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COMPARISON OF MEASURED AND PREDICTED VALUES FOR MAXIMAL RESPIRATORY PRESSURES IN YOUNG ADULTS

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ABSTRACT
Respiratory muscle strength is the maximal pressure generated during an inspiration or expiration against an occluded airway, and it is evaluated by means of the maximal inspiratory and expiratory pressures. This study aimed to compare the values of maximal respiratory pressures measured in sedentary young adults to the values predicted by the literature. The research had the participation of 35 sedentary young adults, aged between 20 and 30 years. The maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were measured by using an analog mano vacuum meter, a flattened mouthpiece, and a nose clip. The International Physical Activity Questionnaire (IPAQ), short version, was used to determine the physical activity level. The statistical analysis was performed through Wilcoxon's test for data on women and paired *t*-Student test for men, at 5% significance level. The results showed a significant difference between the values measured for MEP and the values predicted by the Brazilian reference equation for men (p value = 0.0409) and women (p value < 0.0001). The equation used underestimated the values of MEP for both sexes. The need for further multicenter studies was found out, with a larger sample, in order to determine more accurate reference values for the various Brazilian populations.

Keywords: Respiratory Muscles. Muscle Strength. Respiratory Function Tests.

INTRODUCTION

Respiratory muscles have the function to move the chest wall, rhythmically, to pump air in and out the lungs and, thus, maintain arterial blood gases within acceptable limits. The coordinated action of these muscles promotes, as a result, normal breathing, and any change, either by lung disorders or neuromuscular diseases, cause changes in ventilatory mechanics[1,2].

A clinical parameter of choice to evaluate these disorders is measuring respiratory muscle strength (RMS), which consists in determining respiratory pressures generated through maximal inspiratory and expiratory efforts, representing a very useful procedure for functional evaluation of muscles[3-6].

There are several methods for evaluating RMS, but in the literature the most cited is the evaluation by measuring maximal respiratory pressures with a mano vacuum meter, as this is a simple, quick, and non-invasive method, consisting of two measurements: maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), which respectively indicate the strength of inspiratory and expiratory muscles against an occluded airway[7].

Measuring MIP is of paramount importance in mechanically ventilated patients to predict the success of weaning from mechanical ventilation, constituting a major action of physiotherapists in intensive care units (ICUs), where MEP is important to diagnose neuromuscular disorders and evaluate the effectiveness of cough and the

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ability to clear secretions. The evaluation of RMS also predicts the evolution of physiotherapy, it is useful to analyze the response to respiratory muscle training and establish load, as well as the quality of exercises that these patients are undergoing[1,2,7].

However, these measures are influenced by various factors, such as gender, age, weight, height, and smoking, as well as the different methodological reviews and the individual's degree of cooperation[7-11].

A study evaluated 100 healthy individuals of both sexes, aged between 20 and 80 years, in the state of São Paulo, and, by means of multiple regression, developed predicted equations to evaluate MIP and MEP in this population[12].

In Brazil, more recently, in 2010, two other reference equations were published for measuring maximal respiratory pressures. In a study, the results showed that age and anthropometric characteristics influence on the values of RMS and propose equations to predict the values of MIP and MEP exclusively for sedentary healthy individuals from 20 to 89 years[7]. However, in a recent publication, the proposed equations were not able to predict the values of MIP and MEP for all individuals in the sample, suggesting that these results can only facilitate predicting RMS for healthy adults in Brazil and contribute to develop better tables or equations in the Brazilian population[13].

Many authors report reference values[5,7,12,13], but there is still controversy about the reference value to be used for evaluating MIP and MEP in normal subjects[13-16].

In this sense, the Brazilian Society of Pulmonology and Phthisiology reports large discrepancy between the reference values for maximal respiratory pressures, justified by the various processes used to select the sample and methodological differences. Thus, this research is justified by the need of further studies that evaluate these pressures, since comparative studies involving the predicted and expected values for maximal respiratory pressures did not agree with each other and did not show conclusive results[14-16].

This study aimed to compare the values measured for maximal respiratory pressures to the values predicted by the equation of Neder et al.[12] in young sedentary adults, students of Physiotherapy at Centro Universitário de João Pessoa (UNIPÊ).

METHODOLOGY

This is a field study, with a descriptive design, conducted in May and June 2010, in UNIPÊ. The study was approved at the 24th Ordinary Meeting of the Research Ethics Committee of UNIPÊ, held on 02/09/2010. All participants signed the free and informed consent term.

The sample, non-probabilistic, was stratified by sex and consisted of 35 university students from courses in the health field of UNIPÊ, 25 women and 10 men, considering the following inclusion criteria: age from 20 to 30 years, body mass index (BMI) between 18.5 and 25 (kg/m²), and being sedentary or insufficiently active, according to the International Physical Activity Questionnaire (IPAQ), short version[16].

These exclusion criteria were established: presence of cardiac, pulmonary, musculoskeletal, or neurological diseases, being active or very active, being a smoker or drinker, consumption of alcohol and/or caffeine within 24 hours before the test, having had fever, flu, or cold in the week before the procedure and using oral corticosteroids, central nervous system depressant, and muscle relaxant.

Data collection was conducted in the Clinical School of Physiotherapy of UNIPÊ. The following information was collected: gender, age, height, weight, BMI, physical activity level, and health status. The latter were obtained through self-reports, in order to determine the participation of volunteers in the research according to the inclusion and exclusion criteria mentioned above.

To determine the physical activity level of volunteers the IPAQ was used, in its short version[16]. Based on the concept of sedentary lifestyle and the IPAQ classification regarding the physical activity level, the selected volunteers were those classified as sedentary or insufficiently active, since in both categories the individuals were considered as insufficiently active, therefore, as sedentary people.

For evaluating RMS we needed: a chair, a nose clip, a flattened mouthpiece, a trachea, an analog mano vacuum meter (*Ger-Ar*®) with an

operating range of ± 300 cmH_2O, a digital weight scale (Personal Line PL 150 da marca Filizola®), and stadiometer (Sanny®).

The measurement of MIP and MEP values was performed in a sitting position with feet on the floor, using the mano vacuum meter. The latter was connected to a plastic trachea and the end of it was connected to a rigid plastic flattened mouthpiece, besides a nose clip, in order to prevent the escape of air through the nose.

The volunteers were instructed to, while measuring MIP, take a maximal inspiration, sustained for 2 s against a completely occluded airway, preceded by a maximal expiration in the mouthpiece close to the residual volume (RV). And, for measuring MEP, take an inspiration in the mouthpiece up to total lung capacity (TLC) and, then, execute a maximal expiratory effort, sustained for 2 s, against a completely occluded airway. To prevent leakage and accumulation of air in the lateral region of the oral cavity, the volunteer was instructed to hold the facial muscles with her/his hands during the evaluation of MEP.

Verbal encouragement was performed and the evaluation of RMS was repeated at least 3 and at most 5 times, in order to generate some learning and obtain values with a difference smaller than 10%, applying the highest value obtained to the statistical analysis.

The values for each volunteer were compared to those proposed by a study[6] using the equation of Neder et al.[12], described below:

Men: MIP (cmH_2O) = - 0.80 × age + 155.3; standard error of estimate = 17.3;

MEP (cmH_2O) = - 0.81 × age + 165.3; standard error of estimate = 15.6.

Women: MIP (cmH_2O) = - 0.49 × age + 110.4; standard error of estimate = 9.1;

MEP (cmH_2O) = - 0.61 × age + 115.6; standard error of estimate = 11.2.

For descriptive analysis of data, central tendency measures (mean) and dispersion measurements (standard deviation) were used for the variables age, weight, height, and BMI, stratified by gender and arranged into tables. To tabulate the results, the software *Microsoft Excel*, version 2007, was used.

For inferential statistics, data normality was initially tested by using the Shapiro-Wilks test, where it was observed that the variables analyzed for women were not normally distributed, however, for men the distribution was normal ($p > 0.05$). Through this result, it was decided to use the non-parametric Wilcoxon's test for women and the paired parametric *t*-Student test for men, both with a 5% significance level. The results were obtained by using the statistical software *R.2.9.0*.

RESULTS AND DISCUSSION

Out of the 43 eligible individuals, 4 were excluded due to their health conditions (asthma, hypertension, and reduced respiratory capacity demonstrated by spirometry) and 3 because they were considered as active individuals, after answering the IPAQ. Therefore, the survey consisted of 35 volunteers, 10 men and 25 women, aged from 20 to 27 years, with a mean age of 22.6 years (± 2.27) for men and 21.8 years (± 1.55) for women.

For better observation and analysis, the anthropometric data of volunteers are shown in Table 1. When analyzing the BMI found (18.5-24.9 kg/m^2), by means of Quetelet's index, the volunteers were considered as eutrophic, thus constituting a sample with homogeneous nature (Table 1). Regarding the results obtained after applying the IPAQ, 7 volunteers had a sedentary physical activity level (5 women and 2 men) and 28 were considered as insufficiently active (20 women and 8 men).

Table 1 - Anthropometric data of the study population, according to gender.

Variables	Men (mean ± SD)	Women (mean ± SD)
Weight (kg)	75.82 ± 13.10	57.92 ± 10.96
Height (cm)	176.85 ± 6.13	161.93 ± 5.86
BMI (kg/m^2)	23.87 ± 3.05	22.02 ± 3.07

Source: Prepared by the authors. BMI = body mass index; kg = kilograms; m = meters; cm = centimeters; SD = standard deviation.

Table 2 shows the values measured and predicted for MIP and MEP. Data were presented separately for women and men and expressed in cmH_2O. As for MIP, in both genders, there was no significant difference between the values measured and provided. The values measured for MEP both in the group of women and men were significantly lower than those predicted.

The differences in the equipment used to evaluate maximal respiratory pressures may generate inconsistency in the values observed by the various authors. However, data from a study suggested a relative uniformity regarding the measurement of maximal respiratory pressures between Brazilian physiotherapists[9]. In this study, the evaluation of MIP and MEP was made with an analog mano vacuum meter, similar to that used in the study by Neder et al.[12], but without the air release orifice. However, the exhaust valve seems to be an important element in the mano vacuum meter and its presence may or may not influence on the measured values[3-5,12].

A study that evaluated the influence of various types of mouthpiece and diameters of tracheae in mano vacuum measuring concluded that there was no significant difference in diameters of tracheae, but the mouthpieces interfered with the evaluation of maximal respiratory pressures[11]. Another study evaluated the maximal respiratory pressures with a digital mano vacuum meter and 4 interfaces using different combinations of mouthpieces and tubes and it concluded that there was no significant difference when MIP and MEP were measured by means of these 4 interfaces[10]. So, in this context, there is not an available or standardized consensus that considers the various factors able to influence on the measurements of maximal respiratory pressures.

Table 2 - MIP and MEP values measured and predicted by the equations proposed.

Maximal respiratory pressures	Values measured (mean ± SD)	Predicted values (mean ± SD)	*P* value
MIP (cmH_2O)			
Men	107 ± 54.22	137.22 ± 1.816	0.7373*
Women	93.6 ± 28.41	99.71 ± 0.761	0.4395**
MEP (cmH_2O)			
Men	178 ± 49.78	146.994 ± 1.839	0.0409*
Women	137.2 ± 27.57	102.32 ± 0.948	< 0.0001**

Source: Prepared by the authors. *Paired *t*-Student test; **Wilcoxon's test.

Pressure evaluation was carried out adopting a sitting position with the mano vacuum meter connected to a trachea and the latter to a flattened mouthpiece, using a nose clip to prevent leakage; the method was executed in a different way by the studies cited in the literature[3-5,12].

The lack of standardization in the number of maneuvers, which also relates to the effect of the evaluated learning, may interfere with the results measured for MIP and MEP. In this study, the individuals performed from 3 to 5 acceptable and replicable maneuvers using the highest value for the record, except if produced in the last effort, analogous to the study by Neder et al.[12]. However, studies recommend that the individual perform 3 acceptable maneuvers and, among them, at least 2 replicable actions, where the last value measured could not be higher than the others[14].

The type of command and the evaluated individual's motivation also influence on the results. The evaluation of maximal respiratory pressures depends on understanding the maneuver to be performed and the individual's will to cooperate. In the methodology of studies described and conducted, the kind of command was not reported nor if there was evaluator's encouragement towards the individual[3-5,12]. However, some authors recommend that the evaluated individual, while performing maximum efforts, must observe the movement of the mano vacuum meter's needle, so she/he will have an idea of her/his performance and will help the evaluator to encourage her/him[14].

The study by Neder et al.[12] concludes that their equations can elucidate only 40-50% of the variety of RMS. In this study, there was a significant difference in MEP values for women and men, where the equations underestimated the measured values. The result may be justified by the small sample size and the evaluation of an only age group, since age is the only variable used by this author.

Two studies were published in Brazil comparing the values of RMS, measured and predicted by different equations. A study concluded that the best equation to evaluate

MEP is that proposed by Neder et al.[12], disagreeing with our study. The other claims that these equations were not able to consistently predict values for MIP and MEP[15,16].

Another group of authors compared the MIP and MEP measured in healthy individuals to the predicted values, by using the equations proposed, and concluded that the results may contribute to those from the study by Neder et al.[12] to predict, particularly, MIP, a finding similar to our study. However, the equations proposed by this group were not able to predict MIP and MEP for all individuals in the sample and also suggested further studies, with individuals from different regions in the country, in order to contribute to develop better reference tables or equations regarding maximal respiratory pressures in the Brazilian population[13].

Many studies on maximal respiratory pressures were also conducted with children and adolescents, in order to standardize the evaluation methods and reference equations[17]. A group of authors concluded that equations proposed in the literature have been successful in predicting maximal respiratory pressures among Brazilian children[18]. Nevertheless, two articles evaluated conclude that the reference equations in the literature failed to predict reliably the values for maximal respiratory pressures in healthy students and those with cystic fibrosis, reinforcing the need for new equations[19,20].

Sample size may be indicative of a possible limitation of our study regarding the values measured for maximal respiratory pressures. This study had the participation of 35 sedentary individuals, thus neither the number of individuals or the age group were similar to the studies described in the literature[3-5].

The criteria for selecting the sample emerge as another factor that may have influenced the values measured. The subjects of this study were considered as healthy through self-report, in a different way from the studies described in the literature, where volunteers underwent spirometric test and cardiopulmonary evaluation, and it is not possible to assert that the 35 subjects had no cardiopulmonary diseases[12].

Thus, there is a need to think through certain issues. In 2002, the Brazilian consensus on pulmonary function tests was published, where a large discrepancy between the reference values for maximal respiratory pressures was reported, which may be due to the various procedures used for sample selection and the methodological differences[14].

More recently, in 2009, a task force was published in order to update and expand the recommendations on maximal respiratory pressures, based on the American Thoracic Society/European Respiratory Society (ATS/ERS). They concluded, based on a critical literature review and the fusion of available data, that the reference equations and the lower limits of normality for maximal respiratory pressures vary according to age and gender. And that further data on MEP values, especially among women, are needed[1]. Finally, in the last 20 years, various evidence sources were published on maximal respiratory pressures and great variability was observed in the results.

FINAL REMARKS

In this study, although the sample constituted a limitation, we observed that the equations proposed by Neder et al.[12] were able to predict only the values measured for MIP in both sexes.

Several authors reported that the variability of RMS may be attributed to various methodologies and the different populations under study. Thus, this article reinforces the recommendation by the Brazilian Society of Pulmonology and Phthisiology regarding the importance and need for further studies evaluating maximal respiratory pressures, as well as a methodological standardization, in order to establish reference equations for the populations in various Brazilian regions.

COMPARAÇÃO DOS VALORES OBTIDOS E PREVISTOS DAS PRESSÕES RESPIRATÓRIAS MÁXIMAS EM ADULTOS JOVENS

RESUMO

A força muscular respiratória é a máxima pressão gerada durante uma inspiração ou expiração contra uma via aérea ocluída, sendo avaliada por meio das pressões inspiratória e expiratória máximas. Este estudo objetivou comparar os valores das pressões respiratórias máximas obtidos em adultos jovens sedentários com os valores previstos na literatura. Participaram da

pesquisa 35 adultos jovens sedentários, com idade entre 20 e 30 anos. A pressão inspiratória máxima (Pimáx) e a pressão expiratória máxima (Pemáx) foram medidas utilizando um manovacuômetro analógico, um bucal achatado e um clipe nasal. Foi aplicado o Questionário Internacional de Atividade Física (IPAQ), versão curta, para determinar o nível de atividade física. A análise estatística foi realizada por meio do teste de Wilcoxon para os dados femininos e do teste *t* de Student pareado para o sexo masculino, com nível de significância de 5%. Os resultados mostraram diferença significativa entre os valores obtidos da Pemáx e os valores previstos pela equação de referência brasileira para os sexos masculino (valor p = 0,0409) e feminino (valor p < 0,0001). A equação utilizada subestimou os valores de Pemáx para ambos os sexos. Constatou-se a necessidade de novos estudos multicêntricos, com uma amostra maior, a fim de determinar valores de referência mais precisos para as diferentes populações brasileiras.

Palavras-chave: Músculos Respiratórios. Força Muscular. Testes de Função Respiratória.

COMPARACIÓN DE LOS VALORES MEDIDOS Y PREDICHOS DE LAS PRESIONES RESPIRATORIAS MÁXIMAS EN ADULTOS JÓVENES

RESUMEN

La fuerza muscular respiratoria es la máxima presión generada durante una inspiración o espiración contra una vía aérea ocluida, y se evalúa por medio de las presiones inspiratoria y espiratoria máximas. Este estudio tuvo como objetivo comparar los valores de las presiones respiratorias máximas medidas en adultos jóvenes sedentarios a los valores previstos en la literatura. Participaron en la investigación 35 adultos jóvenes sedentarios, con edad entre 20 y 30 años. La presión inspiratoria máxima (Pimáx) y la presión espiratoria máxima (Pemáx) se midieron mediante el uso de un manovacuómetro analógico, una boquilla aplanada y una pinza nasal. El Cuestionario Internacional de Actividad Física (IPAQ), versión corta, se aplicó para determinar el nivel de actividad física. El análisis estadístico se realizó mediante la prueba de Wilcoxon para los datos femeninos y la prueba *t* de Student emparejada para el sexo masculino, con nivel de significación de 5%. Los resultados mostraron diferencia significativa entre los valores medidos de la Pemáx y los valores predichos por la ecuación de referencia brasileña para los sexos masculino (valor p = 0,0409) y femenino (valor p < 0,0001). La ecuación utilizada subestimó los valores de Pemáx para ambos sexos. Se constató la necesidad de nuevos estudios multicéntricos, con una muestra más amplia, con el fin de determinar valores de referencia más precisos para las distintas poblaciones brasileñas.

Palabras clave: Músculos Respiratorios. Fuerza Muscular. Pruebas de Función Respiratoria.

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