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Cough peak flow in preschoolers: success rate and test-retest reproducibility

Pico de fluxo da tosse em pré-escolares: taxa de sucesso e reprodutibilidade teste-reteste

Pico de flujo de tos en niños en edad preescolar: tasa de éxito y reproducibilidad test-retest

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ABSTRACT | It is important to evaluate lung function in preschoolers. There are few studies related to pulmonary function tests with this part of the population. The purpose of this study was to evaluate the success rate and test-retest reproducibility of the cough peak flow (CPF) in a sample with children between four and six years old. The CPF was tested in 44 healthy children (26 boys, 18 girls), selected according to the ATS-DLD-78-C questionnaire, used to detect the presence of common respiratory diseases or induced by environmental exposure. An expiratory peak flow meter (Piko-I Electronic Peak Flow Meter, Pulmonary Data Services, USA) was used to measure CPF. The success rate was defined as the percentage of children able to perform the test according to the acceptability and reproducibility criteria. To evaluate the test-retest reproducibility, 10 children (according with the sample calculation) were reevaluated after three weeks. The study was approved by the Ethics Research Committee of the Institution. The test-retest reproducibility was evaluated by the paired t-test, considering a significance of $p<0.05$ and intraclass correlation coefficient (ICC). The results showed a success rate of 91% for CPF, with 80%, 88% and 100% for children with four, five and six years, respectively. Regarding the test-retest reproducibility, there was no significant difference between data of the first assessment and reassessment ($p=0.39$) and an ICC of 0.84 was observed. These results suggest an elevated success rate in the performance of CPF and an excellent test-retest reproducibility for this variable in healthy preschoolers.

Keywords | Respiratory Function Tests; Child, Preschool; Reproducibility of Results; Cough.

RESUMO | É importante avaliar a função pulmonar em pré-escolares. Poucos estudos relacionados aos testes de função pulmonar nessa população estão disponíveis. O objetivo deste estudo foi avaliar a taxa de sucesso e reprodutibilidade teste-reteste do pico de fluxo da tosse (PFT) em uma amostra de crianças com idade entre 4 e 6 anos. O PFT foi estudado em 44 crianças saudáveis (26 meninos e 18 meninas), selecionadas de acordo com o questionário ATS-DLD-78-C, utilizado para detectar a presença de doenças respiratórias de base e exposição ambiental. O medidor de pico de fluxo expiratório (Piko-I Electronic Peak Flow Meter, Pulmonary Data Services, USA) foi usado para mensurar o PFT. A taxa de sucesso foi definida como a porcentagem de crianças capazes de realizar o teste de acordo com os critérios de aceitabilidade e reprodutibilidade. Para avaliar a reprodutibilidade teste-reteste, 10 crianças (de acordo com o cálculo amostral) foram reavaliadas após três semanas. A reprodutibilidade teste-reteste foi avaliada pelo teste t pareado, considerando significativo $p<0,05$ e coeficiente de correlação intraclasse (CCI). Os resultados mostraram uma taxa de sucesso de 91% para PFT, sendo de 80, 88 e

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100% para crianças com 4, 5 e 6 anos, respectivamente. Quanto à reprodutibilidade teste-reteste, não houve diferença significativa entre os dados da primeira avaliação e da reavaliação (p=0,39) e foi observado CCI de 0,84. Esses resultados sugerem elevada taxa de sucesso na realização do PFT e reprodutibilidade teste-reteste de magnitude excelente para essa variável em pré-escolares saudáveis.

Descritores | Testes de Função Respiratória; Pré-Escolar; Reprodutibilidade dos Testes; Tosse.

RESUMEN | La evaluación de la función pulmonar en niños en edad preescolar es importante pues hay pocos estudios que investigan los test de función pulmonar en este grupo. Este estudio tuvo el propósito de evaluar la tasa de éxito y la reproducibilidad test-retest del pico de flujo de tos (PFT) en una muestra con niños entre 4 y 6 años de edad. Se estudió el PFT en 44 participantes saludables (26 chicos y 18 chicas) elegidos a través de un cuestionario ATS-DLD-78-C para detectar la presencia de enfermedades respiratorias de base y exposición ambiental. Se utilizó el medidor del pico de flujo espiratorio (Piko-I Electronic Peak Flow Meter, Pulmonary Data Services, USA) para medir el PFT. Se definió la tasa de éxito como el porcentaje de niños capaces de realizar el test según los criterios de aceptabilidad y de reproducibilidad. Para evaluar la reproducibilidad test-retest tras tres semanas se reevaluaron 10 niños según el cálculo de la muestra. Se analizó la reproducibilidad a través del test t pareado, considerando significativo <0,05 y el coeficiente de correlación intraclase (CCI). Los resultados mostraron una tasa de éxito del 91% para el PFT, siendo un 80, 88 y 100% para niños con 4, 5 y 6 años, respectivamente. En cuanto a la reproducibilidad test-retest no hubo diferencias significativas entre los datos de la primera evaluación y de la reevaluación (p=0,39) en que se observó el CCC de 0,84. Estos resultados proponen alta tasa de éxito en la ejecución del PFT y excelente reproducibilidad test-retest en esa variable en niños saludables en edad preescolar.

Palabras clave | Pruebas de Función Respiratoria; Pré-Escolar; Reproducibilidad de Resultados; Tos.

INTRODUCTION

Cough peak flow (CPF) is the maximum expiration flow measured during a cough maneuver by means of an expiratory peak flow meter. This maneuver reflects cough efficiency and is associated with the removal of mucus secretion and maintenance of free air flow without secretion and strange bodies[1,2].

In preschool aged children, the measurement of CPF is an important data in the clinical examination of diseases that reduce efficacy of the cough mechanism, aiming to monitor the progress of the disease and the therapeutic response to any interventions. In addition, this measurement has been correlated with extubation success, as a criterion for tracheostomy decannulation[3,4] and with the risk of respiratory failure due to ineffective coughing in adults with neuromuscular disease[5,6].

The literature has many studies that used CPF to assess the need and/or the maneuvering effects of assisting cough in patients with neuromuscular diseases[7-15]. Children account for a significant portion of these patients, however, of the studies that evaluated this maneuver in children[5,10,11,14,16], few have done with preschoolers[5,11,16].

The international literature reports that between 75 and 86% of preschool aged children are able to understand and properly perform spirometry maneuvers[17]. To ensure the precise monitoring of the progression of the disease or the individual response to treatment, beyond the successful performance of the maneuvers, it is essential that the trial show test-retest reproducibility.

Despite CPF being a simple test of easy application[5], only one study evaluated the accuracy of pulmonary function tests in preschool aged children[18]. Eigen et al.[18] evaluated the test-retest reproducibility of spirometric data obtained and observed a significant reduction in some parameters. We also did not find studies that described their success rate or that evaluated the test-retest reproducibility of CPF in the preschool population.

It is important to evaluate CPF success rate and reproducibility in healthy children to identify the reliability of the measurement when used in children with respiratory disorders, since measure variations are related to the clinical condition. Since CPF performance requires cooperation/attention and preschoolers are easily distracted and more unfocussed, the evaluation of the success rate contributes to analyze the feasibility of this test. On the other hand, a test-retest reproducibility analysis will offer information about the accuracy of the data, ensuring the correlation results, insofar as the test is repeated under identical or substantially close conditions[17]. Thus, observing good reproducibility will guarantee precision measurements performed

sequentially that, in this context, can be applied to children with, for example, neuromuscular dysfunction.

In this regard, the objective of this study was to evaluate CPF success rate and test-retest reproducibility in a sample of children from four to six years old.

METHODOLOGY

Sample

The volunteers of this study (healthy preschool children) were selected from two schools randomly selected in the city of Sete Lagoas, state of Minas Gerais, Brazil. The sample included healthy children who met the following inclusion criteria: absence of respiratory diseases, according to the ATS-DLD-78-C[18-20] questionnaire, adapted and validated for the Brazilian population; aged between four and six years (48-83 months); body mass index (BMI) between 3 and 95 percentile for the age according to the World Health Organization curves; no previous experience in performing pulmonary function tests[19,21]; no flu episode or any other respiratory illness within the last 7 days; lack of exposure to cigarette smoke or wood stove; mother with no history of smoking during pregnancy; and no history of chest or abdominal surgery or major thoracic deformities, genetic syndromes, metabolic disorders, heart disease, neuromuscular disorders, psychiatric disorders, cognitive deficits and regular use of medicaments[22]. The study excluded children who showed allergies, a cold or the flu in the time between measurements, or who refused to participate. The study was approved by the Ethics Research Committee of the Federal University of Minas Gerais (ETIC 0612.0.203.000-09) and the legal guardians of all children signed the free and informed consent form.

The calculation of the size of the sample needed for reproducibility was established after a pilot study with the first 10 children evaluated, considering a statistical power of 80% and a significance level of 0.05[23]. The GPower 3.1 software was used (available at http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3), which determined that eight children needed to be evaluated.

Measuring instruments

Seeking to select healthy children, the ≠≠≠ATS-DLD-78-C questionnaire was used to identify the presence of common respiratory diseases or induced by environmental exposure. This instrument was validated for use in the Brazilian population[20] and its use was recommended by the Epidemigoly Standardization Projects[18-20]. The questionnaire is composed by questions regarding signs and symptoms, diseases and hospitalizations related to the respiratory system. The overall score varies from zero to 22, with a score of 7 or more indicating chronic respiratory disease[18-20].

The expiratory peak flow measured during a cough maneuver is called Cough Peak Flow (CPF), and to measure it, the same expiratory peak flow (PEF)[2] equipment can be used. In this study, the Piko-I (Electronic Peak Flow Meter) was the instrument used to measure the CPF. Piko-I is one of the most sophisticated instruments to easily and quickly measure the peak flow and it is recognized as the best equipment for self-care according to US Medical Design Excellence Awards. Scale amplitude values vary between 15 and 999L/min, with 95% accuracy and technology flow sensors in accordance with the recommendation of the American Thoracic Society[17].

Procedures

First, two schools were drawn, one public and one private, in the city of Sete Lagoas, state of Minas Gerais, Brazil. After the sortition, the ATS-DLD-78-C20 questionnaire, plus supplementary questions (about the birth, previous diseases, demographics and socioeconomic factors), were sent to the legal guardians of all children aged between four and six years. After analyzing the questionnaires, children who met the inclusion criteria were invited to participate. The guardians then signed the free and informed consent form and the children were evaluated at school during the school day.

Weight and height were measured after the initial assessment, including the measurement of blood pressure, heart rate, respiratory rate, peripheral hemoglobin saturation in oxygen and lung auscultation, performed only to confirm the absence of clinical alterations not detected by the ATS-DLD-78-C questionnaire.

To evaluate the CPF, the children were instructed and received prior training on the maneuvers to be performed. The test was performed in a seated position without using a nose clip, to avoid scaring

the children[5]. The evaluator, besides encouraging them, placed the mouthpiece and pressed on the perioral area, seeking to prevent leaks. Participants were asked to fill their chests completely and then to cough as strongly as they could into the mouthpiece. After the training maneuvers, at least three acceptable maneuvers were performed and, among these, at least two reproducible[5]. One minute intervals were observed between maneuvers and the maximum time for the test was limited to 20 minutes to ensure feasibility in the clinical practice. Maneuvers were considered acceptable if they had full inspiration, maximum cough effort and the absence of leakage and reproducible, maneuvers with maximum difference of 10%[24]. The amount recorded for analysis was the higher of the acceptable and reproducible variables[5].

For the test-retest reproducibility, an interval of three to four weeks was made between the first assessment and the reassesment[17], performed by the same examiner.

Statistical analysis

Initially, the data normality was assessed by the Shapiro-Wilk test. The intraclass correlation coefficient (ICC) was used to assess correspondence and the Bland-Altman analysis was employed. The Student t-test for paired samples was used to check the equality/statistical difference between the first assessment and reassessment data.

The success rate was assessed by calculating the percentage of the number of children able to perform each test in relation to the total number of children evaluated, according to the acceptability and reproducibility criteria.

Data appear as mean ± standard deviation. The significance level (α=0.05) was established for all the tests and the data was analyzed using the SPSS software (version 13.0, Chicago, IL, USA).

RESULTS

Fifty children were selected without known respiratory diseases, whose parents signed the informed consent. Six were excluded from the study: three had colds, two changed schools and one refused to participate. Thus, 44 children were included in the assessment: 10 four year-olds, 17 five year-olds and 17 six year-olds, respectively. All children showed baseline results (blood pressure, respiratory rate, peripheral saturation of oxygen in hemoglobin and auscultation) within the normal limits. Table 1 shows the demographic and anthropometric data of children according to age.

Table 1. Anthropomorphic and demographic data of the children under study according to age (n=44)

Age (years)	Sex (boys/girls)	Weight (kg)	Height (cm)	BMI (kg/m²)
4 years	6/4	20.23±2.46	114.88±7.10	15.31±1.07
5 years	9/8	20.32±2.61	115.01±6.97	15.34±1.12
6 years	11/6	20.48±2.62	115.38±7.52	15.37±1.14
Total	26/18	20.33±2.61	115.01±6.97	15.34±1.12

Values expressed in means ± standard deviation; BMI = Body Mass Index

Table 2 shows the CPF values and the success rate in performing the test according to the age of the participants. An analysis of the whole sample showed a success rate of 91%, with 80%, 88% and 100% for children aged four, five and six years, respectively.

Table 2. Cough Peak Flow values and success rate according to age (n=44)

Age	CPF (L/min)	n (N)	Success Rate
4 years	153.00±33.71	8 (10)	80%
5 years	170.00±34.70	15 (17)	88%
6 years	172.17±30.70	17 (17)	100%
Total	169.77±34.34	40 (44)	91%

CPF = Cough Peak Flow; n = Number of children who were able to perform the test; N = Total number of children in each age group. Values according to frequency (%); Values expressed in means ± standard deviation

For the test-retest reproducibility, 10 children were evaluated (3 four year-olds, 5 five year-olds and 2 six year-olds), respecting the sample calculation. Of this total, 50% (n=5) were male and 50% (n=5) were female, with an average age of 4.8±0.63 years; an average height of 115.75±5.97cm; an average weight of 19.97±3.03kg and an average body mass index (BMI) of 14.87±1.19kg/m^2. No child, both during the test and the retest, displayed conditions that could compromise the results of this study, such as allergy symptoms, a cold or the flu.

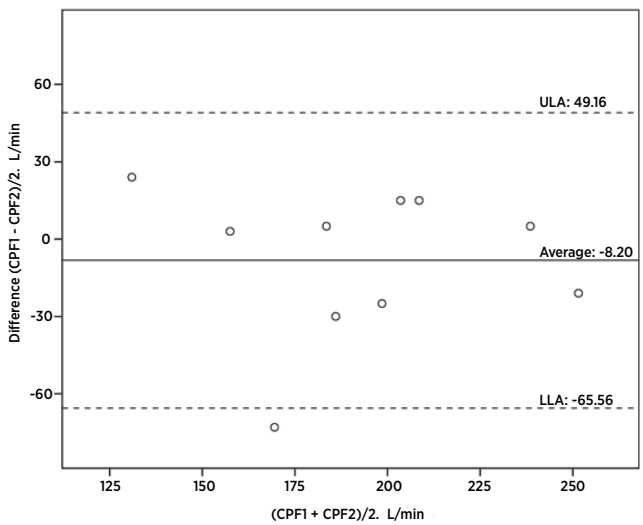
Table 3 shows the CPF results of the first assessment (test) and reassessment (retest). It also shows the significance level (p) referred to the test-retest comparison, and ICC values. There was no significant difference between the test and the retest data, and an ICC of 0.84 was observed.

Table 3. Cough Peak Flow during the test and retest in the ten children under evaluation

	Test	Retest	P value (t test)	CCI (95% CI)
CPF (L/min)	188.70±38.17	196.90±39.54	0.39	0.84 [0.37-0.95]

CPF = Cough Peak Flow; p = significance level; ICC = Intraclass correlation coefficient, 95% CI = 95% confidence interval

The Bland-Altman graphic showed that the difference average between the test and retest was not statistically different from zero (average: -8.20L/min, p=0.40), with the upper and lower limits of correspondence ranging from -65.56 to 49.16 (Figure 1).



ULA= Upper limit of agreement
LLA= Lower limit of agreement

Figure 1. Bland-Altman analysis between the measurements achieved for the cough peak flow (CPF) in the test and the retest

DISCUSSION

The results of this study showed that CPF can be successfully performed by most children aged between four and six years, and that this test had high magnitude test-retest reproducibility in the studied population.

Although the development of techniques for the measurement of lung function begun more than a century ago, only in the last two decades have these tests been used in the pediatric population, making it extremely useful in epidemiological studies for the evaluation of children with lung and neuromuscular diseases[25]. Thus, the assessment of the success of the test and test-retest reproducibility adds important information, because it ensures testing quality of the pulmonary function in this population.

Regarding the success rate, most children were observed to adequately perform CPF maneuvers, fulfilling acceptability and reproducibility criteria. No studies evaluating the success in conducting this test were found, though Bianchi et al.[5] reported that CPF is a simple method with quick application and which can be considered feasible in the preschool population, reiterating the claim by Beydon et al.[17] that most lung function tests can be performed successfully by preschoolers. The success rate observed in this study corroborates with the data described by these authors.

In addition to the high success rate in the performance of the CPF, another factor that can be used as an indication that the test was performed properly is the fact that the CPF values observed in this study are within the normal range of values described by Bianchi et al.[5]. With the increase of age, there was an increase in the success rate in achieving the CPF (which ranged between 80 and 100%). This finding has also been observed in other tests of lung function such as spirometry and respiratory inductive

plethysmography[18,21,26,27-29,30]. Younger children are more unfocused and more easily distracted than older ones, while the test requires cooperation and attention. These factors may have influenced the test, thus justifying the lower success rate found in the younger age group. Failure was observed in children who were not able to perform full inspiration, who coughed improperly and/or dispersed for other reasons, failing to reach the acceptability criteria in the test.

Regarding accuracy of data, CPF showed test-retest reproducibility, with excellent correspondence and no statistical difference between the first assessment and the reassessment data. The literature has only one study of the test-retest reproducibility of methods to assess lung function in healthy preschool children[18], and there is, to our knowledge, no study evaluating the CPF in this population. Eigen et al.[18] evaluated spirometric data and re-evaluated, after a week, 14 children aged between three and six years (mean age of 11.1±59.7 months), in order to check the learning effect. A significant reduction of some parameters were observed, which may reflect a small reduction in the maximum effort or the absence of a learning effect. One can hypothesize that the short period between assessment and reassessment (one week) may have discouraged the children in the test, and may explain the significant reduction in some parameters. In this study, unlike Eigen et al.[18], there was no significant difference between test and retest data (the interval between the first assessment and reassessment was three to four weeks). This time lapse was determined in order to avoid the training effect and maintain child motivation, given that a short period could discourage volunteers, ensuring, on the other hand, the maintenance of anthropometric data, since children in this age group are in the development stage and height can be considered a major predictors of CPF[5]. The Bland-Altman analysis showed that the vast majority of the data (90%) was within the upper limit of correspondence and the limits of correspondence, which confirms the ICC results.

This study had limitations. The number of four year-old children who were evaluated was relatively smaller than the number of five and six year-olds. Another limitation may be the number of children evaluated for reproducibility. Though, according to the sample calculation, this number was sufficient. To our knowledge, this study was the first to evaluate the CPF success rate and test-retest reproducibility in preschoolers. Since the test is viable (good success rate) in this population, further studies assessing the reproducibility for each age group (4, 5 and 6 years), can significantly contribute for a complete elucidation of this issue.

CONCLUSION

The results suggest that healthy children between the ages of four and six years are able to successfully perform the CPF and this test also showed an excellent test-retest reproducibility for the sample used.

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