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Assessment of exercise capacity among asthmatic and healthy adolescents

Avaliação da capacidade de exercício em adolescentes asmáticos e saudáveis

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Abstract

Objectives: To compare the physical performance and responses obtained in the six-minute walking test (6MWT) and the six-minute step test (6MST) between asthmatic and healthy adolescents; and to investigate the relationship between the responses obtained in the tests and the body mass index (BMI), physical activity level and spirometric variables. **Methods:** Nineteen asthmatic adolescents (AG) and 19 healthy adolescents (HG) of both sexes, aged between 11 and 15 years, were assessed by means of spirometry, the 6MWT and the 6MST, and their physical activity levels were quantified using the International Physical Activity Questionnaire (IPAQ). **Results:** The AG had poorer physical performance, lower heart rate (HR) and greater lower-limb (LL) fatigue in the 6MST. In the 6MWT, the AG had positive correlations between walked distance (WD) and duration of intense activity, and between HR and BMI, whereas the HG had positive correlations between WD and HR and between WD and respiratory rate (RR). In the 6MST, the AG showed positive correlations between RR and maximum voluntary ventilation (MVV) and between duration of moderate activity and physical performance. The AG also showed negative correlations between physical performance in the 6MST and BMI, and between sensation of dyspnea and duration of walking. Also in the 6MST, the HG showed positive correlations between RR and MVV, and between BMI and LL fatigue ($p \leq 0.05$). **Conclusion:** The 6MST demonstrated differences in exercise capacity between the asthmatic and healthy individuals. Furthermore, the physical performance and responses obtained in the tests were correlated with the MVV, BMI and physical activity level.

Key words: asthma; spirometry; muscle fatigue; dyspnea.

Resumo

Objetivos: Comparar o desempenho físico e as respostas obtidas nos testes de caminhada de seis minutos (TC6) e do degrau de seis minutos (TD6) entre adolescentes asmáticos e saudáveis e correlacionar o índice de massa corpórea (IMC), o nível de atividade física e as variáveis espirométricas com as variáveis obtidas nos testes. **Métodos:** Foram avaliados 19 adolescentes asmáticos (GA) e 19 saudáveis (GS), com idades entre 11 e 15 anos, de ambos os sexos, por meio da espirometria, do TC6 e do TD6 e foi quantificado o nível de atividade física pelo Questionário Internacional de Atividade Física (IPAQ). **Resultados:** No TD6, observaram-se menores valores de desempenho físico (TD6-T) e frequência cardíaca (FC) e maiores valores de fadiga de membros inferiores (MMII) no GA. No TC6, houve correlação positiva no GA da distância percorrida (DP) com o tempo de atividade intensa e da FC com o IMC e, no GS, da DP com a FC e com a frequência respiratória (FR). No TD6, houve correlação positiva no GA da ventilação voluntária máxima (VVM) com a FR; do tempo de atividade moderada com o TD6-T; além de correlação negativa do TD6-T com o IMC e da dispneia com o tempo de caminhada; no GS, correlações positivas da VVM com a FR e da fadiga de MMII com IMC ($p \leq 0,05$). **Conclusão:** O TD6 demonstrou diferença na capacidade para o exercício entre asmáticos e saudáveis. Além disso, o desempenho físico e as respostas obtidas nos testes correlacionaram-se com os valores de VVM, IMC e nível de atividade física.

Palavras-chave: asma; espirometria; fadiga muscular; dispneia.

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Introduction

Asthmatic individuals tend to have poorer physical exercise tolerance compared to healthy individuals[1] due to limitations found in the practice of regular physical activity, caused by factors such as the degree of airway obstructions at rest, the occurrence of exercise-induced bronchospasms (EIB)[2], decreased ventilatory capacity and increased sensations of dyspnea, which determine the early interruption of physical activity and a more sedentary lifestyle[3]. Another limiting factor is obesity, since weight gains can cause the exacerbation of symptoms and, thus, lower the tolerance to physical exercises[4]. However, previous studies shown that when individuals are clinically stable, the levels of physical activity seem to be the determining factor for asthmatic and healthy individuals to achieve similar exercise intensities, even in those where EIB occurs[5-7].

Objective measures of assessment are important to determine the exercise capacity, to better assess and guide the prescription of a rehabilitation program suited to individual limitations and to the severity of the disease. To accomplish this, it is recommended the execution of maximal performance tests, considered ideal to detect EIB[2], and submaximal performance tests, which are easy to use, safe, and accessible in clinical routine assessments and also predict exercise capacity in the performance of activities of daily living[8]. They are also able to detect EIB and provide early diagnoses of physical activity limitations[9,10]. Among the submaximal tests, the six-minute walking test (6MWT) and the six-minute step test (6MST) are commonly used[10,11].

Although these tests are described to assess the exercise capacity of individuals with lung disease[9-11], there is lack of documented clinical experience on the application of these tests in asthmatic individuals. In addition, there are no studies that used the 6MST and compared the physical performance and the cardiorespiratory responses obtained with these tests between asthmatic and healthy adolescents. Therefore, the aims of this study were to compare the physical performance and the responses obtained in the 6MWT and in the 6MST between asthmatic and healthy adolescents and to correlate the body mass index (BMI), levels of physical activity, and spirometric variables with those obtained in the tests.

Methods

This study was conducted between March and October 2008 in the Special Unit of Respiratory Therapy of the Universidade Federal de São Carlos (UFSCar), São Carlos (SP), Brazil and in a public state school in São Carlos city (SP), where 38 adolescents were assessed, between 11 and 15 years of age, of both sexes: 19 asthmatic adolescents, who formed the asthmatic group (AG) and 19 healthy adolescents, who formed the healthy group (HG). Parents or guardians of all adolescents signed a consent form and the study was approved by the Committee of Ethics and Research of the UFSCar (protocol nº119/2008).

Inclusion and exclusion criteria

The AG consisted of adolescents with clinical and/or spirometric diagnosis of asthma, confirmed by spirometry before and after the use of bronchodilator (BD), which was perforemed under the supervision of a pulmonologist[12]. These individuals were clinically stable, without a history of respiratory infections or crises in a minimum period of three weeks. The HG consisted of adolescents without a history of respiratory diseases, verified by the ISAAC questionnaire (International Study of Asthma and Allergies in Childhood) for asthma and allergic rhinitis [13,14] and who had ventilatory function within the norms, and confirmed by spirometry. Adolescents with other respiratory, cardiac, rheumatic, musculoskeletal and orthopedic diseases and with associated neurological sequelae which could interfere in the performance of the proposed assessment were excluded from both groups.

Experimental procedures

At school and at the University, the adolescents were first submitted to an interview in which an anamnesis form was filled in. The assessment of the level of physical activity was performed and then, they underwent anthropometric, spirometric and exercise capacity assessments.

Assessment of physical activity levels

The assessment of physical activity levels consisted of the application, by interviewers, of the International Physical Activity Questionnaire - short version (IPAQ)[15], which consists of seven open-ended questions. This information allows the therapist to estimate the weekly time spent in physical activities, asked about the time and the frequency, during the last week, of moderate and vigorous activities and walking[15].

Anthropometric and spirometric assessments

Measurements of height (m) and weight (kg) were perfirned by means of an anthropometric scale (Welmy®, 110FF model, São Paulo, SP, Brazil), with the adolescents barefoot and dressed in shorts and shirt. With these measures, the body mass index (BMI = weight/height^2) was calculated and the classification was made, according to the percentile curves, the gender and age; and malnutrition levels <5, normal 5≤x<85, overweight 85≤x<95 and obese x≥95[16,17].

All adolescents underwent a spirometry test, with a portable spirometer (Easy One ®, ndd, Zurich, Switzerland). The technical procedures, criteria for acceptability and reproducibility for this test followed the ATS/ERS standards, according to Miller et al.[18]. Three technically acceptable curves were obtained of Slow Vital Capacity (SVC), Forced Vital Capacity (FVC) and Maximal Voluntary Ventilation (MVV). The obtained values were compared with those predicted by Polgar and Promadhat[19].

Evaluations of exercise capacity

The Six-minute walking test (6MWT) and the Six-minute step test (6MST) were performed on different and non-consecutive days.

Six-minute walking test

The 6MWT was conducted in a corridor of 30 ms in length and 1.5 ms. in width, in an outdoor area. The temperature and relative humidity were recorded for every test with a portable termohygrometer (HT-200 Digital-Instrutherm, São Paulo, SP, Brazil). The 6MWT followed the standards of the ATS[20]. To ensure mouth breathing, a nose clip was used during the test, as recommended by other authors to check the occurrence of EIB[21-23]. The physical performance on the test was determined through the total walked distance (WD), in ms, and the maximal heart rate was obtained through the formula: HRmax=210-(0.65 x yrs of age) [5].

Six-minute step test

The 6MST was performed with a one step of 20 cm or 25 cm in height, defined according to the height of the adolescent. For those up to 1.37 m, the step of 20 cm was used, and for those with greater heights, the step of 25 cm was used. This procedure was done according to Feinstein et al.[9], due to safety and to standardize the muscular effort required during the test. The test followed the same principles of ATS[20] for the 6MWT, and the cadence was free, according to Dal Corso et al.[11]. The physical performance in the test was determined by the total number of ascents and descents in the step (6MST-T).

In both tests, every minute, the individual received pre-established sentences of encouragement, and every two minutes, the peripheral oxygen saturation (SpO_2), with a pulse oximeter (Nonin®, 2500 model, Minneapolis, Mn, USA), the heart rate (HR), with a frequency counter (Polar Vantage NV™®, 1901001 model, Finland) and symptoms of dyspnea and fatigue of the lower limbs (LL), through the CR10 scale of Borg[24] were recorded. These measures, associated with the measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP), with a stethoscope (Littmann®, Classic II S.E. model, Oakdale, MN, USA) and a sphygmomanometer (BD®, Curitiba, PR, Brazil), and the RR, were recorded at rest, immediately after the test and in the first, third and sixth minutes of recovery.

Moreover, spirometric maneuvers of FVC were performed before, immediately after, and 5, 10, 15 and 30 mins after the test and the best of the two measures were considered. Measures 15 and 30 mins after the test were performed only if there was a 15% decrease in FEV_1 in relation to the baseline values at the 10th minute[9,21,22].

Statistical analyses

The Shapiro-Wilk test was performed to verify the normality of the data. Descriptive statistics were performed to characterize the sample, with data expressed by means ± standard deviations and median (interquartile range) for variables of parametric and nonparametric distributions, respectively.

For the intergroup analyses, independent *t* test or Mann-Whitney test were performed and, for the intragroup analyses, paired *t* test or Wilcoxon test were performed. Pearson's correlation or Spearman's correlation coefficients were also performed, for variables with parametric and non-parametric distributions, respectively. The statistical program used was the Statistical Package for Social Sciences (SPSS) for Windows, version 13.0.. The significance level was established at $\alpha<0.05$.

Results

Asthmatic adolescents were classified into intermittent and mild persistent asthma groups, according to the Global Initiative for Asthma[12]. Five of these adolescents made regular use of inhaled corticosteroids (mean doses of 200 mcg) and the others used beta-2 agonists, when necessary, for relief of their symptoms. In relation to the classification of BMI, in the AG, there were 13 normal, two overweight and four obese adolescents and, in the HG, there were 12 normal, five overweight and two obese adolescents[2].

Anthropometric and spirometric characteristics of each group, as well as the level of physical activity are shown in Table 1. The level of physical therapy was verified by the time (in mins) of walking, of moderate and intense activities and of total activities performed in the week. There was significant difference only for MVV% of predicted (MVV% pred) (p = 0.003), sendo que a media foi maior para o HG.

Physical performance and behaviors of the cardiovascular, respiratory and spirometric variables and sensations of dyspnea and fatigue during the 6MWT and the 6MST between the AG and the HG groups.

In the 6MWT, there were no significant differences between the groups in relation to the assessed variables immediately after the end of the test (Table 2). In relation to the 6MST, there were significant differences in the 6MST-T (p=0.005), as well as for the cardiovascular variables at the end of the test, such as the HR (p=0.020) and the percentages of maximal HR (% HRmax) (p=0.021), with higher values for the HG, and for the fatigue of the lower limbs (p=0.035), with higher values for the AG (Table 2).

In both tests, there were no significant differences in the FEV_1 before and after the tests (immediately, 5, 10 and 15 mins later), and in any group there was fell over 15% in FEV_1 post-test, which characterized the occurrence of EIB.

For both groups, each test was performed in similar temperature conditions and relative humidity, whereas there were no significant differences between them. It is noteworthy that three individuals of the AG group discontinued the 6MST for about 20 seconds, on average, due to fatigue of their lower limbs, and then resumed. This behavior did not occur during the 6MWT.

Comparisons of the behaviors of the cardiovascular, respiratory, spirometric variables and sensations of dyspnea and fatigue between 6MWT and 6MST in the AG and in the HG groups.

In the inter-test analyses, in the HG and in the AG were observed significantly greater values for the 6MST of HR ($p\leq$0.004), HRmax% (p≤0.004) and lower limb fatigue ($p\leq$0.009) at the end of the test (Table 2). Moreover, only in the HG, significantly greater values of SBP (p=0.036) in the 6MST were observed. For both groups, there were no significant differences in the SpO_2, RR, DBP and sensations of dyspnea as well as in the FEV_1, before and after each test (immediately, 5, 10 and 15 mins after).

Table 1. Anthropometric and spirometric variables and the weekly time of physical activity in the asthmatic (AG) and healthy groups (HG).

	AG	HG
Gender (Men/Women)	15/4	13/6
Age (years)	12±1.4	12±1.0
Weight (kg)	52±14.1	46±9.8
Height (m)	1.6±0.1	1.5±0.9
BMI (Kg/m^2)	21±4.1	21±4.8
FEV_1(L)	2.5±0.6	2.3±0.3
FEV_1 (%pred)	88±8.1	93±11.6
FVC (L)	2.9±0.6	2.7±0.4
FVC (%pred)	93±6.5	97±12.5
FEV_1/FVC (L)	0.9±0.1	0.9±0.5
FEV_1/FVC (%pred)	93±7.5	95±4.7
MVV (L/min)	78±20.6	86±16.1
MVV (%pred)	80±13.9*	96±13.1
Duration of weekly walking (min.)	40 (0-100)	100 (20-150)
Duration of moderate weekly activity (min.)	30 (0-120)	90 (30-180)
Duration of intense weekly activity (min.)	60 (0-180)	60 (30-180)
Total duration of weekly activity (min.)	225 (90-420)	310 (180-590)

Data are expressed as means±standard deviations, except the time of physical activity of the International Physical Activity Questionnaire (IPAQ) (median and interquartile ranges). BMI=body mass index, FEV_1=forced expiratory volume in one second; FVC=forced vital capacity; FEV_1/FVC=ratio FEV_1/FVC, MVV=maximum voluntary ventilation. *Independent t Test ($p\leq$0.05).

Table 2. Physical performance, respiratory, cardiovascular and the sensations of dyspnea and fatigue at the end of 6MWT and 6MST in the asthmatic group (AG) and healthy group (HG).

	6MWT		6MST	
	AG	*HG*	*AG*	*HG*
WD (m)	589±63.6	622±50.8	-	-
6MST- T (nº)	-	-	147±30.4	171±14.1*
SpO_2 %	96 (95-97)	97 (95-98)	97 (96-97)	97 (95-97)
RR (bpm)	21±2.9	22±2.5	21±2.7	22±4.5
HR (bpm)	132±17.0	142±22.5	149±21.6†	165±19.7*†
%HRmax (%)	65±8.0	69±11.0	73±10.0†	81±9.8*†
SBP (mmHg)	115 (110-125)	120 (110-120)	120 (110-130)	120 (114-130)††
DBP (mmHg)	70 (60-70)	80 (70-80)	70 (60-80)	80 (70-80)
Dyspnea	2 (0-3)	0 (0-1)	2 (0.87-4.3)	1 (0-3)
Fatigue of the LL	2 (0.5-2)	0.5 (0-2)	3 (1-4.3)**††	2 (0.9-3)††

Data are expressed as means±standard deviations, medians and interquartile ranges, when parametric or nonparametric, respectively. WD=walking distance, 6MST-T=total number of ascents and descents; SpO_2=peripheral oxygen saturation; RR=respiratory rate; HR=heart rate; %HRmax=percentage of maximum heart rate; SBP=systolic blood pressure; DBP=diastolic blood pressure; LL=lower limbs. Intergroup analysis: *Independent t Test ($p\leq$0.05); **Mann-Whitney Test (p≤0.05); Intragroup analysis (inter-tests): †Paired t Test ($p\leq$0.05); ††Wilcoxon Test ($p\leq$0.05).

Correlations between the 6MWT and 6MST in the AG and HG

In the AG, there were positive correlations of weekly walking time with MVV (L/min) (r=0.55; p=0.021). In the 6MWT, the same occurred between WD and the time of weekly intense activity (r=0.48; p=0.037) and in HR with BMI (r=0.48; p=0.035).

In the 6MST, the MVV in L/min and in % pred correlated positively with the RR (r=0.50 and r=0.58, respectively; $p\leq0.05$) as well as weekly time of moderate relationships with 6MST-T (r=0.50; p=0.033). Negative correlations were found between the 6MST-T and BMI (r=-0.53; p=0.023) and between the sensation of dyspnea and weekly walking times (r=-0.53; p=0.021).

Regarding the correlations between the HG for the 6MWT, there were positive correlations of WD with HR (r=0.57; p=0.01) and with RR (r=0.68; p=0.01) and of RR with MVV (% pred) (r=0.73; p=0.003), in 6MST, and there were positive correlations between the MVV (% pred) with RR (r=0.54; p=0.029) and of the lower limb fatigue with BMI (r=0.61, p=0.006).

Discussion

In the present study, two submaximal tests for the assessment of exercise capacity (6MWT and 6MST) among asthmatic and healthy adolescents were compared and there were differences in physical performance, in cardiovascular responses and in lower limb fatigue between the groups only for the 6MST. Different responses were observed between the tests for each group, as expected, since the profiles of physiological responses were different between tests.

The 6MST requires muscle groups to work against gravity and these muscles are not often used in activities of daily living, thus, the 6MST makes the metabolic and ventilatory demands more intense than the 6MWT, with the maximal limits often achieved[11]. In the present study, the HRmax achieved during the 6MWT was 65% in the AG and 69% in the HG and in the 6MST, 73% in the AG and 81% in the HG.

The 6MWT is a test of lower intensity and the asthmatics adolescents were clinically stable and with anthropometric characteristics and physical activity levels similar to those of healthy adolescents. This fact may have contributed to the similar patterns of responses to physical exercise stress[6,7], observed between the groups. On the other hand, in the 6MST, the observed differences in physical performance and cardiovascular responses could be explained by the fact that asthmatic individuals, especially in exercises of greater intensity, often did not reach the same level of physical effort as the healthy individuals, probably, to minimize the ventilatory demands, the exacerbation of dyspnea and the avoidance of EIB[3,10,25]. This was observed in the present study due to the fact that the respiratory and spirometry variables and sensations of dyspnea were similar between groups and between tests. Furthermore, the 6MST, since it is a test that requires greater use of the muscles of lower limbs than the 6MWT, caused greater levels of fatigue in both groups, which was higher for the AG. This was responsible for the interruption of the tests of three asthmatic individuals, indicating that LL fatigue was an important factor for limiting exercise, which contributed to the fact that the AG did not reach greater physical performance and cardiopulmonary stress. Thus, the limitation in physical performance observed in the 6MST, appeared to have occurred due to peripheral ventilatory and muscle factors.

The limitation in exercise levels due to ventilatory factors is cited by other authors[6,25], and, in the present study, it might be justified also due to the fact that the AG had lower MVV (% pred) than the HG. While the MVV decreased, the ventilation required for a particular exercise intensity increased, thus reducing the ventilatory efficiency in these individuals and, hence, the tolerance to exercise[25]. In this sense, Santuz et al.[7], analyzing ventilation during the performance of incremental exercises on the treadmill between asthmatic and healthy children, found that both groups reached similar values of ventilation. However, for this to occur, the asthmatic subjects increase tidal volume and decreased RR, to reduce the work of the respiratory muscles. Similarly, in the present study, the MVV was positively correlated with the RR in both tests and groups and tended to be lower in the AG, but not significantly.

When the relationships between physical performance and the responses obtained in the 6MWT in both groups were evaluated, it was observed that in the HG, the HR was positively correlated with WD, i.e., it increased when walking longer distances, responding to required physiological demands, which matched the performances obtained in the test. However, in the AG, HR was positively correlated with BMI, highlighting the fact that weight gains in asthmatic adolescents may worsen the symptoms of the disease[4], resulting in greater physical inactivity and, therefore, poorer physical fitness, since a greater HR did not mean, for this group, a greater WD.

In the 6MST, physical performance was negatively correlated with BMI in the AG, which may be explained by the fact that a greater body mass requires greater demands of both the peripheral and the ventilatory muscles[3], especially in this kind of exercise in which the individual has to overcome the force of gravity to shift the center of mass, which would further impair the test performance. For the HG, in the same test, greater body mass showed correlations to greater fatigue of the lower limbs. However, in the AG, this did not occur, and there were greater values of fatigue of the lower limbs in this group. It could be speculated that asthmatic individuals showed decreases in peripheral muscle strength, perhaps because of the use of corticosteroid medications, since the level of physical activity was similar between groups, but this was not assessed in this study.

Studies show that physical activity in asthmatic individuals improves their exercise tolerance and aerobic capacity, decreases the sensations of dyspnea, the use of medication and the severity of EIB, with consequent improvements in quality of life, but without changing baseline lung functions[26,27]. In the present study, only for the AG, significant correlations were observed between of the time of physical activity in physical performance and the responses obtained in the tests, highlighted the benefits reported for this group.

Both the 6MWT and 6MST were chosen because they are tests that easily applied and do not require expensive equipment and the presence of a physician. The nose clip was used in both tests, as reported in other studies[21-23], to simulate mouth breathing that these individuals demonstrated during physical effort. In addition, it allowed to investigate if the inspired drier air could change spirometric variables in the post-test, even in exercises of lower intensity, since the air humidity significantly influences the occurrence of EIB[23]. However, in the present study there were no decreases in the post-test FEV_1, especially in the 6MST. This highlighted the fact that the reached intensity was the determining factor and asthmatic individuals did not achieve and maintained high levels of HR in both tests.

Some limitations may be considered in the present study, such as the application of the questionnaire to determine the level of physical activity, which is an instrument of good reproducibility[15], but has the difficulty of obtaining reliable answers in the population used in this study. The 6MST[11], and the 6MWT, which were performed in the present study, allowed freely chosen cadence and, thus, they may need to be standardized. Furthermore, it was not possible to perform a maximal test to observe the maximal exercise capacity of these individuals and the occurrence of EIB, as to compare it with the performance on the applied tests.

Conclusions

The 6MST, is a test which required greater cardiorespiratory responses than the 6MWT, showed differences in exercise capacity between adolescents with intermittent and mild persistent asthma and healthy adolescents. Thus, asthmatic adolescents had greater fatigue of the lower limbs and lower physical performance and lower cardiovascular responses than healthy adolescents. The 6MST might be a good alternative for the assessment of clinical changes of these individuals after an intervention program. In addition, physical performance and the responses obtained in the tests were correlated with the values of MVV, BMI and physical activity levels.

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