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ORIGINAL ARTICLE

COMPARISON BETWEEN MAXIMAL RESPIRATORY PRESSURES OBTAINED FROM DIGITAL AND ANALOG MANOVACUOMETER IN HEALTHY CHILDREN

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Respiratory muscles; Muscle strength; Evaluation; Diagnostic equipment; Child.

Background: The assessment of respiratory muscle strength in children is needed for clinical reasons; the instrument used to measure the strength of respiratory muscles is the manometer, which can be either analog or digital.
Objectives: To compare the values obtained by analog and digital manometer in healthy children aged between 7 to 11 years old.
Methods: 49 schoolchildren (25 boys) from public schools were assessed. Anthropometric measurements were collected in addition to the measurement of maximal respiratory pressures by analog and digital manometer. The paired Student's t test was used to compare the measurements of maximal inspiratory and expiratory pressures obtained by the two instruments. The Bland-Altman analysis assessed mean differences (BIAS) and agreement between the equipment's used.
Results: No significant difference between values for maximal respiratory pressures in both devices. However, Bland-Altman analysis showed large limits of agreement between the values obtained by the two manometers.
Conclusion: Data from this study demonstrate that, although no significant differences were observed between the measures obtained by the two devices in a sample of healthy children, agreement between them showed a clinically unacceptable range for measures of maximal respiratory pressure.

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INTRODUCTION

The functional integrity of respiratory muscles is very important for life. Respiratory muscle weakness is related to symptoms such as dyspnea, reduced tolerance to exercise, nocturnal desaturation and prolonged mechanical ventilation[1]. Assessment of respiratory muscle strength allows us to identify and diagnose respiratory muscle failure, in addition to serving as a supportive measure to indicate intubation and weaning from invasive ventilation[2,3]. Moreover, for respiratory and cardiac physical therapy, respiratory muscle assessment is an important parameter for measuring clinical evolution and the results of different physiotherapeutic interventions to which patients may be submitted[4].

It is important to underscore the clinical importance of monitoring respiratory muscle strength in children and adolescents due to physiological modifications resulting from the growth and development of the respiratory system that occur during this stage of life[5]. Developing children are particularly susceptible to respiratory failure owing to the existence of several interrelated factors that favor this evolution, from anatomic peculiarities to physiological and immunological characteristics[6,7].

Assessment of respiratory muscle strength using maximum respiratory pressures (MRP) has been considered a practical, accurate and low-cost method to monitor respiratory muscles. Different studies in healthy individuals and patients with respiratory or neurological disorders have demonstrated the applicability of assessing respiratory muscle strength using maximal respiratory pressures[1,8]. An analog or digital[10] compound gauge was used to measure maximal respiratory pressures[9], aimed at measuring positive and negative (vacuum) pressures [11]. In the last decade, the development of compound gauges has resulted in more accurate instrumentalization to obtain respiratory muscle pressures[10]. Despite this technological advance, less accurate analog compound gauges are still widely used[12]. The present study aimed to compare respiratory muscle strength in healthy children aged 7 to 11 years using two types of analog and digital equipment.

METHODS

Subjects

Study participants were children aged 7 to 11 years, enrolled in public schools of Natal, Brazil. Age limits were based on article 2 of the Statute for Children and Adolescents (1990)[13], which considers children as being up to 12 years of age. The minimum age was determined according to the ability of understanding and correctly performing maximal respiratory pressure assessment techniques[4]. Individuals unable to understand or perform these techniques as well as those exhibiting absolute or relative restrictions in terms of maximal respiratory pressures, as previously described[9,15], were excluded from the study. Also excluded were children whose parents refused to take part in the study and those exhibiting body mass index percentile less than 5 and greater than 85, classified as underweight, overweight or obese, respectively[16]. Schools were selected in a draw of four state institutions from the universe of all the schools in Natal. Next, consent was obtained from the 1st Regional Educational Directorate (DIRED), and from the directors of the four schools drawn. A total of 50 children were randomly selected, 10 from each age range. The parents or guardians of each child received an informed consent form, containing explanations regarding the objectives, importance and procedures of the study, as well as recommendations for the assessment day. They were also given a questionnaire containing questions on the health status of the child. A subsequent meeting was held to receive the signed informed consent form and the completed questionnaire, which were analyzed to determine eligible participants. The study was approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte (protocol 342/09), in accordance with resolution 196/96 of the National Health Council. The research followed Declaration of Helsinki criteria[17].

Anthropometric Measures

A Personal Scale balance (QIE - 2003B, Brazil) with maximum capacity of 150 kilograms, was used to

measure body composition. Participants were asked to stand barefoot on the scale for measurement of body weight. Height was measured with a 150-cm tape measure, fixed to the wall 50 cm above floor level. Children remained erect, with their head in the neutral position, with backs and heels against the wall. The measure was taken from the floor to the top of the head.

Respiratory muscle strength

Respiratory muscle strength was evaluated by maximal inspiratory and expiratory pressures (MIP and MEP, respectively). Children were given a simple demonstration on how to perform the test. For MEP assessment, subjects were instructed to perform maximal inspiration up to total lung capacity, followed by maximal sustained expiratory effort up to residual volume. To assess MIP, children had to expire up to residual volume, followed by maximal inspiratory effort up to total lung capacity, as proposed by Black and Hyatt[8]. The procedure was conducted with participants sitting comfortably, without lung expansion restrictions such as clothes, among others[9]. All pressures were measured with a nasal clip and the mouthpiece was adjusted to prevent air from escaping. The mouthpiece has a 1mm-diameter opening at the upper end to avoid glottis closure [18]. The maneuver was repeated at most seven times, with each compound gauge used, from which three technically acceptable maneuvers, according to Black & Hyatt[8], could be obtained, as well as two reproducible ones, with values not differing by more than 10% of the highest value[9]. All values were recorded, but only the highest was considered[19]. The choice of which pressure (MIP or MEP) would be measured first was random, using a draw conducted by the participants themselves.

Instruments Used

The analog and digital compound gauges used were the Criticalmed MV150, calibrated from -150 to +150 cmH_2O (Wika®, Rio de Janeiro, Brazil), and the MVD 300 (Globalmed®, Porto Alegre, Brazil) calibrated from -300 to +300 cmH_2O, respectively. The latter was connected to a computer containing data acquisition software (version 1.5, Hardware version 1.28, Acer), where the participant could visualize the test through visual biofeedback. The software also stores all the test graphs (pressure x time); however, only the values of the three highest measures were recorded. The digital device has a 50 cm-long tube, with 0.3 cm internal diameter, while the analog is 35 cm long with an internal diameter of 0.5 cm. The orifice was occluded when specific lung volumes were reached for each measure[15,20]. The same interface was used to measure maximal respiratory pressures with the two instruments. Peak pressure was used for assessment.

Statistical Analysis

Descriptive statistics was conducted to characterize the sample. The Kolmogorov-Smirnov test showed that the data exhibited normal distribution and the paired Student's t-test was applied to determine whether there were any differences between MIP and MEP, as measured by the two instruments. Bland-Altman analysis was carried out in order to assess mean differences (BIAS) and levels of agreement between the two devices with respect to maximal respiratory pressures at a 95% confidence level. Data analysis was performed using SPSS 15 (Statistical Package for the Social Science) and GraphPad Prism® 5 software (GraphPad Software Inc.) with a 5% significance level.

RESULTS

A total of 200 questions were handed out at the 4 randomly drawn schools. Sixty-two were returned (with parents' consent and the questionnaire properly filled out), and from these, 55 children were considered eligible to take part in the study. Six individuals were excluded for being unable to satisfactorily complete analog and/or digital testing. The final sample was composed of 49 children (24 girls and 25 boys).

Table 1: Anthropometric characteristics and respiratory muscle strength

Variable	Girls	Boys	Total
Sex (n)	24	25	49
Age (years)	8.8 ± 1.5	8 ± 1.4	8.9 ± 1.4
Weight (Kg)	31.6 ± 7.4	34.5 ± 10.2	33.1 ± 9.0
Height (m)	1.3 ± 0.1	1.3 ± 0.1	1.3 ± 0.1
$PImax_d$ (cmH_2O)	67.0 ± 24.9	83.1 ± 20.2	75.2 ± 23.9
$PEmax_d$ (cmH_2O)	72.0 ± 22.7	94.2 ± 20.8	83.3 ± 24.3
$PImax_a$ (cmH_2O)	62.7 ± 23.8	79.3 ± 18.0	71.2 ± 22.4
$PEmax_a$ (cmH_2O)	66.1 ± 19.8	89.7 ± 20.9	78.1 ± 23.4

Data detailed in mean ± standard deviation. $PImax_d$: maximal inspiratory pressure with digital manovacuometer; $PEmax_d$: maximal expiratory pressure with digital manovacuometer; $PImax_a$: maximal inspiratory pressure with analog manovacuometer; $PEmax_a$: maximal expiratory pressure with analog manovacuometer

Mean anthropometric values and maximal respiratory pressures, distributed by sex, are described in table 1. Comparisons between the values of MIP and MEP with digital and analog manovacuometer according to sex are described in table 2.

Graphic statistical analysis conducted using the Bland-Altman test for MIP and MEP measures obtained for boys and girls with the two compound gauges are illustrated in figures 1 and 2, respectively.

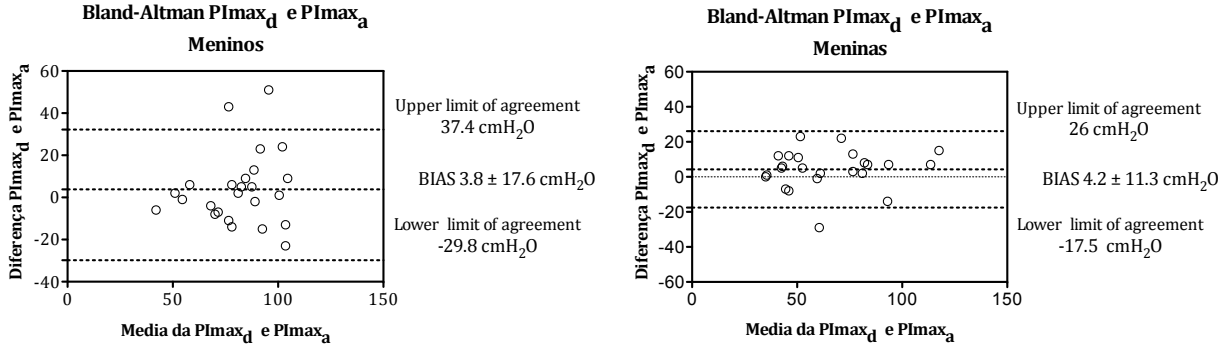

Figure 1: Bland-Altman plot among maximal inspiratory pressure in both equipment's

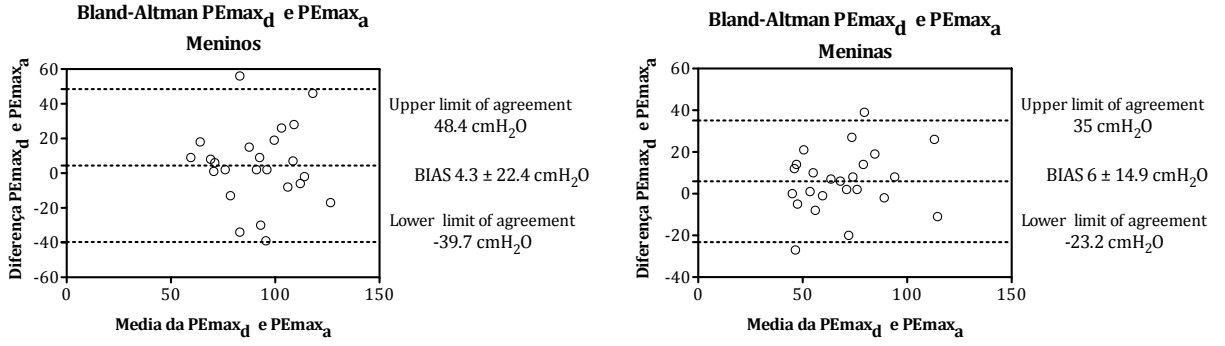

Figure 2: Bland-Altman plot among maximal expiratory pressure in both equipment's

Table 2: Comparison between the values of maximal inspiratory and expiratory pressures with digital and analog manovacuometer according to sex

Sex	$PImax_d$	$PImax_a$	P-value	$PEmax_d$	$PEmax_a$	P-value
Boys	83.1 ± 20.2	79.3 ±18.0	0.27	94.2 ± 20.8	89.7 ± 20.9	0.32
Girls	67.0 ± 24.9	62.7 ± 23.8	0.07	72.0 ± 22.7	66.1 ± 19.8	0.06

Data detaliled in mean ± standard deviation.$PImax_d$: maximal inspiratory pressure with digital manovacuometer; $PImax_a$: maximal inspiratory pressure with analog manovacuometer; $PEmax_d$: maximal expiratory pressure with digital manovacuometer; $PEmax_a$: maximal expiratory pressure with analog manovacuometer.

DISCUSSION

The present study aimed to compare respiratory muscle strength in healthy children, aged 7 to 11 years, using two types of devices (analog and digital). The results demonstrate that, although no significant differences were observed between the measures obtained by the two devices, agreement between them showed a clinically unacceptable range for measures of maximal respiratory pressure.

To the best of our knowledge, only one earlier study compared maximal respiratory pressures between digital and analog compound gauges. Lima and Costa[12], who used a digital and analog compound gauge to compare the maximal respiratory pressures of 120 individuals aged between 20 and 80 years (10 men and 10 women in each 10 year age range), found higher values with the digital device.

However, it is important to underscore that the comparison was between peak pressure values obtained with a digital compound gauge and sustained pressure values measured with an analog device. Higher peak pressure values compared to those of sustained pressure have been previously described in the literature[21-23].

With respect to the type of device used to assess maximal respiratory pressures, an article published in 2002 by the ATS/ ERS[24] (American Thoracic Society and European Respiratory Society) states that an analog compound gauge is not recommended for measuring maximal respiratory pressures, although assessment of respiratory muscle strength has historically been determined using this instrument. This is due to the fact that reading an analogic signal can be difficult and that transitory pressure is not easily eliminated. However, a recent study by Montemezzo et al.[10], conducted with 19 research groups in Brazil, showed that the analog compound gauge is the most widely used to measure maximal respiratory pressures. According to these authors, analog compound gauges, in addition to requiring a complex calibration procedure, have an operational range that may be inadequate, depending on the individual assessed, which could compromise the results obtained. Another important aspect is that most studies on maximal respiratory pressure in adults[1,20,25] and children[26-28] use reference values obtained with analog compound gauges. A recent study used a digital compound gauge, but only reference values for nasal inspiratory pressure were determined[29].

Despite the importance of the results of the present study, there are some potential limitations. The sample size was small, thereby hindering more adequate analysis. Moreover, the technical limitations of the digital compound gauge used precluded comparison between peak pressures obtained by the two types of compound gauges.

In conclusion, the findings of the present study suggest that using a digital compound gauge is more suitable and accurate in assessing respiratory muscle strength in children aged 7 to 11 years.

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