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Thoracic kyphosis comparison between a patient with chronic obstructive pulmonary disease and a healthy individual by flexicurve method

Comparação da cifose torácica entre o paciente com doença pulmonar obstrutiva crônica e o indivíduo saudável pelo método flexicurva

Comparación de la cifosis torácica entre el paciente con enfermedad pulmonar obstructiva crónica y el individuo sano por el método flexicurva

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ABSTRACT | Chronic obstructive pulmonary disease (COPD) is characterized by airflow obstruction, air entrapment and pulmonary hyperinflation. These pathophysiological factors can compromise the diaphragmatic mobility, causing deformities in the thoracic cavity and consequently increasing the angle of the thoracic curvature. We compared the angle of the thoracic curvature between COPD patients and healthy individuals by the flexicurve method. Thirty-seven patients with COPD and 37 healthy individuals participated in the study. All subjects performed the following evaluations: anthropometry, spirometry, and measurement of the thoracic curvature angle. The data were analyzed and treated with descriptive analysis such as mean and standard deviation. The Shapiro-Wilk test was used to verify the normality of the data. The Student's t-test was used to compare the thoracic curvature angle of patients with COPD with healthy individuals. The significance level adopted was 5%. The mean age of the COPD group was 65.70±7.91 years, body mass index (BMI) of 26.73±5.34kg/m^2, and FEV_1 (expected %) of 50.65±19.08, showing moderate obstruction degree. Healthy individuals showed an average of 7.27±62.49 years, BMI of 26.97±3.55kg/m^2 and FEV_1 (expected %) of 94.05±0 9.44. We did not observe any significant difference between patients with COPD and healthy individuals in the thoracic curvature angle: 56.67±11.31 and 55.42±9.61 degrees, respectively (p=0.61). The flexicurve method proved to be a useful and practical tool for assessing the thoracic kyphosis, and it also identified no difference between the thoracic curvature of COPD patients with moderate obstruction and of healthy individuals.

Keywords | Pulmonary Disease, Chronic Obstructive; Evaluation; Spine; Kyphosis; Posture.

RESUMO | A doença pulmonar obstrutiva crônica (DPOC) é caracterizada pela obstrução do fluxo aéreo, aprisionamento de ar e pela hiperinsuflação pulmonar. Esses fatores fisiopatológicos podem comprometer a mobilidade diafragmática, causar deformidades na caixa torácica e consequentemente aumentar o ângulo da curvatura torácica. Comparamos o ângulo da curvatura torácica entre pacientes com DPOC e indivíduos saudáveis pelo método flexicurva. Participaram do estudo 37 pacientes com DPOC e 37 indivíduos saudáveis. Todos os indivíduos realizaram as seguintes avaliações:

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antropometria, espirometria e mensuração do ângulo da curvatura torácica. Os dados foram analisados e tratados com análise descritiva como média e desvio-padrão. O teste de Shapiro-Wilk foi utilizado para verificar a normalidade dos dados. O teste t de Student foi utilizado para comparar o ângulo da curvatura torácica dos pacientes portadores de DPOC com os indivíduos saudáveis. O nível de significância adotado foi de 5%. A média de idade do grupo com DPOC foi de 65,70±7,91 anos, o índice de massa corporal (IMC), 26,73±5,34kg/m^2, e VEF_1 (% previsto), 50,65±19,08, apresentando grau de obstrução moderada. Os indivíduos saudáveis apresentaram em média 62,49±7,27 anos, IMC de 26,97±3,55kg/m^2 e VEF_1 (% previsto) de 94,05±9,44. Não houve diferença significante entre os pacientes com DPOC e os indivíduos saudáveis no ângulo da curvatura torácica: 56,67±11,31 e 55,42±9,61 graus, respectivamente (p=0,61). O método flexicurva mostrou-se uma ferramenta útil e prática para avaliar a cifose torácica, identificando que não houve diferença entre as curvaturas torácicas dos pacientes com DPOC com obstrução moderada e dos indivíduos saudáveis.
Descritores | Doença Pulmonar Obstrutiva Crônica; Avaliação; Coluna Vertebral; Cifose; Postura.

RESUMEN | La enfermedad pulmonar obstructiva crónica (EPOC) se caracteriza por la obstrucción del flujo de aire, aprisionamiento de aire e por la hiperinsuflación pulmonar. Estos factores fisiopatológicos pueden comprometer la movilidad diafragmática, causar deformidades en la caja torácica y consecuentemente aumentar el ángulo de la curvatura torácica. Se comparó el ángulo de la curvatura torácica entre pacientes con EPOC y de individuos sanos mediante el método flexicurva. Participaron del estudio 37 pacientes con EPOC y 37 individuos sanos. Todos los individuos realizaron las siguientes evaluaciones: antropometría, espirometría y medición del ángulo de la curvatura torácica. Los datos fueron analizados y tratados con análisis descriptivo como media y desviación estándar. Se utilizó la prueba de Shapiro-Wilk para comprobar la normalidad de los datos, y la prueba t de Student para comparar el ángulo de la curvatura torácica de los pacientes portadores de EPOC con los individuos sanos. El nivel de significancia adoptado fue del 5%. La edad promedio del grupo con EPOC fue 65,70±7,91 años, el índice de masa corporal (IMC), 26,73±5,34kg/m^2, y VEF_1 (% previsto), 50,65±19,08, presentando grado de obstrucción moderada. Los individuos sanos presentaron un promedio de 62,49±7,27 años, IMC de 26,97±3,55kg/m^2 y VEF_1 (% previsto) de 94,05±9,44. No hubo diferencia significante entre los pacientes con EPOC y los pacientes sanos en el ángulo de la curvatura torácica: 56,67±11,31 y 55,42±9,61 grados, respectivamente (p=0,61). El método flexicurva ha mostrado ser una herramienta útil y práctica para evaluar la cifosis torácica, identificando que no hubo diferencia entre las curvaturas torácicas de los pacientes con EPOC con obstrucción moderada y de los individuos sanos.
Palabras clave | Enfermedad Pulmonar Obstructiva Crónica; Evaluación; Columna Vertebral; Cifosis; Postura.

INTRODUCTION

Thoracic hyperkyphosis is a condition indicated by the abnormal increase in the curvature convexity of the thoracic vertebral column[1], which may be related to increased age[2], vertebral fractures[3], postural alterations[4], degenerative disease in the vertebral disc[5], muscle weakness[6], intervertebral ligament degeneration[7], and genetic predisposition[8].

Pachioni et al.[9] demonstrated that patients with chronic obstructive pulmonary disease (COPD) have a higher angle in thoracic kyphosis when compared to healthy older adults. This increase in the thoracic kyphosis can occur both due to aging, and to pathophysiological factors related to the disease such as increase in the anteroposterior diameter of thorax[10], ribs in horizontal position[11], excessive use of accessory muscles and reduced diaphragmatic mobility[12].

With the increased thoracic kyphosis, the clinical pattern of the COPD patient can be exacerbated, since thoracic hyperkyphosis may cause many adverse consequences to health[13], such as harming the pulmonary function[14], increasing dyspnea[14], affecting the performance of daily activities[15], reducing the quality of life[16], and increasing the risk of mortality regardless of the subjacent vertebral osteoporosis[17]. As COPD patients present all these losses as a result of the illness, the increase in the angle of the thoracic curvature can be more evident, especially in more advanced stages of the disease[18], and affect even more their health.

Several instruments have been used to evaluate thoracic kyphosis[19]. In clinical practice, radiography is used as the gold standard for measuring the Cobb angle[2,20]. Although it is a non-invasive method, easy to apply and with a relatively low cost, it has radiation that in some situations are harmful to health[21].

The flexicurve method is equivalent to the radiographic (Cobb angle)[22, 23, 24]: it is not invasive, it provides an evaluation of the thoracic curvature in the sagittal plane, it is a validated tool in Brazil, considered reliable and reproducible[22-24], and it uses a mathematical model (specific software) to calculate the angle of thoracic curvature values from measurements obtained by the rule molded into the thoracic spine of the individual[22].

There is a lack of studies that use the flexicurve method to evaluate the thoracic spine of patients with COPD. In the study by Pachioni et al.[9] conducted with COPD patients, we used the Postural Analysis Software (SAPO). However, it seems that this tool is not suitable for evaluating thoracic kyphosis, and still lacks reference values and standardization to accomplish this measure[25]. On the other hand, the flexicurve rule offers a standardized way of measurement, reference angular values and can be used in clinical practice, considering its low cost and easy use and transport.

Therefore, the objective of this study was to evaluate the angle of thoracic curvature of COPD patients and healthy individuals by the flexicurve method.

METHODOLOGY

This study is an analytical cross-cutting-type research and of quantitative approach. It was approved by the Ethics Committee in Research with Human Beings at the State University of Santa Catarina, Florianópolis (CAAE: 08857612.2.0000.0118). All individuals were informed about the research, and signed a free and informed consent form, according to the resolution 466/12 of the National Health Council.

Seventy-four individuals of both genders (34 men) participated in the study. They were divided into two groups: group 1 consisting of 37 patients with COPD, with mean age of 65.70±7.91 years, and group 2 consisting of 37 healthy subjects with a mean age of 62.49±7.27 years.

In the COPD group, patients with COPD diagnosis were included according to the classification of the Global Initiative for Chronic Obstructive Lung Disease (GOLD)[26]. We also used a diagnostic record developed by researchers linked to the Laboratory of Respiratory Physiotherapy, aiming to identify the characteristics of the individuals and verify if they met the following inclusion criteria: 1) clinical stability during the last month and at the beginning of the evaluation protocol: absence of exacerbations characterized as persistent worsening in the stable basal condition, of acute onset (typically by the accentuation of dyspnea, with or without cough, increased expectoration volume, sputum purulence and thoracic oppression) and which may require additional treatment; 2) patients nondependent on oxygen supplementation; 3) absence of other respiratory and cardiovascular diseases; 4) patients without involvement in training programs in the 6 months prior to the beginning of this study; 5) patients who have not undergone recent surgery on the spine or in lower limbs and/or who have not had fractures in the 6 previous months.

For patients with COPD, we considered the following exclusion criteria: 1) presence of exacerbations of the disease during the research; 2) cardiorespiratory and/or musculoskeletal clinical recurrences during the evaluations; 3) incapacity to perform any of the evaluations of the study (lack of understanding or collaboration) and; 4) withdrawal of the patient during the evaluation period.

We included in the healthy group individuals with normal spirometry (FEV_1/FVC ≥0.7; FEV_1 ≥80% of the expected, FVC ≥80% of the expected), without associated comorbidities, and with age, weight, and BMI compatible with COPD patients. We excluded from this group individuals who were incapable to perform any of the evaluations of the study (lack of understanding or collaboration) and/or who withdrew during the process of evaluation.

Evaluated parameters

Anthropometry

For body mass measurement, we used a scale previously calibrated and a stadiometer for measuring the height, Welmy® model W200/5. After obtaining the anthropometric values (body mass and height), we calculated the body mass index (BMI) by the equation: body mass/height^2 (kg/m^2). Patients were classified, according to the BMI, in low weight (≤18.5kg/m^2), normal weight (18.5-24.9kg/m^2), overweight (25-29.9kg/m^2) and obese (≥30kg/m^2)[27].

Spirometry

Spirometry was performed with the portable digital spirometer Easy One, from ndd Medical Technologies,

previously calibrated in accordance with the methods and criteria recommended by the American Thoracic Society and the European Respiratory Society[28]. Spirometric variables were expressed as absolute values and as the percentage value of the expected values of normality, according to those determined by Pereira et al.[29]. The criteria for normal pulmonary function test consist of FVC and FEV_1≥80% of the expected, and FEV_1/FVC≥0.7.

Angle of the thoracic curvature

It was evaluated by the flexicurve method that consists of using a flexible ruler of 80cm (TRIDENT® Precision Industry, Brazil) composed of a folding metal rod protected with flexible plastic. During the measurement of the thoracic curvature, the individual remained in an static orthostatic position, as relaxed as possible, and used a disposable apron with a posterior opening, remaining with the elbows and shoulders extended throughout the body. Then, spinous processes of C7 and T12 were located and marked with a pencil. The flexible ruler was placed initially in the spinal process of C7, being shaped with the format of the curvature of the kyphosis until the spinal process T12. Then, we performed the transcription of the dorsal column format to the graph paper, and the following straight lines were drawn: from the C7 equivalent point to the T12 point named *Xtotal*, from the greater angle of thoracic curve to the *Xtotal* straight line named *H line* (cm), and from the beginning of T12 to the *H line* named *Xmiddle* (cm)[22] (Figure 1).

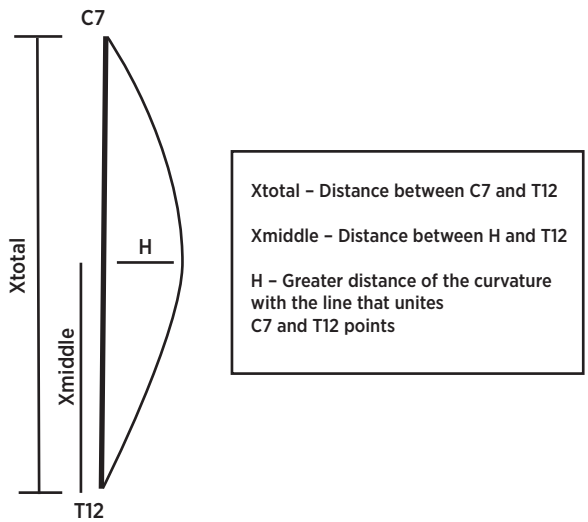


Figure 1. Schematic drawing of thoracic kyphosis measurement by Flexicurve (Teixeira & Carvalho, 2007)

Finally, we performed the application of angle calculation by the third degree polynomial, in which a math formula was employed[4]. We considered as normal values for the curvature of the thoracic kyphosis angles between 20° and 50° in adults[22], and angles up to 56° in the older adults[30].

Statistical Analysis

Data were analyzed using the SPSS for Windows program, version 20.0, and treated with descriptive analysis as mean and standard deviation, applied in all variables. The normality of the data was verified using the Shapiro-Wilk test. According to the data distribution, the Student's t-test (parametric data) and the U Mann Whitney test (nonparametric data) were used for comparing the parameters between the groups. The significance level adopted was equal or inferior to 5%.

RESULTS

We included 44 patients diagnosed with COPD (aged from 49 to 81 years), but 07 were excluded during the study: 03 for not understanding how to perform the spirometry test and 04 for not completing all evaluations. We also evaluated 48 healthy individuals (aged from 49 to 78 years), and 11 were excluded, 05 for not completing all evaluations, 05 for lack of understanding how to perform the spirometry test, and 01 due to musculoskeletal problems. Therefore, 37 patients with COPD (19 men) and 37 healthy individuals (15 men) participated in the present study.

Table 1 presents the characterization of the studied groups, showing that there was no statistically significant difference between the groups regarding age, body mass, weight and BMI, confirming that the groups were matched in relation to the anthropometric variables.

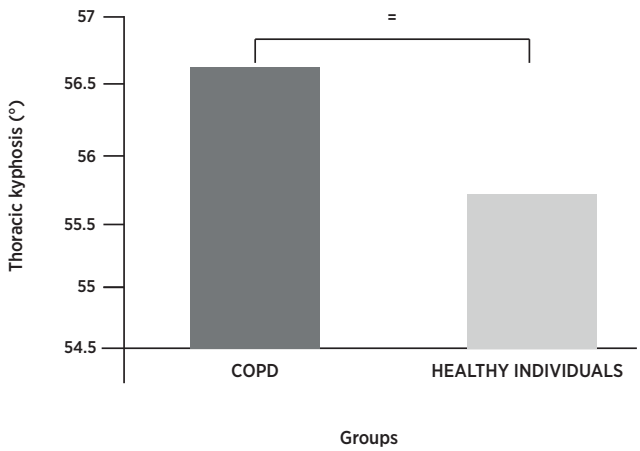
There was a statistically significant difference in all the spirometry variables, especially in forced volume in the first second (FEV_1), which characterizes the presence of COPD. The COPD group showed moderate degree of obstruction, whereas healthy individuals showed spirometry values within the normal range (FEV_1 expected % 50.65±19.08 and 94.05±0 9.44 respectively, p<0.001).

Table 1. Basal characteristics of the studied sample

Variables	COPD (n=37)	Healthy Individuals (n=37)	P
Gender (M/F)	19/18	15/22	–
Age (years)	65.70±7.91	62.49±7.27	NS
Body mass (kg)	73.49±15.54	72.53±13.80	NS
Height (m)	165.70±7.58	163.59±10.84	NS
BMI (kg/m^2)	26.73±5.34	26.97±3.55	NS
FEV1/FVC (L)	0.57±0.12	0.78±0.06	<0.001*
FEV1/FVC (exp %)	72.54±14.92	98.30±7.66	<0.001*
FEV1 (L)	1.46±0.68	2.63±0.62	<0.001*
FEV1 (exp %)	50.65±19.08	94.05±9.44	<0.001*
CVF (L)	2.48±0.83	3.42±0.79	<0.001*
CVF (exp %)	67.84±16.06	96.65±9.59	<0.001*
Thoracic kyphosis (°)	56.67±11.31	55.42±9.61	NS

The values are expressed as mean and ± standard deviation; COPD: Chronic obstructive pulmonary disease; M: male; F: female; BMI (kg/m^2): body mass index in kilograms by meters^2; FEV1 (L): forced expiratory volume in the first second, in liters; FEV1 (exp %): percentage of schedule of the forced expiratory volume in the frist second; FVC (L): forced vital capacity in liters; FVC (exp %): percentage of predicted forced vital capacity; (°): degree. p: * significant difference (p<0.05)

The value of the angle of thoracic curvature in each group is displayed in Figure 2. We observed that there was no significant difference between patients with COPD and healthy individuals in the angle of the thoracic curvature (56.67±11.31; 55.42±9.61 degrees, respectively) (p=0.61), showing similarity in the curvatures.



(p=0.61). = Significance p>0.05

Figure 2. Comparison of the thoracic curvature angle between COPD patients and healthy individuals

DISCUSSION

In this study, the angle of the curvature of the thoracic kyphosis, evaluated by the flexicurve method of the group of COPD patients, was similar to the group of healthy individuals, probably due to the age similarity between the groups. That is because the thoracic hyperkyphosis is a postural change commonly observed and associated with age[23], and we observed that both groups showed aging, a characteristic that can be a determining factor for the increase in the thoracic kyphosis degree.

Few studies have investigated the thoracic kyphosis in COPD patients and compared it with healthy individuals. Our results are consistent with the study of Dias et al.[18], performed with 19 CODP patients and 19 healthy individuals, and they also found no significant differences in the curvature of the cervical and thoracic column regions between the groups. However, our results contrast with those presented in the study of Pachioni et al.[9], with 15 patients with COPD and 15 healthy individuals, in which it was found a statistically significant difference in thoracic kyphosis between the groups.

These differences in results between the studies may be related to the methodology used for the analysis of thoracic kyphosis, since in the study of Pachioni et al.[9], the Postural Evaluation Software (SAPO) (with adaptation) was used to evaluate the thoracic kyphosis. Considering the complexity of the evaluation offered by SAPO, which involves a formula of correction of values proposed by Leroux et al.[25], the authors adapted his method to other studies[22,31], and based on the angle formed between T3/T12, with apex on the most prominent vertebra, to find the degree of thoracic kyphosis. In our study we used the flexicurve method and angles formed between C7 and T12, according to the methodology proposed by Teixeira & Carvalho[22], when analyzing a larger extension of the thoracic spine.

Although the SAPO software is used to evaluate the thoracic kyphosis, it is not considered the most suitable method because of its limitations. According to Leroux et al.[25], this method of evaluation of the vertebral column is particularly vulnerable to evaluate the thoracic kyphosis, since it depends on the placement of markers in specific anatomical landmarks as well as the type of marker used. In addition, the small polystyrene balls used as markers are not visible in lateral view due to the scapula, and there is no standardization on the evaluation technique of the angle of curvature of the thoracic kyphosis.

On the other hand, the flexicurve method is equivalent to the radiographic one (Cobb angle), considered gold standard[22,23,24], and which was validated

in Brazil[22]. This method is considered as a reliable and reproducible tool, and shows good sensitivity and specificity for measuring the thoracic and lumbar curvature, besides having low cost, portability and being a non-invasive method[19,22,23,24,32].

In this study we found that both COPD and healthy individuals do not present serious changes in the angle of the thoracic curvature. The mean of the angles in the COPD group and healthy individuals was 56.67° and 55.42°, respectively. According to Loubresse, Vialle & Wollf[33], more severe angles can affect the ventilatory function. Libby et al.[34] report that more severe thoracic curvatures feature angles above 65°.

One limitation of this study is related to lack of knowledge about the epidemiology of thoracic hyperkyphosis in patients with COPD. Another limitation was the prevalence of patients with moderate degree of obstruction, since more severe obstructions may present greater change in the thoracic cavity. Thus, we need more studies to identify the causes and consequences of changes in the thoracic spine of a patient with COPD.

It is important to highlight the relevance of evaluation of thoracic kyphosis by an easily accessible and practical tool for clinical use. The early detection of changes in the angle of the thoracic curvature will provide an adequate therapeutic approach to prevent late complications caused by severe thoracic hyperkyphosis, mainly regarding losses on the pulmonary function, since patients with COPD have this feature that may be exacerbated.

CONCLUSION

The flexicurve method proved to be a useful and practical tool for assessing thoracic kyphosis, and it also identified no difference between the thoracic curvature of COPD patients with moderate obstruction and of healthy individuals.

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