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Comparison of the physiological responses of the Incremental Shuttle Walk test and Glittre-ADL test: complementary instruments for the evaluation of functional capacity

Comparação das respostas fisiológicas do incremental shuttle walk test *e do* Glittre-ADL test*: instrumentos complementares para avaliação da capacidade funcional*

Comparación de las respuestas fisiológicas de incremental shuttle walk test *y de* Glittre-ADL test*: instrumentos complementarios para evaluar la capacidad funcional*

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ABSTRACT | The aim of the study was to assess and compare the cardiovascular, ventilatory and metabolic responses of the Incremental Shuttle Walk test (ISWT) and Glittre Activities of Daily Living test (Glittre-ADL test). This is a cross-sectional study with individuals. The functional capacity (FC) was evaluated by distance and peak oxygen consumption (VO_{2peak}) in the ISWT and time spent and VO_2 in Glittre-ADL test. Thirty individuals went through 656.67 (CI95%:608.8-704.5) meters at the ISWT and performed the Glittre-ADL test in 2.4 (CI95%:2.2-2.6) minutes. The peak VO_2 of the ISWT was 27.8 (CI95%25.6-29.9) vs. 22.2 (CI95%20.5-24.1) $mL \times kg^{-1} \times min^{-1}$ ($p<0.001$) in the steady state (SS) of the Glittre-ADL test. Correlations between distance traveled in the ISWT and the time spent in Glittre-ADL test, VO_2 peak of ISWT and VO_2 in SS of Glittre-ADL test and HR at the ISWT peak and at the Glittre-ADL test SS were moderate to high magnitude. The Glittre-ADL test has lower metabolic, cardiovascular and ventilatory responses compared to ISWT, despite correlations between variables.

Keywords | Oxygen Uptake; Exercise Test; Activities of Daily Living; Walk Test.

RESUMO | O objetivo deste estudo foi avaliar e comparar respostas metabólicas, cardiovasculares e ventilatórias do *incremental shuttle walk test* (ISWT) e do *Glittre activities of daily living test* (Glittre-ADL test). Trata-se de um estudo transversal, realizado com indivíduos saudáveis. A capacidade funcional (CF) foi avaliada pela distância percorrida e consumo de oxigênio pico (VO_{2pico}) no ISWT e pelo tempo gasto e VO_2 no Glittre-ADL test. Trinta indivíduos percorreram 656,67 (IC95%:608,8-704,5) metros no ISWT e executaram o Glittre-ADL test em 2,4 (IC95%:2,2-2,6) minutos. O VO_2 pico do ISWT foi 27,8 (IC95%25,6-29,9) *versus* 22,2 (IC95%20,5-24,1) $mL \times kg^{-1} \times min^{-1}$ ($p<0,001$) no estado estável (EE) do Glittre-ADL test. As correlações entre distância percorrida no ISWT e o

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tempo gasto no Glittre-ADL test, o VO_{2pico} do ISWT e o VO_2 no EE do Glittre-ADL test e a FC no pico do ISWT e no EE do Glittre-ADL test foram de moderada a alta magnitude. O Glittre-ADL test apresenta menores respostas metabólicas, cardiovasculares e ventilatórias se comparado ao ISWT.

Descritores | Consumo de Oxigênio; Teste de Esforço; Atividades Cotidianas; Teste de Caminhada.

RESUMEN | El presente estudio tuvo el objetivo de evaluar y comparar las respuestas metabólicas, cardiovasculares y ventilatorias de *incremental shuttle walk test* (ISWT) y de *Glittre activities of daily living test* (Glittre-ADL test). Es un estudio transversal realizado con individuos sanos. La capacidad funcional (CF) se evaluó utilizando la distancia recorrida y consumo máximo de oxígeno ($VO_{2máx}$) en el ISWT y el tiempo empleado y VO^2 en el Glittre-ADL test. Treinta individuos caminaron 656,67 (IC95%:608,8-704,5) metros en el ISWT y realizaron el Glittre-ADL test en 2,4 (IC95%:2,2-2,6) minutos. El VO_2 máx del ISWT fue de 27,8 (IC95%25,6-29,9) versus 22,2 (IC95%20,5-24,1)$mL \times kg^{-1} \times min^{-1}$ ($p<0,001$) en el estado estable (EE) del Glittre-ADL test. Las correlaciones entre la distancia recorrida en el ISWT y el tiempo empleado en el Glittre-ADL test, el $VO_{2máx}$ del ISWT y el VO_2 en el EE de Glittre-ADL test y la FC en el máximo del ISWT y en el EE de Glittre-ADL test fueron de moderada a alta magnitud. El Glittre-ADL test presenta respuestas metabólicas, cardiovasculares y ventilatorias más bajas en comparación con el ISWT.

Palabras clave | Consumo de Oxígeno; Prueba de Esfuerzo; Actividades Cotidianas; Prueba de Paso.

INTRODUCTION

Field tests associated with predictive equations to indirectly determine peak oxygen consumption (VO_{2peak}) have been extensively used in clinical practice[1] as reproducible alternatives[2] for assessing functional capacity (FC), as they are able to express the functional capacities of the respiratory, cardiovascular and musculoskeletal systems[3]. They are operationally simple, accessible and low cost[4]. The use of these tests makes it possible to assess FC and identify limiting factors for exercise performance, as well as the response to interventions quickly and safely[5].

These are tests applied under different health conditions, in which the predominant activity is walking[6-8]. The incremental shuttle walk test (ISWT), controlled by external audible signals, aims to assess FC, considering limiting symptoms[9,10]. The test is valid and reliable to estimate the FC of individuals with chronic respiratory disorders, in addition to being responsive to pulmonary rehabilitation and the use of bronchodilator agents[11,12]. The Glittre activities of daily living test (Glittre-ADL test), a multitasking test[13,14], is valid for assessing the FC of individuals with chronic obstructive pulmonary disease (COPD). It has adequate test-retest reliability[15], reproducible for different populations[16-18], and is responsive to pulmonary rehabilitation[15] and valid for differentiating the functional status of healthy individuals from those with COPD[19].

Considering that both tests are indicated to assess FC under different aspects, the possibility of identifying its peculiarities provides subsidies for physical therapists and expands the body of knowledge on the subject. Thus, the study aimed to evaluate and compare the metabolic, cardiovascular and ventilatory responses of ISWT and Glittre-ADL test in healthy individuals.

METHODOLOGY

This is a cross-sectional study, approved by the institution's Ethics Committee. All participants signed the Free and Informed Consent Form. Healthy individuals between 18 and 59 years old; regular body mass index (BMI)[20] and spirometric parameters[21]; non-smokers[19]; without neuromuscular, respiratory and/or cardiac diseases[22]; and without limitation for walking were eligible. Those with resting blood pressure (BP)≥160/105 mmHg[23] and/or peripheral oxygen saturation (SpO_2)<90%[24] and/or heart rate (HR)>120bpm[25] were excluded before the tests were performed, in addition to those unable to understand and/or perform the study procedures.

The sample calculation initially considered the following variables: oxygen consumption (VO_2) in the steady state (SS) of the Glittre-ADL test and VO_{2peak} of the ISWT, with statistical power of 0.80 and effect size of the difference of 0.50 established arbitrarily[26], in which the sample size was 64 participants. Later, with 31 participants, the effect size of the difference was 2.47, corresponding to nine individuals.

Procedures were carried out by trained researchers. BP, respiratory rate (*f*), HR and SpO_2 were measured and the percentage of $HR_{maximum}$ was calculated[27].

The spirometric data obtained in the pulmonary function test[28] were compared to those predicted[21], with values ≥80% of expected. The perceived level of physical activity was assessed using the human activity profile (HAP)[29].

Functional capacity was evaluated by the ISWT and Glittre-ADL test[15], with direct measurement of breath-by-breath gas exchange[30], made with a portable gas analyzer MetaMax 3B (MetaSoft Cortex, from Germany). The participant received specific instructions and demonstrations on how to perform each test[9,15], in a random order, within an interval of 20 minutes. Metabolic, cardiovascular and ventilatory variables were recorded during one minute of rest in a sitting position, cardiovascular parameters and the subjective perception of pre and post-test effort. HR was recorded continuously using a cardiofrequency meter (Polar, HR Transmitter Belt H7, from Finland). At the end of both tests, the cardiovascular parameters were again. The considered operational variables for the Glittre-ADL test were time spent and VO^2 in the SS and for the ISWT, the distance covered and the VO_{2peak}. The VO_2 achieved in the Glittre-ADL test was compared to the predicted values[31]. The VO_2 processing of the Glittre-ADL test was performed by analyzing time series to define the SS[32] and the ISWT was related to the 10 seconds with the highest VO_2 average, obtained during the last 30 seconds of the test[30].

The data were reported as measures of central tendency and dispersion, according to the Shapiro-Wilk test. Paired t-tests or Wilcoxon tests were applied for comparison while Pearson correlation was applied between variables. The statistical power and the magnitude of the correlations were considered according to Portney and Watkins[26]. Statistical significance was considered 5% (Statistical Package for Social Science-SPSS®, version 15).

RESULTS

Among 42 eligible participants, 11 were excluded due to pulmonary function (Figure 1).

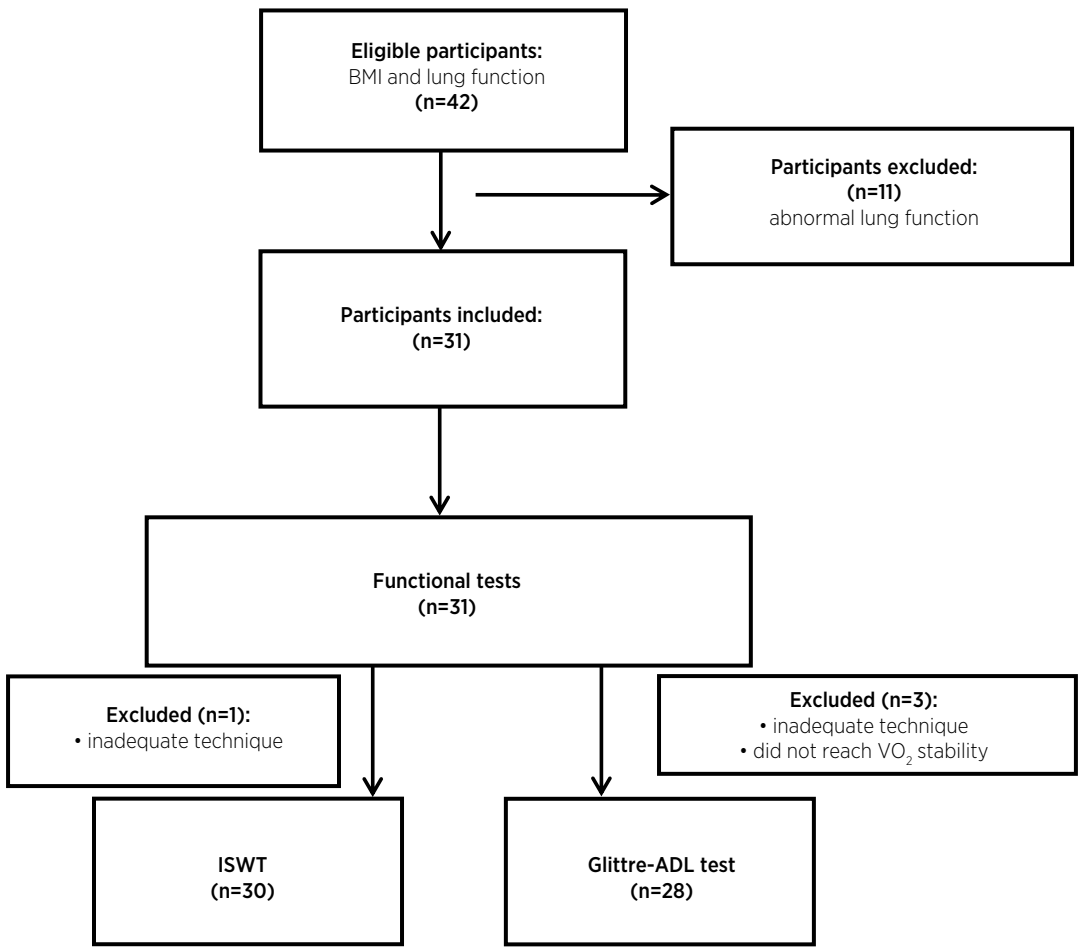

Figure 1. Study flowchart

n: sample number; BMI: body mass index; VO_2: oxygen consumption; ISWT: incremental shuttle walk test; Glittre-ADL test: Glittre activities of daily living test.

Table 1 shows demographic and anthropometric characteristics, lung functionality and the perceived level of physical activity of the participants.

Table 1. Characterization of study participants

Characteristics	n=30
Age (years)	29 (26.31-31.7)
Sex (n)	
Women	22
Men	8
BMI (kg/m^2)	22.6 (21.62-23.58)
FVC (% predicted)	95.1 (91.7-98.4)
FEV_1 (% predicted)	95.6 (92-99.4)
FEV_1/FVC (% predicted)	100.2 (98.1-102.3)
EAA_PAH	91.30 (89.85-92.75)

Data presented as mean (95% confidence interval of mean) or absolute frequency. n: sample number, BMI: body mass index, kg/m^2: kilogram per square meter, FVC: forced vital capacity,%:FEV_1 percentage, FEV_1: forced expiratory volume in the first second, FEV_1/FVC: forced expiratory volume ratio in the first second and forced vital capacity, EAA_PAH: adjusted activity score of the human activity profile.

At ISWT, participants completed the test between the 7th and 12th level (median=10; Q_1-Q_3: 9-10) and walked, on average, 656.67 (95%CI: 608.84-704.5) meters (m), in 9.1 (95%CI: 8.71-9.5) min, reaching a final speed close to 2 m/s. For the execution of the Glittre-ADL test, the average time spent was 2.4 (95%CI: 2.24-2.62) min.

Figure 2 shows the metabolic, cardiovascular and ventilatory variables obtained at the beginning and at the end of the ISWT and the Glittre-ADL test. A significant difference of 5.3 (95%CI: 4.1 - 6.5) mL×kg^{-1}×min^{-1} was found in the VO_2 achieved in the ISWT, equivalent to 81.6% of the predicted maximum, compared to the value achieved in the Glittre-ADL test, equal to 61.6%. The average percentage of HR reached in the ISWT represented 85.1% and in the Glittre-ADL test, 71.5%, of the predicted $HR_{maximum}$, which resulted in a statistically significant difference of 25.4 (95%CI: 21.4-29.3) bpm between tests. The ratio of ventilation and maximum voluntary ventilation (VE/VVM) was also significantly higher in the ISWT (46% of predicted), when compared to the Glittre-ADL test (27.4% of predicted), resulting in an average difference of 21.7 (95%CI: 18.2-25.3) L/min between tests.

Figure 3 shows the associations between distance covered in the ISWT and time spent in the Glittre-ADL test, VO_2 peak in the ISWT and VO_2 in the SS of the Glittre-ADL test and HR in the ISWT peak and in the steady state of the Glittre-ADL test.

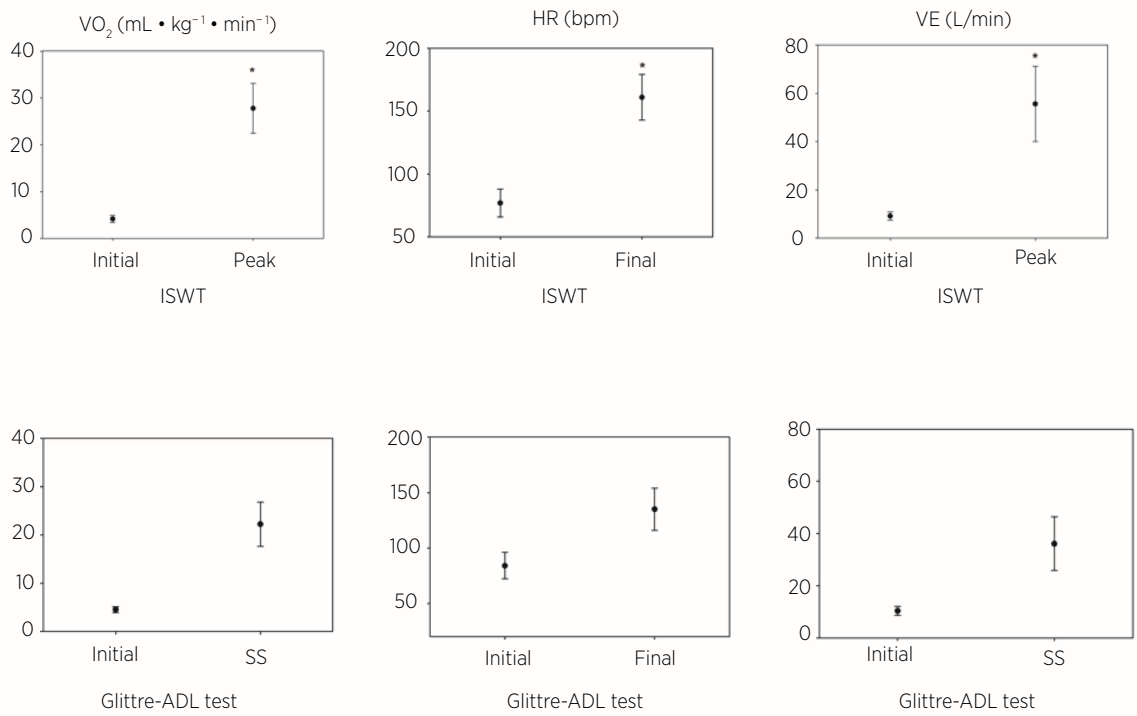

Figure 2. Data presented as mean and 95% confidence interval of the mean for metabolic, cardiovascular and ventilatory variables at the beginning, peak, stable state and end of the tests.

ISWT: incremental shuttle walk test; Glittre-ADL test: Glittre activities of daily living test; VO_2: oxygen consumption; mL: milliliters; kg: kilogram; m: meters; min: minutes; HR: heart rate; bpm: beats per minute; VE (L/min): ventilation in liters per minute; SS: steady state; circle: average; bars: 95% confidence interval of the mean, *p<0.0001 between ISWT and Glittre-ADL test.

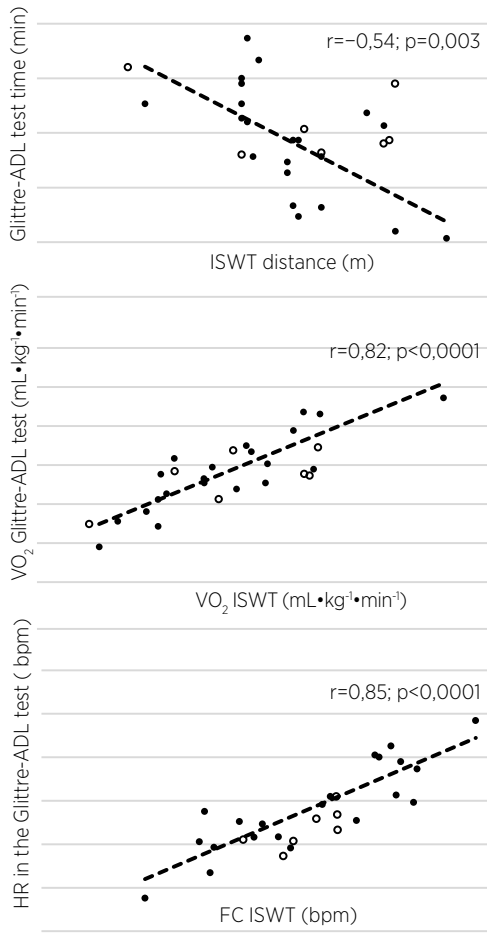

Figure 3. Correlation between time spent in the Glittre-ADL test and distance covered in the ISWT (upper), VO_2 in the steady state of the Glittre-ADL test and VO_2 peak of the ISWT (average), HR in the stable state of the Glittre-ADL test and in the peak of the ISWT (bottom)

Hollow circles: men; filled circles: women; ISWT: incremental shuttle walk test; Glittre-ADL test: Glittre activities of daily living test; m: meters; min: minutes; VO_2: oxygen consumption; mL: milliliters; kg: kilogram; bpm: beats per minute.

DISCUSSION

The main result of the study indicates that the Glittre-ADL test requires lesser metabolic, cardiovascular and ventilatory overload. There was an increase of 25.2% in VO_2 and 19.2% in HR (power 99% and 96%; p<0.001, respectively) to perform the ISWT, when compared to the Glittre-ADL test. This finding confirms the proposal of the Glittre-ADL test to evaluate FC through mimicking of ADLs[15,33].

The greater overload required by ISWT was expected to be an incremental and externally paced test. Singh et al. showed that the ISWT reflects similar responses to the cardiopulmonary stress test (TECP) in individuals with COPD, in addition to showing a high correlation between VO_{2peak} and workload, being valid for assessing maximum exercise capacity[9,11]. Depending on the health condition, the ISWT can be representative of a maximum stress test. In this study, although the VO_{2peak} of the ISWT represents 81.6% of the VO_2 estimated by equations, the respiratory exchange ratio (R) achieved in the ISWT was >1, indicating a maximum effort even in young and healthy individuals. This finding in the Glittre-ADL test characterizes it as a submaximal test (R=0.71)[34].

Cardiovascular overload, assessed by the percentage of expected maximum HR generated by ISWT, was significantly higher when compared to the Glittre-ADL test. Previous studies have shown that in healthy individuals[35] and in those with COPD[36], activities with the upper limbs may cause significant cardiovascular overload. Although the Glittre-ADL test is on average 3.8 times shorter than the ISWT, there was a 16.2% difference in the HR achieved in the two tests. This behavior is evidenced by the cardiovascular overload generated when performing activities with the upper limbs.

In individuals with COPD, Karloh et al.[37] compared responses induced by the Glittre-ADL test and the six-minute walk test and observed a high magnitude

correlation between the VO_{2peak} of the two tests, being significantly higher at the end of the Glittre-ADL test. Systematic reviews[11,12] showed a strong correlation between $VO_{2\ peak}$ in TECP and ISWT in individuals with COPD, suggesting that the two tests may cause similar behavior in physiological responses.

The time spent on the Glittre-ADL test and the distance covered on the ISWT are moderately correlated. The individual who takes the Glittre-ADL test in the shortest time is likely to travel the longest distance on the ISWT. However, VO_2 and HR had a strong correlation, indicating that these variables showed the same behavior. Although the Glittre-ADL test is self-certified, it requires at least 80% cardiovascular/metabolic and 60% ventilatory demand than that required by ISWT. This finding contributes to the choice of the FC assessment instrument, considering the individual's health condition and the objectives of the assessment.

The results presented are restricted to healthy individuals and their generalization to other health conditions must be considered with caution.

CONCLUSION

It is recommended that the evaluated tests become complementary tools in the evaluation of FC. Although the Glittre-ADL test presents lower metabolic, cardiovascular and ventilatory responses, when compared to ISWT, the correlations between these variables are moderate to high. Thus, the choice for an assessment method depends on goals, resource availability and the specificities of the population to which they will be applied.

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