International Journal of EXERCISE SCIENCE

Original Research

Rating of Perceived Exertion in Three-Minute Step Test in Children with Cystic Fibrosis

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ABSTRACT

International Journal of Exercise Science 14(3): 177-186, 2021. The purpose of the study was to assess whether there are differences in cardiorespiratory fitness between children with and without cystic fibrosis (CF). Ten children with CF attended at a referral center for the treatment of CF and 13 children without CF were evaluated. The average age of the children with CF was 10.40 (3.13) years and those without CF was 9.39 (3.25) years. The children performed the three-minute step test with monitoring of hemodynamic parameters and the rating of perceived exertion (RPE) every minute. Oxygen desaturation of 4% during the test occurred in three children with CF and none of the children reached a SatO2 percentage < 75%. After the step test, the findings showed that children with CF presented higher RPE scores during the test (p = 0.002) when compared to children without CF (p < 0.001). The RPE was the only parameter that changed during the test and demonstrated that children with cystic fibrosis tired more during the test when compared to children without CF despite the lack of changes in hemodynamic variables.

KEY WORDS: Children, cystic fibrosis, exercise tolerance, desaturation

INTRODUCTION

Cystic Fibrosis (CF) is a rare, progressive, autosomal genetic pathology, caused by a perceived defect in the transmembrane conducting and regulating gene in the long arm of chromosome 7. The alteration in the gene alters the production of the cystic fibrosis transmembrane regulator (CFTR) protein, which makes up the chlorine channels of various body tissues, mainly the lungs, thus impairing respiratory function, functional capacity, and cardiorespiratory fitness (1, 2).

In the respiratory system, cystic fibrosis causes greater consistency in the mucus, which prevents the cilia from moving, generating an accumulation of pulmonary secretions in the alveoli. This condition results in recurrent inflammation and infections of the respiratory tract, dyspnea, a hyperinflated chest, difficulty in expelling CO2, and an increased respiratory rate. Clinical signs

and symptoms lead to impairment in functional capacity and exercise tolerance and, when associated with COPD, become the main cause of morbidity and mortality in CF (3).

In addition to monitoring pulmonary function, cardiorespiratory fitness is considered as a prognostic tool for disease severity and mortality. There are several tests to assess cardiorespiratory fitness in children with cystic fibrosis, such as the shuttle run, shuttle walk test, 6-minute walk test, and 3-minute step test (4-6). The three-minute step test was used for the first time in 1998 with the aim of assessing desaturation in children and is considered a low-cost tool that portrays the activities of daily living. Furthermore, this tool shows the global response of all systems involved in the course of physical exercise, such as the cardiovascular and pulmonary systems, neuromuscular units, and muscle metabolism, being considered an easy to administer submaximal exercise tolerance test (7).

Some studies have compared the three-minute step test with the six-minute walk test and ergoespirometric test and shown no differences in the variables evaluated (4, 8, 9). When comparing the 6-minute walk test with the 3-minute test in children who would undergo lung transplantation, the study by Aurora et al. (9) showed that the 3-minute test is more feasible to perform, as the drop in saturation and increase in heart rate are also noticeable, which can be explained by the low blood oxygen levels at rest.

The assessment of cardiorespiratory function in children with CF is considered a protective factor for comorbidities and can provide information on the functioning of the cardiovascular and pulmonary system in the face of physical stress (6, 10), as well as being used as a parameter of disease progression and mortality. Therefore, it was decided to use the three-minute test because is an easy, inexpensive test and in addition allows to observe the drop in saturation, it is also possible to objectively assess hemodynamic parameters and subjective rating through the subjective perception of effort. The group of children with CF assessed in the present study is attended at a referral center that accompanies underprivileged children and it has a multidisciplinary team, however, there are still difficulties in assistance due to the lack of assessment and monitoring equipment.

Considering the aspects mentioned above for this study, it was hypothesized that the three-minute step test will indicate changes in hemodynamic parameters and RPE. Given the above, the objective of the present study was to assess whether children with cystic fibrosis present changes in hemodynamic parameters and rating of perceived exertion when compared to children without the disease.

METHODS

Participants

This is a cross-sectional study conducted with children attended at a referral center for the diagnosis and treatment of cystic fibrosis - Association of Parents and Students of the Disabled (APAE) - in the City of Anápolis and healthy children without the disease (students from a school located in the city) aged from five years. The study was carried out between November

2018 and April 2019. Children without CF included in the study could not present any acute clinical conditions. As CF is a rare disease and the treatment centers are very widely spaced around the country, no sample calculation was performed, and the sample consisted of convenience. Children without CF included could not present, at the time of participation, any acute or chronic health conditions and without use of medications. In general, children with any physical limitation that prevented them from performing the cardiorespiratory fitness test or with impaired understanding of the guidelines for the test were excluded.

An evaluation form was completed with data regarding age, sex, the affected gene, and use of medications. The power analysis calculation was conducted with G*Power (version 3.1) (Universitat Kiel, Germany) considering 23 participants (ten with CF and 13 without CF), giving an 84% power, medium effect size of 0.25, and significance level of 5%. All procedures were in accordance with the ethical standards of the International Journal of Exercise Science (11) and the ethical standards of the Helsinki Declaration, and the study was approved by the Ethics and Research Committee of Centro Universitário de Anápolis - UniEVANGÉLICA under nº 2.908.073/2018. Parents/guardians signed the consent form and the children signed the minor's consent form.

Protocol

Body mass index (BMI): Body mass was measured using a digital scale (Filizola, model 2096 PP, São Paulo, Brazil), with a precision of 0.1 kg and a capacity of up to 150 kg. Height was measured in meters (m) with the use of a stadiometer (Sanny, São Paulo, Brazil). The BMI categorization followed the guidelines of the World Health Organization (12) cutoff points for classifying children and adolescents.

To perform the measurements, the children remained in an orthostatic position, wearing light clothing, with bare feet together, their bodies erect, and their backs to the stadiometer. After weight and height measurements, the body mass index (BMI–kg/m^2) was calculated by dividing weight by height squared. For participants between 5 and 18 years old, referring to BMI for age, the children were classified as marked thinness with z-score < -3, thinness with z-score > -3 and z-score < -2, eutrophic z-score > -2 and z-score < +1, overweight z-score > +1 and z-score < +2, obesity z-score > +2 and z-score < +3, and severe obesity z-score > +3 (12).

Blood pressure: The measurement of systemic blood pressure followed the guidelines established in the literature (13). To measure systolic (SBP) and diastolic (DBP) blood pressure and resting heart rate, a semiautomatic device (OMRON, model HEM 705CP, Kyoto, Japan) was used with the cuff adapted to the arm circumference of children aged 6-17 years. To obtain the measurements, the procedure was explained and then the children were instructed not to talk during the measurement. Two measurements were taken with the participants sitting at rest for five-minute rest, legs uncrossed, feet flat on the floor, and left arm in the supine position. The measurements were performed with an interval of 1 minute. The first measurement was discarded and the reference values were considered according to sex and height and children with values above the 95th percentile were considered hypertensive (13).

Cardiorespiratory fitness: To perform the 3-minute step test, a metronome obtained through a cell phone application (Metronome Beats) was used to dictate the time of the steps up and down the stair. Throughout the test, a pulse oximeter (Rossmax, model SB100, Taiwan, China) was used to measure peripheral saturation and pulse rate. If the children presented saturation below 75% the test would be ended immediately. The values of the rating of perceived exertion (RPE) can vary from six to 20, where six is very easy and 20 is exhaustive (14).

Cardiorespiratory fitness was assessed by the 3-minute step test and the child was required to perform 30 steps per minute, up and down a step (15 cm high) (8). The test interruption criteria were saturation below 75% and tiredness/fatigue to continue the test. The main response of this test is desaturation in children with CF and values > 4% were considered desaturation. Systolic blood pressure (SBP) and diastolic blood pressure (PAD) were measured pre-, post-, and five minutes after the test. Heart rate and peripheral oxygen saturation were monitored throughout the test, and the RPE (Borg Scale) was collected at the beginning of the test, at the end of the first (T1), second (T2), and third minutes (post), and five minutes after the test (5 min). The three-minute step test was applied to the children to evaluate peripheral oxygen desaturation, but it also offers aspects related to cardiac functioning through the evaluation of blood pressure and heart rate. We also measured exercise tolerance using the RPE. The analyses were performed between groups and within groups.

Rating of perceived exertion (RSE) was assessed using an objective scale to quantify the effort when performing physical exercise by assessing the intensity and stress that occurs in the pulmonary and muscular systems during exercise by hemodynamic parameters. To collect of RSE (validity by BORG) was used with a variation between 6 to 20 points and also presented the categorization of effort (ranging from very easy to exhaustive) and in colors (white to red). The scale was printed and presented to the child, where they were instructed to show with the index finger at all times of the test the color that most reflected how they were tired (14).

Spirometry in a respiratory measurement technique is commonly used in studies on respiratory physiology (15). In the present study, it was not measured by the difficult performance of this examination via the Unified Health System (UHS), as it has a high cost for families.

Statistical Analysis

The data are described as mean, standard deviation, frequencies, and percentages. The evaluation moments were expressed as pre-test, first minute (T1), second minute (T2), immediately post-test, and after five minutes (T5). For comparisons between groups, the Student's t-test or Mann-Whitney test was used. The ANOVA test for repeated measures with Bonferroni's post hoc compared the measurements pre-, during, and post the step test within each group. Categorical variables were associated by the Chi-square test. The univariate ANOVA (ANCOVA) was used to evaluate the interaction between groups according to the variation (Δ) calculated between moments pre with T1 (T1-Pre), T2 (T2-Pre), post-test (Post-Pre), and T5 (Post-T5). The Cohen effect size (d) was calculated and the value considered for $p < 0.05$. The software used for analysis was Statistical Package for Social Science (SPSS).

RESULTS

The baseline characteristics of the children are described in Table 1. Of the children with CF, 90% had been prescribed digestive enzymes and 70% used bronchodilators.

Table 1. Baseline characteristics of children in the study.

Variables	Cystic fibrosis (n = 10)	No cystic fibrosis (n = 13)	d	p
Age (years)	10.40 ± 3.13	9.39 ± 3.25	4.04	0.46
Body mass (kg)	35.99 ± 26.17	37.85 ± 14.16	0.09	0.83
Height (m)	1.28 ± 0.12	1.40 ± 0.18	0.78	0.07
BMI (kg/m²)	20.52 ± 10.04	18.59 ± 4.02	0.25	0.53
Sex				
Male	04 (40.0)	08 (61.50)	-	0.30
Female	06 (60.0)	05 (38.50)	-	
Mutation				
ΔF508	10 (100.0)	0 (0)	-	-
Classification of BMI				
Eutrophic	09 (90.0)	13 (100.0)	-	0.19
Obese	01 (10.0)	0 (0)	-	
Drugs/supplements				
Digestive enzymes	09 (90.0)	-	-	-
Vitamins	01 (10.0)	-	-	-
Digestive	01 (10.0)	-	-	-
Respiratory inhalant	07 (70.0)	-	-	-
Antibiotics	01 (10.0)	-	-	-
No drugs	01 (10.0)	-	-	-

Note. Numeric variables as mean ± standard deviation; Categorical variables as frequencies (percentages).

As expected, SBP increased at the end of the exercise, however, at the end of five minutes it returned to pre-test values (p = 0.99) in both groups (Table 2). Regarding heart rate, the increase occurred during the test when compared to the rest values (p = 0.002). The same occurred with the RPE scores (between Pre–T_1, p = 0.01; Pre and T_2, p = 0.01; Pre-post, p < 0.001), however, five minutes after the test, perception had returned to the pre-test values in children with CF. The perception of the children with CF remained between slightly tiring and very tiring at the end of the test, while children without CF reported between easy and relatively easy. However, in the group without CF, five minutes after the test, the RPE was still greater when compared to the pre-test values (p < 0.001). Desaturation above 4% occurred in three children with CF, but none presented saturation below 75%.

In the comparison between groups, RPE was higher in children with CF at all moments during the test when compared with children without CF (Table 2). The greatest variations between groups occurred at T_2 (Δ = 3.48, p < 0.001) and at the end of the test (Δ = 4.42, p < 0.001). Five minutes after the test, the perception of effort was the same (p = 0.08).

Table 2. Comparison of hemodynamic parameters and RPE intra-groups and inter-groups pre, during, and post the three-minute step test in children and adolescents.

Variables	Cystic fibrosis (n = 10)	No cystic fibrosis (n = 13)	Δ	d	p*
Systolic blood pressure (mmHg)					
Pre-test	93.00 ± 21.11	93.10 ± 13.77	0.10	0.01	0.53
Post-test	106.00 ± 24.59	110.77 ± 23.26	4.77	0.20	0.64
T_5	92.00 ± 19.32	98.46 ± 15.19	6.46	0.37	0.38
p**	0.001	0.01			
Diastolic blood pressure (mmHg)					
Pre-test	66.00 ± 17.76	56.92 ± 13.16	-9.08	0.58	0.99
Post-test	74.00 ± 23.19	62.31 ± 16.91	-11.69	0.58	0.18
T_5	63.00 ± 21.63	59.23 ± 12.56	-3.77	0.21	0.63
p**	0.03	0.70			
Heart rate (bpm)					
Pre-test	89.60 ± 18.50	84.62 ± 13.11	-4.98	0.31	0.46
T_1	121.00 ± 31.33	124.69 ± 24.32	3.69	0.13	0.75
T_2	126.30 ± 21.09	129.00 ± 20.95	2.70	0.13	0.76
Post-test	124.90 ± 20.38	129.69 ± 24.18	4.79	0.21	0.62
p**	0.002	0.003			
Oxygen Saturation (%)					
Pre-test	93.10 ± 7.91	96.46 ± 2.96	3.36	0.56	0.17
Post-test	93.50 ± 3.21	92.39 ± 8.36	-1.10	0.16	0.67
p**	0.88	0.13			
Rating of perceived exertion					
Pre-test	8.2 ± 1.03	6.23 ± 0.83	-1.97	2.11	< 0.001
T_1	11.40 ± 2.46	8.54 ± 0.66	-2.86	1.59	0.005
T_2	13.40 ± 3.50	9.92 ± 0.64	-3.48	1.38	0.012
Post-test	15.20 ± 2.57	10.78 ± 0.83	-4.42	2.31	< 0.001
T_5	8.40 ± 1.35	9.54 ± 1.56	1.14	0.78	0.08
p**	0.002	< 0.001			

Δ- variation of measures between two groups; d- Cohen effect size; T_1- first minute of test; T_2- second minute of test; T_5- five minutes after test. * difference between groups; ** difference intra-group.

RPE variation presented a significant difference both within the groups with and without CF and when comparing between the groups (p < 0.001) (Figure 1). In the CF group children, the variation in RPE between the T_1-Pre (Δ = 3.20 ± 2.15, p = 0.01) with Post-Pre (Δ = 7.00 ± 2.36, p < 0.001) was greater and with T_5-Pre (Δ = 0.20 ± 1.75, p = 0.018) was lower. In children without CF, the variation T_1-pre (Δ = 2.31 ± 0.95, p = 0.001) was lower when compared to T_2-Pre (Δ = 3.69 ± 0.75, p < 0.001) and Post-Pre (Δ = 4.54 ± 0.88, p < 0.001).

Children with CF demonstrated greater variation in RPE in the Post-Pre (CF: 7.00 ± 2.36; no CF: 4.54 ± 0.88, p = 0.009), while the T_5-Pre variation was lower (CF: 0.20 ± 1.75; no CF: 3.31 ± 1.18, p < 0.001) (Figure 1). The ANCOVA showed greater variation in the group of children with CF in the Post-Pre (p = 0.002) and lower variation in the T_5-Pre (p < 0.001) suggesting that, immediately

after the three-minute step test, the RPE was greater and five minutes after the perception was lower than that of children without cystic fibrosis.

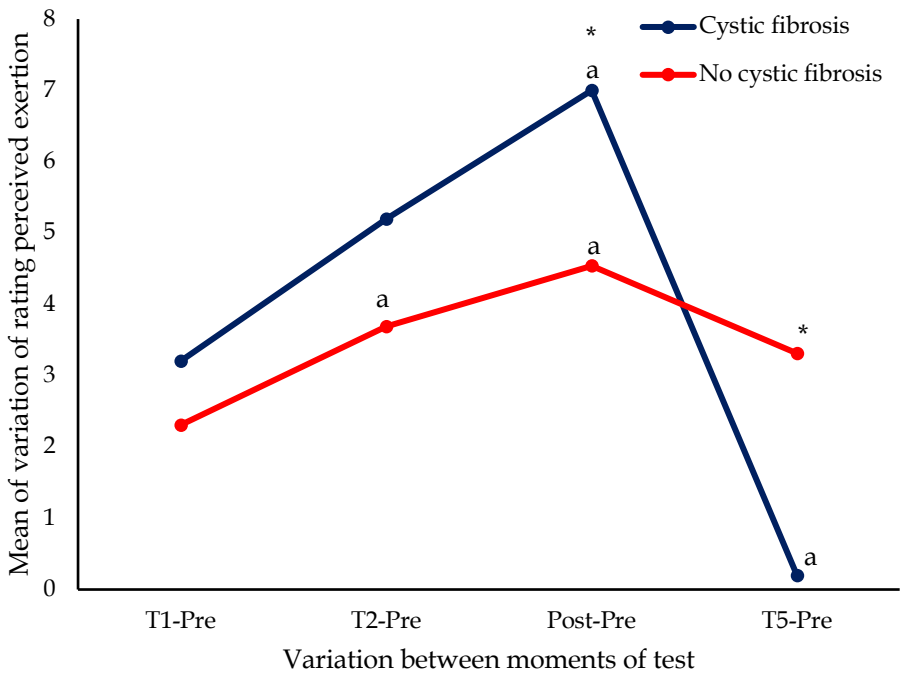

Figure 1. Variation in rating of perceived exertion between Pre with T1, T2, post, and T5 of children/adolescents (cystic fibrosis x no cystic fibrosis). [a] Difference in relation to Pre; *Difference between groups.

DISCUSSION

The main findings of the study were oxygen desaturation of 4% during the 3-minute test in three children with CF and no child reached a SatO2 percentage < 75%. Higher perceived exertion scores (between slightly tiring and very tiring) were to children with the pathology. This result suggests lower efficiency of the cardiovascular and respiratory system during the test. Thus, in the current study, the subjective perception of exertion was the only measurements that demonstrated changes during the 3-minute step test in children with and without CF.

In the literature, three studies were found that used the 3-minute step test, with the objective of evaluating desaturation in children with CF. The study by Balfour-Lynn et al. (8) compared the step test with the six-minute walk test and found a higher heart rate and RPE (between weak and moderate effort) in the three-minute test, while oxygen saturation ($SatO_2$) was similar. In the present study, at the end of the test, the heart rate reached higher values and $SatO_2$ values were similar while the RPE varied between slightly tiring and very tiring.

The results of the present study demonstrated that the group of children with CF presented a significantly higher RPE when compared to the group of children without CF. In contrast, in the

study by Coelho et al. (16) where the RPE was compared in 28 children aged 7 to 15 years with and without CF using the shuttle walk test, there was greater fatigue in healthy children, a fact that can be explained by the greater distance covered when compared to children with CF.

The RPE consists of a subjective evaluation that demonstrates the subject's opinion of the intensity of the test performed, which can be measured using various instruments. The Borg scale (14) is the most commonly used, with scores varying from 6 to 20 points to measure the perception of effort during exercise. When a physical test is applied to children and adolescents with chronic or neuromuscular respiratory diseases, it is important to quantify this effort, in order to increase the safety of the test (17). In the case of the children evaluated in the present study, the RPE was a very useful tool since there were no changes in $SatO_2$ and the heart rate variations were within the expected range.

The study by Aurora et al. (9) evaluated the compatibility of the 3-minute step test and the 6-minute walk test and showed that both presented the same intensity. There were no significant differences between the tests in saturation and heart rate, that is, both produced a drop in saturation and an increase in heart rate with the step test leading to higher desaturation. In the present study, increases in heart rate were observed throughout the step test as well as a 4% drop in saturation in three children with CF.

Although the desaturation that occurred in the three children evaluated was only 4%, this can lead to hemodynamic changes due to the pathophysiology of CF. The decrease in the function of a membrane protein, known as the cystic fibrosis transmembrane conductance (CFTR) regulating gene, acting in ion transport in epithelial cells, results in thick and viscous mucous secretions that cause obstruction of glandular ducts and canaliculi (chlorine channels) (18). This impairs effective lung and tissue oxygenation, especially during exercise. Thus, it is suggested that any loss of saturation places the child in a position of susceptibility to reduced efficiency of tissue oxygenation.

In the study by Ziegler et al. (19), 15% of the sample (88 children) aged over 10 years with CF, presented desaturation when the 6-minute test was applied. However, the authors point out that attention is necessary with regard to the application of the test and its monitoring, in order to obtain greater estimates regarding changes in hemodynamic and subjective parameters. In another study by the same author (20), which evaluated the submaximal exercise capacity in CF patients aged 16 years and over, it was noted that desaturation was greater in the group with severe ventilatory disorder after the 6 min walk test.

Tests that assess the cardiorespiratory fitness of children with CF have been adapted over time and, currently, the most common tests used in studies are the shuttle run, 3-minute test, laboratory tests associated with the assessment of respiratory gases (5, 21), and an adaptation of the shuttle run test performed for children with CF - shuttle walk test (6). The necessity to assess children routinely with respect to pulmonary function is already recommended (21), but exercise tolerance also needs to be monitored since impairments are associated with low

immunity (greater propensity to respiratory tract infections), early tiredness, and reduced muscle mass (22, 23).

Children without CF had a greater perception of effort after 5 min when compared to children with CF. This fact may be related to the continuous use of bronchodilators by children with the pathology, suggesting that this medication has helped these children to recover more quickly after exercise. According to Marostica and Amin (24, 25), the drug proves to be effective in reducing pulmonary exacerbations and improving other functional outcomes, even in patients with incipient lung disease and with normal functional parameters.

The strength of this study was the inclusion of children from a project for the assessment and monitoring of cardiorespiratory fitness, since no work of this scope had previously been carried out. Among the limitations of the study is the adaptation of the office where the consultations were held to perform the test. However, it was necessary to apply the test inside the office because of the care environment, where several children with other clinical conditions remain for some hours, which can lead to respiratory infections. Other types of outpatient clinics (hemoglobinopathies, children with cerebral palsy) operate at the same place of care, generating circulation of other people. It is also worth noting that the main parameter to assess cardiorespiratory fitness is maximum oxygen consumption (VO_{2max}), however, the test performance depends on specific equipment and the cost-benefit ratio is high, so it was not possible to use this test in the current study.

ACKNOWLEDGEMENTS

Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Centro Universitário de Anápolis.

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