Reference values and factors related to thoracic mobility in Brazilian children

Valores de referência e fatores relacionados à mobilidade torácica em crianças brasileiras

Valores de referencia y factores relacionados con la movilidad torácica en niños brasileños

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ABSTRACT

Objective: To provide reference values and to evaluate the factors influencing thoracic mobility in children aged 7 to 11 years old.

Methods: A total of 166 children were assessed from public and private schools (90 girls and 76 boys) in the city of Natal (Northeast Brazil). Demographic and anthropometric data were collected, and the thoracic perimeter was assessed by cirtometry. Non-paired Student's t-test and variance analysis compared xiphoid respiratory coefficient between sex and ages, respectively. Axillary respiratory coefficient differences between sex and ages were tested by Mann-Whitney and Kruskal-Wallis tests, respectively, with differences located by Duncan *post-hoc* test. Spearman and Pearson correlation coefficients were used to verify the association between independent variables with the assessed coefficients.

Results: Xiphoid and axillary perimetry means were 5.00±1.59 and 4.75±1.56cm, respectively. There was a low correlation, without statistical significance, between xiphoid respiratory coefficient and age, sex, weight, height, and body mass index. The axillary respiratory coefficient was correlated with weight and height. Differences were found in the axillary respiratory coefficient in the age groups between 8–10 (p=0.03) and 10–11 years old (p=0.02).

Conclusions: Reference values for thoracic cirtometry were provided for children aged between seven and 11 years old. Sex, age, weight, height, and body mass index did not influence xiphoid respiratory coefficient. The axillary respiratory coefficient was different between ages, from eight years onwards, being significantly influenced by height and weight regardless of sex.

Key-words: respiratory muscles; evaluation methods; thorax; reference values.

RESUMO

Objetivo: Fornecer valores de referência e avaliar os fatores que influenciam a mobilidade torácica de crianças entre sete e 11 anos.

Métodos: Foram avaliadas 166 crianças de escolas públicas e privadas (90 meninas e 76 meninos) da cidade de Natal, no estado do Rio Grande do Norte. Foram coletados dados pessoais, antropométricos e perímetros torácicos por cirtometria. O teste *t* de Student não pareado e a análise de variância compararam o coeficiente respiratório xifoidiano entre os sexos e as idades, respectivamente. Diferenças no coeficiente respiratório axilar entre os sexos e as idades foram verificadas com os testes de Mann-Whitney e Kruskal-Wallis, respectivamente, com diferenças localizadas pelo teste *post-hoc* de Duncan. Coeficientes de correlação de Spearman e Pearson relacionaram variáveis independentes com os coeficientes avaliados.

Resultados: As médias das perimetrias axilar e xifoidiana foram 5,00±1,59 e 4,75±1,56cm, respectivamente. Observou-se baixa correlação, sem significância estatística, entre o coeficiente respiratório xifoidiano e as variáveis idade, sexo, peso, altura

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e índice de massa corpórea. O coeficiente respiratório axilar correlacionou-se com peso e altura. Foram encontradas diferenças no coeficiente respiratório axilar nas faixas etárias entre oito e dez anos (p=0,03) e 10 e 11 anos (p=0,02).

Conclusões: Foram disponibilizados valores de referência de cirtometria torácica para crianças entre sete e 11 anos. Sexo, idade, peso, altura e índice de massa corpórea não influenciaram o coeficiente respiratório xifoidiano. O coeficiente respiratório axilar diferiu-se entre idades, a partir dos oito anos, sendo influenciado pelo peso e pela altura, independentemente do sexo.

Palavras-chave: músculos respiratórios; métodos de avaliação; caixa torácica; valores de referência.

RESUMEN

Objetivo: Suministrar valores de referencia y evaluar los factores que influencian la movilidad torácica de niños de 7 a 11 años.

Métodos: Se evaluaron 166 niños de escuelas públicas y privadas (90 muchachas y 76 muchachos) de la ciudad de Natal (Rio Grande do Norte). Se recogieron datos personales, antropométricos y los perímetros torácicos por cirtometría. Las pruebas t de Student no pareada y ANOVA compararon el coeficiente respiratorio xifoideo entre los sexos y edades, respectivamente. Diferencias en el Coeficiente respiratorio axilar entre los sexos y edades fueron probadas con Mann-Shitney y Kruskal-Wallis, respectivamente, con diferencias localizadas por la prueba *post-hoc* de Ducan. Coeficientes de Correlación de Spearman y Pearson correlacionaron variables independientes con los coeficientes evaluados.

Resultados: Los promedios de la perimetría axilar y xifoidea fueron 5,00±1,59 y 4,75±1,56cm, respectivamente. Se observó baja correlación, sin significancia estadística, entre el coeficiente respiratorio xifoideo y las variables edad, sexo, peso, altura e índice de masa corporal. El Coeficiente Respiratorio Axilar se correlacionó con el peso y la altura. Se encontraron diferencias en el coeficiente respiratorio axilar en las franjas de edad entre 8 y 10 años (p=0,03) y 10 y 11 años (p=0,02).

Conclusiones: Se pusieron a disposición varios factores de referencia de cirtometría torácica para niños entre 7 y 11 años. El sexo, la edad, el peso, la altura y el índice de masa corporal no influenciaron el Coeficiente Respiratorio Xifoideo. El Coeficiente Respiratorio Axilar difirió entre edades, a partir de los ocho años, siendo influenciado por el peso y la altura, independientemente del sexo.

Palabras clave: músculos respiratorios, métodos de evaluación, caja torácica, valores de referencia.

Introduction

Evidence-based practice is currently a reality in healthcare. It consists of developing a clinical assessment through quality tests and measurements, which enables the identification of the problem. In Physical Therapy, this scientific basis is the responsible for guiding the choice of interventions[1].

Thoracic mobility is related to the integrity of respiratory muscles that assist in thoracic expansion and retraction[2]. In clinical practice, this measurement is also used with the aim of evaluating parameters such as chest width, lung volumes and capacities, pulmonary compliance, thoracoabdominal mechanics, diaphragmatic function, muscle work, and dyspnea[1]. Thoracoabdominal mobility and/or expansibility also provide information on the presence or absence of thoraco-pulmonary stiffness, which is often related to respiratory diseases[3]. This method has been used in individuals with respiratory diseases, in the postoperative period, and before and after therapeutic interventions[4], since thoracic mobility, among other evaluation criteria of lung function, can be considered an important parameter for diagnosis, follow-up of disease evolution, and assessment of the efficacy of the treatment proposed for different clinical conditions that present with respiratory impairment[5].

There are several methods to assess thoracic mobility, mainly non-invasive, since invasive methods affect respiratory movements[6]. Some authors[7,8] state that the most effective way of measuring thoracic mobility is cirtometry, or dynamic thoracic perimeter measurement, because it is a simple, accessible and low cost technique[9]. This evaluation method consists of a set of measurements of the circumference of the chest and abdomen taken during respiratory movements. Thus, it is possible to evaluate lung expansion on an estimate basis[9]. Currently, the applicability of the model has increased, and it is capable of providing parameters referring to lung expansion.

Thoracic mobility and lung function may be altered not only due to growth and the onset of respiratory diseases, but also due to other factors, such as body composition, sex, age, height and ethnicity[7]. During children's growth, several changes are observed in the respiratory system[1], which makes the knowledge on thoracic mobility relevant in physical therapy practice[10].

According to Carvalho[6], in 1994 the values considered normal for healthy adults would be between 6 and 7 centimeters, and values lower than those corresponded to reduced lung capacity. In 2001, Barros[11] showed values higher than 3cm as normal for the mammillary region. In 2004, after evaluating healthy children and adolescents aged 8 to 14 years living in South Brazil, with no stratification by age, Panizzi[12] proposed normal values for respiratory coefficients in both sexes. In 2011, Oliveira *et al*[2] assessed cirtometry values and the influence of muscle training on them in children between 5 and 14 years of age diagnosed with acute leukemia, using coefficients for axillary and xiphoid expansion and retraction.

Chest variations in dimension and proportion are partially individual and are also related to age and sex, which becomes more evident in childhood, a period of great body changes. The use of reference values to assist and guide health care professionals provides more favorable conditions for accurate diagnosis and for the adequate evaluation of the care provided. However, although thoracic cirtometry is widely used, references for normal values are still scarce for the assessment of thoracic mobility in a population comprising exclusively children. Thus, the present study aims to provide reference values for thoracic mobility using thoracic cirtometry, and to evaluate the factors correlated with chest mobility in healthy Brazilian children aged 7 to 11 years from the city of Natal, state of Rio Grande do Norte, Brazil (Natal-RN).

Methods

This project was submitted to the Research Ethics Committee of Universidade Federal do Rio Grande do Norte (UFRN) and was approved under protocol number 278/2009, in accordance with Resolution 196/96 of the National Health Council. Data were collected after parents and children signed the Free and Informed Consent (FIC).

This is an observational descriptive, cross-sectional study[13]. The sample comprised children of both sexes, between seven and 11 years, enrolled in state and private schools of the city of Natal-RN. Sample size was calculated using a formula to estimate mean values[14], considering a confidence level of 95%, for which z value is equal to 1.96. Standard deviation values and error estimate were those found by Wilson *et al*[15]. Error estimate was calculated by the difference in mean maximal inspiratory pressures among the groups of boys and girls. The calculation was performed by sex, resulting in 14 boys and 12 girls for each age group, totaling a minimum sample of 130 children.

Study inclusion criteria were the following: children who were not underweight or overweight/obese[16,17], it means, those who were between the 5th and 85th percentiles in the charts of body mass index (BMI) for age and for-sex of children/adolescents proposed by the National Center for Health Statistics[18] (NCHS); children with no evident deformity in the thorax and/or diagnosis of acute or chronic lung disease or neuromuscular disease, no history of previous thoracic surgery or recent trauma of the upper airways, thorax or abdomen, no history of smoking nor the presence of neurological and/or cognitive impairment; as well as those who were not using medication affecting muscular strength.

The following children were excluded from the sample: those who refused to complete the evaluation during the procedure, those who did not understand the necessary commands to perform the thoracic cirtometry, those who were absent on the evaluation day or that presented some acute respiratory disease or fever, those children who performed strenuous physical activity on the previous day or on a few moments before collection, children who were not wearing comfortable clothes and those who had a large meal until three hours before the procedures.

The schools participating in the study were selected through a randomized draw of schools in the city of Natal/RN, based on the list provided by the State Department of Education. In each of the 27 schools drawn, 50 children were selected. These children were listed by age group, and then five boys and five girls for each studied age were drawn. After a previous contact with these students, the following material was handed in: 1) A Free and Informed Consent for parents/legal guardian, written in an adequate language, containing explanations about the objectives, importance and procedures of the work, as well as some recommendations for the assessment day; 2) A Questionnaire that should be answered by the guardian, including questions about the general health condition of the child. Data on the eligible subjects were collected after documentation was returned. It should be emphasized that, even if the guardian had signed the consent, the child's will was respected in case of refusal to participate.

A standardized assessment form was used to collect personal and anthropometric data and information on thoracic cirtometry. Body weight was assessed using an digital scale (Douer Trading Company Limitada), with capacity of 150kg. Height was estimated with a 150cm measuring tape of, mounted on the wall 50cm above the floor. The child was positioned erect, with the head in neutral position, his/her back against the wall and heels touching the wall. The measurement was taken from the ground to the top of the head. The weight/height^2 formula was used to calculate the Body Mass Index (BMI), whose percentile was obtained through a graph specific for age and sex[19].

Thoracic perimeter was measured with a non-stretchable 150cm measuring tape, on a single occasion. With the child in an erect upright position, feet apart at shoulders' width and arms loose besides his/her body, measurements were taken in two regions: initially in the axillary region, with the measuring tape under the axillary hollows, on the level of the third pair of costal arches, and subsequently in the xiphoid region, with the measuring tape on the xiphoid appendix, on the level of the seventh costal cartilage[20]. The examiner, positioned in front of the child, after adapting the measuring tape around the chest, performed three maneuvers with verbal encouragement. Initially the child was asked to breathe normally in order to determine tidal volume. Next, thoracic perimeter was measured in a maximal inhalation and subsequently in maximal exhalations. With the difference obtained between these values, the xiphoid respiratory coefficient (XRC) and the axillary respiratory coefficient (ARC) were calculated[21]. To minimize possible interferences caused by heterogeneity, data were measured by the same examiner.

The results obtained were analyzed using the SPSS 17.0 (Statistical Package for the Social Science). Descriptive statistics were expressed using mean and standard deviation. The Kolmogorov-Smirnov test was used to test the normality of the data. Normal distribution was found for xiphoid respiratory coefficient; therefore, the non-paired Student t test was used to the difference in XRC among the sexes. ANOVA was applied to assess the difference between ages. To evaluate the differences in the axillary respiratory coefficient among sexes and age groups, the Mann-Whitney and Kruskal-Wallis tests were used, respectively. The Duncan's Post Hoc test was used to determine the differences in ARC for each age analyzed. In order to observe the existence of an association between independent variables (height, age, BMI and weight) with ARC and XRC, Spearman and Pearson correlation coefficient were applied, respectively.

Results

Among the 900 questionnaires sent to the parents of students from the 27 drawn schools, 331 were adequately completed, with the free and informed consent signed by parents and/or the legal guardian. Among these, 166 school children were eligible, according to the established criteria. There were no sample losses. Therefore, the final sample comprised 166 children, 90 girls (54.21%) and 76 boys (45.9%), with an overall mean age and for each sex of 9.0±1.2 years. Mean weight of the analyzed children was 29.6±5.6kg and mean height was 1.35±0.92m, with mean BMI of 16.18±1.46kg/m².

Mean xiphoid and axillary perimetries for the total sample were 5.00±1.59cm and 4.75±1.56cm, respectively. Mean values for girls were 4.87±1.57cm for axillary perimetry and 4.62±1.55cm for xiphoid perimetry. Among boys, the values found were 5.00±1.60 and 4.87±1.58cm, respectively.

No statistical difference was observed between the xiphoid respiratory coefficient and the variables: sex, age, weight, height and BMI. The ARC showed significant differences in the age groups from eight years onwards (*p*=0.03), and these differences were found in the age groups between 8 and 10 years and 11 months (*p*=0.03) and between 10 years and 11 years and 11 months (*p*=0.02). The ARC was also significantly correlated with weight and height.

Table 1 shows the correlations between the independent variables (sex, age, weight, height and BMI) and xiphoid and axillary respiratory coefficients. Means obtained in the thoracic perimetry of the axillary region for each age assessed

Table 1 - Correlations between respiratory coefficients and independent variables

	Sex	Age	Weight	Height	BMI
Axillary Respiratory Coefficient	r=0.13 *p*=0.08	r=0.09 *p*=0.23	r=0.16 *p*=0.03	r=0.20 *p*<0.001	r=0.01 *p*=0.92
Xiphoid Respiratory Coefficient	r=0.05 *p*=0.45	r=0.12 *p*=0.11	r=0.09 *p*=0.24	r=0.14 *p*=0.05	r=0.01 *p*=0.80

BMI: body mass index

Table 2 - Means and standard deviations of the axillary respiratory coefficient measured in cm, for each age and sex

	Total Sample (n=166)	Girls (n=90)	Boys (n=76)
7 years – 7 years and 11 months (n=29)	5.00±1.04	4.75±0.96	5.37±1.10
8 years – 8 years and 11 months (n=42)	4.75±1.63	4.75±0.93	4.75±2.06
9 years – 9 years and 11 months (n=40)	5.00±1.85	4.75±2.10	5.50±0.88
10 years – 10 years and 11 months (n=37)	5.25±1.57	5.00±1.50	5.87±1.67
11 years – 11 years and 11 months (n=18)	4.37±1.41	4.25±1.67	4.50±1.16

Table 3 - Means and standard deviations of the xiphoid respiratory coefficient measured in cm, for each age studied

	Total Sample (n=166)	Girls (n=90)	Boys (n=76)
7 years – 7 years and 11 months (n=29)	4.50±1.13	5.00±1.24	4.37±0.92
8 years – 8 years and 11 months (n=42)	4.37±1.55	4.50±0.84	4.25±1.96
9 years – 9 years and 11 months (n=40)	5.12±1.90	4.50±2.29	5.50±0.67
10 years – 10 years and 11 months (n=37)	5.00±1.54	5.00±1.31	5.50±1.79
11 years – 11 years and 11 months (n=18)	4.62±1.11	4.50±1.06	4.87±1.18

are described in table 2. Table 3 displays the values obtained in the thoracic perimetry of the xiphoid region.

Discussion

The findings of the present study propose reference values for thoracic cirtometry in axillary and xiphoid regions for male and female schoolchildren aged 7 to 11 years from the city of Natal-RN. In a previous study with the same age group, Simon *et al*[7] suggest values for thoracic mobility in a sample of 91 boys from South Brazil. Panizzi *et al*[12] interpreted the thoracic mobility values of healthy children and adolescents and proposed reference values using axillary and xiphoid respiratory coefficients. In 2007, Caldeira *et al*[1] proposed reference values for thoracic mobility, but in an adult population comprising 40 subjects.

The results found indicate that there is no association between xiphoid respiratory coefficient and the variables sex, age, weight, height and BMI. However, the association of the independent variables weight and height with the axillary respiratory coefficient was significant, although weak.

The lack of influence of child's gender on the respiratory coefficient (RC), observed in this study, corroborates the findings of the study by Kerkoski *et al*[22], which compared RC values of two cirtometry techniques in children and adolescents. These authors observed that the values obtained did not differ among the sexes. On the other hand, other authors who compared thoracic cirtometry results among the sexes in child and adolescent samples[12] observed that the values measured for males were higher compared with those of females. Recently, when assessing thoracic cirtometry values among groups of health individuals and those with respiratory disease, Gouilly *et al*[23] observed higher values for the male sex. This contradiction is possibly due to the methodological rigor of the present study regarding the selection of the eligible children to participate in the study. The proposed methodology ensured a homogeneous sample for both sexes, especially in terms of anthropometric variables. These criteria were not described by the above mentioned authors.

The findings of this study demonstrate that axillary perimetry differed among ages, between eight and 11 years, which may be explained by the predominance of the apical breathing pattern usually observed at this age[7]. This presumably occurs due to a better control of external intercostal muscles in comparison with diaphragmatic muscles. In this period of maturation of the respiratory system, the full control of these muscles is not obtained when a maximal inhalation is required[1,7]. According to Murahovschi *et al*[24], this phase leads to changes in size, shape, physiology and growth speed, indicating that this population should have a different approach than that used in adults.

The results obtained reveal that, among the study variables, height is the one that has a stronger influence on thoracic mobility in children. These findings corroborate the results found by Simon *et al*[7], who analyzed the thoracic mobility of 91 healthy boys aged 7 to 11 years from a private school in Itajaí, state of Santa Catarina, Brazil. The authors concluded that there is a strict relationship between thoracic mobility and the variables height and age, and boys' height was the variable that had the most significant influence on the increase in thoracic mobility. The values obtained in the present study for thoracic cirtometry, both for axillary and xiphoid coefficients, were similar to those proposed by Simon *et al*[7] for healthy boys.

Although some authors[1,6,7,10,25] have proposed different methods for thoracic cirtometry, there is no consensus on its use yet. In 2005, Fregonezi *et al*[26] proposed that thoracic mobility should be measured by indices of chest wall expansion and reduction in axillary and xiphoid regions only. Later, Malaguti *et al*[10] recommended that the analysis was performed using the thoracic mobility index, which consists of the difference between a maximal inhalation and total pulmonary capacity and a maximal exhalation until residual volume. Additionally, Jamami *et al*[27] proposed the use of the Amplitude Index (AI), considering the highest value of three measurements, which would be included in a specific equation, in order to take individual anthropometric differences into consideration. These authors considered as normal values for AI the interval between 4 and 7cm, but for an adult population. Despite such disagreements, thoracic cirtometry is routinely used in physical therapy to quantify the measures of thoracoabdominal mobility and has been considered an accurate measure[1], with adequate intra and interrater reliability[28].

One of the limitations of the present study could be the fact that it was conducted in a single city, which could jeopardize its external validity and data inference, and it is also necessary to consider the possibility of intra and interrater variability, an issue that can be observed in thoracic cirtometry. Moreover, the interpretation of the results was hindered by the scarcity of previous studies with the assessed age group, the lack of standardization in the literature regarding the technical performance of thoracic cirtometry, as well by the disagreements about how to interpret the values obtained in the thoracic mobility assessment.

In conclusion, the present study provides reference values of thoracic cirtometry for children aged 7 to 11 years. Sex, age, weight, height and BMI of the children assessed did not influence xiphoid respiratory coefficient. However, the axillary respiratory coefficient showed differences among ages, from eight years onwards, and was influenced by children's weight and height, regardless of sex.

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