

RESPIRATORY MUSCLE STRENGTH OF BRAZILIAN ADOLESCENTS: OBTAINED AND PREDICTED VALUES

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Abstract

Objectives: To compare the obtained values for maximal respiratory pressures of a sample of Brazilian adolescents with the values predicted by Wilson *et al.* and Domènech-Clar *et al.* **Methods:** 156 adolescents (84 boys) aged between 12 and 17 years were assessed. Maximal respiratory pressures were assessed by a digital manometer with the adolescents in the seated position and wearing a nose clip. Maximal inspiratory and expiratory pressures were performed from residual volume and total lung capacity, respectively. Comparison of the values of maximal respiratory pressures obtained in this study with those predicted by the equations proposed by Wilson *et al.* and Domènech-Clar *et al.*, was performed by the paired Student's t test. To verify the association between these values, the Pearson's correlation test was used. **Results:** Mean maximal inspiratory pressure was $74,66 \pm 22,95$ cm H₂O and $103,52 \pm 25,67$ cm H₂O for girls and boys, respectively. Mean maximal expiratory pressure was $86,23 \pm 25,92$ cm H₂O and $120,08 \pm 27,37$ cm H₂O for girls and boys, respectively. The values obtained by this study did not differ and also did not significantly correlate with those predicted by the equations proposed by Wilson *et al.*, e Domènech-Clar *et al.* **Conclusions:** The equations proposed by Wilson *et al.* and Domènech-Clar *et al.* were not successful in predicting the values for maximal respiratory pressures in the population studied, indicating the necessity of using in clinical practice reference values from a healthy population of the same ethnicity.

Key words: muscle strength, respiratory muscles, evaluation, reference values, adolescent.

INTRODUCTION

The measurement of maximal static respiratory pressures (MRP) at the mouth provides subsidies to direct the preoperative and postoperative therapeutic goals¹, assess the response to respiratory muscle training and allows early muscle weakness identification in various pathological conditions². The measurement of maximal expiratory and inspiratory pressures (MEP and MIP, respectively) are crucial to the adequate assessment of pulmonary function, and can be performed in healthy individuals of different ages, or in individuals with disorders of different origins^{3,4}.

Several studies have been developed in order to provide reference values for MRP or formulate equations able to predict these values^{5,6}. Thus, variables such as: age, sex,

height, weight, physical activity level and ethnicity were considered, which motivated further researches with different samples in order to compare values found with predicted ones in previous studies, or to present new predicted equations^{2,7-11}.

In 1984, Smith *et al.*⁷ highlighted the lack of studies with MR Pin adolescents and evaluated 112 individuals of different ages, among them 76 adolescents of both sexes, publishing the data as normal values. In the same year, Wilson *et al.*⁵ studied 235 subjects between 7 and 17 years, of both sexes, and provided predicted equations for MIP and MEP considering the independent variables: weight and age. Later, Szeinberg *et al.*, in 1987¹², published reference values from a sample of 270 subjects aged between 8 and 40 years (243 children and adolescents). In 2003, Domènech-Clar *et al.*⁸ provided predicted

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equations from the assessment of 392 Spanish children and adolescents between 8 and 17 years. Similarly to the study of Wilson *et al.*⁶, the equations proposed by Domènech-Claret *et al.*⁸ considered the same variables, however adding the variable height. All mentioned studies have performed the comparison between obtained and predicted values, finding differences between results.

Studies conducted in Brazil have shown that it is necessary to evaluate different populations and provide different parameters for them, once there may be differences between the characteristics of these individuals, in distinct regions of the same country^{9,10} and even in the same region⁹.

To the best of our knowledge, the predicted equations and parameters of normality offered by Wilson *et al.*⁶ and Domènech-Clar *et al.*⁸ have been the most widely used as reference in the evaluation of respiratory muscle strength of adolescents from different nationalities. However, comparative studies using a sample of Brazilian adolescents were not found.

Thus, the aim of this study is to compare the values found with those predicted by Wilson *et al.*⁶ and Domènech-Clar *et al.*⁸ and to verify if the predicted values are suitable to be used in a population of Brazilian adolescents.

METHODS

This is a cross-sectional study conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of Federal University of Rio Grande do Norte (UFRN), protocol number 278/2009. Sample calculation was conducted according to the formula to estimate the mean supplied by the Laboratory of Epidemiology and Statistics¹³ resulting in 14 boys and 12 girls for each age group assessed.

The subject's selection was made from a list of public and private schools in the city of Natal provided by the 1st Regional Education Directorate (DIRED). By a previous contact, a letter explaining the study was delivered to parents and/or guardians, accompanied by an informed consent form and a respiratory questionnaire, composed of nine questions regarding respiratory symptoms, validated for diagnosis of respiratory diseases. This is recommended by The American Thoracic Society and Division of Lung Diseases¹⁴. Inclusion criteria were: aged between 12 and 17 years¹⁵, be eutrophic¹⁶; do not have chronic lung, neuromuscular or cardiovascular disease, as well as reporting the use of medications that might interfere in the performance during assessments¹⁷; neurological damage or inability to understand the guidelines for using the manovacuometer^{3,17}; recent upper airway, chest or abdominal trauma; acute middle ear infection; abdominal hernia; glaucoma or retinal detachment³; fever in the three previous weeks³ and flu and/or cold in the week prior to the procedure; or have past history of smoking;

thoracic deformity³; or a score of 7 or higher on the standardized questionnaire of the *American Thoracic Society and Division of Lung Diseases ATS-DLD-78-C14*.

Individuals excluded were those unable to perform the necessary procedures and those who declined to participate; exhibited acute respiratory tract disease during the collection period; missed class during the evaluation period at their school; displayed values lower than 80% of those predicted for Peak Expiratory Flow (PEF), Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV), Forced Expiratory Volume in the first second (FEV₁) and the FEV₁/FVC ratio, as well as values less than 70% of those predicted for mean Forced Expiratory Flow between 25 and 75% of the FVC curve (FEF_{25-75%}) – in accordance with ATS¹⁸ criteria. The measures proposed by Mallozi¹⁹ were used as reference values.

On the scheduled day, each adolescent underwent anthropometric assessment. The Anthro Plus software from the World Health Organization (WHO) automatically provided the nutritional status.

Heart rate and peripheral oxygen saturation were verified with the purpose of monitoring the adolescent for possible interruption of the evaluation before complications. The instruments used were a Visomat® Handy IV digital sphygmomanometer (UEBE Medical GmbH, Germany) and an Onyx® II 9550 Pulse Oximeter (Nonin Medical, Plymouth-MN, United States of America).

In order to avoid air escape, all measurements were performed with the adolescent using a nose clip and instructed to properly adjust their lips around the mouthpiece⁸. Because this was an effort-dependent test, the examiner provided verbal encouragement during assessments. The adolescents remained seated with their heads in a neutral position.

Spirometry

Spirometry was performed using a hand held One Flow FVC digital spirometer (Clemente Clark International – England)

Initially, the adolescents performed three respiratory cycles at tidal volume, and then they were instructed to perform one maximum inspiration (indicated by a predetermined gesture), close their mouth firmly around the mouthpiece and, following a minimum pause, make a vigorous maximum expiration. The maneuvers produced flow - volume and time-volume curves that, for its use in the interpretation, should be in accordance with the acceptability and reproducibility criteria recommended by the American Thoracic Society²⁰: realization of a maximum inspiration before the beginning of the test; a minimum pause (1-2 seconds); expiration with maximum effort; satisfactory test duration (6 seconds); and the lack of artifacts.

A minimum of three and maximum of eight maneuvers were executed. Of these, three were acceptable, and the best two did not exhibit a maximum difference of 0.150 L between them,

with the better of the two tests chosen. A one-minute rest was permitted between each maneuver¹⁸.

Manovacuometry

After 10 minutes of rest, the same examiner conducted the assessment of maximal respiratory pressures. MRP were assessed using an MVD 300 digital manometer (Globalmed®, Porto Alegre – RS, Brazil). A disposable biological filter (Vida Tecnologia Biomédica, São Paulo - SP, Brazil) was attached to a Rescal adaptor which connects the system with the ambient air. This was coupled to a rigid and flattened plastic mouthpiece (Globalmed®, Porto Alegre – RS, Brazil) with a 2-mm wide hole on its upper surface.

The evaluation was performed with the manometer connected to a laptop (Compac Presario CQ50-113BR). The computer software provided the subject with visual feedback, and auditory feedback was given by the examiner. MRP measurement was performed in accordance with the method proposed by Souza³.

Initially, adolescents randomly selected the first MRP to be assessed. To assess MIP the adolescents were instructed to perform three respiratory cycles at tidal volume and then perform a maximum expiratory effort up to approximately the residual volume (RV). The adolescents indicated the maximum effort by a predetermined gesture. At that moment they were instructed to perform a maximal inspiration (until approximate total lung capacity - TLC). Instructions were similar for MEP assessment, except participants first performed a maximal inspiration and then maximal expiration following occlusion of the orifice. During this measurement the examiner manually supported the adolescents' cheeks²¹.

A maximum of nine maneuvers were performed for each MRP assessment⁸. Of these, at least three had to be acceptable (without leaking, with a duration of at least 2s and sustained for 1s), from which a minimum of two were required to be reproducible (with a difference between them of no more than 10% of the highest value). The better of these two values was selected⁸. However, the last measurement could not be the highest, and another measurement was taken when this occurred. A one-minute rest was permitted between each maneuver, with five minutes allowed between MIP and MEP assessments.

The equipment used in this investigation only directly supplies peak pressure values (the highest value during the maneuver)²². As such, sustained pressure values were determined by examining the pressure versus time curve provided by the manometer software.

Analysis of data

Data were analyzed using SPSS statistics software version 17.0, with a significance level of 5%. Data normality was verified by the Kolmogorov-Smirnov test. Descriptive statistics are expressed as mean and standard deviation.

One-way analysis of variance (ANOVA), followed by the Bonferroni post hoc test, was used to determine whether there was a significant difference in MRP according to age and sex. Non-paired Student's t-test was applied to verify inter-gender differences. Unpaired Student's t-test was used to establish the existence of differences between the mean MIP and MEP values obtained in the present study and those from the equations proposed by Wilson *et al.*⁶ and Domènech-Claret *et al.*⁸ The Pearson's correlation test was performed to verify the association between those values. Levene's test was performed to assess the homogeneity of variances (homoscedasticity). The lower limit of normal (LLN) was calculated by subtracting a value two times greater than the standard deviation of the measurements from mean MRP³.

RESULTS

244 questionnaires were returned, 28 teenagers were not included in the sample for non-compliance with one of the inclusion criteria. Among the 216 adolescents selected, 60 were excluded (3 refused to take part, 39 were not classified as eutrophic, 13 did not meet criteria established by spirometry and 5 were unable to perform acceptable and reproducible manovacuometer maneuvers among the maximum number of nine measurements), resulting in a total sample of 156 subjects, 84 boys and 72 girls. Table 1 describes the anthropometric variables, expressed as mean and standard deviation.

MIP and MEP values had normal distribution with a significant level of $p = 0,49$ and $p = 0,55$, respectively. ANOVA indicated no significant difference between respiratory muscle strength and age (12-17 years) with a P value of 0,18 for MIP and 0,749 for MEP.

Table 2 describes the means obtained for maximal respiratory pressures in boys and girls. This table also shows the lower limits of normal of the adolescents assessed.

Table 3 shows the inexistence of significant difference for comparison of maximal respiratory pressure values found with the ones predicted by the equations proposed by Wilson *et al.*⁶ and Domènech-Clar *et al.*⁸

The dispersion graphs of MRP values found and those predicted in equations proposed by Wilson *et al.*⁶ and Domènech-Clar *et al.*⁸ are shown in figures 1 and 2, respectively. Obtained values of MIP and MEP in both sexes had low coefficients and did not present significant correlation with the values predicted by Wilson *et al.*⁶ and Domènech-Claret *et al.*⁸

DISCUSSION

When comparing the values found for maximal respiratory pressures from a sample of 156 healthy Brazilian adolescents with the values

Table 1: Description of anthropometric variables, expressed as mean and standard deviation, according to age and sex

Age (years)		Girls (n = 72)	Boys (n = 84)
12 (n = 12♀ 14♂)	Weight (Kg)	46,33 ± 9,80	42,92 ± 6,12
	Height (m)	1,56 ± 0,08	1,54 ± 0,08
	BMI (Kg/m ²)	18,69 ± 2,57	17,92 ± 2,26
13 (n = 12♀ 14♂)	Weight (Kg)	44,75 ± 6,60	54 ± 6,96
	Height (m)	1,58 ± 0,05	1,66 ± 0,05
	BMI (Kg/m ²)	17,72 ± 2,32	19,41 ± 1,74
14 (n = 12♀ 14♂)	Weight (Kg)	49,33 ± 4,79	54,14 ± 9,72
	Height (m)	1,59 ± 0,04	1,66 ± 0,08
	BMI (Kg/m ²)	19,41 ± 2,29	19,50 ± 1,96
15 (n = 12♀ 14♂)	Weight (Kg)	53,50 ± 7,45	60,07 ± 7,94
	Height (m)	1,62 ± 0,07	1,72 ± 0,06
	BMI (Kg/m ²)	18,46 ± 6,36	18,71 ± 5,49
16 (n = 12♀ 14♂)	Weight (Kg)	52,50 ± 7,11	64,14 ± 8,52
	Height (m)	1,61 ± 0,05	1,74 ± 0,07
	BMI (Kg/m ²)	20,06 ± 2,70	20,95 ± 1,87
17 (n = 12♀ 14♂)	Weight (Kg)	54,25 ± 10,92	68,07 ± 8,68
	Height (m)	1,62 ± 0,06	1,74 ± 0,07
	BMI (Kg/m ²)	20,45 ± 3,15	22,35 ± 1,94

BMI: body mass index.

♀: Female; ♂: Male.

Table 2: Comparison of maximal respiratory pressures between boys and girls and lower limits of normal for the adolescents assessed

Obtained values	Girls (n=72)	Boys (n=84)	P value
MIP (cmH ₂ O)	74,66 ± 22,95	103,52 ± 25,67	0,000
MEP (cmH ₂)	86,24 ± 25,92	120,08 ± 27,37	0,000
LLN MIP (cmH ₂ O)	28,76	52,18	
LLN MEP (cmH ₂ O)	34,40	65,34	

MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure.

LLN: lower limit of normal. Statistically significant (p < 0.05).

Table 3: Comparison of obtained maximal inspiratory and expiratory pressures with those predicted by Wilson *et al.*⁶ and Domènech-Claret *et al.*⁸

MRP	n	Obtained values (cmH ₂ O)	Predicted values by Wilson <i>et al.</i> ⁶ (cmH ₂ O)	P value	Predicted values by Domènech-Claret <i>et al.</i> ⁸ (cmH ₂ O)	P value
MIP						
Girls	72	74,67 ± 22,92	68,47 ± 4,91	0,579	91,88 ± 7,86	0,398
Boys	84	103,52 ± 25,67	86,95 ± 8,69	0,583	116,00 ± 13,21	0,709
MEP						
Girls	72	86,24 ± 25,92	93,50 ± 8,21	0,963	98,67 ± 9,63	0,980
Boys	84	120,08 ± 27,37	114,50 ± 9,37	0,382	159,86 ± 21,01	0,436

MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure. MRP: maximal respiratory pressures. Statistically significant (p < 0.05).

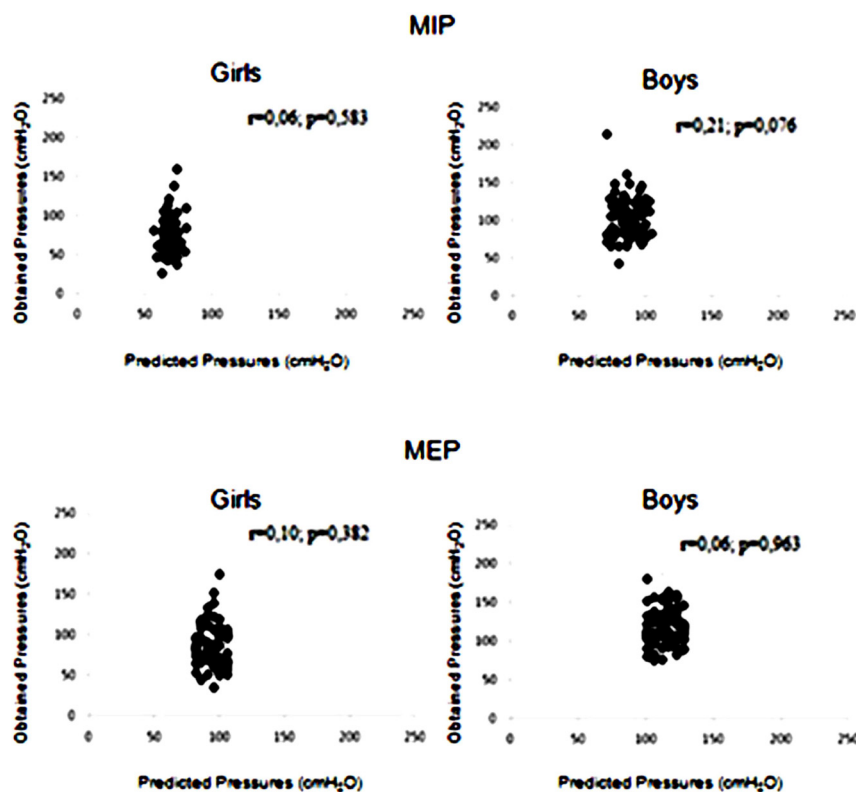


Figure 1: Dispersion diagrams of maximal inspiratory pressures (MIP) and maximal expiratory pressures (MEP) obtained in the present study and the values predicted by equations proposed by Wilson et al.⁶

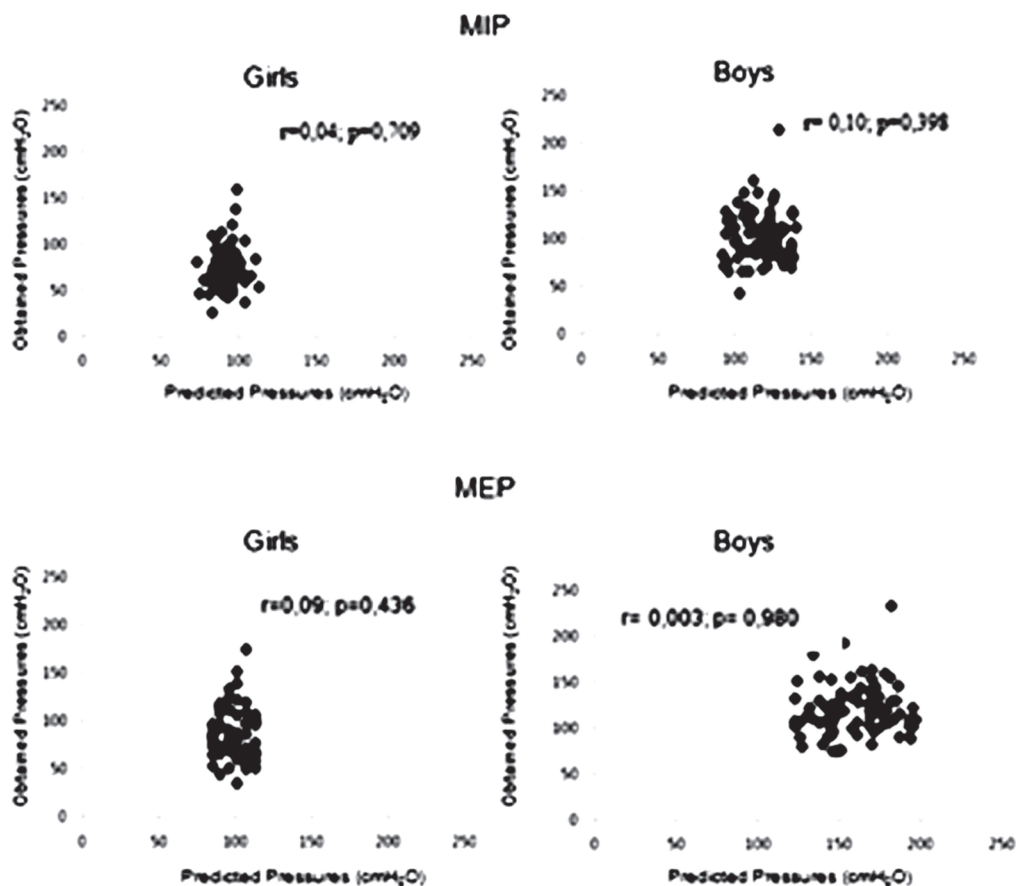


Figura 2: Dispersion diagrams of maximal inspiratory pressures (MIP) and maximal expiratory pressures (MEP) obtained in the present studies and the values predicted by equations proposed by Domènech-Claret al.⁸

predicted by Wilson *et al.* (1984)⁶ and Domenèch-Clar *et al.* (2003)⁸ it was verified that the equations proposed by these authors were not able to predict respiratory muscle strength of Brazilian adolescents.

Although the differences are not significant, there was weak correlation without statistical significance between the values found in the current study and the predicted ones by both studies^{6,8}. According to Parreira *et al.*⁹, to assert that there is concordance between found and predicted maximal respiratory pressures values it is necessary that these measures do not show statistical difference and present a significant correlation.

During the last years, several studies have comparatively analyzed maximal respiratory pressures and highlighted the discrepancies observed between found and predicted values in different age groups^{7,9-11}. Such fact has been attributed to methodological differences, to the quantity and quality of samples evaluated, to equipments and techniques used, besides geographical, social and anthropometric differences of the individuals⁹.

With regard to technique's aspects, it is argued that the use of a nose clip and a flanged mouthpiece contribute to reduce the risks of air escape and consequently avoid the under estimation of the real values measured for maximal respiratory pressures¹⁰. This aspect may justify the possible underestimation of the obtained values by the study of Wilson *et al.*⁶ in which a nose clip has not been used. Another aspect to be considered, is the examiner support of the cheeks during the expiratory efforts which according to Clanton and Diaz²¹ aims to ensure that the pressure exerted by the respiratory muscles is transmitted to the device instead of staying stuck in the oral cavity by distention of the cheeks and air concentration in that area. In the study of Domenèch-Clar *et al.*⁸ the adolescents performed MEP with their hands over their cheeks, while in the current study the examiner supported the adolescents' cheeks. Studies with the aim to investigate differences in results regarding this aspect were not found; however it is possible that this methodological factor might interfere in the results.

The results show that the mean values of MRP in boys were significantly higher than those observed in girls. Similar findings have been reported in several studies performed with samples of children^{6,12}, adolescents^{7,8}, and adults^{2,6,9,10}. The most accepted explanation for this difference involves the existence of greater

amount of lean body mass in boys, which is even greater after puberty⁸, and to the fact that, in general, the males are more physically active²³. In females, hormonal changes play an important role in puberty and during the menstrual cycle may interfere in MRP measures as it was verified by Silva *et al.*²⁴ These authors commented on the existence of a positive influence of estradiol and progesterone hormones on the respiratory muscle strength in the luteal phase.

Considering the learning effect, a minimum of 3 and a maximum of 9 maneuvers were performed in the current study to achieve 3 acceptable and 2 reproducible maneuvers¹¹. Domenèch-Clar *et al.*⁸ used a similar parameter. However, Wilson *et al.*⁶ did not establish a maximum limit, it was only determined the performance of at least 3 maneuvers. In 1997, a study conducted by Wen *et al.*²⁵ stated that a larger number of maneuvers could determine more effectively there respiratory muscle weakness. In opposition to this perspective, Smyth *et al.*⁷ stated that in clinical practice the performance of successive repetitions of these maneuvers can be impractical in the assessment of patients. In addition, a recent study when comparing the number of maximal respiratory pressures maneuvers performed, observed that there was no difference in the perceived exertion rate of children who performed up to five or more than five maneuvers²⁶.

One important difference to be considered among maximal respiratory pressures studies consists of the ethnic differences. Several authors emphasized the differences in MRP values of individuals from different nationalities, and even in the same region of a country^{5,9-11}. Nevertheless, references of studies that compared MRP values obtained in a sample of Brazilian adolescents with the predicted values by previous studies from other nationalities were not found. This theme was only previously studied in populations of children and adults^{27,28}. Such fact highlights the importance of this study to contribute to the advancement of investigation of MRP values that can be used as reference.

A limiting factor in the present study was the absence of hormonal evaluation which would allow a better understanding of the puberty changes influences in respiratory muscle strength during adolescence. Another aspect that may limit the interpretation of the findings of the current study is the divergence observed between the age groups evaluated in previous studies, as well as the lack of information about the characteristics of samples evaluated which would allow more appropriate comparisons.

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