

# Comparison between the measures of thoracoabdominal cirtometry in supine and standing

*Comparaç o entre as medidas de cirtometria t raco-abdominal realizadas em dec bito dorsal e em ortostatismo*

*Comparaci n entre las medidas de cirtometr a t raco-abdominal realizadas en dec bito dorsal y en ortostatismo*

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**ABSTRACT** | With the objective to evaluate possible differences in the values obtained in the thoracoabdominal cirtometry in orthostatism compared with the results in supine, 30 subjects with mean age  $27.8 \pm 4.4$  years were evaluated according to the following parameters: anthropometry, pulmonary function test and thocacoabdominal cirtometry. Shapiro-Wilk test was used to verify data normality and the *t* test was performed in order to compare the thoracoabdominal cirtometry measurements in supine and in orthostatism positions. There were no significant differences in axillar and xiphoid mobility between measurements obtained in supine and orthostatism. The abdominal mobility measured in orthostatism ( $2.54 \pm 1.39$  cm) was significantly lower (34.35%) when compared to the mobility obtained in supine ( $3.71 \pm 1.78$  cm;  $p < 0.001$ ). The thoracic cirtometry can be performed in orthostatism as an alternative for the evaluation of patients with orthopnea. The abdominal cirtometry can also be performed in this posture, with the expected one-third reduction in the abdominal mobility obtained in supine.

**Keywords** | Evaluation; Thorax; Supine Position.

**RESUMO** | Com o objetivo de avaliar poss veis diferenas nos valores obtidos na realizao da cirtometria t raco-abdominal em ortostatismo comparado com os resultados aferidos em dec bito dorsal, foram avaliados 30 participantes

com m dia de idade de  $27.8 \pm 4.4$  anos, por meio dos seguintes par metros: antropometria, prova de funo pulmonar e mobilidade t raco-abdominal pela cirtometria. O teste de *Shapiro-Wilk* foi utilizado para verificar a normalidade dos dados e o teste *t* pareado para a comparao entre as mensuraes obtidas pela cirtometria t raco-abdominal em dec bito dorsal e em ortostatismo. N o houve diferenas significativas na mobilidade axilar e xifoidea entre as medidas em dec bito dorsal e ortostatismo. A mobilidade abdominal mensurada em ortostatismo ( $2.54 \pm 1.39$  cm) foi significativamente menor (34,35%) em comparao   mobilidade obtida em dec bito dorsal ( $3.71 \pm 1.78$  cm;  $p < 0,001$ ). A cirtometria tor cica pode ser realizada em ortostatismo como uma alternativa para a avaliao de pacientes que referem ortopn a. A cirtometria abdominal tamb m pode ser realizada nessa postura, com a ressalva de ser esperada uma reduo em torno de um tero da mobilidade abdominal obtida em dec bito dorsal.

**Descritores** | Avaliao; T rax; Dec bito Dorsal.

**RESUMEN** | Con el objetivo de evaluar posibles diferencias en los valores obtenidos en la realizaci n de la cirtometr a t raco-abdominal en ortostatismo comparados con los resultados medidos en dec bito dorsal, fueron evaluados 30 participantes con media de edad de  $27.8 \pm 4.4$  a os, por medio de los siguientes par metros:

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antropometría, prueba de función pulmonar y movilidad tóraco-abdominal por la cirtometría. El test de *Shapiro-Wilk* fue utilizado para verificar la normalidad de los datos y el test *t* pareado para la comparación entre las mediciones obtenidas por la cirtometría tóraco-abdominal en decúbito dorsal y en ortostatismo. No hubo diferencias significativas en la movilidad axilar y xifoidea entre las medidas en decúbito dorsal y ortostatismo. La movilidad abdominal medida en ortostatismo ( $2,54 \pm 1,39$  cm) fue significativamente

menor (34,35%) en comparación a la movilidad obtenida en decúbito dorsal ( $3,71 \pm 1,78$  cm;  $p < 0,001$ ). La cirtometría torácica puede ser realizada en ortostatismo como una alternativa para la evaluación de pacientes que refieren ortopnea. La cirtometría abdominal también puede ser realizada en esa postura, con la salvedad de ser esperada una reducción en torno de un tercio de la movilidad abdominal obtenida en decúbito dorsal.

**Palabras clave** | Evaluación; Tórax; Posición Supine.

## INTRODUCTION

Measuring thoracoabdominal mobility has been considered as an important parameter to assess respiratory dysfunctions and to monitor training programs in different populations<sup>1-3</sup>. Several instruments have been used to analyze respiratory patterns<sup>4</sup>, among which are: inductance plethysmography<sup>5</sup>, magnetometry<sup>6</sup>, laser monitors<sup>7</sup> and video image analysis systems<sup>8</sup>. Despite being considered precise to assess the movements of the thoracic wall, these instruments are expensive, which makes their use in clinical practice limited<sup>9</sup>.

Cirtometry, also known as thoracoabdominal perimetry, consists of a set of measurements of thoracic and abdominal circumferences during respiratory movements, and it aims at quantifying the thoracoabdominal mobility in a simple manner, which is accessible and has low cost, therefore, only one metric tape is required for its performance<sup>10</sup>. Malaguti *et al.*<sup>11</sup> conducted thoracoabdominal cirtometry evaluations in 26 patients with Chronic Obstructive Pulmonary Disease (COPD) in 2 different days and with 2 independent observers, and they found high intra and interobserver reproducibility of measurements. The same result was described in the study by Caldeira *et al.*<sup>10</sup>, in which 2 independent observers performed 3 cirtometry measurements in 40 healthy individuals, and they also found high intra and interobserver reliability, which proves that cirtometry is a reproducible method to assess thoracoabdominal mobility.

Even though it is very common in clinical practice, cirtometry is still a method with little scientific investigation; therefore, it is very questioned<sup>12</sup>, since there is no standardization for its conduction. Most studies<sup>10,11,13</sup> uses cirtometry with participants in the supine position, however, a technique with the participants in orthostatic position has recently been described and found good reproducibility among three different evaluators<sup>14</sup>. However, the authors did not demonstrate if this form

of evaluation is different from that conducted with subjects in supine position.

The assessment of cirtometry in the orthostatic position can facilitate the placement of the metric tape around the thorax and the abdomen, besides allowing the evaluation of patients submitted to thoracoabdominal surgeries, obese patients and those with chronic pneumopathy and heart disease, who frequently present with orthopnea. Therefore, it is important to investigate if there are differences in values obtained by thoracoabdominal cirtometry in different postures. The objective of this study was to compare the values obtained after the conduction of thoracoabdominal cirtometry in the orthostatic and the supine positions.

## METHODOLOGY

This is a cross-sectional study. It was approved by the Human Research Ethics Committee (74/2011). All of the participants were previously enlightened as to the study and signed the informed consent form, as established in resolution 196/96 of the National Health Council.

In the laboratory of respiratory physical therapy (LAFIR) at *Universidade do Estado de Santa Catarina* (UDESC), a convenience sample composed of 30 healthy volunteers was assessed. Participants should meet the following inclusion criteria: to present proof of normal pulmonary function and body mass index  $< 30$  kg/m<sup>2</sup>; not being smoker; not presenting cardiorespiratory or neuromuscular conditions, or any other dysfunction that might interfere in the performance of the tests. Exclusion criteria were: inability to perform some of the proposed evaluation measurements for not understanding them or for not cooperating; request to be excluded from the study.

Participants were assessed only one by the same evaluator as to the parameters: anthropometry, proof of pulmonary function and thoracoabdominal cirtometry.

In order to measure body mass, a previously calibrated scale was used. Participants were told to wear light clothes, to take off their shoes before standing on the scale and to remain erect, with their heads facing the front until the measured value was stable. A stadiometer was used to measure height, and participants should also be barefoot, with heels together. After anthropometric values were obtained (body mass and height), body mass index (BMI) was calculated by the following equation:  $\text{body mass/height}^2$  ( $\text{kg/m}^2$ ).

The proof of pulmonary function was conducted with a portable digital spirometer EasyOne (ndd Medical Technologies), previously calibrated, according to the methods and criteria recommended by the American Thoracic Society (ATS)<sup>15</sup>. The following parameters were measured: Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1) and the ration FEV1/FVC. At least three acceptable and two reproducible maneuvers were performed. Spirometric variables were expressed in absolute values and in percentages of the predicted normal values<sup>16</sup>.

The assessment of thoracoabdominal mobility was conducted by the cirtometry with a metric tape (Prim, Ind. Brasil. Korona), in two postures successively: (1) participant in the supine position; and (2) participant in orthostatic position. For the supine position, the participant was placed with 0° inclination, without a pillow, with upper limbs along the body and uncovered thorax. After cirtometry was performed in this position, the participant was asked to stand up, with upper limbs along the body, and the examination was repeated.

In both postures, the circumferences of three anatomical points were measured in the following order: axillary fold, xiphoid process and umbilical line in two different moments: maximum inspiration and maximum expiration. The difference between measurements obtained in maximum inspiration and expiration in each anatomic level was considered as the thoracoabdominal mobility of each measured region. All of the measurements were conducted by the same evaluator, with experience to perform cirtometry, and each measurement was repeated twice in all of the anatomic levels, and the average between the two obtained values was considered.

Data were analyzed with the software SPSS for Windows, version 17.0 (IBM SPSS Statistics, IBM, Armonk, NY, USA) and treated with descriptive

analysis (mean and standard deviation) and inferential analysis. The Shapiro-Wilk test was used to verify data normality and homogeneity of variance. In order to compare the measurements obtained by thoracoabdominal cirtometry in supine and orthostatic positions, the paired t test was used. A 5% significance level was adopted ( $p < 0.05$ ).

Sample size was determined by means of a two-tailed test to calculate the difference of means, according to the following presuppositions obtained by the analysis of the 10 first volunteers: difference between postures for axillary mobility of 0.75 cm; standard deviation of 1.37 cm; test power of 80% and significance level of 5%, suggesting the sample size of 29 individuals.

## RESULTS

Thirty participants were assessed (13 men and 17 women), with mean age of  $27.8 \pm 4.4$  years old. One participant was excluded from the study for presenting altered proof of pulmonary function ( $\text{FEV1} < 80\%$ ). The anthropometric characteristics and the pulmonary function of the participants are described in Table 1. Pulmonary function was within normality parameters (Table 1).

The values of thoracoabdominal mobility are described in Table 2. There was no significant difference of axillary ( $p = 0.55$ ) and xiphoid mobility ( $p = 0.68$ ) between the measurements obtained in supine and orthostatic positions. The abdominal mobility measured in the orthostatic position ( $2.79 \pm 1.79$  cm) was significantly lower (34.35%) in comparison to the mobility measured in the supine position ( $4.25 \pm 2.08$  cm) ( $p < 0.001$ ).

## DISCUSSION

In this study, the thoracoabdominal mobility of healthy individuals was quantified by the supine and orthostatic cirtometry. Results showed that thoracic cirtometry values (axillary and xiphoid regions) were similar in both investigated postures. Considering abdominal cirtometry, a significant reduction of 34.35% was observed in the mobility obtained for the orthostatic position in relation to the one obtained in the supine position.

Cirtometry is a widely used method, easy to execute and with low cost, since only a metric tape is

Table 1. Anthropometric characteristics and pulmonary function of the participants

Variables	Mean±SD (n=29)
Age (years)	27.80±4.40
Body mass (kg)	65.66±13.48
Height (m)	169.31±9.67
BMI (kg/m <sup>2</sup> )	22.73±3.22
FVC (L)	4.25±0.95
FVC (%)	95.52±8.58
FEV <sub>1</sub> (L)	3.51±0.66
FEV <sub>1</sub> (%)	94.24±8.73
FEV <sub>1</sub> /FVC (L)	0.91±0.23
FEV <sub>1</sub> /FVC (%)	107.28±27.64

FVC: forced vital capacity; FEV<sub>1</sub>: forced expiratory volume in the first second; BMI: body mass index; SD: standard deviation

Table 2. Values of thoracoabdominal mobility of the participants assessed in supine and orthostatic position

	Supine position	Orthostatic position	p-value
Axillary mobility (cm)	6.84±1.62	6.33±1.65	0.55
Xiphoid mobility (cm)	5.92±1.81	5.82±1.48	0.68
Abdominal mobility (cm)	4.25±2.08	2.79±1.79	<0.001*

Values are expressed by mean±standard deviation. \*Statistically significant difference was considered when p<0.05

required for its performance<sup>10</sup>. Several studies have used this resource to assess thoracoabdominal mobility, and among the found studies, all of them describe the performance of cirtometry with the individuals placed in the supine position<sup>10,11,13</sup>.

Orthopnea is described as respiratory difficulty that occurs when the patient is in the supine position, being relieved when the person changes to the orthostatic position<sup>17</sup>. This symptom is frequently reported by patients submitted to thoracic surgeries<sup>18</sup>, those with heart diseases<sup>19</sup>, phrenic nerve palsy<sup>20</sup>, pulmonary thromboembolism<sup>21</sup>, morbid obesity<sup>22</sup>, COPD<sup>23</sup> and other pictures of respiratory insufficiency<sup>24</sup>. In these individuals, measuring cirtometry in the orthostatic position can be an option to enable the performance of the examination with less intolerance in comparison to the supine position. In our study, no significant differences were found between cirtometry measurements conducted in supine and in orthostatic positions in the axillary (7.45%) and xiphoid (1.7%) regions. This result may have resulted from the structural architecture of the thoracic cage that sustained the thoracic wall in both analyzed postures, which made thoracic mobility similar. Some authors<sup>25,26</sup> describe that, at rest, in vertical positions (sitting down or orthostatic), the abdomen presents similar complacence to the one of the thoracic wall, and its elastic properties may be altered due to the position changing to more horizontal

levels. Concerning the mobility assessed in the abdominal region, there was significant difference when both postures were compared: the abdominal mobility in the orthostatic position was lower (34.35%) in comparison to the mobility obtained in supine position. Our results corroborate those presented in previous studies, using different measurement instruments to assess abdominal mobility<sup>27,28</sup>. These studies report that the adopted posture during evaluation significantly influenced the mobility of the abdominal wall, both for healthy individuals and those with neuromuscular conditions.

Recently, Magalhães<sup>29</sup> investigated the thoracoabdominal mobility by using the optoelectronic plethysmography in 20 individuals (10 healthy ones and 10 with amyotrophic lateral sclerosis), and observed increased abdominal mobility in the supine position when compared to the sitting position, which corroborates the statement by Verschakelen and Demetes<sup>30</sup>. They stated that, in supine position, people tend to present abdominal breathing. The increased abdominal mobility in the supine position can be explained by the greater displacement of the diaphragm in the craniocaudal direction due to the stronger opposition generated by hydrostatic pressure of the abdomen in the dependent regions. In supine, the weight of the abdominal viscera dislocates the diaphragm in the cephalic direction, reducing the radius of curvature of the diaphragm and consequently generating more mobility due to the more favorable tension-length ratio<sup>31</sup>.

The supine posture has been more used by the researchers, however, facing the limitations to conduct the assessment in the supine position in individuals with orthopnea, there is the proposal to measure the cirtometry of these patients in the orthostatic position. Therefore, the suggestion is that more studies are conducted with thoracoabdominal cirtometry being measured in the orthostatic position, considering that its reproducibility has been confirmed in a previous study<sup>14</sup>.

The main limitation of this study was the absence of random postures to measure the thoracoabdominal cirtometry. The methodological design defined that individuals would have cirtometry assessed firstly in the supine position, and afterwards in the orthostatic position. Therefore, the effect expected for the second assessed posture (orthostatic) would be the possible optimization of results because of the learning effect, which would result in increased movement amplitude. However, it was observed that abdominal

mobility did not present reduction in this posture, which means that indeed the altered complacence of the abdominal section, due to the altered body position, was the main factor responsible for the variation of abdominal mobility.

## CONCLUSION

It is possible to conclude that thoracic mobility values in the axillary and xiphoid regions were similar, both in the orthostatic and in the supine positions. Therefore, the thoracoabdominal cirtometry can be performed in the orthostatic position as an alternative to assess patients who report orthopnea. The abdominal cirtometry can also be conducted in this position, however, a reduction of approximately one third of the abdominal mobility obtained in supine position is expected.

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