Feasibility of spirometry in preschool children*

Viabilidade da realização de espirometria em pré-escolares

Tiago Neves Veras, Leonardo Araujo Pinto

Abstract

Objective: To determine the rate at which satisfactory spirometry results are obtained (spirometry success rate) in preschool children. **Methods:** We analyzed the spirometry results of children ≤ 6 years of age. All tests were conducted between June of 2009 and February of 2010 in the Pulmonary Function Laboratory of the *Hospital Infantil Jeser Amarante Faria*, located in the city of Joinville, Brazil. The spirometry program employed features an animated incentive (soap bubbles). The procedures were performed by a pediatric pulmonologist, in accordance with the reproducibility and acceptability criteria recommended by the American Thoracic Society. We attempted to achieve an expiratory time of at least 1 s. The following parameters were measured: FVC, $FEV_{0.5}$, FEV_1, and the FEV_1/FVC ratio. **Results:** Our sample comprised 74 children. The spirometry success rate was 82%. Although the performance improved with age, the difference between younger and older children was not significant ($p > 0.05$). An average of 6.6 attempts/test were needed in order to achieve acceptable, reproducible curves. All 61 successful tests produced satisfactory $FEV_{0.5}$ and FEV_1 values. By calculating Z scores, we found that 21.6% of the children presented with an obstructive pattern. **Conclusions:** In our sample, the spirometry success rate was high, showing that spirometry is a valid method for assessing pulmonary function in preschool children. The high success rate in our sample might be attributable to the use of an incentive and to the fact that the tests were performed by professionals specializing in pediatrics.

Keywords: Spirometry; Feasibility studies; Respiratory function tests.

Resumo

Objetivo: Determinar a taxa de sucesso na obtenção de resultados adequados de espirometria em pacientes pré-escolares. **Métodos:** Foram analisados os resultados de espirometrias de crianças menores que 6 anos. Todos os testes foram realizados no Laboratório de Função Pulmonar do Hospital Infantil Jeser Amarante Faria, em Joinville (SC) entre junho de 2009 e fevereiro de 2010. O programa utilizado continha um incentivo de animação (bolhas de sabão).Os procedimentos foram realizados por um pneumologista infantil e obedeceram aos critérios de reprodutibilidade e aceitabilidade preconizados pela *American Thoracic Society*. Buscou-se atingir um tempo expiratório de pelo menos 1 s. Os seguintes parâmetros foram registrados: CVF, $VEF_{0,5}$, VEF_1 e relação VEF_1/CVF. **Resultados:** Nossa amostra consistiu de 74 crianças. A taxa de sucesso foi de 82%, com melhora no desempenho do teste em idades mais avançadas, mas sem significado estatístico ($p > 0,05$). Em média, foram necessárias 6,6 tentativas durante o exame para a obtenção de curvas aceitáveis e reprodutíveis. Todos os 61 testes bem sucedidos tiveram resultados de $VEF_{0,5}$ e VEF_1 satisfatórios. Através de escore Z, constatou-se que 21,6 % das crianças apresentavam com padrão obstrutivo. **Conclusões:** A taxa de sucesso da espirometria foi alta em nossa amostra, mostrando que esse é um método válido de avaliação da função pulmonar em pré-escolares. O uso de métodos de incentivo e a realização do teste por profissionais treinados no trabalho com crianças podem estar associados à elevada taxa de sucesso em nossa amostra

Descritores: Espirometria; Estudos de praticabilidade; Testes de função respiratória.

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Introduction

The management of chronic diseases, such as asthma, in childhood requires appropriate medication and objective parameters for measuring therapeutic success.[1] The use of pulmonary function tests in children and adolescents is well established. However, the use of such tests in preschool children poses a challenge, whether due to lack of cooperation from children in performing forced expiratory maneuvers or due to the need for special strategies on the part of the medical team to perform the tests. The measurement of pulmonary function is important not only as a clinical parameter, but also as an instrument to measure the growth and pulmonary development of children.[2]

Longitudinal evaluation by means of pulmonary function tests is an important element of the appropriate management of chronic respiratory diseases. The improvement of strategies for the use of tests in neonates and preschool children can improve understanding of the evolution and natural history of conditions such as asthma and chronic lung disease of prematurity.[3]

Children between 2 and 6 years of age often have difficulty in understanding the instructions for performing appropriate expiratory maneuvers[4] and are easily distracted during the initial approach. Therefore, the team performing the test must be very attentive, enthusiastic, and aware of the inherent limitations of this age group. The environment of the pulmonary function laboratory should be cozy and playful in order to encourage patient interaction.

Spirometry is the most widely used pulmonary function test in adults and children.[5-7] Most preschool children are able to perform forced expiratory maneuvers, although, in general, expiratory time is shorter than 1 s.[6,8] The American Thoracic Society has recently published guidelines for pulmonary function testing in preschool children in which the importance of parameters such as $FEV_{0.5}$ and $FEV_{0.75}$ is underscored.

In view of the lack of data in the Brazilian literature, the objective of the present study was to determine the rate at which satisfactory spirometry (pulmonary function test) results are obtained (spirometry success rate) in preschool children treated at a pediatric pulmonology outpatient clinic in the south of Brazil.

Methods

This was a cross-sectional descriptive study. We analyzed the results of the spirometric tests conducted between June of 2009 and February of 2010 in the Pulmonary Function Laboratory of the *Hospital Infantil Jeser Amarante Faria* (HIJAF, Jeser Amarante Faria Children's Hospital), located in the city of Joinville, Brazil. All children 6 years of age or younger who agreed to perform spirometric maneuvers were included. An appointment with a pulmonologist or an allergist was made for the patients through an appointment scheduling system of the Municipality of Joinville. During appointment scheduling, parents or legal guardians were instructed to stop giving their children their medications, especially bronchodilators, antihistamines, anticholinergics, and leukotriene receptor antagonists, one day prior to the test, not to let them drink tea or coffee, and to postpone the test if their children had exacerbations.

On the day of the test, the patients were screened by the nursing staff. Weight (in kg) and height (in cm) were measured, in order to calculate the body mass index. After a 10-min rest period, the patients were referred to the examination room, where, together with their parents, they were given instructions and were introduced to the device. The test was performed by a pediatric pulmonologist, with the aid of a nurse technician. During the tests, these professionals used techniques to encourage the children and win their trust. A maximum of eight attempts were made in each phase of the test.[8] A nose clip was used in all maneuvers.

The following parameters (expressed as absolute values and percentage of the predicted values) were measured: $FEV_{0.5}$; FEV_1; FVC; and $FEF_{25\%-75\%}$; as well as expiratory time (in s) and PEF. In addition, the number of attempts needed in order to achieve at least three acceptable, reproducible curves[2] in the pre-bronchodilator and post-bronchodilator phases were recorded, as were the indication for the test and the success or failure of the procedure.

The acceptability criteria were as follows: artifact-free curves on visual inspection (no cough, no obstruction of the mouthpiece, no leaks, no glottic closure, and no Valsalva maneuver); satisfactory start of exhalation; evidence of maximal effort; appropriate ending

(presence of a plateau in the last second); and peak expiratory flow and back-extrapolated volume < 5% of FVC or < 80 mL. Curves in which the difference in FVC and FEV_1 values did not exceed 10% were accepted as reproducibility criteria. In order to increase the reliability of the tests, we obtained at least three acceptable curves, two of which were reproducible. If the criteria were not met after eight attempts, the test was interrupted and the three best curves were chosen.

Spirometry was performed with a MicroQuark Pony FC spirometer (Cosmed, Rome, Italy), which was calibrated daily prior to testing. The spirometry program employed features an animated incentive (soap bubbles) in order to facilitate testing.

The Statistical Package for the Social Sciences, version 13.0 (SPSS Inc., Chicago, IL, USA), was used for building and analyzing the database. Quantitative variables are described with measures of central tendency and dispersion (mean and standard deviation, respectively). In addition, maximum and minimum pulmonary function test values are described. The chi-square test was used for evaluating differences in the proportions.

The study was approved by the Ethics Committee of the HIJAF and, throughout its duration, followed the Brazilian National Health Council regulations and guidelines for research involving human beings (Resolution 196/96).

Results

During the study period, 254 spirometry sessions were conducted, 74 of which included preschool children 6 years of age or younger. The population had a mean age of 4.80 ± 0.85 years and a median age of 5 years (range: 2.92-6.00 years; Table 1). Most children were 5 years of age or younger (Table 2). Male children predominated, at a ratio of 2:1, and there were no gender-related differences in test performance ($p > 0.05$).

Acceptable, reproducible curves were obtained in 82.4% of the tests, which represents a total of 61 children. Improvement in performance increased in parallel with the age of the patient (Table 3). There was a trend toward a significant difference when 3-year-olds were compared with 6-year-olds ($p = 0.069$). In the pre-bronchodilator phase, an average of 6.6 attempts/maneuver were needed in order to achieve acceptable curves, whereas, in the post-bronchodilator phase, an average of 5.1 attempts/maneuver were needed ($p > 0.05$).

Table 1 - Characteristics of the study population of preschool children.[a]

Characteristic	Result
Age, years	4.80 ± 0.85
Weight, kg	20.3 ± 3.9
Height, cm	109.6 ± 6.2
BMI, kg/m^2	16.7 ± 2.1

[a]Values expressed as mean ± SD.

The major clinical indication for the test (in 95.6% of the cases) was a diagnosis of asthma. In 100% of the successful tests, $FEV_{0.5}$ and FEV_1 values were obtained (Table 4). The mean expiratory time in the best maneuver was 1.96 s, increasing significantly with age. The comparison with reference equations for this age group,[8] by calculating Z scores, revealed that 21.6% of the children presented with an obstructive pattern. The mean back-extrapolated volume was 42 mL.

Discussion

In our study, spirometry was successfully performed in 82% of the cases, which results in spirometry being a test that is quite feasible and can provide relevant clinical information. Because this pulmonary function test is noninvasive and easy to perform when the professionals involved are skilled, its clinical application is more than justified. Recently, the use of spirometry in children and adolescents has grown in importance due to its capacity to measure pulmonary function. The use of objective measures, especially in adolescents with asthma, is justified because of the high discordance between clinical findings, physical examination, and disease severity.[9,10]

One group of authors achieved success rates of 78% in children between 4 and 5 years of

Table 2 - Distribution of the patients by age.

Age, years	n	%
3	4	5
4	25	34
5	25	34
6	20	27
Total	74	100

Table 3 - Spirometry success rate by age.

Age, years	n (N)	Success rate, %
3	3 (4)	75.0
4	18 (25)	72.0
5	22 (25)	88.0
6	18 (20)	90.0*
Total	61 (74)	82.4

*p = 0.06 when compared with the success rate for 3-year-old children.

age, who were able to perform at least two technically acceptable maneuvers.[11] Other authors achieved success in 214 of the 248 healthy children recruited for the test[12]

In our sample, $FEV_{0.5}$ and FEV_1 were obtained from all children. This was possible thanks to the intensive effort to encourage the child to achieve maximum performance. These two parameters, together with FVC, define the pulmonary function pattern, serving to monitor disease progression and treatment. One group of authors, comparing healthy children and children with respiratory symptoms, concluded that forced expiratory maneuvers were able to discriminate the severity of the symptoms.[3]

In 2007, two studies involving children 6 years of age or younger reported interesting data.[11,13] Those two studies used equations with the parameter $FEV_{0.75}$, which is probably the most appropriate parameter for this age group. This is due to the fact that preschool children have airways that are proportionally larger than are their lung volumes. Therefore, during expiratory maneuvers, they can perform forced expiration in less than 1 s.[14]

The limitations of the present study are those inherent to descriptive studies. The sample chosen consisted of children with respiratory diseases, preventing the extrapolation of our results to healthy children in the same age group. The fact that the tests were performed by an experienced professional who was interested in achieving maximum success might explain the high success rate found in our sample. In addition, only 4 children in our sample belonged to the age group at the highest risk for failure (≤ 3 years of age). However, this does not invalidate the results of the sample as a whole, a high spirometry success rate being found when the tests are performed by a trained and qualified professional.

In the beginning of the 1990s, in a pioneering study, only 32% of a sample of preschool children were able to perform appropriate FEV_1 maneuvers.[15] The further development of spirometers, the animations used, and the systematic discussion on the subject have made it possible to inquire into the best parameters for effectively performing pulmonary function measurements in this age group. In 2001, one group of authors proposed the measurements of $FEV_{0.5}$ and $FEV_{0.75}$ as the most appropriate parameters for this age group.[16] Since then, several authors have achieved spirometry success rates always above 75% in preschool children, either healthy or with cystic fibrosis.[17-19]

Polgar et al. conducted a broad review of spirometric equations, considering a population in the American state of Michigan and subsequently listed those that they considered the most coherent and feasible for use in the (predominantly White) population of the region.[20] Mallozi proposed equations considering a population consisting of various ethnic groups in the state of São Paulo, Brazil.[21] The results obtained in those two studies were extremely similar.[22]

Descriptive studies such as ours show the need for nationwide studies aimed at determining reference values for spirometry in healthy schoolchildren in Brazil. This has already been done in populations of preschool children in the United States,[8] the United Kingdom,[23] and Norway.[18]

In conclusion, spirometry success rates are high in preschool children. In our sample, the fact that the tests were performed by professionals specializing in pediatrics might be associated with the high success rate described.

Table 4 - Values obtained in the successful spirometry tests (n = 61).

Parameter	Mean ± SD	Range
$FEV_{0.5}$, L	0.77 ± 0.19	0.33-1.15
Best curve		
FEV_1, L	0.97 ± 0.24	0.41-1.44
FEV_1, % of predicted	101.52 ± 25.02	44.80-150.90
Second best curve		
FEV_1, L	0.94 ± 0.25	0.38-1.46
FEV_1, % of predicted	98.69 ± 25.32	38.30-147.30

In addition, the use of an incentive, which might also be associated with a high success rate, should be encouraged. Spirometry is a valid and useful method for assessing pulmonary function in preschool children, especially when modified parameters, such as $FEV_{0.5}$ and $FEV_{0.75}$, are used. In view of the data presented here, it is necessary to establish reference values in Brazilian preschool children for future use in clinical practice and scientific studies.

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MI: body mass index.

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