

## Concurrent validity and intra-rater reliability of the Glittre ADL-Test in obstructive sleep apnea

### Validade concorrente e reprodutibilidade intra-avaliador do teste de AVD-Glittre na apneia obstrutiva do sono

José Carlos Nogueira Nóbrega Júnior<sup>1</sup>, Armêle Dornelas de Andrade<sup>2</sup>, Adília Karoline Ferreira Souza<sup>3</sup>, Maria Inês Remígio de Aguiar<sup>2</sup>, Rodrigo Pinto Pedrosa<sup>4</sup>, Maria do Socorro Brasileiro-Santos<sup>5</sup>, Anna Myrna Jaguaribe de Lima<sup>6</sup>

1. Facottur, Olinda, PE, Brazil

2. Universidade Federal de Pernambuco, Recife, PE, Brazil

3. Universidade Estadual da Paraíba, Campina Grande, PB, Brazil

4. Pronto Socorro Cardiológico de Pernambuco (PROCAPE), Universidade de Pernambuco, Recife, Brazil

5. Universidade Federal da Paraíba, João Pessoa, Brazil

6. Universidade Federal Rural de Pernambuco, Recife, PE, Brazil

#### ABSTRACT

**Objective:** To evaluate the concurrent validity and intrarater reliability of the Glittre-ADL test to determine exercise capacity in subjects with obstructive sleep apnea (OSA). **Methods:** Twenty-two (22) subjects with mild to severe OSA ( $50.7 \pm 11.2$  years,  $32.0 \pm 4.0$  kg/m<sup>2</sup>) performed the Glittre-ADL test and the cardiopulmonary exercise testing (CPET). The tests were carried out in two different days, twice a day, and the order was determined by randomization. **Results:** The maximum HR (HR<sub>max</sub>) in the Glittre-ADL test was  $130.6 \pm 13.3$  bpm. Regarding the variables related to CPET, the volunteers had values of maximal oxygen consumption (VO<sub>2max</sub>) of  $25.4 \pm 5.3$  ml/kg/min, VO<sub>2</sub> on the first threshold of  $19.4 \pm 3.9$  ml/kg/min and maximum HR of  $161.3 \pm 15.2$  bpm. A moderate negative correlation was found between the Glittre-ADL test performance time and VO<sub>2max</sub> ( $r = -0.424$ ;  $p = 0.049$ ). Excellent agreement and consistency between measurements was observed in analyzing the test-retest reliability of the total performance time of the Glittre-ADL test (intraclass correlation coefficient (ICC) = 0.865, 95% CI: 0.379-0.965 ( $p \leq 0.0001$ )). **Conclusion:** According to the results of the present study, Glittre-ADL test is reliable and valid for evaluating functional exercise capacity in patients with moderate and severe OSA. Furthermore, it also could be considered as a submaximal clinical exercise tolerance test for this population.

**Keywords:** obstructive sleep apnea; exercise tolerance; exercise test.

#### RESUMO

**Objetivo:** O objetivo deste trabalho foi testar a hipótese que o teste de AVD-Glittre (TGlittre) tem validade concorrente e reprodutibilidade intra-avaliador em indivíduos com apneia obstrutiva do sono (AOS). **Métodos:** Foram avaliados 22 indivíduos, de ambos os sexos, com diagnóstico AOS. O TGlittre e o teste de esforço cardiopulmonar (TECP) foram realizados em dois dias diferentes, duas vezes cada, e a ordem era determinada por randomização. **Resultados:** A FC máxima (FC<sub>máx</sub>) obtida no TGlittre foi de  $130,6 \pm 13,3$  bpm e o tempo total para a realização do teste foi de  $3,4 \pm 0,5$  min. Sobre as variáveis analisadas no TECP, foram obtidos os seguintes valores: consumo máximo de oxigênio (VO<sub>2max</sub>) =  $2,4 \pm 5,3$  ml/kg/min, VO<sub>2</sub> no primeiro limiar =  $19,4 \pm 3,9$  ml/kg/min, FC<sub>máx</sub> =  $161,3 \pm 15,2$  bpm e o tempo total de realização do teste foi de  $8,3 \pm 1,6$  min. Uma correlação negativa moderada foi verificada entre o tempo de realização do TGlittre e VO<sub>2max</sub> ( $r = -0,424$ ;  $p = 0,049$ ). Na análise da confiabilidade teste-reteste do tempo total de realização do TGlittre, foi observada uma excelente concordância e consistência entre as medidas (coeficiente de correlação intraclassa (CCI) = 0,865; IC95%: 0,379-0,965 ( $p \leq 0,0001$ )). **Conclusão:** O teste de TGlittre é válido e reprodutível na AOS. Além disso, é um teste de intensidade submáxima, fácil aplicação e baixo custo, que pode ser utilizado em larga escala.

**Palavras-chave:** apneia obstrutiva do sono; tolerância ao exercício; teste de esforço.

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Correspondence: Anna Myrna Jaguaribe de Lima, Universidade Federal Rural de Pernambuco, Rua Dom Manuel de Medeiros, s/n Dois Irmãos 52171-900 Recife PE, e-mail: anna.myrna@ufrpe.br

## Introduction

Obstructive sleep apnea (OSA) is characterized by recurrent hypoxia/reoxygenation patterns that cause oxidative stress and muscle injury [1-3]. These bioenergetic and structural changes in skeletal muscles are responsible for generalized fatigue and impaired functional exercise capacity in these individuals [3,4]. In addition, OSA may cause respiratory muscle weakness, thus promoting activation of cardiovascular reflexes. The muscle abnormalities that commonly occur in OSA associated with intermittent blood gas disorders compromise the integrity of the cardiorespiratory system, triggering the decline of exercise tolerance [5-8].

Thus, assessing functional exercise capacity provides important information for the diagnosis and prognosis of cardiopulmonary function through the behavior of metabolic, cardiac and respiratory systems during the cardiopulmonary exercise testing (CPET) [9]. Despite CEPT is the gold standard to assess exercise tolerance, the cost is high, and it requires specialized and trained personnel. Furthermore, CEPT is a maximum exercise test and could be not well-tolerated in elderly with comorbidities [10]. On the other hand, field tests appear as a less strenuous alternative. In addition to presenting good correlation with the activities of daily life, they are low cost, simply executed and easily reproducible [11,12].

In this context, the Glittre-ADL test has been able to reflect the functional limitations in studies with healthy subjects [13] and those affected by varied conditions such as COPD [14,15], cardiovascular diseases [16] and obesity [17].

Regarding OSA, there are still no reports in the literature on the use of the Glittre-ADL test to determine exercise tolerance in these subjects. Therefore, the objective of this study was to test the hypothesis that the Glittre-ADL test has concurrent validity and reliability in subjects with OSA.

## Methods

### *Sample*

This is a cross-sectional study and was approved by the Human Research Ethics Committee of the Federal University of Pernambuco (UFPE) in accordance with the resolution 466/12 CNS (No: 1068362). All volunteers included in the study were informed about the research and signed an informed consent form, designed by the principal investigator.

Volunteers were recruited from the Cardiologic Emergency Hospital of Pernambuco (PROCAPE) based on the evaluation of 428 individual (medical) records. All volunteers underwent a polysomnography (ApneaLink™-Resmed) for OSA diagnosis. Patients aged between 30 years and 65 years, with AHI (=Apnea Hypopnea Index)  $\geq 15$  events/hour (moderate to severe OSA), without a history of musculoskeletal, pulmonary or cardiac diseases and with BMI  $\leq 39.9$  kg/m<sup>2</sup> were included in the study.

An independent evaluator who did not participate in patient recruitment or in the testing performed the randomization for the test order, using the randomized.com software.

### *Cardiopulmonary exercise test (CPET)*

To evaluate the functional exercise capacity, CPET was performed using a treadmill ramp protocol (Centurium 300, Micromed, Brazil) and ErgoPCElite® software associated with an electrocardiogram (Micromed Brazil) with twelve derivations. In this protocol, the system suggests the velocity and inclination to be increased, so that the patient reaches their maximum oxygen consumption (VO<sub>2</sub>max.) within 10 minutes. The respiratory variables during exercise were obtained under standard conditions of temperature (18-22°C), pressure and humidity (50-70%), and collected using a face mask attached to a gas analyzer (Cortex - Metalyzer II - Germany). The patient was instructed not to verbally communicate during the examination, informing their levels of fatigue through manual gestures and requesting the end of the examination only at the moment of exhaustion. The test was considered maximal when the respiratory exchange ratio (R) was  $\geq 1.1$  [18].

### *Glittre-ADL Test*

The patients were instructed to walk 10 meters with a backpack (5.0 kg for men and 2.5 kg for women). The circuit consisted of 5 laps starting with the patient sitting on a chair, and upon receiving the command they would get up and walk fast up the middle of the course and go up and down a two-step staircase (17 cm height x 27 cm deep). Then they would continue (walking) until the end of the circuit, where there was a shelf containing three objects (1 kg each) on the highest shelf. They should move them one by one to the middle shelf (waist height), and finally to the lowest shelf (floor height). Next, the objects were replaced on the middle shelf and then on the highest shelf. The patient re-did the course, sitting, getting up and repeating the circuit. Heart rate (Frequency-Polar) and peripheral oxygen saturation (Oximeter-Pulse Oximeter PM 50) were monitored at each lap. Blood pressure and the subjective perception of effort (modified BORG scale) were measured at baseline at the end and after two minutes of recovery [19].

Two Glittre-ADL tests were performed within a maximum interval of one week, and with an interval of at least twenty-four hours between them. The data obtained for the fastest timed test were used for analyzing the physiological responses. The formula used to calculate the estimated HR<sub>max</sub> was:  $HR_{\text{max.estimated}} = 208 - (0.7 \times \text{age})$ , described by Tanaka H, Monahan K and Seals D [20].

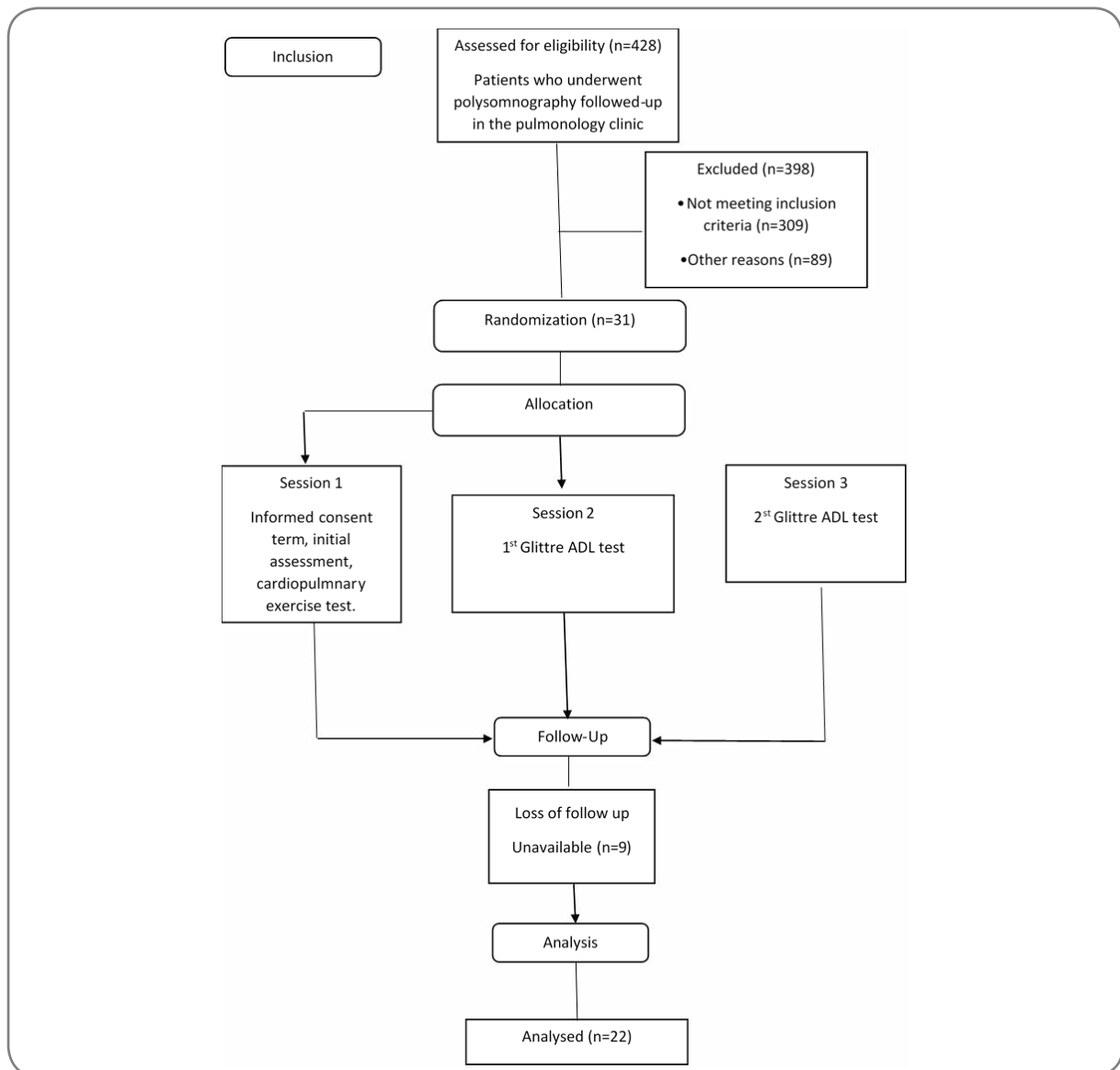
### *Data analysis*

Data were analyzed using the SPSS software version 20.0. The Spearman correlation test was used for the concurrent validation of the Glittre-ADL test, and the intraclass correlation coefficient (ICC) and the Bland-Altman method were used for

the reliability evaluation. The results were presented as mean and standard deviation, considering  $p < 0.05$  as the level of statistical significance.

## Results

In figure 1 is showed process of recruitment, allocation, follow-up and analysis of the participants.



**Figure 1-** Flow diagram of patient recruitment and progress

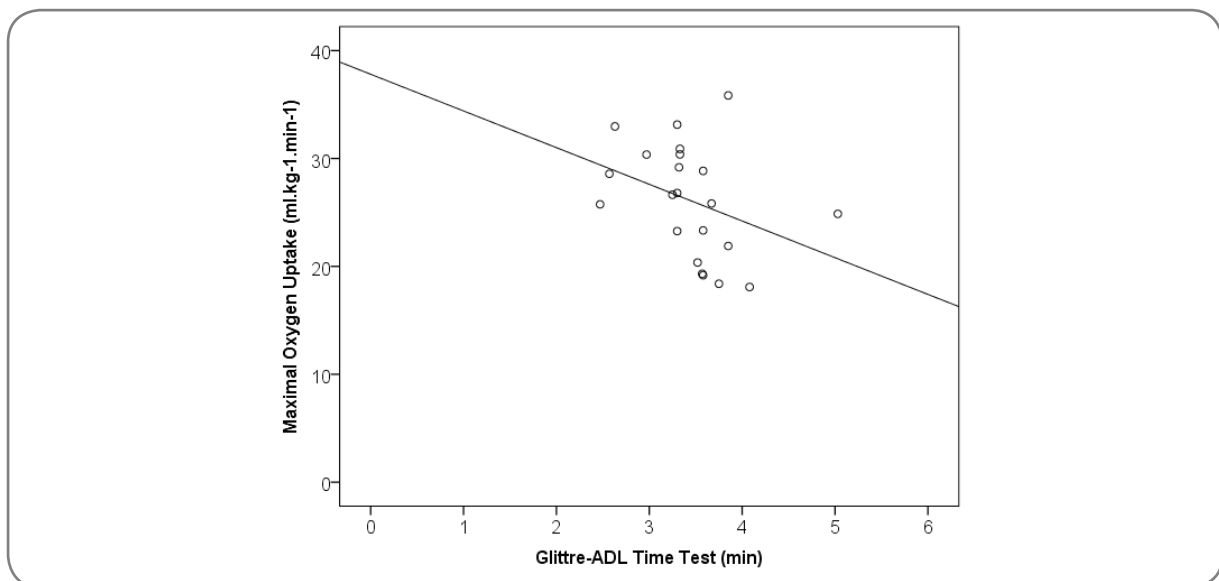
Twenty-two patients were evaluated (14 males (64%) and 8 females). The anthropometric and clinical characteristics of the sample are shown in Table I. The sample mostly consisted of individuals with OSA classified as severe (59.1%).

A negative and moderate correlation ( $r = -0.424$ ;  $p = 0.049$ ) was found in figure 2 between the  $VO_{2max}$  obtained on CPET and the performance time for the Glittre-ADL test.

**Table I** - Characteristics of the sample

Characteristics	
n (M/F)	22 (14M/8F)
Age (years)	50.7 ± 11.2
Weight (kg)	87.6 ± 15.5
Height (m)	1.65 ± 0.09
BMI (kg/m <sup>2</sup> )	32.0 ± 4.0
Abdominal circumference (cm)	105.9 ± 9.3
Neck circumference (cm)	42.1 ± 4.0
AHI (events/h)	33.7 ± 19.8
15<AHI<30 events/h (n/%)	13/59.1%
AHI>30 events/h (n/%)	9/40.9%
Comorbidities (n/%)	Hipertension (14/63.3%) Diabetes (7/31.8%)

n = sample size; M = males; F = females; BMI =body mass index; AHI = apnea-hipopnea index. Data are reported as mean ± standard deviation and percentage



**Figure 2** - Correlation plot between maximal oxygen consumption and Glittre-ADL time test ( $r = -0,424$ ;  $p = 0,049$ )

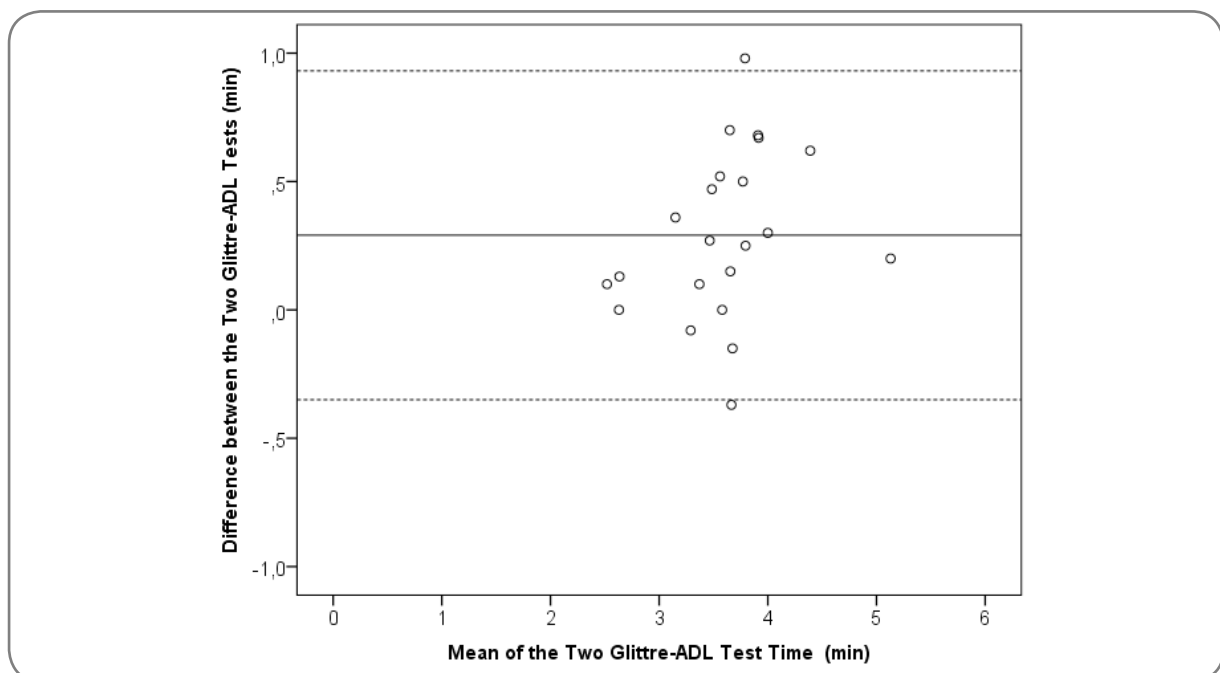
Table II shows the cardiorespiratory responses obtained on the maximum CPET and on the submaximal Glittre-ADL test. The volunteers presented  $VO_{2max}$  values of  $25.4 \pm 5.3$  ml/kg/min,  $VO_2$  at the first threshold of  $19.4 \pm 3.9$  ml/kg/min and  $HR_{max}$  of  $161.3 \pm 15.2$  bpm. The  $HR_{max}$  was  $130.6 \pm 13.3$  bpm for the Glittre-ADL test and the  $HR_{max}$  (%predicted) for the Glittre-ADL test was  $80.9 \pm 6.9\%$  of the  $HR_{max}$  obtained on the CPET.

**Table II** - Results of cardiopulmonary exercise testing and Glittre-ADL test

Variables	CEPT	Glittre-ADL Test
VO <sub>2 max</sub> (ml/kg/min)	25,4 ± 5,4	-
VO <sub>2 max</sub> (%predicted)	69,5 ± 10,8	-
VO <sub>2 (1st threshold)</sub> (ml/kg/min)	19,4 ± 3,9	-
HR <sub>max</sub> (bpm)	161,3 ± 15,2	130,6 ± 13,3
HR <sub>max</sub> (%predicted)	93,6 ± 5,2	80,9 ± 6,9
SBP <sub>rest</sub> (mmHg)	131,2 ± 9,9	127,6 ± 13,4
SBP <sub>max</sub> (mmHg)	176,7 ± 16,1	-
SBP <sub>recovery1'</sub> (mmHg)	-	156,2 ± 24,8
SB <sub>Precovery 2'</sub> (mmHg)	-	136,2 ± 16,6
DBP <sub>rest</sub> (mmHg)	80,8 ± 5,0	86,7 ± 10,1
DBP <sub>max</sub> (mmHg)	90,0 ± 8,3	-
DBP <sub>recovery 1'</sub> (mmHg)	-	91,4 ± 11,3
DBP <sub>recovery 2'</sub> (mmHg)	-	86,8 ± 9,9
Time (min)	8,2 ± 1,6	3,4 ± 0,5

CEPT = cardiopulmonary exercise testing; VO<sub>2max</sub> = maximal oxygen consumption; VO<sub>2</sub> = oxygen consumption; HR<sub>max</sub> = maximum heart rate; SBP<sub>max</sub> = maximum systolic blood pressure; SBP<sub>recovery1'</sub> = systolic blood pressure in the first minute of the recovery; SBP<sub>recovery2'</sub> = systolic blood pressure in the second minute of the recovery; DBP<sub>max</sub> = maximum diastolic blood pressure; DBP<sub>recovery1'</sub> = diastolic blood pressure at the first minute of the recovery; DBP<sub>recovery2'</sub> = diastolic blood pressure in the second minute of the recovery. Data are reported as mean and standard deviation

In the test-retest reliability for the total time to perform the Glittre-ADL test, the intraclass correlation coefficient (ICC) presented high reliability (0.865, 95% CI = 0.379-0.965,  $p < 0.0001$ ) (Figure 3).

**Figure 3** - Bland-Altman plot of agreement between test and retest of Glittre-ADL test

## Discussion

This is the first study to assess the concurrent validity and reliability of the Glittre-ADL test in OSA patients. The results showed a moderate negative correlation between the performance time of the Glittre-ADL test and VO<sub>2</sub>max, showing an association between the direct measurement of functional exercise capacity through the CPET, and the indirect measurement of functional exercise capacity through the Glittre-ADL test. Moreover, the test-retest reliability found of the Glittre-ADL was excellent, showing good agreement and consistency between the intra-rater measurements.

In the present study, the Glittre-ADL test can be considered an alternative to evaluate exercise tolerance, since a moderate concurrent validity was found between the Glittre-ADL test performance time and the VO<sub>2</sub>max obtained on the CPET. The Glittre-ADL test has already been used to assess exercise capacity in healthy subjects and in diseases such as COPD [14,15], heart failure [16] and obesity [17]. Although all conclude that the Glittre-ADL test may be useful in clinical practice to quantify functional capacity and functional capacity to exercise in these populations, only Karloh *et al.* [15] have compared their results with direct VO<sub>2</sub>max measurement.

The study conducted by Reis *et al.* [13] evaluated the Glittre-ADL test total performance time in a sample of healthy adult subjects and found that the mean time to finish the test was  $2.62 \pm 0.34$  min. In the present study, the time was  $3.44 \pm 0.54$  min. The longer time demanded by patients with OSA for completing the test can be attributed to the systemic repercussions caused by reoccurring episodes of hypoxia/reoxygenation present in the disease. The presence of associated comorbidities such as hypertension and diabetes which may also limit performance on tests that assess functional exercise capacity should also be evaluated. Silva *et al.* [21] determined the validity and the reliability of the Glittre-ADL in subjects with Parkinson disease and observed that the time to execute the Glittre-ADL test was 3.69 min (2.96-4.48 min).

In this study, the HR<sub>max</sub> obtained during the Glittre-ADL test was  $130.6 \pm 13.3$  bpm, which corresponds to  $80.9 \pm 6.9\%$  of the HR<sub>max</sub> observed on the CPET, characterizing the Glittre-ADL test as a submaximal test in our sample. The evaluation of the exercise tolerance in clinical settings is related to the test type choice. Submaximal tests are low-cost, simple to apply, and it is possible to perform them in regular facilities with easy access to the professional and the patient who needs to perform it, thus better representing the daily activities of the individual [22]. In addition, OSA is a disease commonly associated with cardiovascular comorbidities that may hinder the performance of maximal stress testing by these patients. Thus, submaximal exertion tests appear as a safe alternative for data collection for exercise prescription and follow-up of the evolution in these patients.

Regarding the hemodynamic responses of the Glittre-ADL test in the present study, we can consider that the test promoted a submaximal physiological stress,

since systolic (SBP) and diastolic blood pressure (DBP) were moderately elevated during the recovery period. Evaluating subjects with OSA submitted to CPET, Hargens *et al.* [23] found higher values of systolic ( $196.9 \pm 7.0$  mmHg) and diastolic ( $90.7 \pm 3.1$  mmHg) blood pressure in the recovery period due to the maximum characteristic of the applied test. In our study, the performance of a submaximal test such as the Glittre-ADL test led to milder SBP and DBP values in the recovery period.

Other submaximal tests have already been used to assess exercise tolerance in subjects with OSA [24-26]. Billings *et al.* [27] used the incremental shuttle walk test (ISWT) to determine exercise capacity in patients with moderate to severe OSA treated with Continuous Positive Airway Pressure (CPAP). They concluded that the ISWT is safe, well-tolerated and easy to apply in this population. Masa *et al.* [28] used the 6MWT to assess exercise capacity in subjects with severe OSA treated with CPAP for two months. Similarly, Goel *et al.* [29] also used the 6MWT to assess exercise capacity in subjects with moderate and severe OSA. Both studies using the 6MWT found that this test is indicated to assess functional capacity in individuals with OSA, requiring few resources and without significant risks to the participants.

The present study showed high reliability and excellent agreement between the measurements of the two performed Glittre-ADL tests. When comparing the total test time of both tests, no differences were observed between them, demonstrating that there was no learning effect, and therefore there is only the need to perform a single test for the clinical practice. A study carried out by Santos *et al.* [30] in patients with chronic obstructive pulmonary disease (COPD) presented similar results with an ICC of 0.97, also indicating high reliability between the measurements. Also, Reis *et al.* [13] evaluated the Glittre-ADL total time in a sample composed of healthy adults and found an ICC of 0.88 ( $p < 0.05$ ) between the times of the two Glittre-ADL measurements, corroborating the results obtained in our study.

### *Clinical implications*

Submaximal field tests are a widely used option in daily clinical practice for the evaluation of exercise capacity. This type of test allows for an efficient and simpler approach, requiring fewer resources when compared to maximum effort tests. They can be performed in any environment with the available space, making it possible to evaluate and obtain data for exercise prescription. In addition to its easy reproduction, the Glittre-ADL test has been used due to being able to efficiently evaluate efforts, generating lower cardiovascular physiological stress, but enough so that we can get an adequate evaluation of the submaximal functional capacity of exercise for individuals with OSA.

In this context, the Glittre-ADL test is an interesting and viable option for assessing exercise tolerance in OSA valid, independent of the associated comorbidities. This kind of test promotes less physiological stress and therefore, can be considered safe and not overloading the subjects.



### Limitations of the study

The limitations of the present study include the absence of subjects with mild OSA, as the study just included patients with moderate and severe OSA. Mild sleep apnea patients could have less effects of hypoxia and the adverse impact on the cardiovascular system and in exercise tolerance of these patients with a low AHI may be less pronounced.

## Conclusion

Therefore, according to the results of the present study, the Glittre-ADL test shows concurrent validity and excellent intrarater reliability in obstructive sleep apnea patients.

### Conflict of interest

No conflict of interest with relevant potential.

### Financing source

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### Author's contributions

**Conception and design of study:** Lima AMJ. **Acquisition, analysis and/or interpretation of data:** Souza, AKF, Aguiar MIR, Nóbrega-Júnior JCN; Lima AMJ, Brasileiro-Santos MS; **Drafting the manuscript:** Nóbrega-Júnior JCN, Lima AMJ; **Revising the manuscript critically for important intellectual content:** Pedrosa RP, Andrade AD, Brasileiro-Santos, MS.

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