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MEASURE OF KYPHOSIS DOES NOT DETERMINE RESPIRATORY MUSCLE STRENGTH AND SPIROMETRIC VALUES IN ELDERLY

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ABSTRACT

The aging process is constant and growing, reducing functional capacity and the presence of chronic diseases that can affect the respiratory system and posture. The present study analyzed the influence of kyphosis measure and Charpy angle on respiratory strength and spirometric parameters in apparently healthy elderly. Spirometric, manovacuometric, Charpy angle, and thoracic kyphosis evaluation were performed. A low correlation was found between the measure of thoracic kyphosis and the Charpy angle. The sample had a high level of education and a low prevalence of comorbidities. There was no statistically significant difference between the measure of thoracic kyphosis and the Charpy angle, as well as between these and maximal inspiratory pressure, maximal expiratory pressure, and spirometric variables

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INTRODUCTION

The process of population aging is constant and growing, and in most countries, it is expected to live more than 60 years (WHO, 2015), and it is estimated that the elderly population will be two billion by 2050 (Sander *et al*., 2015). An essential problem of aging is the reduction of functional capacity, which is related to the presence of chronic diseases (Divo *et al*., 2014) as well as exposure to risk factors throughout life (Barnes, 2015). The functional capacity of the elderly is closely related to the respiratory system. In the aging process, this system undergoes important cellular, histological, and structural changes that contribute to the decline of its functioning and result in changes in diagnostic criteria and treatment responses (Zeleznik, 2003). Even more, the loss of elastic recoil and changes in respiratory mechanics cause functional limitations (Roman *et al*., 2016). The evaluation of this system can be performed by direct measurements such as spirometry, which measures lung volume and capacity and is able to diagnose obstructive, restrictive and mixed ventilatory disorders (Pereira, 2002) and manovacuometry, which evaluates the strength of the respiratory muscles (McConnell *et al*, 1999) or indirect as postural evaluation (Ferreira *et al*., 2012; Lopes, 2012), which can be performed by software or by traditional visual inspection. Changes in the above measures may lead to the inference of clinical consequences in the elderly in order to facilitate the assessment of the need for treatment. It is noteworthy that aging causes significant postural changes such as decreased lumbar lordosis, widening of the knee flexion angle, posterior dislocation of the hip joint, anterior trunk inclination and increased thoracic kyphosis (Silveira *et al*., 2010) interfering not only in the aspects of postural balance, but also with consequences on the respiratory system (Culham *et al*, 1994). Increased thoracic kyphosis is related to impaired mobility (Kado *et al*. 2005 and Ryan *et al*., 1997), risk of falls (Kado *et al*. 2007), and early mortality (Kado *et al*., 2009). It may also lead to changes in the functioning of the respiratory system, due to the reduction of the intervertebral disc (Bartynski *et al*., 2005), which leads to less rib movement caused by altered vertebrae positioning (Culham *et al*., 1994). Furthermore, the limitation of pulmonary expansion (Lorbergs *et al*., 2018), resulting in interference with the adequate functioning of the respiratory system (Lombardi *et al*., 2005). Given the above, it is clear that a careful evaluation of the elderly could early identify such changes in the respiratory system. Thus, flexicurve is a method used to measure kyphosis, non-invasive, practical, affordable, and inexpensive that has excellent reliability (Teixeira *et al*., 2007) and can be used to evaluate the elderly patients with good reproducibility (Gonçalves *et al*., 2015). Also, the Charpy angle, formed by the last ribs and the xiphoid appendix (Tarantino *et al*., 2008), when measured, assists in the assessment of respiratory function as it identifies the diaphragm positioning. This angle can be measured by photogrammetric and postural assessment software (SAPO) (Ferreira *et al*., 2012). It is known that the increased Charpy angle could lead to a decrease in muscle power by shortening positioning (Lopes *et al*., 2012).

Therefore, this study aimed to analyze the influence of the kyphosis angle and the Charpy angle on respiratory strength and spirometric parameters in apparently healthy elderly. Materials and methods. A descriptive cross-sectional study with a quantitative approach was performed. The Research Ethics Committee approved the study of the Universidade Católica de Brasília under number: 3,013,137. All individuals were informed about the research and signed an Informed Consent Form, as determined by the National Health Council Resolution 466/12. The elderly were recruited through newsletters and social media ads. Inclusion criteria were having an independent gait and presenting a minimum score that indicates cognitive health in the Mini-Mental State Examination (MMSE). Exclusion criteria were: previous pulmonary or neuromuscular disease, inability to maintain orthostatic posture without support, any viral or infectious condition that could interfere on the day of data collection. The study took place in a climate-controlled room with privacy for the volunteer. The MMSE was performed, followed by a complete demographic data sheet and useful data by manovacuometry, spirometry, flexicurve, and SAPO. The spirometric evaluation was performed by a Volumetric Incentive Spirometer (CONTEC®, model SP10), using disposable mouthpieces, in which the volunteer sitting with his feet flat on the floor, was instructed to perform a maximum inspiration, followed by a rapid breath, which must be kept for at least six seconds (Souza, 2002). This maneuver was performed three times, with an interval of one minute between each attempt, and the highest score was used for the analysis. The values of FVC, FEV1, and FEV1 / FVC were recorded.
Charpy angle evaluation was made by the SAPO program, for which the participant had a bare chest, and for women was allowed to wear a bathing suit. The three points used were the xiphoid appendix level and the last ribs bilaterally. The camera distance was 3 m from the volunteer and at a height corresponding to half the height, in order to provide a correct framing of the participant. To measure kyphosis by Flexicurva, a flexible 80 cm ruler (TRIDENT® Precision Industry, Brazil) was used, the participant remained with the bare chest, and for women, the use of a bathing suit was allowed. The marking was made of the spinous processes of C7 and T12, after shaping of the flexible ruler on the volunteer's back, transcription of the dorsal spine format to the graph paper and angular calculation through the third-degree polynomial, according to the method validated by Teixeira *et al* (2007). This software can be used with excellent reliability for angular inference (Braz *et al*., 2008; Ferreira *et al*., 2012; Lopes, 2012) To measure inspiratory and expiratory muscle strength, a respiratory manometer (GLOBAL MED®) was used, where the volunteer sitting, with feet flat on the floor, with his back in a relaxed position against the chair back, used a nasal clip, keeping firmly buccal between the lips. To measure maximal inspiratory pressure (MIP), the volunteer was instructed to exhale in the buccal until residual volume later generated a maximal inspiratory effort and to maximal expiratory pressure (MEP), instructed to perform an inspiration to total lung capacity and then a maximum expiratory effort. Three measurements were performed, and their average was used for the analysis. The one-minute interval between attempts was adopted.

Statistical Analysis

Results are expressed as mean and standard deviation. The Shapiro-Wilk test verified data normality. From the analysis of the flexicurve of the thoracic kyphosis, the participants were classified in three different groups from the tertile: <36o,> 36o, and <58o, and> 58 o to answer the aims of the present study. The correlations presented were by Pearson's test. ANOVA One way with Bonferroni post hoc was used to verify differences between means. Data were analyzed using the Prisma GraphPad 8® statistical package (California, USA). A value of $p < 0.05$ was adopted as the significance level.

RESULTS

The sample consisted of 55 older adults of both sexes, with the characteristics described in Table I.

Table 1. Sample Characterization

SEX		42 F
		13 M
AGE (years)		66,53 ± 3,70
BMI		27,00 ± 4,82
HWR		0,89 ± 0,10
SPIROMETRY (%)		
	FEV1	85,64 ± 18,57
	FVC	80,16 ± 22,19
	FEV1/FCV	83 ± 13
MANOVACUOMETRY		
	MIP	54,50 ± 19,58
	MEP	50,97 ± 16,45
FLEXICURVE		44,20 ± 16,69
CHARPY ANGLE		137,04 ± 13,69

Legend: Caption: F: female; M: male; BMI: body mass index; WHR: waist-hip ratio; FEV: forced expiratory volume in one second; FVC: forced vital capacity; MIP: maximum inspiratory pressure; MEP: maximal expiratory pressure.

The most prevalent comorbidities were systemic arterial hypertension (SAH), with 30%, followed by the combination of SAH and diabetes mellitus, 13%. In the present sample, 48% of the volunteers had no comorbidities. Figure 1 shows a weak correlation between flexicurve and Charpy angle, with r = - 0.17. Figure 2 also shows a weak correlation between Charpy's angle and the study variables. The comparison of MIP and MEP with tertile-divided degrees of kyphosis can be seen in Figures 3 and 4. It is observed that there is no difference between respiratory muscle strength regardless of the degree of kyphosis presented, as well as no statistically significant correlation. between the degree of Charpy angle and the respiratory muscle forces (Figure 2).

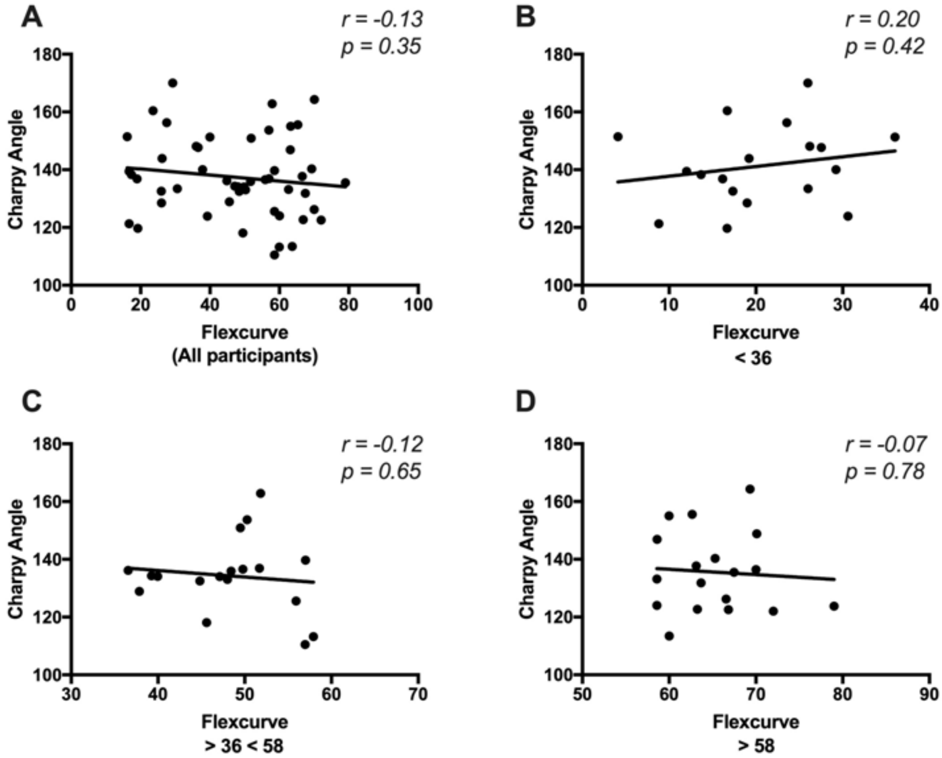
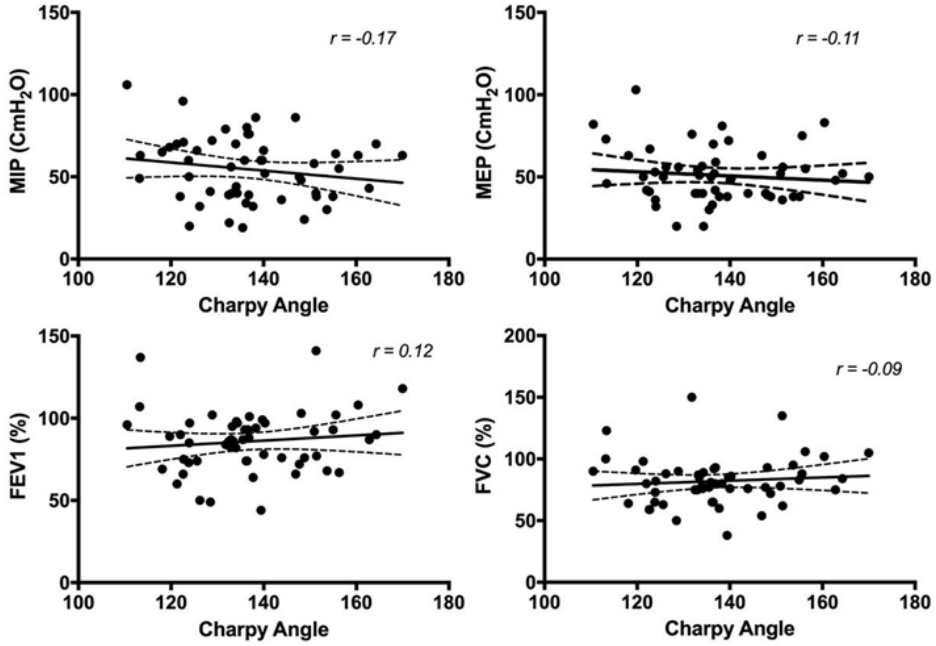
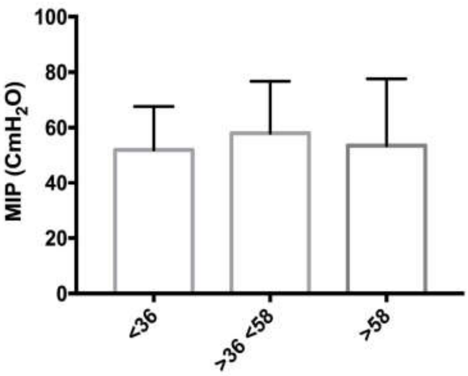


Figure 1. Correlation between flexicurve and Charpy angle. r = 0.17



Legend: MIP: maximum inspiratory pressure; MEP: maximal expiratory pressure; FEV1: forced expired volume in the first second; FVC: forced vital capacity.

Figure 2. Charpy angle correlation with MIP, MEP, FEV1 and FVC



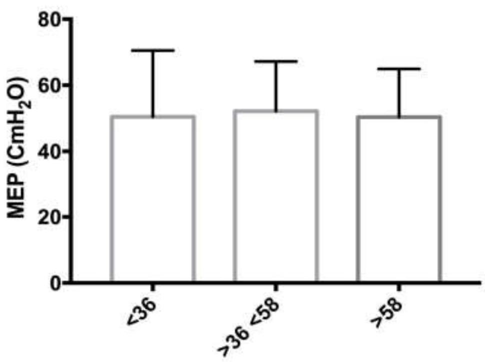


Figure 3. MIP: Maximum Inspiratory Pressure **Figure 4. MEP: maximal expiratory pressure**

DISCUSSION

The present study observed a weak correlation between thoracic kyphosis and Charpy angle in healthy elderly, showing no significant differences between respiratory muscle strength and thoracic kyphosis angulation. This finding may, in part, be attributed to the high level of education and the relatively low incidence of comorbidities, which leads to better living habits of the research participants. The aging process can be seen from various perspectives, which highlights the functional and intellectual capacity, and in any case, is a process considered heterogeneous and individual (Fechine *et al*, 2012). Progressive tissue degeneration harms organ structure and function, and this degenerative process occurs to a greater or lesser extent in aging (Kirkwood, 2005). Thus, there is an increased risk of developing diseases and comorbidities (MacNee *et al*, 2014). In the present study, the presence of comorbidities was relatively low, as only 52% had chronic degenerative diseases, when compared to other studies where the prevalence of reported comorbidities reaches 80% (Pimenta *et al*, 2015), being the most prevalent SAH (48%) which was also observed in the aforementioned study. This can be attributed in part to the high level of education of the participants since more than 80% of the sample had at least completed higher education. Thus, Rodrigues *et al* (2012) observed that the level of education influences the patient's knowledge and attitude and agreeing with them; Lima-Costa (2004) concluded that schooling influences disease prevention.
Chronic diseases that lead to disability are a critical factor to be considered in the aging process since morbidity leads to a more significant loss of functional capacity of the elderly (Divo *et al*, 2014). The mechanism of development of these diseases in old age is associated with long-term oxidative stress that leads, among other things, to mitochondrial and DNA alteration (Barnes, 2015). The level of physical activity of the participants was not measured. However, it may be related to the excellent performance presented since the presence of chronic diseases is associated with physical inactivity (Booth *et al*, 2012). Improving the quality of life in the aging process is linked to the understanding of chronic processes since death itself is inevitable, but proper care can lead to a long life without significant disabilities (Divo *et al*, 2014). The lungs, diaphragm, and chest wall function in an integrated manner so that any change in one of these components causes significant changes in ventilation (ventilation/perfusion changes and increased dead space) (Fernandes *et al*, 2002). Zeleznik (2003) states that there are complex, interrelated changes involving pulmonary mechanics, rib cage changes, and muscle strength that contribute to changes in lung volume and capacity. The structure of the rib cage is fundamental to the proper functioning of the respiratory system, such that changes in the spine, musculature and ribs that occur with aging can impact the proper functioning of this system (Lowery *et al*., 2013). In a study by Kado *et al*. (2004), it was observed that older people with hyperkyphosis had reduced pulmonary function, which among other factors, led to increased mortality in this population and the study by Lorbergs *et al* (2016), hypertrophic women had decreased FEV1. Unlike in this study, where volunteers with hyperkyphosis did not show decreased pulmonary function verified by spirometry. Contrary to what was observed in the present study, Di Bari *et al* (2004) conducted a study of 130 elderly with hyperkyphosis and observed that they had both restrictive and obstructive dyspnea and ventilatory disorders, suggesting that the measurement of kyphosis is part of the differential assessment of dyspnea of the older person. A review by Harrison *et al* (2007) shows the need for further studies with higher methodological rigor to relate the degree of kyphosis with changes in lung function. The respiratory system undergoes several changes with aging, and there is a wide variation among the elderly, which makes it difficult to establish parameters considered normal and also the consequences of this aging (Sharma *et al*, 2006). Some evaluation parameters can be used to measure this decrease in capacity and depending on the changes found and the measurement performed, one can infer the clinical consequences in the elderly. Another critical item to be evaluated in the respiratory function of the elderly is the strength of the respiratory muscles, which can be measured by measuring the static pressure generated by the mouth during maximal inspiration and expiration (McConnell *et al*, 1999). Aging leads to a reduction in diaphragm strength by up to 25% (Tolep *et al*, 1995), and morphological differences in diaphragm associated with advancing age have also been found (Caskey *et al*, 1989). Decreased respiratory muscle strength leads to a lower ability to maintain the airway without mucus because in addition to generating lower peak respiratory flow, aging leads to less mobility and beating of the hair cells (Lowery *et al*., 2013). The decrease in age-related respiratory muscle strength reported in the study by McConnell *et al* (1999) did not reproduce in the present study. The elderly did not show a significant decrease in respiratory strength, which can partly be explained by the fact that the majority of the sample had less of 70 years since studies show that older people from 70 years old present more significant loss of respiratory muscle strength (Simões *et al*, 2010). Another question is that the reduction in respiratory muscle strength is associated with sarcopenia (Ohara *et al* 2018) and lower functional capacity (Giua *et al*, 2014), variables that were not evaluated in the present study.

Taratino *et al* (2008) affirm the importance of thorax configuration in the proper functioning of the rib cage that can be evaluated by the Charpy angle and angles higher than 90º reflect diaphragm shortening and consequently greater use of accessory muscles (Lopes *et al*, 2012). In the present study, the average Charpy angle was 137 ± 13.69 degrees, implying significant shortening and possibly overload. No study was found in the literature that measured Charpy's angle and compared it with respiratory muscle strength in the elderly; however, studies were found that related the angle to mouth-breathing children and the postural consequences of changes (Ferreira *et al*, 2012; Baraúna *et al*, 2000). In the present study there was no correlation between Charpy angle and respiratory muscle strength, however, further research with this direction is suggested, since the positioning of the diaphragm may interfere with its proper functioning, especially in overload situations such as diseases, and Charpy's angle is a noninvasive way to predict the positioning of this muscle. It is concluded that the degree of kyphosis and the Charpy angle do not determine respiratory strength or spirometric values in apparently healthy elderly. Acknowledgments: Special thanks to Jeeser Alves de Almeida for the statistical treatment and revision of the main text.

Acknowledgments

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