Functional performance on the six-minute walk test in patients with cystic fibrosis*

Desempenho funcional de pacientes com fibrose cística e indivíduos saudáveis no teste de caminhada de seis minutos

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Abstract

Objective: To compare patients with cystic fibrosis and healthy individuals in terms of their functional performance on the six-minute walk test (6MWT). **Methods:** A prospective, cross-sectional study involving healthy individuals and patients with cystic fibrosis treated at a referral university hospital in the city of Campinas, Brazil. The 6MWT was administered in accordance with the American Thoracic Society guidelines, and it was repeated after a 30-min rest period. For all of the participants, RR, HR, SpO_2, and Borg scale scores were obtained. For the cystic fibrosis patients, nutritional status and spirometric values were determined. Patients with pulmonary exacerbation were excluded. Spearman's correlation coefficient and repeated measures ANOVA were used. **Results:** The cystic fibrosis group comprised 55 patients, and the control group comprised 185 healthy individuals. The mean ages were 12.2 ± 4.3 and 11.3 ± 4.3 years, respectively. The six-minute walk distance (6MWD) was significantly shorter in the cystic fibrosis group than in the control group for both tests (547.2 ± 80.6 m vs. 610.3 ± 53.4 m for the first and 552.2 ± 82.1 m vs. 616.2 ± 58.0 m for the second; $p < 0.0001$ for both). The 6MWD correlated with age, weight, and height only in the cystic fibrosis group. During the tests, SpO_2 remained stable, whereas HR and RR increased. **Conclusions:** In our sample, functional performance on the 6MWT was poorer among the cystic fibrosis patients than among the healthy controls in the same age bracket, and we found immediate repetition of the test to be unadvisable.

Keywords: Cystic fibrosis; Exercise tolerance; Dyspnea.

Resumo

Objetivo: Comparar pacientes com fibrose cística e indivíduos saudáveis quanto ao desempenho funcional no teste de caminhada de seis minutos (TC6). **Métodos:** Estudo transversal e prospectivo, com indivíduos saudáveis e com fibrose cística de um hospital universitário de referência na cidade de Campinas (SP). O TC6 foi aplicado de acordo com as normas da *American Thoracic Society* e repetido após 30 min de repouso. Foram determinados FR, FC, SpO_2 e escore da escala de Borg em todos os participantes, assim como o status nutricional e valores espirométricos para os pacientes com fibrose cística. Excluíram-se pacientes em exacerbação pulmonar. Foram utilizados coeficientes de correlação de Spearman e ANOVA para medidas repetidas. **Resultados:** Foram incluídos 55 pacientes no grupo fibrose cística e 185 indivíduos saudáveis no grupo controle, com médias de idade de 12,2 ± 4,3 anos e 11,3 ± 4,3 anos, respectivamente. A distância percorrida no TC6 (DTC6) foi significativamente menor no grupo fibrose cística que no grupo controle em ambos os testes (547,2 ± 80,6 m vs. 610,3 ± 53,4 m no primeiro e 552,2 ± 82,1 m vs. 616,2 ± 58,0 m no segundo; $p < 0,0001$ para ambos). A DTC6 se correlacionou com idade, peso e altura somente no grupo fibrose cística. A SpO_2 manteve-se estável durante o teste, com aumento da FC e da FR. **Conclusões:** Nesta amostra, os pacientes com fibrose cística apresentaram um menor desempenho funcional no TC6 quando comparados a indivíduos saudáveis de mesma faixa etária, sem a necessidade de repetição imediata do teste.

Descritores: Fibrose cística; Tolerância ao exercício; Dispneia.

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Introduction

The six-minute walk test (6MWT) is a submaximal, self-paced exercise tolerance test that is easy to administer and well tolerated. The 6MWT is reflective of activities of daily living and evaluates the global and integrated responses of all the systems involved during exercise: pulmonary and cardiovascular systems; peripheral and systemic circulation; neuromuscular units; and muscle metabolism.[1]

The 6MWT is used for assessing results before and after treatment of patients with moderate or severe pulmonary heart disease and for assessing cardiopulmonary status, as well as being used in epidemiological studies. The 6MWT is an inexpensive tool, is easily reproducible in outpatient settings, and yields sufficiently reliable results.[2]

The use of the 6MWT by numerous health care facilities worldwide has raised interest in standardizing the test. Some authors[3,4] have denounced a lack of standardization, in children and adults, as a negative aspect of the choice of the test as a research tool. There have been advances in the standardization and use of the 6MWT in scientific investigations in adults.[1,2]

Cystic fibrosis is a severe autosomal recessive hereditary disease, with variability in symptom onset and presentation. Its incidence varies according to ethnicity. In Brazil, the incidence of cystic fibrosis is estimated at 1/10,000 live births.[5]

The clinical triad that characterizes the disease consists of progressive, chronic, suppurative, obstructive pulmonary disease, pancreatic insufficiency (causing poor digestion and poor nutrient absorption), and abnormally high concentrations of sweat electrolytes.[5] Although the mechanisms of physical activity intolerance remain unclear, children and adolescents with cystic fibrosis appear to have a favorable therapeutic response to physical activity, including an improved prognosis. Favorable prognosis is associated with better aerobic conditioning and better nutritional status. In most patients, death results from a decline in pulmonary function.[6]

Various studies have administered the 6MWT to patients with cystic fibrosis (Chart 1), with different purposes. Recent studies[7,8] have attempted to establish reference values for the 6MWT in healthy children and adolescents. However, those studies lack consistency in terms of sample size and ethnic variability. The objective of the present study was to compare cystic fibrosis patients with healthy individuals in terms of their performance on the 6MWT, as assessed by the six-minute walk distance (6MWD).

Methods

This was a prospective, cross-sectional study carried out between March of 2009 and March of 2010 and involving a nonrandom sample of patients treated at the University Hospital of the *Faculdade de Ciências Médicas da Universidade Estadual de Campinas* (FCM-Unicamp, State University at Campinas School of Medical Sciences), located in the city of Campinas, Brazil. The study was approved by the FCM-Unicamp Research Ethics Committee (Protocol no. 504/2008). All of the participants or their legal guardians gave written informed consent.

The sample size was planned to accommodate a ratio of at least two controls per case of cystic fibrosis. All patients between 6 and 25 years of age who were under treatment at the cystic fibrosis outpatient clinic of the university hospital were invited to participate in the study. The cystic fibrosis (CF group) comprised patients in whom the diagnosis of cystic fibrosis had been confirmed by two abnormal sweat test results (chloride > 60 mEq/L) or by the presence of two confirmed mutations in the gene that encodes the cystic fibrosis transmembrane conductance regulator protein.

To identify pulmonary exacerbations and assess the severity of cystic fibrosis, we used the cystic fibrosis clinical score, the Cystic Fibrosis Foundation score, and the Shwachman-Kulczycki score.[9] Patients with acute pulmonary exacerbation, as identified by the scores (cystic fibrosis clinical score > 25 and Cystic Fibrosis Foundation score ≥ 4), were excluded from the study, as were those who were oxygen-dependent and those who failed to return to the outpatient clinic during the collection period.

The control group consisted of students attending a public elementary school, as well as of healthy health professionals and volunteers who agreed to participate in the study. Ages ranged from 6 to 25 years. Individuals with a history of respiratory disease were excluded, as

Chart 1 - Major studies on the use of six-minute walk tests for patients with cystic fibrosis.

Study	Groups studied (n)	Age, years[a]	Course	Verbal encouragement	Repetition	Particularity	Results
Gulmans et al.[3]	CFG (23)	11.1 ± 2.2	8-m straight course	Standardized, given at every turn	2 tests separated by a 1-week interval	There were 2 tests for training purposes in the weeks prior to the assessment	Correlation between the VO_2 results, negative correlation with the index of lung hyperinflation
Prasad et al.[14]	CFG (54) vs. CG (33)	12.5 vs. 12.6[b]	17-m straight course	Not mentioned	A test for training purposes 30 min earlier	The investigator walked next to the patient. A new dyspnea scale was tested	The new dyspnea scale is objective and user-friendly
Chetta et al.[17]	CFG (25) vs. CG (22)	25 ± 5 vs. 26 ± 6	Not mentioned	Standardized, given every 30 min	2 tests separated by a 60-min interval	A control group of the same age and gender distribution was used	The 6MWD was within the predicted range, with $\downarrow SpO_2$ in the CFG
Cunha et al.[12]	CFG (16)	11.0 ± 1.9	28-m straight course	Standardized	2 tests separated by a 30-min interval	The investigator walked next to the patient	The 6MWT is valid and reproducible in children with cystic fibrosis
Gruber et al.[16]	CFG (286) vs. CG (44,000)	11.8 ± 3.4	54-m course	Standardized, given every minute	1 test	Music was used during the walk	The rehabilitation program increased the 6MWD
Troosters et al.[19]	CFG (64) vs. CG (20)	26 ± 8	50-m straight course	Yes, not specified	2 tests	It investigates the correlation between peripheral muscle weakness and exercise intolerance	Quadriceps strength affects the 6MWD but not VO_2
Hommerding et al.[25]	CFG (41)	11.2 ± 4.1	30-m straight course	Not mentioned	1 test	It relates the use of modified Borg scale to FEV_1	It recommends that the Borg scale be used as a valid and sufficiently accurate tool in children aged 9 years or older
Lesser et al.[15]	CFG (11) vs. CG (13)	15.8 ± 3.6 vs. 14.3±3.8	Not mentioned	Given before, during, and at completion of the test	1 test	It uses the 6MWW to assess for correlations with the treadmill test. It uses equations in another study[27]	Good correlation between the 6MWW and VO_2 only in the CFG
Gruet et al.[18]	CFG (23) vs. CG (17)	27.9 ± 6.8 vs. 29.7±11	40-m straight course	Not mentioned	2 tests separated by a 6-week interval	Peak HR is measured during the 6MWT	It suggests that peak HR be used as a measure for exercise prescription

CFG: cystic fibrosis group; CG: control group; VO_2: maximal oxygen uptake; 6MWD: six-minute walk distance; 6MWT: six-minute walk test; and 6MWW: six-minute walk work. [a]Values expressed as mean ± SD. [b]SD not specified.

were those with orthopedic impairments and those who were smokers.

Anthropometric measurements (weight and height) were taken, and body mass index (BMI, kg/m²) was calculated, the latter classified in accordance with the Centers for Disease Control reference values, by gender and age.[10] All measurements were performed by standard measurement techniques.

Only the CF group underwent spirometry, which was performed in the Pulmonary Function Laboratory of the FCM-Unicamp Center for Pediatric Research. To that end, a CPFS/D spirometer (Medical Graphics Co., Saint Paul, MN, USA) and Breeze PF software, version 3.8B (Medical Graphics Co.), were used, in accordance with the guidelines of the European Respiratory Society and the American Thoracic Society. The predicted values of the following spirometric variables were studied: FVC; FEV_1; and $FEF_{25-75\%}$, with the use of the reference values proposed by Polgar & Promadhat.[11] For the CF group patients whose test had been performed up to 3 months before the 6MWT, data were obtained retrospectively. All other CF group patients were referred for a second test.

The 6MWT was performed identically in both groups. A 30-m indoor course was delineated with cones, which were arranged in a straight line, 3 m apart, on level ground. While the patient remained seated, RR, HR, and SpO_2 were measured, the last with a portable pulse oximeter (Oximed Plus®; Oximed, Porto Alegre, Brazil), and modified Borg scale scores were obtained.[1]

Each participant was instructed to complete as many laps as possible in 6 min, walking briskly, but without running or jogging. At the end of every minute, the patient was informed of how many minutes remained and was given verbal encouragement in a neutral tone of voice ("You're doing well" and "Keep up the good work"). The investigator stood at one end of the walking course holding a stopwatch.[1]

After 6 min, the patient was instructed to stop. The distance from the cone to the spot where the patient stopped was then measured. While the individual remained seated, HR, RR, SpO_2, and Borg scale scores[1] were again obtained, immediately after the test and after a 3-min rest period. After a 30-min rest period,[12] a second 6MWT was administered. Each test was administered to one individual at a time. It was explained to participants that, during the test, they could stop walking at any time if they experienced discomfort, but that test time would continue to be counted.[1]

Statistical analyses were performed with the SAS System software for Windows, version 9.2 (SAS Institute, Cary, NC, USA). Data are presented as mean ± SD. The Mann-Whitney test was employed to compare the two groups. We used repeated measures ANOVA on rank-transformed data in order to evaluate differences among tests over time. Spearman's correlation coefficient was employed to assess linear correlation between variables. Multiple linear regression analysis was used for the identification of factors affecting the 6MWT, whereas the intraclass correlation coefficient and Bland & Altman plots were used for the assessment of reproducibility.[13] The greatest 6MWD achieved by each participant was chosen for analyses. The level of significance was set at 5%.

Results

In 2009, 168 patients were being treated at the cystic fibrosis outpatient clinic. Of those, 96 were considered eligible, in terms of age, to participate in the study. Of those 96, 41 were excluded for the following reasons: declining to participate in the study (n = 15); having pulmonary exacerbation (n = 12); missing physician visits (n = 10); and being on continuous oxygen therapy (n = 4). Therefore, the CF group comprised 55 patients, and the control group comprised 185 healthy individuals. The mean ages were 12.2 ± 4.3 years and 11.3 ± 4.3 years, respectively (overall range, 6.0-24.9 years).

The groups were found to be homogeneous in terms of their distributions by age, weight, height, and gender (Table 1). There were differences in terms of BMI and nutritional status. The percentage of malnourished individuals was higher in the CF group than in the control group (25.45% vs. 8.11%; p = 0.0016).

In the CF group, the mean Shwachman-Kulczycki score was 75.29 ± 10.11 (range, 50-90), clinical status being classified as follows: excellent, in 4; good, in 29; mild, in 14; and moderate, in 4. None of the patients were classified as having severe disease. The calculation of the Shwachman-Kulczycki score

Table 1 - Age and gender distribution, as well as distribution of weight, height, BMI, and six-minute walk distance values, by study group.

Variable	Group	n	Mean ± SD	Minimum	Median	Maximum	p
Age, years	CF	55	12.2 ± 4.3	6.1	11.1	23.3	0.0962*
	CG	185	11.3 ± 4.3	6	10.2	24.9	
Weight, kg	CF	55	37.3 ± 15.5	18.2	35	79	0.0960*
	CG	185	41.6 ± 18.0	18.0	37.2	105	
Height, m	CF	55	1.04 ± 0.20	1.1	1.4	1.8	0.3967*
	CG	185	1.5 ± 0.2	1.1	1.4	1.9	
BMI, kg/m²	CF	55	17.4 ± 3.1	11.9	17.1	27.3	0.05*
	CG	185	18.6 ± 4.0	12	18	33.3	
6MWD 1st test, m	CF	55	547.2 ± 80.6	390.6	540.0	768.0	
	CG	185	610.3 ± 53.4	420.00	612.0	739.0	
6MWD 2nd test, m	CF	55	552.2 ± 82.1	374.4	554.0	772.8	0.0625***
	CG	185	616.2 ± 58.0	450.0	618.0	771.0	
Gender			Male		Female		
	CF	55	40.00%		60.00%		0.6692**
	CG	185	43.24%		56.76%		

CF: cystic fibrosis; CG: control group; BMI: body mass index; and 6MWD: six-minute walk-distance. *Nonparametric Mann-Whitney test. **Chi-square test. ***Value of p for the purpose of the test. Repeated measures ANOVA on rank-transformed data.

could not be completed in 4 patients because of the lack of a recent chest X-ray.

The mean percentage of predicted FEV_1 was 77.33% ± 21.90% (range, 38%-132%), whereas the mean percentage of predicted FVC was 85.56 ± 18.95% (range, 52-131%) and the mean percentage of predicted $FEF_{25-75\%}$ was 64.17 ± 32.84% (range, 14-138%).

All of the participants completed the 6MWT without stopping. The 6MWD was shorter in the CF group than in the control group for the first test (547.2 ± 80.6 m vs. 610.3 ± 53.4 m; $p < 0.001$) and for the second test (552.2 ± 82.1 m vs. 616.2 ± 58.0 m; $p < 0.0001$). There were no differences between the mean 6MWD for the first and second tests in either of the two groups ($p = 0.0625$).

The 6MWD was not found to be affected by gender ($p = 0.1586$ and $p = 0.7753$ for the CF group and the control group, respectively) or genetic mutations ($p = 0.8892$ for the CF group).

The reproducibility of the 6MWT, as assessed by the intraclass correlation coefficient, showed concordance of 0.810 (95% CI: 0.696-0.885) and 0.770 (95% CI: 0.704-0.823) in the CF group and the control group, respectively. The Bland & Altman plots (Figure 1) show that the tests were very close and indicate the reliability of the measurements.

Spearman's linear correlation test revealed that the 6MWD correlated moderately with height, weight, and age in the CF group. In the control group, the 6MWD did not correlate with any of the variables studied.

Stepwise multiple linear regression was used for the selection of the variables that most affected the 6MWD in the CF group. Weight ($p = 0.0263$), height ($p = 0.0007$), and FEV_1 (% of predicted; $p = 0.0017$) were responsible for 45.5% of the behavior of the dependent variable ($R^2 = 0.4550$). The formula developed to predict the 6MWD, only for the CF group, was as follows:

$$6MWD = -257 - [5.4 \times \text{weight (kg)}] + [628.03 \times \text{height (m)}] + [164 \times FEV_1 \text{ (\% of predicted)}]$$

It was not possible to develop a formula to predict the 6MWD for the control group because of the lack of correlation between the 6MWD and the variables studied.

In the first and second 6MWTs, the cardiorespiratory variables of the groups were measured at three different time points: at rest; at the sixth minute of the 6MWT; and at three minutes after completion of the 6MWT, i.e., at the ninth minute.

In the control group, RR (Figure 2a) increased significantly in the second 6MWT, at two different time points: at rest (18.6 ± 4.0 breaths/

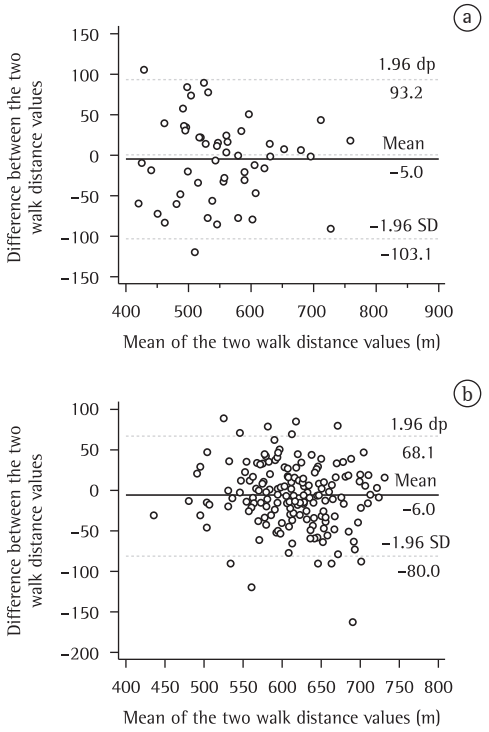

Figure 1 - Bland & Altman plots for the cystic fibrosis group (in a) and the control group (in b).

min vs. 19.6 ± 4.4 breaths/min; p = 0.0012) and at the sixth minute (27.0 ± 7.0 breaths/min vs. 28.0 ± 6.8 breaths/min; p = 0.0164). In the CF group, RR increased considerably between rest and the sixth minute (p < 0.0001) in both tests, demonstrating the effort put forth by patients during physical exercise.

In the control group, HR (Figure 2b) was found to be higher in the second 6MWT (p < 0.0001), being different at all time points assessed in both tests (p < 0.0001), which suggests that the 6MWT caused significant changes in HR of participants.

In the CF group, the greatest HR was observed in the first 6MWT. The variation in HR among the three different time points assessed (i.e., at rest, at the sixth minute, and at the ninth minute) was statistically significant (p < 0.0001). In the second 6MWT, there was no difference in HR between the first and third time points assessed (i.e., at rest and at the ninth minute; p = 0.2798), which suggests a return to values close to baseline.

In the control group, SpO_2 (Figure 3a) showed a statistically significant reduction in the second 6MWT only at the sixth minute, decreasing from 98.2 ± 1.0% to 97.9 ± 1.0% (p = 0.0002). Although 1 patient in the CF group showed SpO_2 values ranging from 82% to 100%, SpO_2 remained stable throughout the three different time points assessed in the two 6MWTs in the CF group.

In the control group, there were statistically significant differences in dyspnea levels, as measured by the modified Borg scale (Figure 3b), at all time points assessed in both tests. In the CF group, there were differences between the two 6MWTs, dyspnea levels being higher in the first 6MWT.

Discussion

The search for inexpensive, user-friendly tools for the assessment and monitoring of chronic pulmonary diseases is a recent concern in the international literature. In our study, the 6MWD

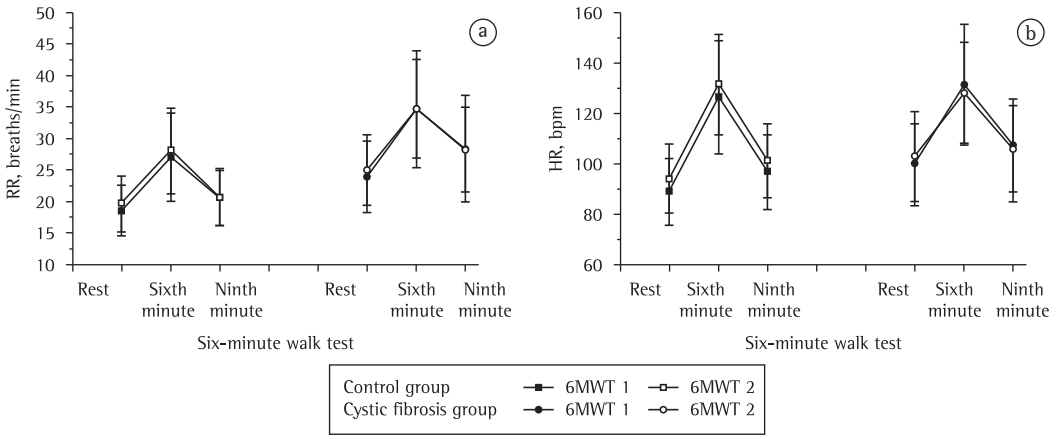

Figure 2 - Behavior of the variables RR (in a) and HR (in b) in the cystic fibrosis and control groups. 6MWT 1: first six-minute walk test; and 6MWT 2: second 6MWT.

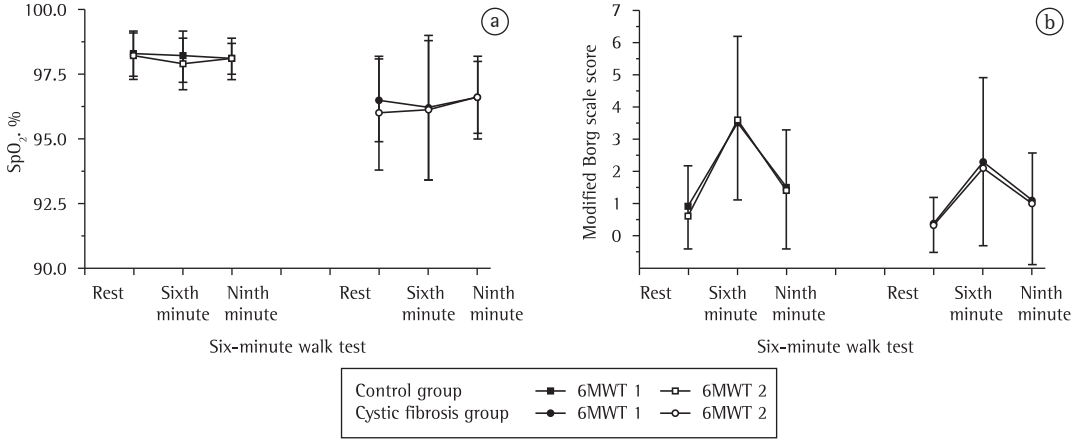

Figure 3 - Behavior of the variables SpO_2 (in a) and dyspnea as assessed by the modified Borg scale score (in b) in the cystic fibrosis and control groups. 6MWT 1: first six-minute walk test; and 6MWT 2: second 6MWT.

was shorter among the individuals with cystic fibrosis than among the healthy individuals. To date, there have been only six studies comparing cystic fibrosis patients and controls in terms of their performance on the 6MWT; only three of those studies have reported mean ages close to those of our sample.

In 2000, with the aim of testing a new assessment tool for dyspnea (the fifteen-count breathlessness score), Prasad et al.[14] evaluated 55 children with cystic fibrosis and 33 healthy children (range, 6-8 years) by using the 6MWT and the step test. However, the authors did not analyze the distances covered. Lesser et al.[15] administered the 6MWT to healthy individuals and cystic fibrosis patients (mean age: 14.3 ± 3.8 years). The 6MWD was shorter among the cystic fibrosis patients than among the controls (468 ± 68 m vs. 557 ± 73 m, respectively; $p < 0.05$). Gruber et al.[16] tested the effects of a physical fitness training program in 286 cystic fibrosis patients and 44,000 healthy children (mean age: 11.8 ± 3.4; range, 6-18 years). The 6MWT was used for assessing aerobic capacity at the end of the fourth and sixth months of training: the 6MWD increased by 4.4% in the CF group ($p < 0.05$). In that study, the 6MWD was shorter in the CF group than in the control group at the beginning and end of the training program ($p < 0.05$, for both measurements). Chetta et al.[17] studied 47 adult patients and reported similar performances in the CF group and the control group (626 ± 49 m and 652 ± 46 m, respectively). Despite including adults, a study by Gruet et al.[18] reported results that corroborate our findings in that the 6MWD was significantly shorter in the CF group than in the control group (675 ± 66 m vs. 808 ± 105 m; $p < 0.05$). Another group of authors,[19] who also administered the 6MWT to adults with cystic fibrosis (n = 64; mean age: 26 ± 8 years; and mean FEV_1 [% of predicted] = 65 ± 19%), reported differences between the CF group and the control group (702 ± 82 m vs. 833 ± 93 m; $p < 0.0001$).

Cunha et al.[12] administered the 6MWT to 16 children with cystic fibrosis and with poorer nutritional and pulmonary status than that of those in our sample (mean FEV_1 and mean BMI of 63.1 ± 21.1% and 15.8 ± 2.4 kg/m^2, respectively). Nevertheless, they reported greater 6MWDs than those achieved in our study: 582.3 ± 60.0 m and 598.2 ± 56.8 m for the first and second tests, respectively. However, the small number of participants should be considered as a limitation of that study.

Factors limiting exercise capacity in cystic fibrosis patients are well described in the literature and include reduced pulmonary function, malnutrition, and muscle weakness. Other factors are higher RR with lower tidal volume, hypoxemia, and poor ventilation.[20-22]

In a study involving 188 healthy children between 6 and 12 years of age, the mean 6MWD was shorter than that achieved by our control group for the first 6MWT (579.4 ± 68.1 m vs. 610.3 ± 53.4 m) and the second 6MWT (569.2 ± 83.4 m vs. 616.2 ± 58.0 m).[8] However, our study included adolescents and young adults, with different anthropometric characteristics.

In the present study, boys and girls covered similar distances in both groups, a finding that has been documented in other studies.[8,23,24] The 6MWDs achieved in the first and second tests were similar in both of our groups, indicating the reproducibility of the test, as reported in other studies.[3,8,12] Repeating the 6MWT is recommended by the American Thoracic Society.[1] However, some authors have suggested that such repetition can be a study limitation.[23] The results achieved in the two 6MWTs in our CF group are indicative that repeating the 6MWT actually requires a level of energy expenditure with which patients with chronic pulmonary disease cannot adequately cope.

In the CF group, SpO_2 decreased in the second 6MWT, although the difference was not statistically significant. Studies have shown that, in healthy individuals, SpO_2 levels do not vary much in the 6MWT, although there are increases in HR and RR.[23] Although the decrease in SpO_2 seen in the control group was statistically significant, we do not believe that it was a clinically significant increase, because it remained within the range of normality (above 96%), even if the variability described by the device manufacturer (± 2%) is taken into consideration.

The 6MWT is an exercise tolerance test in which patients can determine the pace and intensity of the physical exertion. More vigorous exercise and severe forms of COPD can cause major reductions in SpO_2 and reduced exercise tolerance.[22,24]

The self-reported sensation of dyspnea was greater in the control group than in the CF group. Healthy children might not have the ability to measure dyspnea, because this condition is unknown in their experience. In the CF group, however, the sensation of "shortness of breath" and the grading of breathlessness are recurrent and much more intense, which makes the assessment reliable, even in children. Although one group of authors[25] demonstrated that the modified Borg scale is a good tool for assessing perception of dyspnea in preschool children with cystic fibrosis, age can be a limitation to its use.

The equation developed in the present study was able to explain only 45.5% of the variation in our results. This value falls within previously reported rates,[7,8,15,18] which range from 25% to 66%.[26]

Although the equations proposed by Li et al.[7] and Geiger et al.[27] are innovative, they have an ethnic-specific configuration, and this can make it difficult to adopt them as reference equations in Brazil. The study by Priesnitz et al.[8] is certainly the closest to ours in terms of the make-up of the study population. We suggest that the equation devised by Priesnitz et al. be used in research centers throughout Brazil in order to determine whether there is concordance between the results obtained in the 6MWTs and the values predicted by the equation.

Few studies have included percentage of predicted FEV_1 in their equations to predict 6MWD. The use of spirometric values in the reference equation is important for cystic fibrosis patients, because the degree of pulmonary impairment in each individual is taken into account, which translates to the distance predicted by the equation being closer to the actual distance covered by the patient with pulmonary disease.

Our study has some limitations. The absence of patients classified as having severe disease by the Shwachman-Kulczycki score and the number of participants in the CF group might explain the poor correlation between the clinical variables and the 6MWD.

In the present study, we demonstrated, by comparison with a control group, that functional capacity is impaired in patients with cystic fibrosis. Because there is no consensus regarding which published equations should be used for predicting normal values for the 6MWD in children and adolescents, the limitations of the present study, as well as those of other studies in the literature, might be overcome in multicenter studies, involving large samples and varying degrees of cystic fibrosis severity. We found that functional performance on the 6MWT was poorer among the cystic fibrosis patients than among the healthy controls in the same age bracket. We also found immediate repetition of the test to be unadvisable. The 6MWD correlated with weight, height, and percentage of predicted FEV_1 in the CF group, and we developed a cystic fibrosis-specific equation to predict 6MWD.

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