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ORIGINAL ARTICLE

Do impulse oscillometry parameters differ between children and adolescents with symptoms of rhinitis and those without?

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ABSTRACT

Objective: To compare impulse oscillometry parameters between healthy children and adolescents with symptoms of rhinitis and those without. **Methods:** This was a cross-sectional analytical study of healthy individuals 7-14 years of age. Health status was determined through the use of questionnaires. We performed anthropometric measurements, impulse oscillometry, and spirometry. **Results:** The sample comprised 62 students, with a mean age of 9.58 ± 2.08 years and a mean body mass index (BMI) of 17.96 ± 3.10 kg/m^2. The students were divided into two **groups:** those with symptoms of rhinitis (n = 29) and those without such symptoms (n = 33). The oscillometry results and anthropometric parameters were normal in both groups and did not differ significantly between the two. The variables age, height, and body mass, respectively, correlated negatively and moderately with most of the following **parameters:** total airway resistance (r = −0.529, r = −0.548, and r = −0.433); central airway resistance (r = −0.441, r = −0.468, and r = −0.439); respiratory impedance (r = −0.549, r = −0.567, and r = −0.455); reactance at 5 Hz (r = 0.506, r = −0.525, and r = −0.414); reactance area (r = −0.459, r = −0.471, and r = −0.358); and resonance frequency (r = −0.353, r = −0.371, and r = −0.293). We found that BMI did not correlate significantly with any of the parameters evaluated. The same was true when we analyzed each group in isolation. **Conclusions:** In our sample, impulse oscillometry parameters did not differ between the students who had symptoms of rhinitis and those who did not.

Keywords: Oscillometry; Anthropometry; Rhinitis; Child; Adolescent.

INTRODUCTION

There have been numerous studies aimed at developing instruments, methods, and techniques that are specific and effective for the assessment of pulmonary function and respiratory mechanics in children and adolescents with respiratory diseases,[1-3] as well as in healthy individuals. Considered complementary to spirometry, impulse oscillometry (IOS) has been applied in research and in clinical practice because it is a simple, rapid technique that requires little patient collaboration and allows investigation of the involvement of specific lung areas.[4]

Although IOS has increasingly been recommended for the clinical follow-up of some diseases,[1-3,5] studies of IOS in healthy populations are scarce, which complicates comparisons and the establishment of normal ranges.[1] Such an investigation under normal health conditions makes it possible to understand the changes resulting from the presence of respiratory disease, as well as its progression.

Studies have shown the relationship of anthropometric variables with spirometric and IOS parameters,[6,7] reporting that, with increasing age and height, healthy individuals tend to have decreased airway resistance due to the increasing size of the chest and airways In obese individuals, as well as in children with cystic fibrosis[2] and individuals with asthma,[3] there is an increase in IOS parameter values, which are representative of airway obstruction.[1,5]

In common situations, often associated with respiratory symptoms, such as those of rhinitis, investigations are still scarce. Rhinitis is a condition that is commonly related to asthma, which is explained by the one-airway theory, according to which there are similarities in the inflammatory processes in the nasal and bronchial mucosas.[8,9]

Rhinitis is induced by exposure to allergens and is mediated by IgE, being clinically characterized by chronic and recurrent symptoms, including inflammation of the mucous membranes of the nose, nasal congestion and obstruction, coryza with colorless, transparent discharge, pruritus, sneezing, decreased olfactory function, and mouth breathing.[10] The presentation of rhinitis is known to depend on the interaction between genetics and the environment Therefore, the diagnosis is based on history taking, physical examination, and the results of ancillary tests. Although epidemiological data on rhinitis in Brazil are limited, rhinitis is believed to affect approximately 25-35% of individuals, mainly children and adolescents.[9] Despite being considered a less severe condition compared with other respiratory

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disorders, rhinitis can have negative effects in the lungs, such as increased lung resistance and decreased lung compliance, which affects chest expansion and leads to inadequate alveolar ventilation.[11] Thus, it becomes relevant to investigate the effects of rhinitis on respiratory mechanics However, to date, most studies have not investigated rhinitis symptoms.

The primary objective of this study was to compare IOS parameters between healthy children and adolescents with symptoms of rhinitis and those without, and a secondary objective was to investigate the relationships that age and anthropometric variables have with IOS parameters in this population.

METHODS

This was a cross-sectional analytical study involving healthy children and adolescents 7 to 14 years of age who attended schools in the greater metropolitan area of the city of Florianópolis, Brazil. We included students who, at the time of data collection, had no chronic or acute respiratory disease and whose health status was determined through the use of parent/guardian-completed questionnaires. We excluded students who were unable to perform any of the steps of the evaluation and whose FEV_1 was less than 80% predicted,[12] as well as whose FEV_1/FVC ratio was less than 70% predicted.[13] The study was approved by the Research Ethics Committee of the *Universidade do Estado de Santa Catarina* (CAAE no 52891215.7.0000.0118), and the parents or legal guardians of the participants gave written informed consent.

Health status was assessed through the use of two questionnaires: a health diary created by the researchers, assessing aspects such as the presence of concomitant diseases, passive smoking, history of prematurity, level of physical activity, socioeconomic factors, and environmental factors; and the International Study of Asthma and Allergies in Childhood, modules 1 and 2.[14] Module 1 was used in order to screen for asthma (an exclusion criterion), and module 2 was used in order to divide the sample into two groups: participants with symptoms of rhinitis (rhinitis group) and participants without symptoms of rhinitis (non-rhinitis group).

The following measures were recorded: body mass (in kg); height (in cm); and body mass index (BMI), which was calculated with the online calculator of the Brazilian National Ministry of Health.[15] Subsequently, participants underwent IOS, in accordance with the American Thoracic Society standards,[16] with the use of a MasterScreen IOS device (Jaeger, Würtzburg, Germany), which was calibrated before each trial Participants were instructed to remain in a seated position with a nose clip in place and seal their lips around the mouthpiece while their cheeks were pressed by the examiner. Participants were instructed not to obstruct the mouthpiece with their tongue, as well as not to swallow, cough, or vocalize during the maneuver. Maneuvers lasting at least 20 s were accepted, and at least three should be acceptable and reproducible.[5] The minimum acceptable coherence value was 0.8 at 10 Hz.[17] After a rest period of approximately 20 s, spirometry was performed, in accordance with the American Thoracic Society standards.[18]

The following IOS parameters were analyzed: respiratory impedance (Z); respiratory resistance (R), measured at 5 Hz (R5), which represents total airway resistance, or at 20 Hz (R20), which represents central airway resistance; reactance (X), measured at 5 Hz (X5), which characterizes airway obstruction and restriction; and resonance frequency (Fres), which is the point at which capacitive reactance (related to thoracopulmonary elasticity and change in volume) equals inertial reactance (a reflection of the movement of the air column in the airways)[19] and which, together with R, is a parameter that has high specificity and sensitivity for detecting airway obstruction.[20] The reactance area (AX), which is related to lung compliance and to the degree of obstruction of the peripheral airways,[5] was also analyzed. We then recorded absolute and predicted values of R5, R20, X5, Fres, and AX, in accordance with de Assumpção et al.[21] The parameters measured by spirometry included FVC, FEV_1, and PEF.[12,13]

Descriptive statistical analysis was performed with the IBM SPSS Statistics software package, version 20.0 (IBM Corporation, Armonk, NY, USA), and the significance level adopted was 5% for all tests. Initially, we used descriptive and frequency statistics, and data were expressed as means and standard deviations. Data distribution was tested by using the Shapiro-Wilk test, and we used Pearson's or Spearman's test to assess correlations between study variables, the correlations being classified, in accordance with Dancey & Reidy,[22] as weak (0.10 to 0.30), moderate (0.40 to 0.60), or strong (0.70 to 1.0). The Student's t-test for independent samples and the Mann Whitney U test were used for between-group comparisons. To calculate the sample size, we analyzed data obtained in a pilot study, which included 12 children (6 in each group). The IOS parameter R5 was selected for the analysis, with a between-group difference to be detected of 0.11 kPa and a standard deviation of 0.12 kPa. Our calculation indicated that, to achieve a power of 80% and a significance level of 5% (two-tailed test),[23] a sample size of 21 students in each group would be sufficient for our study. Considering a potential loss to follow-up, we estimated the final sample size to be 58 children, 29 in each group.

RESULTS

We evaluated 69 participants. However, 7 were excluded because their performance of spirometry did not meet acceptability and reproducibility criteria. Therefore, a total of 62 healthy children and adolescents, 33 (53%) of whom were girls, participated in this study, with a mean age of 9.58 ± 2.08 years and a BMI of 17.96 ± 3.10 kg/m^2. Of those, 33 children and adolescents (20 girls) comprised the non-rhinitis group, whereas 29 children and adolescents (16 boys) comprised the rhinitis group. Data on the characteristics and health status assessment of participants, which are shown in Tables 1 and 2, reveal that the two groups did not differ in terms of the anthropometric or spirometric variables analyzed.

In the sample as a whole, age correlated negatively with the IOS parameters Z5 ($r = -0.549$), R5 ($r = -0.529$), R20 ($r = -0.441$), AX ($r = -0.459$), and Fres ($r = -0.353$), whereas it correlated positively with the IOS parameter X5 ($r = 0.506$), and all of the correlations were significant ($p < 0.05$). The variables height and body mass, respectively, showed significant negative correlations with Z5 ($r = -0.567$ and -0.455), R5 ($r = -0.548$ and -0.433), R20 ($r = -0.468$ and -0.439), X5 ($r = -0.525$ and -0.414), AX ($r = -0.471$ and -0.358), and Fres ($r = -0.371$ and -0.293). We found that BMI did not correlate significantly with any of the parameters evaluated.

In the rhinitis group, similar to what was seen in the sample as a whole, there were significant correlations between anthropometric/demographic variables and IOS parameters. Age showed negative correlations with Z5, R5, R20, Fres ($r = -0.425$), and AX ($r = -0.522$) and showed a positive correlation with X5 (Figure 1). Height showed negative correlations with Z5, R5, R20, Fres ($r = -0.479$), and AX ($r = -0.501$) and showed a positive correlation with X5 (Figure 2). Body mass correlated positively with X5 ($r = 0.415$) and negatively with Z5 ($r = -0.425$), R5 ($r = -0.414$), and R20 ($r = -0.513$). The BMI showed positive correlations with Fres ($r = 0.497$) and AX ($r = 0.394$).

The results in the non-rhinitis group were similar to those obtained in the rhinitis group, with significant correlations between variables. Age showed negative correlations with Z5, R5, R20, and AX ($r = -0.407$) and showed a positive correlation with X5 (Figure 1). Height correlated negatively with Z5, R5, R20, Fres ($r = -0.356$), and AX ($r = -0.414$) and positively with X5 (Figure 2). Body mass showed a positive correlation with X5 ($r = 0.450$), whereas it showed negative correlations with Z5 ($r = -0.469$), R5 ($r = -0.517$), R20 ($r = -0.374$), Fres ($r = -0.413$), and AX ($r = -0.445$).

There were no significant differences between the rhinitis and non-rhinitis groups in any of the IOS parameters evaluated (Table 2).

DISCUSSION

The behavior of IOS parameters in children and adolescents, in relation to the presence of rhinitis

Table 1. Anthropometric and demographic characteristics in the sample as a whole and by group.[a]

Variable	Sample as a whole	Non-rhinitis group (n = 33)	Rhinitis group (n = 29)	p*
Age, years	9.58 (9.05-10.1)	9.61 (8.85-10.3)	9.55 (8.77-10.3)	0.989
Body mass, kg	36.9 (34.4-39.5)	38.1 (34.6-41.7)	35.6 (31.7-39.4)	0.321
Height, cm	140.7 (137.7-143.7)	142.5 (138.4-146.6)	138.7 (134.3-143.1)	0.207
BMI, kg/m^2	17.9 (17.1-18.7)	17.9 (16.8-19.0)	17.9 (16.7-19.1)	0.982

Non-rhinitis group: participants without symptoms of rhinitis; rhinitis group: participants with symptoms of rhinitis; and BMI: body mass index. [a]Values are expressed as mean (95% CI). *Between-group comparisons with the Student's t-test for independent samples.

Table 2. Spirometric and impulse oscillometry parameters in the sample as a whole and by group.[a]

Parameter[b]	Sample as a whole	Non-rhinitis group (n = 33)	Rhinitis group (n = 29)	p*
%FVC	98.2 (95.1-101.2)	99.9 (95.3-104.5)	96.2 (92.3-100.2)	0.232
%FEV_1	101.6 (100.0-103.2)	101.3 (99.1-103.5)	102.0 (99.6-104.3)	0.623
%PEF	82.8 (78.3-87.3)	83.1 (76.7-89.5)	82.5 (75.8-89.2)	0.989
%$FEF_{25-75\%}$	88.7 (83.5-93.9)	86.6 (79.9-93.3)	91.2 (82.7-99.7)	0.388
R5 (kPa/L/s)	0.64 (0.60-0.68)	0.68 (0.57-0.68)	0.66 (0.59-0.72)	0.521
%R5	107.4 (102.1-112.7)	107.0 (100.3-113.7)	107.9 (99.1-116.6)	0.864
R20 (kPa/L/s)	0.50 (0.47-0.52)	0.50 (0.46-0.53)	0.50 (0.46-0.54)	0.981
%R20	101.1 (96.2-106.1)	104.0 (96.8-111.2)	97.8 (90.9-104.7)	0.213
Z5 (kPa/L/s)	0.67 (0.62-0.71)	0.65 (0.59-0.70)	0.69 (0.62-0.75)	0.370
%Z5	156.7 (146.9-166.5)	157.4 (143.2-171.7)	155.9 (141.7-170.1)	0.876
X5 (kPa/L/s)	−0.17 (−0.19 to −0.16)	−0.17 (−0.19 to −0.14)	−0.18 (−0.21 to −0.15)	0.511
%X5	124.7 (113.9-135.6)	123.2 (108.3-138.1)	126.5 (109.8-143.2)	0.767
Fres (Hz)	18.8 (17.4-20.1)	18.1 (16.3-20.0)	19.4 (17.4-21.5)	0.339
%Fres	113.6 (106.3-121.0)	111.9 (101.3-122.4)	115.6 (104.9-126.4)	0.610
AX (kPa/L)	1.39 (1.13-1.66)	1.26 (0.90-1.62)	1.55 (1.15-1.95)	0.233
%AX	133.8 (107.9-159.7)	120.7 (86.2-155.2)	148.63(107.9-189.2)	0.290

Non-rhinitis group: participants without symptoms of rhinitis; rhinitis group: participants with symptoms of rhinitis; R5: total airway resistance; R20: central airway resistance; Z5: respiratory impedance; X5: reactance at 5 Hz; Fres: resonance frequency; and AX: reactance area. [a]Values are expressed as mean (95% CI). [b]%variable: percent predicted variable. *Between-group comparisons were made with the Student's t-test for independent samples.

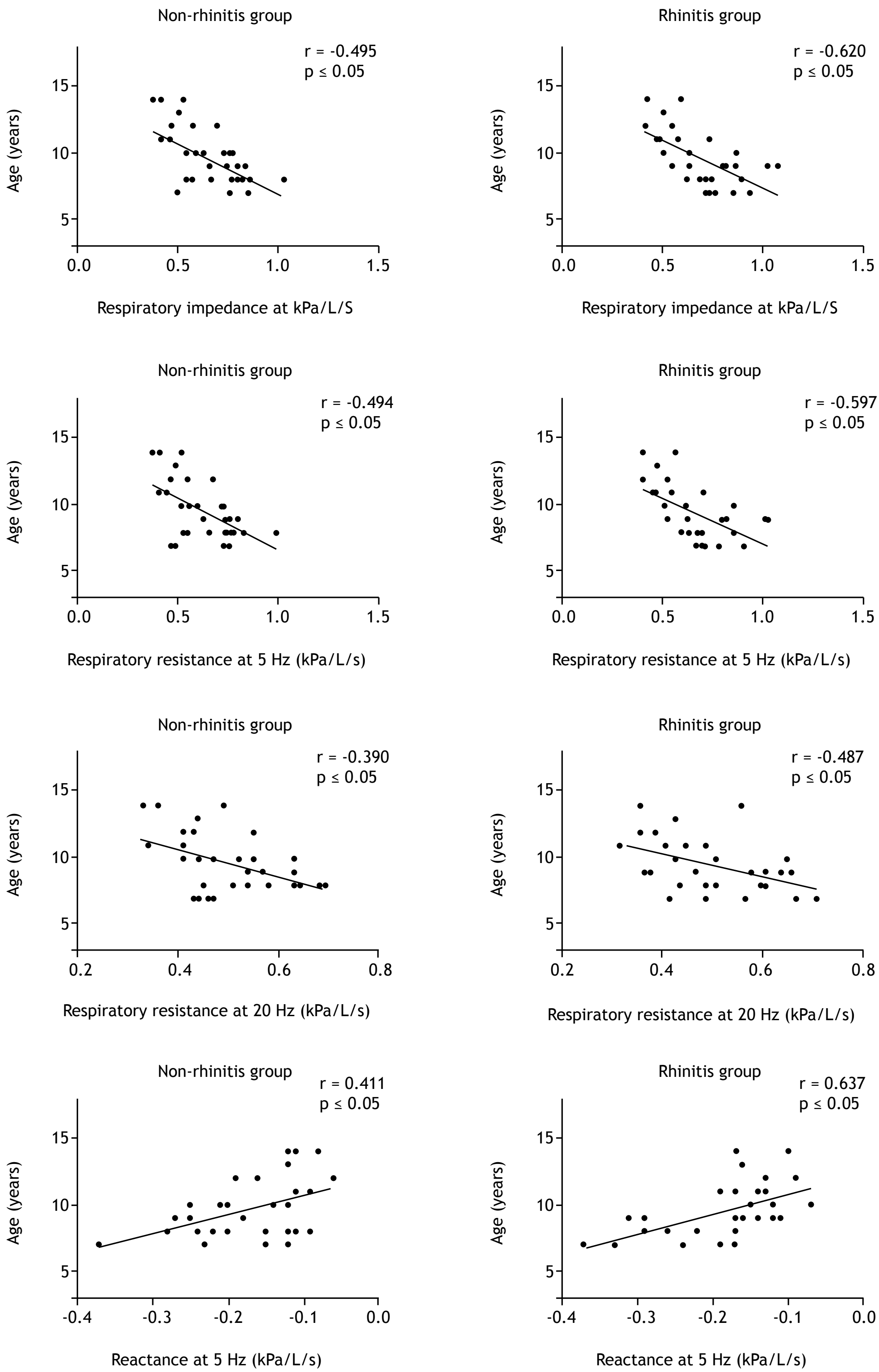

Figure 1. Correlations between age and impulse oscillometry parameters in the rhinitis and non-rhinitis groups. Non-rhinitis group: participants without symptoms of rhinitis; and rhinitis group: participants with symptoms of rhinitis.

symptoms, has not been extensively investigated. Most studies on IOS have reported its relationship with anthropometric variables in studies on reference values,[9] as well as in specific respiratory diseases, such as asthma and cystic fibrosis,[24] and in hyperresponsiveness.[25]

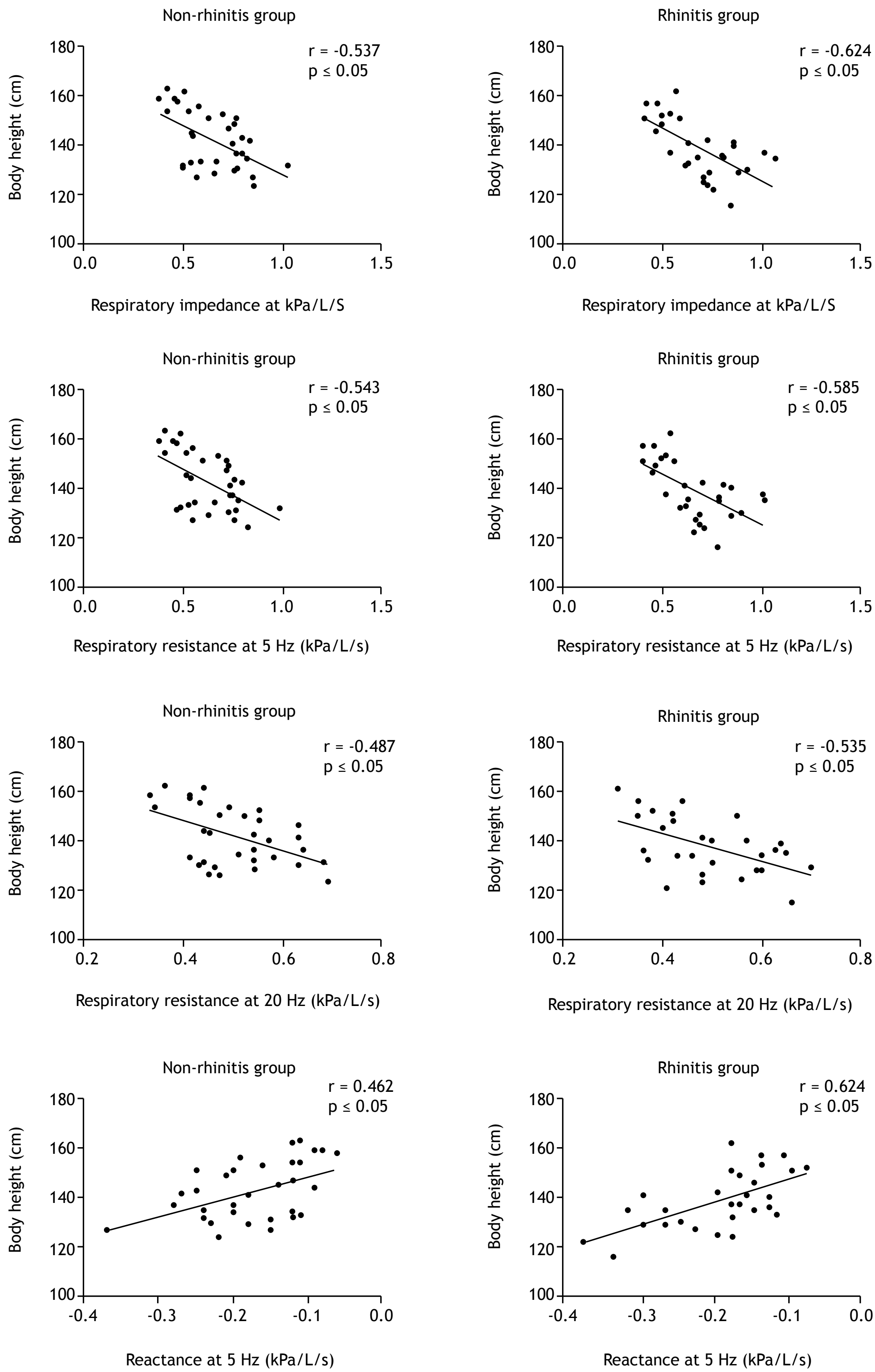

Figure 2. Correlations between height and impulse oscillometry parameters in the rhinitis and non-rhinitis groups. Non-rhinitis group: participants without symptoms of rhinitis; and rhinitis group: participants with symptoms of rhinitis.

In the present study, our hypothesis was that there would be differences between the rhinitis and non-rhinitis groups, given the one-airway theory.[8,9] However, that hypothesis was not confirmed. Symptoms of rhinitis can lead to inflammation and edema of the upper airway mucosa, which generate a turbulent flow to the airways and, consequently, an increase in airway resistance.[10,11] In addition, the presence of such symptoms favors mouth breathing, and, consequently, cold, dry, unfiltered air is allowed to enter, which also has negative effects on the airways,[26] among which is hyperresponsiveness.[25]

According to Galant et al.,[27] IOS, which assesses airway caliber, and spirometry, which reflects airflow characteristics, could detect potential changes resulting from the presence of rhinitis symptoms. The fact that such changes were not detected in the present study can be attributed to the transitory nature of rhinitis symptoms, which thus had no effect on the lower airways. In addition, IOS and spirometry both involve the use of a mouthpiece, with closed nares, and the nares are the primary areas of inflammatory involvement in respiratory tract conditions. Arshi et al.[25] also used IOS and spirometry to compare airway responses in similar patients (i.e., patients with symptoms of rhinitis) before and after treadmill exercise testing. However, their sample consisted of children and adults (12-44 years). Those authors found no relationship between IOS and spirometry measures and considered treadmill exercise testing inappropriate for determining the presence of airway hyperresponsiveness in symptomatic individuals.

It is essential to note that our study sample was homogeneous, consisting of children and adolescents who attended the same school, had a similar socioeconomic status, had no history of passive smoking or prematurity, were physically active but were not athletes registered in sports federations, and were not obese. Participants were differentiated, and consequently grouped, on the basis of the presence or absence of rhinitis symptoms, which is hypothesized to be a determinant of potential differences in IOS parameters, a hypothesis that was not confirmed. Along the same line, Costa[11] also found no differences when comparing IOS parameters between a group with allergic rhinitis and a control group. Therefore, these findings are of great relevance for clinical practice, given that many children who have been included in studies investigating lower airway diseases routinely exhibit symptoms of rhinitis, which do not appear to compromise the results of tests that assess the respiratory system.

In the present study, the normal Fres and R5 values found in the sample as a whole, consistent with lower airway integrity, as well as in the rhinitis and non-rhinitis groups separately, appear to refute the one-airway theory,[8,9] which gave rise to this research. Fres tends to be higher in children, to decrease with increasing age, and to be elevated in restrictive or obstructive disease states. Airway resistance decreases with increasing age, and, in patients with small airway disease, changes in resistance at low frequencies (R5) become apparent[28]; such changes were not detected here. This topic has been investigated. Song et al.[29] conducted a study involving 226 children with allergic and non-allergic rhinitis and examined the relationship between the anatomy of the nasal cavity and increased lower airway resistance, as measured by IOS. As in the present study, participants were selected by means of the International Study of Asthma and Allergies in Childhood questionnaire. The authors found that children with a smaller nasal cavity had higher values for the parameters related to resistance in the lower airways.

Kim et al.[30] evaluated 340 children, among whom were healthy children, children with asthma, and children with allergic rhinitis. The authors concluded, on the basis of the one-airway theory, that children with rhinitis have greater inflammation and mild reversible obstruction of the airways, detectable by IOS, when compared with healthy children. These findings differ from those obtained in the present study, in which there were no significant differences in IOS parameters or anthropometric variables between students with symptoms of rhinitis and those without. One potential limitation of the present study is the lack of a clinical diagnosis of rhinitis, made on the basis of ear, nose, and throat assessment and objective tests, similar to that observed in studies mentioned here,[25,29,30] which leads to a potential selection bias.

When we analyzed the groups separately, we found that the presence of rhinitis symptoms was associated with higher correlation coefficients between the IOS parameters Z5, R5, R20, and X5 and the variables age and height, a finding that was not true for the sample as a whole. Also in the rhinitis group, the correlation between height and the IOS parameters Fres and AX was of greater magnitude, whereas in the non-rhinitis group, no relationship was found between age and Fres. In the rhinitis group, similar to what was seen in the sample as a whole, the variables body mass and BMI correlated significantly with the IOS parameters Z5, R5, R20, X5, AX, and Fres. Assumpção et al.,[31] when comparing obese and normal-weight children and finding that the values of the IOS parameters Z5, R5, Fres, and AX were higher in those with increased body mass, argued that greater attention should be paid to this anthropometric variable in order for us to understand its influence on respiratory system mechanics. This is because enlarged tissue structures, such as adipose tissue, lead to a reduction in lung volumes and, consequently, a decrease in small airway caliber, directly resulting in an increase in respiratory system resistance.[11,32]

The present study primarily found that, although the correlations observed between IOS parameters and anthropometric variables were of greater magnitude in the rhinitis group, there were no statistically significant differences in IOS parameters between the non-rhinitis group and the sample as a whole. These findings raise the need for further studies to investigate the impact that rhinitis symptoms have on respiratory mechanics parameters in children and adolescents, as well as on their anthropometric status. Secondarily, we found correlations between most IOS parameters and the anthropometric/demographic variables analyzed in this sample of students. However, the presence of rhinitis symptoms merits further investigation in this population.

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