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Comparative analysis of the six-minute walk test in healthy children and adolescents

Análise comparativa do teste de caminhada de seis minutos em crianças e adolescentes saudáveis

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Abstract

Objective: To perform a comparative analysis of the six-minute walk test in healthy children and adolescents in corridors of 30.5m (100 feet) 20m (65.6 feet) in length. **Methods**: We evaluated 67 participants (36 boys and 31 girls), aged 7 to 14 years old, from public schools of a city in a metropolitan area. All were submitted to four walking tests, two in each of the corridors. The variables analyzed were: walked distance, work rate, mean blood pressure, heart rate and oxygen saturation. Statistical analysis was performed using one-way ANOVA for repeated measures and significance level at $p \leq 0.05$. **Results:** The comparison between the tests in each corridor and between the best tests in the different corridors did not show significant differences in the blood pressure, heart rate and oxygen saturation. The walked distance was not statistically different in the two tests on each corridor. However, the participants covered greater distances on the 30.5m corridor ($p<0.05$) compared to the best test between corridors. However, this increase was less than 10%. Regarding the cardiac overload and the work rate, there were no significant differences between the corridors. **Conclusions:** There were differences in walked distance between the corridors, however they were less than 10% with no significant changes in the other measured parameters. Therefore, the 20m corridor had a good reproducibility for the population of this study.

Key words: exercise test; task performance; pediatrics; reproducibility of results.

Resumo

Objetivo: Realizar uma análise comparativa do teste de caminhada de seis minutos em crianças e adolescentes saudáveis em pistas de diferentes metragens (30,5 e 20 metros). **Métodos:** Foram avaliados 67 voluntários de escolas públicas de uma cidade de uma região metropolitana, com idades de 7 a 14 anos, sendo 36 meninos e 31 meninas. Todos foram submetidos a quatro testes de caminhada, sendo dois em cada uma das pistas. As variáveis analisadas foram: distância caminhada, trabalho de caminhada, pressão arterial média (PAM), frequência cardíaca (FC) e saturação de oxigênio (SaO2). Para análise estatística, foi utilizado ANOVA One-Way para medidas repetidas para um $p \leq 0,05$. **Resultados:** Na comparação entre os testes realizados em cada pista e na comparação do melhor teste entre pistas, não foram observadas diferenças significativas para a PAM, FC e SaO_2. A distância caminhada não foi estatisticamente diferente entre os dois testes realizados em cada pista. Entretanto, na comparação entre pistas nos testes de melhor desempenho, os voluntários caminharam distâncias significativamente maiores na pista de 30,5 metros ($p<0,05$). Porém, esse aumento foi inferior a 10%. Quanto à sobrecarga cardíaca e ao trabalho de caminhada, não foram observadas diferenças significativas entre pistas. **Conclusões:** Apesar das diferenças encontradas na distância caminhada entre pistas, ela foi menor que 10% sem variações importantes nos outros parâmetros avaliados. Portanto, a pista de 20 metros se adequou aos critérios de reprodutibilidade descritos na literatura para a população do presente estudo.

Palavras-chave: teste de esforço; análise e desempenho; pediatria; reprodutibilidade dos testes.

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Introduction

The six-minute walk test (6MWT) is a form of clinical evaluation performed through a submaximal effort. It is the result of modifications performed on pre-existing tests to suit the limited physical conditions of specific patient populations. The test allows the assessment of physiological changes during an exercise performed in a given time. The 6MWT can be performed with one or more velocities and predicts functional capacity[1-4].

Time-based tests are ideally conducted in quiet and closed corridors, and parameters such as distance, level of perceived exertion, oxygen saturation, blood pressure, respiratory and heart rates at a specific time period are recorded[5]. The 6MWT shows wide applicability because it requires less technical expertise and little equipment, and it is also inexpensive and easy to administer. This test can present an indirect assessment of someone's capacity during activities of daily living, and it can be used to follow-up evolution during treatment[5-7].

According to the American Thoracic Society (ATS), the variables used in the test, besides the walked distance, should evaluate the overall response of the systems involved, such as the cardiopulmonary and musculoskeletal systems[2]. The walked distance is considered a criterion for prognosis of the functional capacity and can be influenced by the length of the corridor[2,8,9].

Several studies have investigated the applicability and efficiency of the 6MWT in different populations, testing its validity, reliability and interpretability, thus establishing reference values and equations to interpret the test results[8-14]. Some of these studies demonstrated the validity and applicability of the 6MWT in heart and respiratory diseases[15-18] and others in children and adolescents, but the reproducibility criteria were based on the adult population[8,11-14,19].

Despite the ATS standardization for the length of the corridor during the test for adults (30.5 meters), some studies have used different lengths in order to make test performance viable[7-9]. Li et al.[19] conducted a large study on children and adolescents with the aim of establishing reference values for the 6MWT in this population, however the length of the corridor followed the ATS criteria. Therefore, the objective of this study was to perform a comparative analysis of the 6MWT in healthy children and adolescents in two corridors of different lengths: a 30.5-meter corridor, as standardized and proposed by the ATS, and a 20-meter corridor that is easier to implement and better suits clinical spaces.

Methods

Sample

The 6MWT is normally used to assess the functional capacity of patients during clinical practice, because it involves activities of daily living (ADLs) and minimal technical resources[2]. In the present study, healthy children and adolescents performed the 6MWT in corridors of different lengths to verify possible interferences in the results, given that the literature describes standard 30.5-meter corridors for the adult population[2], and there are few reports of this test in healthy children and adolescents.

The present study included participants of both genders aged seven to 14 years. They were selected from public schools from a city of a metropolitan area. According to the Brazilian Institute of Geography and Statistics (IBGE), the city has 82820 children and adolescents enrolled in public schools. To take part in the project, the parents or a legal guardian signed the informed consent form. The study protocol (013/2006) was approved by the Research Ethics Committee of Centro Universitário de Belo Horizonte (Uni-BH).

The study included healthy students with no symptoms, particularly those of cardiorespiratory nature, evaluated through a previous anamnesis and a standardized evaluation. Pulmonary function was evaluated by spirometry, and the participants had to show normal spirometry values to be included in the study. The body mass index (BMI) was also evaluated because, according to some authors, this index is important to assess the relationship between the 6MWT performance and the cardiorespiratory fitness and because excess weight may interfere in the walked distance due to changes in energy expenditure[13]. Students were excluded if they performed any physical activity within two hours of the test and if they used any medication that would directly influence the cardiorespiratory, musculoskeletal or nervous systems.

The six-minute walk test (6MWT)

The participants were previously evaluated by an independent examiner who carried out a physical exam and a spirometry test[20,21]. The participants performed the 6MWT according to the general criteria standardized by the ATS[2], i.e. a 10-minute rest in the pre-test period with initial and final measurements of blood pressure and perceived exertion[22]. Heart rate and oxygen saturation were measured before, during and immediately after the tests.

Each participant performed four tests (two in each of the corridors), always at the same location and time and with the same examiner. There was a rest interval of at least 24 hours between the tests. The corridors were 30.5 meters and 20 meters in length. The order of the tests in the corridors were randomly defined in a draw by an independent examiner. The performance of two tests in each of the corridors aimed to exclude a possible learning effect because, to attain reproducibility, the walked distance during the second test could not be greater than 10% compared to the first test. If this happened, it would be necessary to carry out a third test in the respective corridor[9].

Subsequently, the best walked distance in each of the corridors, along with the imposed cardiac overload and work rate, were selected for comparative analysis. This was done because, although the walked distance is considered the main variable to assess functional capacity, the work rate (ω) has a clearer relationship with the walking performance during the test. Work rate is defined as the product of walked distance times the body weight ($Km.Kg^{-1}$).

Instruments

For the 6MWT, the corridors were properly demarcated, and the necessary instruments were: heart rate monitors (POLAR FS1) to measure heart rate and an oximeter (Nonin 9500 Onyx) to measure oxygen saturation before, during and immediately after the tests. The Borg scale was used to evaluate perceived exertion.

Statistical analysis

To calculate the sample size, we used simple random sampling without replacement, with a maximum estimation error (tolerance) of 5% and probability that maximum estimation error was lower than the tolerance of 10%. The optimal sample size, according to this calculation, was 67 participants. The statistical procedures were carried out using GraphPad Prism (scientific graphing, curve fitting and statistics), version 5.0. Statistical analysis of the data was processed using mean and standard deviation. The Kolmogorov-Smirnov test was used to verify the distribution of the sample. One-way ANOVA for repeated measures was used to compare walked distance, work rate and cardiac overload during the test, and the initial and final hemodynamic variables, i.e. heart rate, mean blood pressure and oxygen saturation. To find the differences, Tukey's post-hoc test was used, with the significance level set at $p < 0.05$.

Results

Data were collected from 67 children (36 male and 31 female) aged seven to 14 years (10.80±1.90 yrs) with mean BMI of 18.03±3.05 kg/m^2. For the spirometry test, all participants showed the predicted values of forced vital capacity, forced expiratory volume in one second and Tiffeneau index within the normality. In the comparison between tests in each of the two corridors and in the comparison of the best test between the different corridors, there were no significant differences ($p > 0.05$) between baseline and final mean of blood pressure (MBP), heart rate (HR) and oxygen saturation (SaO2), as seen in Table 1.

In relation to the walked distance, the two tests carried out in each of the corridors showed no significant difference ($p > 0.05$). However, the comparison of the best test between corridors showed a significant difference ($p < 0.05$). Participants walked longer distances in the 30.5-meter corridor, however the difference in distance was less than 10%, as shown in Figure 1.

Regarding heart rate in the best test between corridors, there were no significant differences ($p > 0.05$; Figure 2). Concerning the work rate, there were no differences between the tests performed in each corridor or among the best test between corridors (Figure 3).

Regarding perceived exertion measured by the Borg scale, there were no significant differences between the tests. However, the younger participants had difficulty in quantifying dyspnea using the scale, which may have affected the results.

Discussion

The 6MWT is routinely used to assess functional capacity. In the present study, it was carried out in healthy children

Table 1. Blood pressure, heart rate and oxygen saturation in the 6MWT in the different corridors.

	20-meter corridor				30.5-meter corridor			
	1st test		2nd test		1st test		2nd test	
	Initial	final	Initial	Final	Initial	Final	Initial	Final
BP	81.72±7.31	88.68±7.31	82.41±7.40	89.23±7.11	81.77±7.44	88.31±8.17	82.39±8.10	90.23±7.72
HR	98.93±15.40	164.60±20.09	99.99±14.09	169.01±21.14	102.75±13.51	169.63±24.71	98.62±14.43	169.07±23.80
SaO_2	98.16±1.01	96.58±1.93	98.06±0.97	96.69±1.73	97.85±1.02	96.99±1.49	97.97±0.89	96.77±1.21

BP: Blood pressure in mmHg; HR: heart rate in bpm; SaO_2: oxygen saturation in %, Data expressed as mean ± standard deviation.

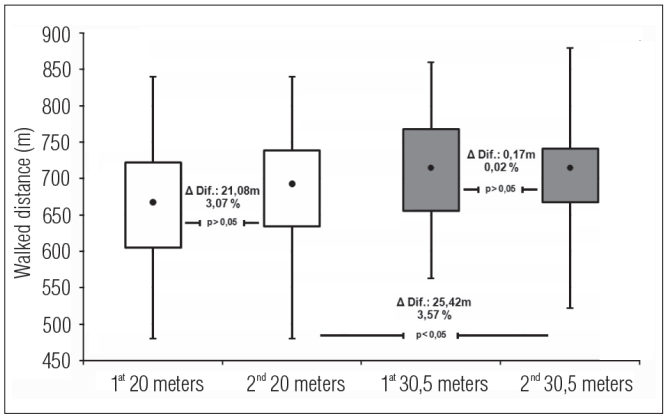

Figure 1. Differences in walked distance (meters) in each corridor test and between the corridor tests.

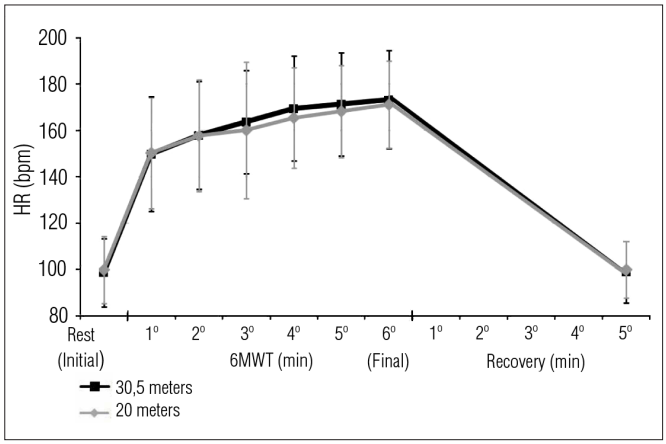

Figure 2. Heart rate (bpm) at rest (initial), during the 6MWT and at the end of the recovery period in the best corridor test.

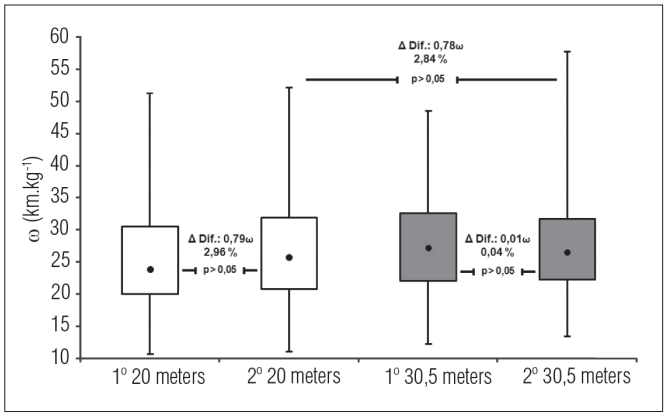

Figure 3. Work rate analysis (ω; Km.Kg^{-1}) in the tests in each corridor and between the best test in the different corridors.

and adolescents in corridors of different lengths. As described in the results, all participants had spirometry values within the normal range. The BMI assessment showed no obesity, therefore test performance and cardiorespiratory conditioning did not interfere in the walked distance due to changes in energy expenditure[13].

According to published reports, there is a learning effect during the tests due to improvements in motor coordination, increase in length stride and decrease in anxiety, and this can affect the results and reproducibility[2,23]. Several studies have demonstrated that this learning effect can be identified through the increase in the walked distance when two or more tests are performed, mostly due to the control of anxiety, recognition of the limits of the test and neuromuscular adaptation to the activity[4,24,25]. However, to ensure that tests are reproducible, the walked distance in the second test should not be greater than 10% when compared with the first test, otherwise it is necessary to perform a third test for the appropriate reproducibility of the results[9]. In the present study, the two tests carried out in each one of the corridors were reproducible because the difference between the walked distances was lower than the values identified in the literature[4,9,24,25]. The second test performed in both corridors had a better performance, therefore it was chosen for analysis and comparison of the different lengths.

Sciurba et al[23] hypothesized that long corridors are more effective when compared to short corridors for the walk test because, in the long corridors, the number of turns is reduced and, therefore, the effort is smaller. Nevertheless, in this study, the walked distances in the long corridor were not statistically greater when compared to the shorter corridor. Therefore, the authors concluded that the length of the corridor during the test would not be relevant to its standardization. However, the corridor should not be shorter than 15.23 meters[23], unlike the ATS minimum standard of corridor length[2]. Other studies compared 20 and 50-meter corridors for the test in adults and found no significant differences in the walked distance[23,26,27].

In the present study, the walked distance during the best test in the 30.5-meter corridor was significantly higher when compared to best test in the 20-meter corridor. However, the difference between these two tests was only 3.57%, i.e. less than 10%, suggesting that both tests in different corridors are reproducible. Furthermore, there were no differences in cardiac overload between corridors, suggesting a similar effort in the performance of the test in different lengths.

Although the walked distance is considered the main variable to measure functional capacity in the 6MWT, Chung, Lin and Wasserman[28] proposed an alternative method to assess functional capacity and defined work rate(ω) as the product of walked distance multiplied by body weight (Km.Kg^{-1}). Other authors concluded that expressing walked distance in work units improves the accuracy and extension of its usefulness, and it is better correlated with walking performance during the

test[29,30]. The work rate measured in the present study did not show significant differences between the tests in the different corridors, with similar energy expenditure between the different proposed lengths.

The perceived exertion evaluated by the Borg scale is well established for the adult population[22], but in the present study, the younger children had difficulty understanding the measurement of fatigue by means of this scale, which may have affected the results in the assessment of dyspnea between the different corridors. Other studies should be carried out in children and adolescents of different age groups and different populations because this difficulty can also affect the walked distance.

Thus, the 20-meter corridor, despite the lower values for walked distance, fulfilled the reproducibility criteria described in the literature for the studied population, showing no difference in cardiac overload imposed by the test and a work rate similar to the 30.5-meter corridor. The 20-meter corridor can be used when the clinical setting does not reach the ATS standard, which may be useful for the assessment of exercise tolerance and resistance of healthy children and adolescents in the studied age group.

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