Physiological and symptomatological responses to two functional tests in adults with asthma

Respostas fisiológicas e sintomatológicas de dois testes funcionais em adultos com asma

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Abstract

Introduction: People with asthma may experience impairment in exercise capacity and activities of daily living (ADLs). The six-minute walk test (6MWT) assesses functional exercise capacity, and the Glittre Activities of Daily Living test (TGlittre-ADL) assesses performance in ADLs. **Objective:** To compare the physiological and symptomatic responses of the 6MWT and the TGlittre-ADL in adults with asthma. **Methods:** Adults with asthma were evaluated for pulmonary function, functional capacity, performance in ADLs, asthma control and severity, and quality of life. Symptomatic responses (Borg fatigue scale - BorgF and dyspnea scale - BorgD) and physiological responses were recorded at the beginning and end of the TGlittre-ADL and the 6MWT: systolic blood pressure (SBP) and diastolic blood pressure (DBP), heart rate (HR), peripheral oxygen saturation (SpO_2), peak expiratory flow (PEF). Delta values (Δ = post–pre) were calculated and the Wilcoxon test was used for comparisons. **Results:** Fifty-eight adults were included (69% women, 44 ± 15 years, body mass index: 26 [22-30] kg/m^2, forced expiratory volume in the first second: 80 ± 7% predicted, 6MWT: 559 ± 88 meters and TGlittre-ADL: 190 [174-232] seconds). There was a higher ΔSpO_2 in the 6MWT ($p = 0.013$) and ΔHR in the TGlittre-ADL ($p < 0.001$), with no difference between the tests in ΔSBP, ΔDBP, ΔBorgD, ΔBorgF and ΔPEF. **Conclusion:** Although there were no differences in the sensation of dyspnea and fatigue, nor in the inotropic response, between the 6-minute walk test (6MWT) and the TGlittre-ADL test showed a greater chronotropic response in the TGlittre-ADL test and greater variation in SpO_2 in the 6MWT. Researchers and clinicians evaluating adults with asthma should consider that these two tests are not interchangeable.

Keywords: Asthma. Quality of life. Daily activities. Physical functional performance.

Resumo

Introdução: *Pessoas com asma podem apresentar comprometimento da capacidade de exercício e das atividades de vida diária (AVDs). O teste de caminhada de seis minutos (TC6min) avalia a capacidade funcional de exercício e o teste Glittre Activities of Daily Living (TGlittre-ADL), o desempenho nas AVDs.* ***Objetivo:*** *Comparar as respostas fisiológicas e sintomatológicas do TC6min e do TGlittre-ADL em adultos com asma.* ***Métodos:*** *Adultos com asma foram avaliados quanto à função pulmonar, capacidade funcional, desempenho nas AVDs, controle e gravidade da asma e qualidade de vida. Foram registrados no início e final do TGlittre-ADL e do TC6min as respostas sintomatológicas (escala de Borg de fadiga-BorgF e de dispneia-BorgD) e fisiológicas: pressão arterial sistólica (PAS) e diastólica (PAD), frequência cardíaca (FC), saturação periférica de oxigênio (SpO_2), pico de fluxo expiratório (PFE). Foram calculados valores de delta (Δ = pós–pré) e utilizou-se o teste Wilcoxon para as comparações.* ***Resultados:*** *Foram incluídos 58 adultos (69% mulheres, 44 ± 15 anos, índice de massa corpórea: 26 [22-30] kg/m², volume expiratório forçado no primeiro segundo: 80 ± 7 %predito, TC6min: 559 ± 88 metros e TGlittre-ADL: 190 [174-232] segundos). Houve maior ΔSpO_2 no TC6min (p = 0,013) e ΔFC no TGlittre-ADL (p < 0001), sem diferença entre os testes em ΔPAS, ΔPAD, ΔBorgD, ΔBorgF e ΔPFE.* ***Conclusão:*** *Apesar de não haver diferenças na sensação de dispneia e fadiga nem na resposta inotrópica entre o TC6min e o TGlitre-ADL, adultos com asma apresentam maior resposta cronotrópica no TGlittre-ADL e maior variação da SpO_2 no TC6min. Pesquisadores e clínicos que avaliam adultos com asma devem considerar que esses dois testes não são intercambiáveis.*

Palavras-chave: *Asma. Qualidade de vida. Atividades cotidianas. Desempenho físico funcional.*

Introduction

According to the Global Initiative for Asthma (GINA), asthma is characterized by chronic inflammation of the airways and bronchial hyperresponsiveness caused by direct or indirect stimuli, including exposure to allergens and irritants such as car exhaust, cigarette smoke, or strong odors, climate changes, respiratory viral infections, and physical exercise.[1] In addition to the presence of typical respiratory symptoms, individuals with asthma may experience limitations in performing exercise, sports, and physical activities carried out as part of daily life, including barriers to occupational activities such as studying and working.[2]

The limitation of these activities in adults with asthma may be related to a reduction in inspiratory muscle strength, which is frequently observed.[3] Furthermore, studies have demonstrated that individuals with asthma may present peripheral muscle weakness due to the use of corticosteroids.[4] Concomitantly, these individuals may experience worsening respiratory symptoms during exertion,[1] resulting in reduced functional capacity and lower levels of physical activity.[5] Simultaneously, patients with poor asthma control may have their activities of daily living (ADLs) impacted by the disease, leading to impaired quality of life.[6]

The six-minute walk test (6MWT) is a widely used clinical field test to assess functional exercise capacity in individuals with chronic lung diseases.[7] Its broad application is due to the fact that it is a simple, low-cost method that does not require sophisticated equipment. During the test, the patient is instructed to walk the greatest possible distance along a 30-meter corridor for six minutes and may pause according to their tolerance. Due to these characteristics, the 6MWT is considered a safe submaximal exercise test.[7]

Additionally, beyond assessing functional capacity, it is necessary to evaluate ADLs, as studies have already shown that patients with asthma exhibit limitations in this outcome due to the disease.[8] A validated and safe field test that can be used to measure the limitation that individuals with asthma present in ADLs is the Glittre Activities of Daily Living test (TGlittre-ADL). The test is a circuit performed at maximum speed and, similar to the 6MWT, it should be performed twice due to the learning effect.[9] From both tests, it is possible to obtain physiological responses such as variations in blood pressure (BP), peripheral oxygen saturation (SpO_2), heart rate, and peak expiratory flow (PEF) before and after the tests, as well as symptomatologic responses through the Modified Borg Scale, which consists of a subjective assessment of dyspnea (BorgD) and fatigue (BorgF) validated for individuals with asthma.[10]

Both tests have a submaximal nature and share the requirement that the patient perform them at a self-paced maximal speed. In addition, the responses elicited by these tests have already been compared in healthy children[11] and in individuals with chronic obstructive pulmonary disease (COPD),[12] with results showing that most

variables are similar between the tests. However, the physiological and symptom responses induced by both tests, especially the TGlittre-ADL, are poorly understood in patients with asthma, and their comparison has not yet been performed in this population.

Understanding the responses of individuals with asthma to these field tests will allow the identification of physiological and symptom differences in the assessment of functional exercise capacity and ADL performance in adults with asthma. Thus, researchers and clinicians will have greater confidence in recommending the use of specific assessment tests. In light of this, the aim of this study was to compare the physiological and symptom responses induced by the TGlittre-ADL with those induced by the 6MWT in adults with asthma.

Methods

The assessments took place at the Physical Therapy Outpatient Clinic of the University Hospital of the Universidade Estadual de Londrina (HU-UEL), at the Specialty Outpatient Clinic of the University Hospital of UEL (AEHU-UEL), or at the Research and Graduate Center of Universidade Pitágoras Unopar Anhanguera, Londrina, according to the availability and logistical considerations of the site and other projects. Participants had their assessments previously scheduled. Data collection was conducted between 2018 and 2021.

Study design and sample

This is a cross-sectional study conducted through a retrospective analysis of another study,[13] with a convenience sample composed of adults with asthma. According to COSMIN (Consensus-based Standards for the selection of health Measurement Instruments),[14] for quantitative research, a sample size of at least 50 patients is considered very good.

The inclusion criteria were: patients older than 18 years; diagnosis of asthma according to GINA;[1] being under medical treatment for at least six months; and clinical stability (no exacerbation, symptoms, or changes in asthma medication for 30 days). The exclusion criteria were: inability to perform the tests; limitation of cardiovascular and/or musculoskeletal disease; diagnosis of another pulmonary disease(s); and refusal to continue the assessments.

Recruitment was conducted throughout the entire data collection period by inviting patients treated at the Pulmonology Department of AEHU-UEL and through advertisements on social media. The present project was submitted to and approved by the Research Ethics Committee of Universidade Pitágoras Unopar Anhanguera under opinion No. 3,060,314, and all participants signed an informed consent form.

Assessments

After verification of the inclusion and exclusion criteria and signing of the informed consent form, the assessments began. At the start of the evaluation, for sample characterization, general data were collected, including age, weight, height, medication use, personal history, and comorbidities.

Asthma severity

Asthma severity is characterized by the medication category required to maintain the disease under control and is divided into five stages. The disease is considered mild when classified as stages 1 and 2, moderate at stage 3, and severe at stages 4 and 5; that is, the higher the stage, the greater the severity of the disease.[1]

Pulmonary function

Pulmonary function assessment was performed before and after bronchodilator use using a spirometer (MicroLab 3500, Care Fusion®, Ireland). The technique was performed according to the American Thoracic Society (ATS) guidelines,[15] using the forced vital capacity (FVC) maneuver to determine forced expiratory volume in one second (FEV_1), FVC), and the FEV_1/FVC ratio. Reference values for the Brazilian population were used.[16]

Asthma control

To assess asthma control, the Asthma Control Test (ACT) questionnaire was used, which consists of five questions regarding the past four weeks concerning symptoms, frequency of rescue bronchodilator use, and asthma control level. Each question has a score ranging from one to five, resulting in a total test score between 5 and 25 points,[17] where 25 points correspond to complete control or clinical remission of asthma symptoms.

The cutoff point for defining "controlled asthma" is an ACT score ≥ 20, while a score between 16 and 19 indicates "partially controlled asthma," and a score ≤ 15 indicates "poorly controlled asthma."[18]

Quality of life

In order to evaluate the individuals quality of life, the Asthma Quality of Life Questionnaire was used, which features 32 questions across four domains: activity limitations, symptoms, emotional function, and exposure to environmental stimuli. Respondents reported the frequency, intensity, and severity of health difficulties experienced due to asthma over the past two weeks. Responses for all 32 items are provided on a seven-point scale, with 7 being the maximum score. The total score is the mean of the responses to the 32 items, the lower the mean score, the worse the respondent's quality of life.[19]

Clinical field tests

Two field tests were performed, each applied in duplicate due to the learning effect, with a minimum interval of 30 minutes or until a return to baseline physiological conditions between trials to ensure data reliability.[7] From these tests, symptomatologic responses were collected using the Modified Borg Scale,[10] with patients being questioned regarding their perception of fatigue and dyspnea, using the printed scale presented before and immediately after each performed test.

Additionally, heart rate and SpO_2 were measured using a pulse oximeter (GEHealthcare, Ohmeda Tuffsat, 2013, Finland); systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a sphygmomanometer (Premium, Wenzhou Kangju Medical Instruments Co. Ltd, 2018, China); and PEF was evaluated with a peak flow meter (Assess, Healthscan Products Inc., 2010, USA). All physiological variables were recorded before and immediately after the tests by the same evaluator.

Activities of daily living

To evaluate performance in ADLs, the TGlittre-ADL was used. The test is a circuit consisting of five laps that individuals must complete as quickly as possible.[9] The test began with the individuals rising from a seated position and carrying a backpack containing 2.5 kg (women) or 5.0 kg (men) through a 10-meter corridor, where there was a two-step staircase (each step 17 cm high and 27 cm deep), to two shelves previously adjusted to each subject's shoulder and waist height. Three 1-kg boxes were positioned on the top shelf and had to be moved one by one to the bottom shelf, then to the floor, back to the bottom shelf, and finally to the top shelf again. The subjects then turned around, returned over the stairs to the chair, sat down, and began the next lap by rising once more. They were permitted to rest if necessary but were instructed to resume the activity as soon as possible.[20] The primary outcome of the TGlittre-ADL is the total time the individual takes to complete the full circuit.[9]

Functional exercise capacity

To evaluate functional exercise capacity, the 6MWT was used. The test was performed according to international ATS standards.[7] Individuals were instructed to walk the greatest distance possible in six minutes in a flat 30 meter corridor, without running.[7]

Statistical analysis

Data tabulation was performed using Microsoft Excel software, and statistical analysis was conducted using SPSS 21.0 Statistical Package and GraphPad Prism 6.0 software. Data distribution was analyzed using the Shapiro–Wilk test. Variables with normal distribution were presented as mean ± standard deviation, variables with non-normal distribution were presented as median and interquartile range (25–75%), and categorical variables were presented as absolute and relative frequencies.

The physiological and symptom responses from the assessment of exercise capacity and ADL performance were classified as pre- and post-test, and the difference values (deltas) were compared according to data normality. The Wilcoxon test was used for pre- and post-test comparisons of each variable within each test and to compare the variation in responses between the two tests. For all analyses, statistical significance was set at $p < 0.05$.

Results

The sample consisted of 58 adults with asthma, of whom approximately 55% (32 individuals) had severe asthma (stages 4 and 5). The remaining characteristics of the sample are shown in Table 1.

Table 1 - Characteristics of the smaple

Variables	n = 58
Sex (female/male), n (%)	40/18 (69/31)
Age (years)*	44 ± 15
Body mass index (kg/m²)#	26 [23 - 31]
Forced vital capacity - FVC (L)*	3.42 ± 1.01
FVC (% predicted)*	90 ± 16
FEV_1 (L)*	2.55 ± 0.84
FEV_1 (% predicted)*	81 ± 8
FEV_1/FVC (%)*	73 ± 12
Asthma Control Test (points)#	20.00 [17.75 - 23.00]
AQLQ (points)#	5.13 [4.24 - 5.84]
Six-Minute Walk Test (meters)*	559 ± 88
Six-Minute Walk Test (% predicted)#	97 [87 – 105]
TGlittre-ADL (seconds)#	191 [174 - 233]
TGlittre-ADL (% predicted)#	124 ± 22

Note: FEV_1 = forced expiratory volume in the first second; AQLQ = Asthma Quality of Life Questionnaire; TGlittre-ADL = Glittre Activities of Daily Living Test. *Variables presented as mean ± standard deviation. #Variables presented as median and interquartile range (25 – 75%).

Regarding the comparison between pre- and post-test values of the physiological and symptom responses to the 6MWT, a statistically significant difference was observed for all variables except PEF (Table 2).

Table 2 - Comparison of physiological and symptom variables before and after the Six-Minute Walk Test

Variables	Pre-test	Post-test	p-value
SBP (mmHg)	110 [100 - 120]	120 [120 - 133]	< 0.0001
DBP (mmHg)	80 [70 - 80]	80 [70 - 90]	0.0170
PEF (L/min)	355 [305 - 493]	350 [308 - 480]	0.9800
BorgD (points)	0.5 [0.0 – 1.0]	2.0 [0.5 – 3.0]	< 0.0001
BorgF (points)	1.0 [0.0 – 2.0]	3.0 [2.0 – 5.0]	< 0.0001
SpO_2 (%)	97 [96 - 98]	97 [96 - 97]	0.0050
HR (bpm)	83 ± 14	116 ± 24	< 0.0001

Note: SBP/DBP = systolic/diastolic blood pressure; PEF = peak expiratory flow; BorgD/BorgF = perceived exertion assessed by the Borg dyspnea scale and by the Borg fatigue scale; SpO_2 = peripheral oxygen saturation; HR = heart rate (beats per minute). Variables are presented as median and interquartile range (25–75%), except for HR (mean ± standard deviation).

Regarding the comparison between pre- and post-test values of the physiological and symptom responses to the TGlittre-ADL, a statistically significant difference was observed for all variables except PEF and SpO_2 (Table 3).

Regarding the comparison between the variation (Δ) of physiological and symptomatologic responses in the two tests, there was no statistically significant difference between the tests for PEF, SBP, DBP, BorgD, and BorgF (Table 4). However, there was a significant difference in ΔSpO_2 ($p = 0.013$), showing a greater variation in the 6MWT. Additionally, there was a significant difference in ΔHR ($p < 0.0001$), which was more expressive in the TGlittre-ADL (Figure 1).

Table 3 - Comparison of physiological and symptom variables before and after the Glittre Activities of Daily Living test

Variables	Pre-test	Post-test	p-value
SBP (mmHg)	120 [107 - 120]	130 [120 - 142]	< 0.0001
DBP (mmHg)	70 [67 - 80]	80 [70 - 90]	< 0.0001
PEF (L/min)	350 [255 - 450]	370 [250 - 460]	0.6970
BorgD (points)	0 [0 - 1]	2 [0.5 - 4]	< 0.0001
BorgF (points)	1 [0 - 3]	3 [2 - 5]	< 0.0001
SpO_2 (%)	97 [96 - 97]	97 [96 - 97]	0.6660
HR (bpm)	81 ± 16	122 ± 23	< 0.0001

Note: SBP/DBP = systolic/diastolic blood pressure; PEF = peak expiratory flow; BorgD/BorgF = perceived exertion assessed by the Borg dyspnea scale and by the Borg fatigue scale; SpO_2 = peripheral oxygen saturation; HR = heart rate (beats per minute). Variables are presented as median and interquartile range (25–75%), except for HR (mean ± standard deviation).

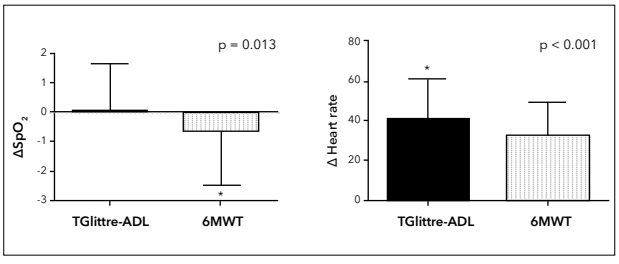

Figure 1 - Comparison of the variation in peripheral oxygen saturation (SpO_2) and heart rate before and after the Six-Minute Walk Test (6MWT) and the Glittre Activities of Daily Living test (TGlittre-ADL). *$p < 0.05$.

Table 4 - Comparison between the variation in physiological and symptom responses of the Six-Minute Walk Test (6MWT) and the Glittre Activities of Daily Living test (TGlittre-ADL)

Vaariables	6MWT	TGlittre-ADL	p-value
ΔPEF (L/min)	0 [-15 - 20]	0 [-11 - 11]	0.450
ΔSBP (mmHg)	10 [0 - 20]	10 [0 - 20]	0.777
ΔDBP (mmHg)	0 [-3 - 10]	0 [-3 - 10]	0.065
ΔBorgD (points)	2.0 [1.0 – 3.0]	2.0 [1.0 – 3.0]	0.463
ΔBorgF (poits)	1.5 [1.0 – 3.0]	2.0 [1.0 – 3.0]	0.486

Note: Δ = change (delta) in peak expiratory flow (ΔPEF), systolic blood pressure (ΔSBP), diastolic blood pressure (ΔDBP), perceived exertion assessed by the Borg dyspnea scale (ΔBorgD), and perceived exertion assessed by the Borg fatigue scale (ΔBorgF). Variables are presented as median and interquartile range (25–75%).

Discussion

Both the 6MWT and the TGlittre-ADL are tests that may reflect the functional limitation caused by asthma in adults.[8,10] When comparing pre and post-test values of the physiological and symptom variables in the 6MWT, significant differences were observed in SBP, DBP, BorgD, BorgF, SpO_2, and HR, however, no difference was found in the variation of PEF. The same result was observed in the comparison performed in the TGlittre-ADL, except for SpO_2, for which no statistically significant differences were found in this variation.

It is understood that the variation in PEF, a measurement that may reflect airway constriction in the patient,[21] did not show statistically significant differences in either test due to the fact that all patients used bronchodilators before pulmonary function assessment. It is known that short-acting beta-agonists are effective in preventing exercise-induced bronchospasm,[22] resulting in no significant variation in PEF measurement in either test.

In addition, besides ΔPEF, ΔSBP, ΔDBP, ΔBorgD, and ΔBorgF also showed no significant differences between the 6MWT and the TGlittre-ADL, a result that may be partially justified by the moderate correlation ($r = -0.61$; $p < 0.0001$) found between the two tests in the validation study of the TGlittre-ADL for adults with asthma.[10] However, in the study, physiological and symptom responses were not compared in that validation analysis, and studies that compared the tests in healthy children[11] and in patients with COPD[12] also found that different variables did not present significant differences between the two tests. However, when comparing SpO_2 values before and after the 6MWT, a statistically significant difference was observed, which was not found in the TGlittre-ADL. This result is consistent with the comparison of ΔSpO_2 between the 6MWT and the TGlittre-ADL, in which the variation in the 6MWT was greater than in the TGlittre-ADL, with a significant difference.

It is understood that during physical activity there is an increased oxygen demand, with elevation of body temperature and reduction in pH. These factors decrease the affinity of oxygen for hemoglobin, which may explain the significant difference in SpO_2 in the 6MWT, suggesting that this test likely generates a greater oxygen demand in metabolically active tissues, including skeletal muscles.[23] When comparing this result with findings in the literature, it is observed that the 6MWT was more sensitive than the cycle test in identifying exercise-induced desaturation in patients with COPD,[24] a result that may be compared with the findings of the present study, in which the variation in SpO_2 before and after the tests was greater in the 6MWT when compared with the variation found in the TGlittre-ADL.

Finally, ΔHR showed significant differences between the 6MWT and the TGlittre-ADL, with the greatest variation observed in the TGlittre-ADL. In a study aimed at determining which daily activities are more demanding for patients with COPD, ascending and descending stairs – an activity included in the TGlittre-ADL circuit – was found to promote the greatest increase in HR,[25] since the autonomic nervous system, in response to a metabolic demand, seeks to increase cardiac output, which is the product of HR and myocardial contractile force, in order to meet that demand.[23] Thus, the significant difference found in HR variation in the TGlittre-ADL may be associated with this test possibly involving activities with greater physiological and metabolic demands. In addition, in a study conducted in healthy adults, upper-limb exercises were observed to result in greater cardiorespiratory and metabolic responses than lower-limb exercises,[26] which may also serve as a justification for the greater HR variation in the TGlittre-ADL, since it involves upper-limb activities in its circuit.[10]

This is the first study demonstrating the physiological and symptom responses of patients with asthma during the performance of the TGlittre-ADL. Furthermore, the validation of this test for this population was carried out

in 2023, suggesting the need to further explore how its performance occurs in adults with asthma. Although the 6MWT is a widely used test in the assessment methodology of adults with asthma, there is still a lack of studies in the literature to identify whether its performance is more closely related to chronotropic, inotropic, or symptom-related changes with respiratory or muscular impact, in order to guide assessment and physical therapy treatment. Therefore, researchers and clinicians may choose to use the TGlittre-ADL to quantify ADL performance with the understanding that this test generates a greater HR response, while selecting the 6MWT to quantify functional exercise capacity in adults with asthma, given its greater variation in SpO_2. Finally, the clinical tests studied are not interchangeable.

This study has some limitations: as it involved a convenience sample composed predominantly of adults with controlled asthma, future studies are needed in adults with uncontrolled asthma. Another limitation is that symptom variables were assessed using the modified Borg scale, that is, a subjective scale that relies solely on individuals self-report, which may have influenced the results found. Finally, the wide variability in disease severity may be cited, although a heterogeneous sample may increase the clinical applicability and external validity of the study.

Conclusion

Both tests have a submaximal nature, and the adults with asthma evaluated showed similar variation in some responses. Although a greater variation in SpO_2 was observed in the 6MWT, HR increased more during the TGlittre-ADL. In summary, this was the first study to compare the responses of the two tests and to demonstrate that performing activities involving both upper and lower limbs simultaneously, as in the TGlittre-ADL, may result in greater HR variation in adults with asthma, and this should be considered for assessment purposes and in clinical practice.

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Authors' contributions

CSB, VCP, and KCF were responsible for the study design, literature search, and manuscript writing. AP, VCP, NBSC, and JMO collected the data, and AMM, CSB, VCP, NBSC, and KCF performed the analyses.

Data availability statement

The data that support the findings of this study are available upon reasonable request.

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