling; an increase in chemical drive to breathe and a higher ventilation while cycling, as a result of high accumulation of lactic acid; or possibly the use of chest wall muscles to perform postural tasks during walking at the expense of ventilation (Poulain et al. 2003; Servino et al. 2000). In this study, the distance walked between both tests were significantly different but were strongly correlated in both tests. This means that the distances walked were consistent and inter-related in both tests, as suggested in previous study (Turner et al. 2004). However; the distance walked should not be considered or measured interchangeably between both tests.

CONCLUSION

Both 6MWT and ISWT elicited similar peak HRs and dyspnea scores suggesting both test could be used to challenge patient to a certain level of cardiovascular and respiratory stress. The pattern of response of heart rate and dyspnea in both test suggest that patients with COPD titrate exertion against dyspnea to achieve a peak tolerable intensity. Thus, both field tests could produce similar physiological responses in COPD patient.

REFERENCES

- ATS. 1999. American Thoracic Society Statement: Pulmonary rehabilitation. *Am. J. Respir. Crit. Care Med.* 159: 1666-1682.

- Australian Lung Foundation & Australia Physiotherapy Association. 2007. The pulmonary rehabilitation toolkit: an initiative of the Australian Lung Foundation and Australia Physiotherapy Association. *Australian Journal of Physiotherapy*. 53: 139.
- Casas, A., Vilaro, J., Rabinovich, A., Mayer, A., Barbera, J.A., Rodriguez-Roisin, R. & Roca, J. 2002. Encouraged six minute walking test reflects 'maximal' sustainable exercise performance in COPD patients. *Am. J. Respir. Crit. Care Med.* 165: A503.
- Cooper, C.B. 2001. Exercise in chronic pulmonary disease: aerobic exercise prescription. *Med. Sci. Sports Exerc.* 33: S671-S679.
- Curtis, J.R., Martin, D.P. & Martin, T.R. 1997. Patient-assessed health outcomes in chronic lung disease: what are they, how do they help us, and where do we go from here? *Am J Respir Crit Care Med.* 156: 1032-9.
- Curtin, J.R. & Patrick, D.L. 2003. The assessment of health status among patients with COPD. *Eur Respir J Suppl.* 41: 36s-45s.
- Jones, P.W. 2001. Health status measurement in chronic obstructive pulmonary disease. *Thorax* 56: 880-887.
- Killian, K.J., Leblanc, P., Martin, D.H., Summers, E., Jones, N.L. & Campbell, E.J. 1992. Exercise capacity and ventilatory, circulatory, and symptom limitation in patients with chronic airflow limitation. *Am. Rev. Respir. Dis.* 146: 935-940.
- Leidy, N.K. 1995. Functional performance in people with chronic obstructive pulmonary disease. *Image J. Nurs. Sch.* 27: 23-34.
- Lewko, A., Marshall, J. & Garrod, R. 2007. Ambulatory oxygen therapy assessment: a comparative study of incremental shuttle and 6-minute walking tests. *Physiotherapy* 93(4): 261-266.
- Palange, P., Forte, S., Onorati, P., Manfredi, F., Serra, P. & Carlone, S. 2000. Ventilatory and metabolic adaptations to walking and cycling in patients with COPD. *J. Appl. Physio.* 88: 1715-1720.
- Pauwels, R.A., Buist, A.S., Calverley, P.M., Jenkins, C.R. & Hurd, S.S. 2001. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. NHLBI/WHO global Initiative for chronic obstructive lung disease (GOLD) workshop summary. *Am J Respir Crit Care Med.* 163: 1256-76.
- Poulain, M., Durand, F., Palomba, B., Ceugniet, F., Desplan, J., Varray, A. & Prefaut, C. 2003. 6-minute walk testing is more sensitive than maximal incremental cycle testing for detecting oxygen desaturation in patients with COPD. *Chest* 123: 1401-1407.
- Servino, S., Marcello, M. & Antonelli, S. 2000. Shuttle walking test induces a similar cardiorespiratory performance than 6 minute walking test in COPD patients. *Eur. Respir. J.* 16: 29s.
- Steele, B. 1996. Timed walking tests of exercise capacity in chronic illness. *J. Cardiopulm. Rehabil* 16: 25-33.
- Singh, S., Morgan, D., Scott, S., Walters, D. & Hardman, A. 1992. Development of a shuttle walking test of disability in patients with chronic airways obstruction. *Thorax* 47: 1019-1024.
- Swinburn, C.R., Wakefield, J.M. & Jones, P.W. 1985. Performance, ventilation, and oxygen consumption in three different types of exercise tests in patients with chronic obstructive lung disease. *Thorax* 40: 581-586.
- Turner, S.E., Eastwood, P.R., Cecins, N.M., Hillman, D.R. & Jenkins, S.C. 2004. Physiologic responses to incremental and self-paced exercise in COPD: a comparison of three tests. *CHEST* 126: 766-773.
- Vagaggini, B., Taccola, M., Severino, S., Marcello, M., Antonelli, S., Brogi, S., Simone, C.D., Giardina, A. & Paggiaro, P.L. 2003. Shuttle Walking Test and 6-Minute Walking Test induce a similar cardiorespiratory performance in patients recovering from an acute exacerbation of chronic obstructive pulmonary disease. *Respiration* 70: 579-584.

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