

# Functional respiratory study in preschool children: a review

## Abstract

**Introduction:** Children of preschool age have high chronic respiratory morbidity and a tendency to progressive increase. The pulmonary function tests (PFT) quantify objectively the lung commitment and are proving very useful in the diagnosis, therapeutic monitoring and prognostic evaluation of several pathologies.

**Purpose:** The purpose of this literature review is to understand the relevance and value of PFT to this age group, taking into account the new criteria of the *American Thoracic Society/European Respiratory Society* (ATS/ERS) (2007).

**Methods:** We conducted a literature review, based on the keywords: respiratory function test, pre-school, spirometry and asthma. We consulted the databases PubMed and B-on, from which 38 articles were selected. 18 of them were analyzed with respect to the keywords above.

**Results/discussion:** PFT are valuable for the diagnostic evaluation of preschoolers, with high technically acceptable success rates and reproducible maneuvers.

**Conclusion:** The evaluation of lung function is very important in the study of the genetic and environmental determinants of lung disease, as well as being a strong predictor of long-term illness.

**Keywords:** respiratory function test, pre-school, spirometry, asthma

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**Abbreviations:** PFT, pulmonary function tests; ATS, American thoracic society; ERS, European respiratory society; RIP, respiratory inductance plethysmography; FRC, functional residual capacity; PET, pulmonary function tests

## Introduction

Children of preschool age have high chronic respiratory morbidity and a tendency to progressive increase.<sup>1</sup> Pulmonary function tests (PFT) quantify objectively the lung commitment and are very useful in the diagnosis, therapeutic monitoring and prognostic evaluation of several pathologies as well as in the risk/benefit assessment of specific clinical interventions.<sup>2-6</sup> These methods have been very useful for the pathophysiological understanding of cystic fibrosis, primary ciliary dyskinesia, recurrent wheezing and bronchial asthma.<sup>1,7,8</sup> The last one is one of the most common problems for public health, with an increase in its incidence at early ages, affecting about 5-10% of children in industrialized countries. PFT have a key role to play in assessing the degree of pulmonary obstruction in order to begin treatment at an early stage.<sup>1,9</sup> In general, these represent a clinical parameter as well as an instrument for measuring growth and lung development.<sup>3</sup>

However, preschool children have difficulties to execute some maneuvers, since they require a degree of coordination and cooperation. They have short time attention, low frustration tolerance and physiological limitations leading to the necessity to establish specific guidelines for this age group, as well as special attention from health professionals.<sup>2,3,10-14</sup> Children must feel comfortable and for that reason, health professionals should establish a friendly conversation or use distraction techniques, such as videos, music, books or games incentives linked to the pulmonary function equipment.<sup>10,14-16</sup>

The American Thoracic Society (ATS) and the European

Respiratory Society (ERS) published in 2007 recommendations for the criteria for acceptability and reproducibility for preschool children, reference values being currently available for spirometry and specific airway resistance (sRaw).<sup>2,15</sup> This age group can perform spirometry, peak flow referenced to functional residual capacity ( $V_{max_{FRC}}$ ), oscillometry, interrupter technique (Rint), specific airway resistance (sRaw), functional residual capacity (FRC) using gas dilution technique and gas mixture ratio measurement.<sup>3,10,14,17</sup>

An ideal PFT is applicable at any age so that longitudinal studies can be made, monitoring the child from his childhood through his adult age. They are simple to perform, safe, reproducible and sensitive enough to distinguish health from disease.<sup>14</sup>

## Spirometry

Spirometry is the respiratory function test most commonly used in adults and children, with the majority of preschoolers capable of performing forced expiratory maneuvers with an expiratory time of less than 1 second. For that reason  $FEV_{0.5}$  and  $FEV_{0.75}$  are very helpful. The latter is more appropriate because preschoolers have proportionally larger airways to their lung volumes, so during expiratory maneuvers, they are able to perform forced expiration in less than 1s.<sup>3,4,7,10,16</sup> Recent studies suggest that they can perform appropriate and reproducible spirometric maneuvers.<sup>15</sup>

In terms of acceptability, the extrapolated volume (EV) $\leq 80$ mL or ratio  $EV/VFC < 12.5\%$  and should always report  $FEV_{0.5}$ ,  $FEV_{0.75}$  and  $FEV_1$ . As to reproducibility, at least two acceptable curves are required, where the second largest VFC and  $FEV_1$  cannot vary more than 0.1 L or 10% of greater valor.<sup>1,4,10,13,14,18</sup> For bronchodilator response, a cut-off of 9% was proposed for  $FEV_1$  in asthmatic children (5 to 10years).<sup>14,19</sup>

## Plethysmography

It is not possible to measure static lung volumes in young children because they do not tolerate valve occlusion in plethysmography. However the measurement of specific airway resistance (sRaw) does not require the use of a valve. sRaw is increased in asthmatic children at preschool age with wheezing and cystic fibrosis.<sup>2,5,7,10,14</sup> It is very useful in the assessment of bronchodilator response of young asthmatics and the effect of leukotriene antagonists and inhaled corticosteroids.<sup>2,5,10,14</sup>

## Tidal breathing

This technique includes the analysis of expiratory flow and thoracoabdominal motion. The analysis of expiratory flow at tidal breathing can be conducted through flow signals collected in the airway (with a mask/mouthpiece and pneumotachograph), or by volume changes collected at the thoracic wall (with bands at the thoracic and abdominal zone) by respiratory inductance plethysmography (RIP).<sup>14,19</sup>

## Interruptor technique (Rint)

This is based on the rapid equilibration between the alveolar pressure and the pressure measured at the mouth during the sudden debt interruption, reflecting the static elastic traction of the respiratory system.<sup>16</sup> There is a good correlation between Gold Standard techniques and the ability to detect changes in airway caliber. The total maximum interruption time is never greater than 100 milliseconds.<sup>10,14,19,20</sup> It may be more easily performed in the preschooler than spirometry.<sup>7</sup> This technique has not gained broad clinical acceptance yet. It is mostly used in clinical research.<sup>16</sup>

## Forced oscillation technique (FOT)

It is a simple tidal breathing technique, non-invasive and easy to perform in preschoolers. Consists of applying an external wave of pressure in the mouth, through a pneumotachograph with mask or mouthpiece and nose clips, allowing the calculation of the respiratory system impedance (Zrs). This identifies airway obstruction and bronchodilators and broncho constriction response, having particular utility in understanding the physiological properties of lung parenchyma in various situations.<sup>10,14,19,21</sup> It is regarded as a complementary method to spirometry.<sup>16</sup> The simplicity of the measurement has led to its widespread use in preschoolers.<sup>7</sup>

## Dilution gas techniques

This technique is performed in tidal breathing and only requires the passive cooperation of the patient, allowing access to the distribution of ventilation in the lungs and measuring FRC. Evaluates small airways in the study of children with cystic fibrosis or obliterative bronchitis.<sup>22</sup> The most commonly used are washing nitrogen, helium dilution and multiple breath washout – MBW.<sup>7,10,14,19</sup> Jensen R et al.<sup>23</sup> suggest that longitudinal studies of MBW are feasible in preschool children.

## Methodology

We conducted a literature review, based on keywords: respiratory function test, preschool, spirometry and asthma. We reviewed PubMed and B-on data, where 38 articles were selected and 23 were analyzed. There was no language restriction.

## Results

Of all the articles, studies and guidelines analyzed, we obtained favourable results regarding the utility of PFT in preschoolers. Many statistical studies were collected regarding the success rates performing these tests and implemented in accordance with the new

criteria of ATS/ERS (2007), including spirometry and specific airway resistance (sRaw).

## Discussion

Preschool age was, until recently, considered the “silent years”, where lung disease began but was unnoticed due to lack of adequate criteria for acceptability and reproducibility for this age group.<sup>20</sup> Previously, several studies had been conducted giving very poor results. In spirometry, Viložni et al. with a total of 112 children, only nine of them (between 3 to 4 years old) had 38.4% of successful results with a total of 355 patients, less than 10% of children aged between 3-4 years were able to accomplish three acceptable maneuvers. Finally, the Nystad et al.<sup>24</sup> study, with 652 subjects, 40% had less than three acceptable maneuvers of FEV<sub>1</sub>, with small children still had a lower probability of performing the test properly. On the other hand, in the ATS (2001) study, it was noted that of a total of 214 children evaluated at pre-school age, 95% of these produced expiratory maneuvers technically acceptable.<sup>11</sup> There is some contradiction in the latter case, and for that reason it is quite evident the emergence of creating new guidelines adapted to this age group. The implementation of novel techniques in addition to established ones might potentially lead to better and earlier clinical diagnosis and therapeutic intervention.<sup>16</sup>

After the implementation of the new ATS/ERS (2007) guidelines, many studies have proven the relevance that PFT represents in the early diagnosis and treatment of chronic diseases in children of preschool age. It was proved in several investigations that spirometry examination has an adequate viability to provide relevant clinical information in this age group.<sup>2</sup> In Veras TN et al.<sup>3</sup> study, the success rate of spirometry in patients in preschool-age was 82%,<sup>3</sup> Santos N et al.<sup>2</sup> found that success rates in spirometry in preschool reached the 85%, *Leipzig Environment and Health Study*, used spirometry to assess lung function in preschoolers. A total of 247 children (mean age 5.1±1.3 years), acceptable results were obtained in 235 of these (95%);<sup>25</sup> also Mariosca et al. who studied 38 children of preschool age with cystic fibrosis, proved the reliability of the method and its feasibility in 87% of these study retrospectively 473 children between 3 and 5 years (referenced in respiratory function laboratory frames of respiratory difficulty), of which 355 (75%) had at least one acceptable expiratory maneuver. 55% of these children, met ATS criteria and 21% had expiratory maneuvers with less than 1 second long.<sup>19</sup> Finally, Eigen et al.,<sup>11</sup> evaluated lung function of 259 children aged between 3 and 6 years, and 82.6% of these had technically acceptable flow-volume curves during the first test and 95% of these achieved the three technically acceptable curves.<sup>21</sup> Similar results were obtained by JM Olaguibel et al.<sup>20</sup>

The assessment of specific airway resistance (sRaw) was also a very useful method for long-term studies.<sup>5,13</sup> According to *The Manchester Allergy and Asthma Study (MAAS)*, where specific airway resistance (sRaw) was measured, produced about 61% of successful results (530/874) in 3 years old children and 87% (730/840) in 5 years old. In this same study, it was found that there is a significant association between sRaw and types of wheezing; in several studies in Copenhagen, the baseline sRaw was increased in a group of asthmatic preschool children, suggesting that this technique may have an important role in the early identification of asthma.<sup>25</sup> Finally, in a 4 year prospective study, 129 children with one or more episodes of wheezing before 2 years of age, persistent wheezers had higher levels of sRaw than transient.<sup>19</sup>

Respiratory functional rating is useful for the establishment and eventual diagnosis of asthma in most cases of atypical presentation. As this is one of the most prevalent chronic diseases in preschool children, late detection and inadequate treatment may culminate in irreversible changes.<sup>26</sup>

Future applications should be invested in preschool children

related with long-term effects of preterm birth, delayed intrauterine growth and smoking, to strengthen the scientific basis for prevention and treatment of respiratory diseases in early life, as well as providing new information about lung development.<sup>25</sup>

## Conclusion

It is concluded, generally, that PFT in preschool children allows not only the understanding of pathophysiological mechanisms underlying respiratory disease in early life, but can also assist in improving care and consequently reducing mortality and morbidity associated with long-term repercussions in adulthood. In this sense, it is appropriate to develop specific strategies and measures for the prevention of respiratory disease and the provision of more effective therapies.<sup>26</sup>

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## Conflict of interest

The author declares no conflict of interest.

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