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RELATIONSHIP BETWEEN DIAPHRAGM ULTRASONOGRAPHY AND MAXIMUM INSPIRATORY PRESSURE

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ABSTRACT

The inhalation process activates the diaphragm muscle, increasing as a result of diaphragmatic contraction. Manovacuometry stands out for being a fundamental resource in the prescription of respiratory muscle training. Thus, the use of muscle thickness by ultrasound has been frequently used in investigations, evaluating the adaptations of diaphragmatic muscle. The aim of this study was to verify the correlation between the manovacuometric measurements and the diaphragmatic cross section area seen through ultrasound. This research consists of a cross-sectional pilot study of analytical approach and quantitative character. In which 30 subjects were recruited for an association between the techniques involved in the assessment. The results show that there is a statistically significant correlation between inspiratory diameter and maximal inspiratory pressure.

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INTRODUCTION

The diaphragm muscle, located below the lungs, has smooth and skeletal muscle characteristics that allow a unique ability to function both unconsciously and consciously. The process of inhaling activates the diaphragm muscle, during inspiration, widens as a result of diaphragmatic contraction. (SANTOS, 2018). According to the same author, this expansion reduces the internal air pressure compared to the external air pressure, capable of pulling the external air to balance the two pressures. In order to perform these movements, the respiratory muscles must overcome the pulmonary resistance of the airways and costal grating in order to expand the rib cage and to establish negative intra-pulmonary pressure. In this regard, numerous evaluation techniques aiming at more accurate prescriptions are being developed in pulmonary rehabilitation programs. Manovacuometry, in this context, stands out as being a fundamental resource in the prescription of respiratory muscle training used in physiotherapeutic interventions. It still needs to be better clarified as to its effectiveness in the treatment of non-lung disease patients (MENEZES *et al*., 2012). Thus, manovacuometry, also known as maximal respiratory pressures, consists in the measurement of maximal static respiratory pressures. It is a simple, fast, noninvasive, voluntary, and effort-dependent test whereby maximal inspiratory pressure (PIMáx) and maximal expiratory pressure (PEMáx) are obtained (SANTOS *et al*., 2017). As for the diagnosis of pulmonary topography, ultrasound (USG) is a diagnostic imaging method that employs high frequency sound wave reflexes to schematize, measure and evaluate internal structures with the benefit of being a noninvasive and non-radiation-exposing procedure, which can be used for functional and structural assessment of the diaphragm and can be performed on an outpatient or hospital basis.(HE *et al*., 2014).
From this perspective, diaphragmatic movement can be easily assessed with the patient supine with the transducer located in the subcostal region, where the right dome can be viewed by modeling the transducer in the cephalic direction below the lower costal edge. Estimation of diaphragm mobility by ultrasound is an option to be used to measure diaphragmatic dysfunction. The greater the diaphragmatic mobility, the greater the difference in muscle shortening resulting from its contraction. (ANDRADE, 2016). Thus, the use of ultrasound muscle thickness has often been used in investigations to evaluate diaphragmatic muscle adaptations in response to different strength training protocols, and is often also

associated with muscle strength production resulting from training. Muscle quality also seems to be an important measure as it reflects the functional capacity of the diaphragm. (SANTANA *et al*., 2016). The objective of this research is to correlate the manovacuometer measurements by digital devices with the thickness and range of motion of the diaphragmatic muscles observed by USG.

MATERIALS AND METHODS

This research consists of a cross-sectional pilot study of analytical approach and quantitative character. To achieve the objectives, a probabilistic sample of 30 individuals was recruited for an association between the techniques involved in the evaluation. Inclusion criteria were individuals aged 18 years or older who did not have neuromuscular diseases that generated plegia or diaphragmatic paresis. Those with cognitive impairment that prevented the practice of manovacuometry and individuals who could not perform the technique with methodological perfection after 6 attempts were excluded. The study was conducted in a hospital unit in the city of Vitória da Conquista – BA. The evaluation to define the results was through the MVD 300 digital manovacometer in the GlobalMed brand and in the MDI system. The USG device used was the LOGIQ P5 with convex and linear GE transducer. The patients underwent manovacuometry and diaphragm ultrasound. The manovacuometry exam was performed sitting in a comfortable position for the individual, using the nasal clip on the patient's nose to ensure optimal sealing. Then, the maximum expiration was requested and, afterwards, the maximum inspiratory effort until the measurement values stabilized. The procedure was performed twice more to measure the highest value. During ultrasound, the patients remained supine. For diaphragmatic mobility analysis, a 2-5 MHz convex transducer was placed in the right subcostal region between the right anterior axillary line and the middle axillary line. The transducer was angled medially and anteriorly so that the ultrasound beam reached the posterior third of the right hemidiaphragm. Ultrasound was used in mode B to view the diaphragm and then in mode M to measure the amplitude of craniocaudal diaphragmatic excursion during quiet breathing and deep breathing. The average value of three consecutive measurements was recorded. Diaphragm thickness was measured in mode B with a 6-13 MHz linear transducer placed over the diaphragm apposition zone, close to the costophrenic angle, between the right anterior axillary line and the middle axillary line. Diaphragm thickness was measured from the most superficial hyperechoic line (pleural line) to the deepest hyperechoic line (peritoneal line). The collected data were tabulated and analyzed through the software *Statistical Package for the Social Sciences* – SPSS 22.0 e *MedCalc* 19.1, for Windows. The treatment performed was descriptive (prevalence, mean and dispersion measurement) and analytical (paired T-Student test, Pearson correlation and measures of specificity and sensitivity). In all tests, reliability was set at 95%. Charts and tables were plotted by Microsoft Excel 2013.

RESULTS

The study population consisted of a sample of 30 individuals with a mean age of 31.0 ± 12.06 years, systolic blood pressure (PAS) 121.67 ± 12.06 mmHg, diastolic blood pressure. (PAD) of 86.0 ± 19.75 mmHg. The mean heart rate (FC) was 73.83 ± 9.38 bpm, oxygen saturation (SpO2) 97.73 ± 1.14% and the number of cigarettes per day was 1.63 ± 5.12 units. . In addition, the sample is classic due to the predominance of females 19 (63.3%), without previous pulmonary disease 29 (96.7%) and without heart disease 26 (86.7%). , as shown in Table 1. With the results shown in Table 2, it is observed that the values obtained for PIMáx are very close to predicted, not providing significant statistical difference (p = 0.656). The same result was not observed in PEMáx, where, due to the considerable difference between the obtained and the predicted value, a statistically significant difference is found (p ≤ 0.001). Regarding the diameter at inspiration, a value lower than the expiration value (0.26 ± 0.11 and 0.18 ± 0.06, respectively) was observed. The results shown in graph 1 show that there is a statistically significant correlation between inspiration diameter and PIMáx (p = 0.002). This correlation is positive, ie, higher inspiratory diameter values are for higher PIMáx values.

Table 1. Sociodemographic and clinical characteristics of the sample. Vitória da Conquista - BA, 2019

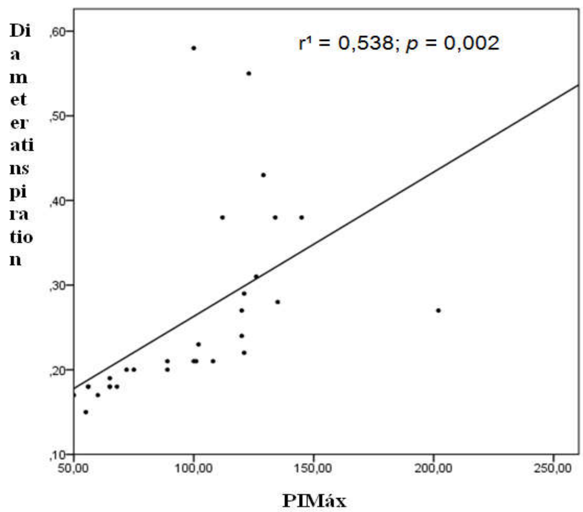
Variables	Mean ± dp[1]	n	%
Age, years	31,0 ± 12,06	30	—
PAS, *mmHg*	121,67 ± 12,06		—
PAD, *mmHg*	86,0 ± 19,75		—
FC, *bpm*	73,83 ± 9,38		—
SpO2, *%*	97,73 ± 1,14		—
Number of cigarettes per day	1,63 ± 5,12		—
Sex			
Male		11	36,7
Female		19	63,3
Prior lungdisease			
Not		29	96,7
Bronchitis		1	3,3
Heart disease			
None		26	86,7
HAS		3	10,0
Heart disease		1	3,3

Sample standard deviation; Source: Research Data.

Table 2. Sonographic and manovacumetric variables of the sample. Vitória da Conquista - BA, 2019

Variables	Mean ± dp[1]		*p**
	Valueobtained	Predictedvalue	
PIMáx	98,80 ± 34,76	103,80 ± 62,73	0,656
PEMáx	95,70 ± 25,69	126,35 ± 32,68	≤ 0,001
Diameteratinspiration	0,26 ± 0,11		
ExhalationDiameter	0,18 ± 0,06		

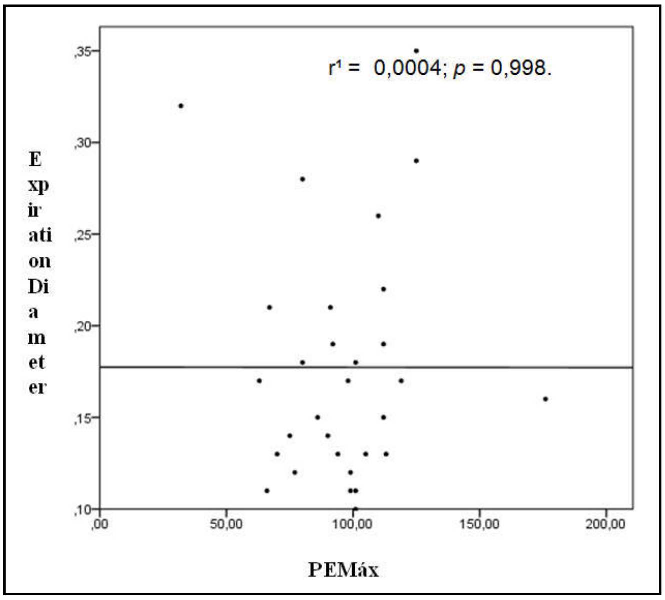
[1] Sample standard deviation; * Paired T-Student test; Source: Research Data.



[1]Pearson correlation; Source: Research Data.

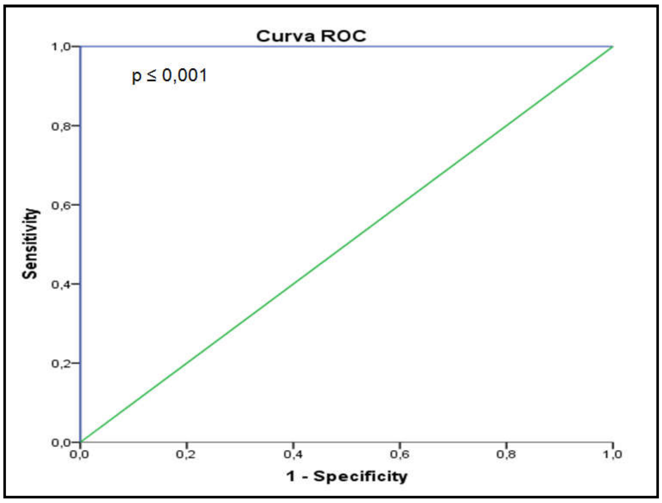
Graph 1. Correlation between inspiratory diameter and PIMáx.Vitória da Conquista – BA, 2019

Unlike the inspiration result, the results shown in graph 2 show that there is no statistically significant correlation (p = 0.998) between expiratory diameter and PEMáx, while larger diameter values have little positive effect on PEMáx. Figure 1 shows the ROC curves of the inspiratory diameter (0.26 ± 0.11) of the entire sample relative to the ability to identify abnormalities using PIMáx. There was a significant superiority of the abnormal diagnosis related to PIMáx (p <0.001), with a cutoff of 82.1.



[1]Correlação de Pearson; Fonte: Dados da pesquisa

Graph 2. Correlation between Exhalation Diameter and PEMáx. Vitória da Conquista – BA, 2019



Graph 1. ROC curve applied to inspiratory diameter with parameter for PIMáx. Vitória da Conquista - BA, 2019

DISCUSSION

The results found in this research revealed a statistically significant correlation between inspiratory diameter and PIMáx. It was also found that this correlation is positive, that is, the higher the diameter values at inspiration, the higher the PIMáx values. Andrade (2016) states that the greater the diaphragmatic mobility, the greater the difference in muscle shortening resulting from contracture. Thus, the findings found and demonstrated by this study are in agreement with the literature, as it exposes similar results to other studies dealing with the theme presented here. Thus, the involvement of ventilatory muscles in inspiratory and expiratory actions is a very common clinical finding, not only in patients with neuromuscular disorders, but also in clients with respiratory diseases that mainly affect the airway or pulmonary parenchyma (CARUSO *et al*., 2015). From this perspective, it is confirmed what reports Ferreira (2015), in which individuals in whom the central respiratory impulse is normal or considered healthy, the strength of the ventilatory muscles necessary to move the respiratory system must be greater than the total sum from the work assigned by the lungs, ribcage and airways. Most of the time, the inspiratory musculature in which the diaphragm is the main muscle is the first to be affected due to its active activation. This study showed that, unlike the inspiration result, the results in the sonographic and manovacumetric variables show that there is no statistically significant correlation with expiratory diameter and PEMáx, considering that larger diameter values have little positive effect on PEMáx. In this sense, Ferreira *et al*. (2016) report that, although the assessment of maximal respiratory pressures is simple, it is subject to patient coordination and collaboration, which makes inaccurate evaluations possible and, therefore, an imperfect diagnosis.

It is worth highlighting what the authors also present Baldwin, Paratz and Bersten (2011), who contribute to the findings of this research, where the use of a single test may not be satisfactory to identify respiratory muscle dysfunction. Thus, the combination of other tests promises to improve the accuracy of the physiotherapeutic diagnosis of concordat with the maximum respiratory pressure values. Corroborating this study, Zambon *et al*. (2017) found in a systematic review study that ultrasound was a procedure performed using different techniques to assess diaphragm thickness, diaphragmatic inspiratory excursion, and thickening fraction. As found by the authors and also demonstrated in this study, ultrasound is feasible, highly reproducible and allows the detection of diaphragmatic dysfunction in critically ill patients. Furthermore, it is valid to consider that manovacuometry, as shown in this study, is the most frequently used method that indirectly measures muscle strength through the generation of maximal expiratory and inspiratory pressures. In the functional assessment of the patient in bed, the degree of diaphragm muscle movements is essential, but this device is subjective and qualitative (ROMANI; MIARA; CARRADORE, 2011).

Conclusion

A direct relationship can be concluded between the morphofunctional aspects of the diaphragm and the examination of the maximal inspiratory pressure with cutoff that configures a change in diaphragmatic diameter associated with manovacuometry. Therefore, it is understood that this work is an important tool in the formulation of new knowledge on the analysis of the effects of respiratory muscle training using manovacuometric and ultrasound findings. Thus, the objective here exposed was achieved from the results presented. However, there are still research gaps related to this subject and further studies are suggested to consider reference values and association between ultrasound markers and manovacuometers.

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