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RPPNEN-1261; No. of Pages 6 ARTICLE IN PRESS

Rev Port Pneumol. 2017;xxx(xx):xxx—xxx

revista portuguesa de
PNEUMOLOGIA
portuguese journal of pulmonology

www.revportpneumol.org

ORIGINAL ARTICLE

Impulse oscillometry, spirometry, and passive smoking in healthy children and adolescents

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Received 4 December 2016; accepted 25 June 2017

KEYWORDS
Adolescents;
Child;
Oscillometry;
Passive smoking;
Spirometry

Abstract
Objective: To identify changes in the forced and quiet breathing parameters of lung function in healthy children and adolescents exposed to passive smoking (PS).
Method: Comparative cross-sectional study. Healthy schoolchildren aged 6 to 14 years. We collected anthropometric data, lung function parameters using spirometry (forced breathing), and quiet breathing parameters using impulse oscillometry. The sample was divided into two groups according to exposure to PS: passive smoking group (PSG) and non-passive smoking group (NPSG). For the statistical analysis, the Shapiro—Wilk test was used to verify data normality and the *T*-test or Mann—Whitney test to compare spirometric and oscillometric parameters between groups ($p \leq 0.05$).
Main findings: The study included 78 children and adolescents, with 14 boys and 25 girls in each group. There were differences in the mean values for peak expiratory flow ($p = 0.01$). There were no significant differences between the groups in values for *z*-score and lower limit of normal. The PSG had higher mean absolute values for reactance area (X5 = 0.05) and significant percentage of predicted values for the following impulse oscillometry parameters: central airway resistance (R20%, $p = 0.03$) and for the indicators of presence of airway obstruction (Fres%, $p = 0.01$; X5% = 0.01% and AX%, $p = 0.01$).
Conclusion: Children and adolescents exposed to PS had lower values for the spirometric variables and higher values for the oscillometric variables, indicating changes in forced and quiet parameters of lung function compared to the NPSG.

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http://dx.doi.org/10.1016/j.rppnen.2017.06.005
2173-5115/

Please cite this article in press as: Schivinski CIS, et al. Rev Port Pneumol. 2017. http://dx.doi.org/10.1016/j.rppnen.2017.06.005

Introduction

Passive smoking (PS) is defined as the inhalation of cigarette, pipe, or cigar smoke in closed environments.[1] Because the prevalence of respiratory diseases in children is high due to their developing respiratory and immune systems, the repercussions of PS have generated interest in this age range.[2,3]

This condition can be aggravated by prolonged exposure to PS as a result of the parents' smoking habit.[4] These findings are reported in the literature and show that passive exposure to cigarette smoke both in the pre- and postnatal period impairs lung function parameters in children.[5–7] Among the recognized organic effects of PS are immediate or medium- and long-term negative repercussions, particularly decreased lung function, acute infections of the lower respiratory tract, frequent hospital admissions, start and incidence of new cases of asthma, and cancer in adult life.[8–10]

PS can compromise the small airways due to the potential inflammatory reaction caused by the irritating substances found in cigarettes. This event can reduce pulmonary ventilation as a result of increased airway resistance.[7–11] The predisposition to increased airway resistance implies the need for studies with quantitative analysis of forced/quiet breathing of lung function in children and adolescents submitted to PS.

Most studies evaluating the effects of PS on the respiratory tract use spirometry to show reduction in lung flow and volumes.[12–14] One of the disadvantages of this tool is its low sensitivity and specificity to changes in the early stages of chronic respiratory disease and in mild forms of this disease.

The impulse oscillometry system (IOS) is useful in evaluating airway resistance values (from the central area to the periphery) and identifying early changes. The IOS is easy to use, does not require forced expiratory maneuvers, and involves rapid and reproducible measurements requiring minimal cooperation from the subject.[15]

To date, only one study has evaluated the role of IOS and spirometry in healthy adults exposed to PS.[11] Because PS harms children, the evaluation of the respiratory system using spirometry and oscillometry can help to maximize the understanding of the harmful effects of PS and provide strategies in health policies for children and adolescents in countries with a high rate of smokers. This study aimed to identify the changes in the forced and quiet breathing parameters of lung function in healthy children and adolescents exposed to passive smoking (PS).

Method

Type of study

This is an analytical comparative cross-sectional study that included healthy schoolchildren from educational institutions in Florianópolis, SC, Brazil. The study was conducted from October 2012 to May 2014 following approval by the Ethics Committee of the University of the State of Santa Catarina (UDESC) under number 97/2011.

Procedures

The schoolchildren's parents/guardians were informed about the objectives, procedures, risks, and benefits of the study and signed an informed consent form agreeing to their children's participation. They also answered the questionnaire of the International Study of Asthma and Allergies in Childhood (ISAAC) validated for the Portuguese language and a recall interview structured by the researchers.[16]

Healthy schoolchildren of both sexes aged between six and 14 years participated in the study. Participant selection was based on the guidelines of the American Thoracic Society/European Respiratory Society (ATS/ERS).[17] The selected children did not have episodes of wheezing, history of premature birth, respiratory diseases, respiratory tract infection in the previous 15 days, muscular changes, neurological disorders, asthma, or rhinitis, as certified by their ISAAC scores. Regarding the asthma score, we excluded the children aged 6–9 years and 10–14 years with scores $\geq$5 and 6, respectively.[18] Regarding the rhinitis score, we excluded children aged 6–9 years and those aged 10–14 years with scores $\geq$4 and 3, respectively[19] and affirmative answers to question number 2. As for the spirometric criteria, children not exposed to PS should present FEV_1 and FVC $\geq$80%.[20]

In order to select the sample, verify the good health of the participants, and identify the PS, we analyzed the recall interviews for affirmative responses in relation to exposure to PS, the number of smokers in the household, and daily contact time with cigarette smoke. If the parent/guardian answered yes to any of the questions in the interview, the student was included in the group of healthy children exposed to PS (PSG). Children and adolescents were considered passive smokers if one or both of their parents smoked or if there was at least one smoker living in their house[8]. Healthy children and adolescents not exposed to PS were included in the non-passive smoking group (NPSG). Data on smoking during pregnancy was also checked.

For the anthropometric assessment, weight was measured using a digital scale (Ultra Slim W903-Wiso®) and height was measured using a portable stadiometer (Sanny®). Body mass index (BMI) was classified according to the Child growth standards (percentiles BMI for age) of the World Health Organization (WHO) in obese children ($\geq$97th percentile) and underweight children (<3rd percentile).[21] For both groups, children and adolescents with obesity or underweight were not included in the present study.

All participants were subjected to analysis of quiet breathing parameters of lung function using the IOS, according to the ATS/ERS standards for the Forced Oscillation Technique (FOT).[17] The IOS technique is performed as follows: the individual remains in position and is instructed to breathe calmly through a mouthpiece (tidal volume and spontaneously) while wearing a nose clip and the researcher holding the child's cheeks in his hands. To minimize oscillatory pressure loss, the pressure pulse generator transmits brief pressure pulses to the respiratory tract and these are processed.

Frequencies of 5 and 20 Hz were used and the measures considered for analysis were: total airway resistance (R5 resistance to 5 Hz), central airway resistance (R20-resistance to 20 Hz), respiratory impedance (Z5-impedance to 5 Hz), peripheral capacitive reactance (X5-reactance to

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