

The Effectiveness of Cirtometry in the Assessment of Lung Expansion in Healthy Adults and Elderly: Scoping Review

A Eficácia da Cirtometria na Avaliação da Expansibilidade Pulmonar em Adultos e Idosos Saudáveis: Revisão de Escopo

Thalia Francisca Martins^a; Gabriela Gonzaga Costa^a; Ariane Hidalgo Mansano Pletsch^a; Maristela Prado e Silva Nazario^b; Mariana Nunes de Moura Vargas^c; Walkiria Shimoya-Bittencourt^{cd}

Universidade de Cuiabá, MT, Brasil.

Instituto Cuiabá de Ensino e Cultura, MT, Brasil.

Universidade de Cuiabá, Programa de Pós-Graduação em Ciências Ambientais, MT, Brasil.

Centro Universitário de Várzea Grande, Curso de Medicina, MT, Brasil.

E-mail: walkiria.bittencourt@kroton.com.br

Abstract

Cirtometry is a low-cost and easy-to-handle technique that aims to quantitatively assess thoracoabdominal expansibility. Despite being commonly taught in undergraduate physiotherapy courses, there is no consensus on the standardization of the method, an essential factor that can affect reproducibility and the techniques used. The present study aims to evaluate the effectiveness of the cirtometry technique in the evaluation of pulmonary expansion in adults and the elderly. A Scoping Review was conducted. A search strategy was performed at Pubmed, Lilacs, PEDro and CAPES journal portal. Observational studies were included. Results: The search strategies listed 949 articles, which after removing the duplicates and selection according to the eligibility requirements, totaled 8 articles. Of these, the majority (62.5%) was published in Brazil and all being in adults. The most used regions were axillary, xiphoid and umbilical and positioning in the orthostatic position. The values found were 4 to 7cm of expandability. Cirtometry is an accurate, reproducible and good quality technique for measuring thoracic mobility. However, consensus lacks that it is an accurate technique for providing data on lung volumes, normal values for adult and older adult statistics than on the degree of lung expansibility.

Keywords: Lung Volume Measurements. Respiratory Mechanics. Respiratory Function Test

Resumo

A cirtometria é uma técnica de baixo custo e fácil manuseio que se propõem a avaliar quantitativamente a expansibilidade tóraco-abdominal. Apesar de ser comumente ensinada nos cursos de graduação em fisioterapia, não há consenso quanto a padronização do método, fator imprescindível que pode afetar a reprodutibilidade e confiabilidade da técnica. O presente estudo tem por objetivo avaliar a eficácia da técnica de cirtometria na avaliação da expansibilidade pulmonar em adultos e idosos saudáveis. Foi realizado um estudo de revisão de literatura do tipo Revisão de Escopo (*Scoping Review*). A estratégia de busca foi realizada na Pubmed, Lilacs, PEDro e portal de periódicos da Capes. Foram incluídos estudo observacionais. As estratégias de busca enumeraram 949 artigos, que após a retirada dos duplicados e seleção de acordo com os critérios de elegibilidade, somaram 8 artigos. Destes, a maioria (62,5%) foram publicados no Brasil e sendo todos em adultos. As regiões mais utilizadas foram axilar, xifoide e umbilical e o posicionamento na posição ortostática. Os valores encontrados foram de 4 a 7cm de expansibilidade. A cirtometria é uma técnica precisa, reprodutível e de boa confiabilidade para a mensuração da mobilidade torácica. No entanto, carece de consenso sobre ser uma técnica acurada para fornecer dados sobre os volumes pulmonares e os valores de normalidade para as populações adulta e idosa e sobre o grau de expansibilidade pulmonar.

Palavras-chave: Medidas de Volume Pulmonar. Mecânica Respiratória. Testes de Função Respiratória.

1 Introduction

Physiotherapy has increasingly sought scientific evidence to support its interventions, as well as the methods of evaluation, especially of respiratory function. In this context, the measurement of thoracic and abdominal mobility has become a useful instrument in the evaluation of respiratory dysfunctions^{1,2} and others³⁻⁵, as well as a clinical parameter of pulmonary expandability in exercise protocols^{6,7}. Therefore, cirtometry, due to being a low-cost and easy-to-manage evaluation instrument, is a technique widely used in clinical practice to evaluate thoracic expandability⁸.

Its use consists of measuring the circumference of the chest during breathing, aiming to quantify the thoracoabdominal displacement in a simple and practical way to measure pulmonary expandability⁹. Regarding the technique, there are divergences in the evaluated regions, because some studies choose to evaluate the axillary, xiphoid and basal region, others remove the basal region or add the umbilical¹⁰. In addition, the authors differ on appropriate postural positions, the form of breathing and the use of verbal encouragement during the technique¹¹.

Although it is commonly used and taught in undergraduate courses, there is still a shortage in the literature on the technique

and consensus on the parameters of normality that can hinder its reliability and reproducibility¹². Therefore, the present study aims to evaluate the effectiveness of the cirtometry technique in the evaluation of pulmonary expansion in healthy adults and the elderly. As well as, the parameters of normality during respiratory movements.

2 Material and Methods

A literature review study of the Scoping Review type was carried out, which aims to map the main concepts that are based on an area of knowledge^{13,14}. As well as evaluating the proportion, scope and nature of the research, simplifying and extracting the search data that allow identifying gaps in existing research for data extraction for a possible production synthesis^{15,16}.

Considering the objective of the research, this scope review aims to address the following guiding question: What is the effectiveness of the cirtometry technique to measure pulmonary expandability in healthy adults and elderly?

Observational studies (cross-sectional, cohort, control case) were included, conducted in adults and elderly, without restrictions on the period of publication, and that were available in full for *online access*. It was excluded subjects that did not have relevance for the achievement of the objective, such as in children, diseases and abstracts published in annals. Scoping reviews do not provide for the exclusion of articles according to methodological quality criteria.

To identify the studies, an initial search was performed in the following databases: Us National Library of Medicine (PubMed), Latin American and Caribbean Literature in Health Sciences (Lilacs), Evidence Database in Physiotherapy (PEDro) and Capes Journal Portal (Coordination for Improvement of Higher Education Personnel). The search strategy was carried out with the following descriptors: *Aged, Respiratory Function Tests, Spirometry, Vital Capacity, Efficacy, Lung, Measurements, Lung Compliance, Thoracic*

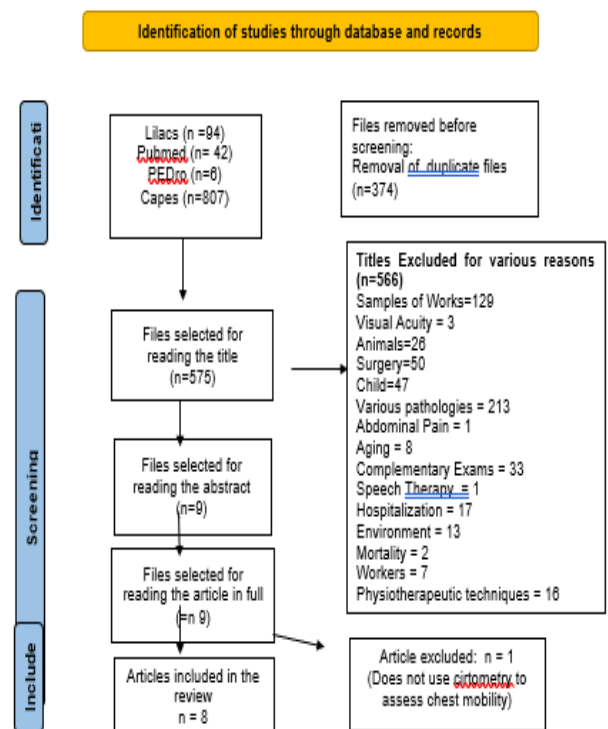
The studies found and included in this review were published between the years 2004 to 2018. Of these, five

Mobility. The keywords were combined with each other using the Boolean operators AND and OR.

3 Results and Discussion

The search strategies enumerated 949 articles, of which 374 were duplicated, totaling 575 titles. Then we proceeded to read the titles, followed by the abstract, ending with nine articles. In the reading stage of the articles, one more was excluded, which did not meet the criteria addressed in the review. Finally, there were eight articles that help to produce the response of the study questioning, as demonstrated in the PRISMA flowchart based on Page et al.¹⁷ (Figure 1).

Figure 1 - Flowchart of the stages of identification, selection, eligibility and inclusion of studies on cirtometry



Source : based on Page et al.¹⁷

(62.5%) were published in Brazil, one (12.5%) in Japan, one (12.5%) in Belgium and one (12.5%) in Argentina (Table 1).

Table 1 - Studies included in the review according to the title, journal and country of publication

Title of Article	Journal	Country	Year
Thoracic mobility assessed in different regions through cirtometry in healthy individuals	Revista Univap	Brazil	2004
Age-related decline in chest wall mobility: a cross-sectional study among community dwelling elderly women	Journal of the American Osteopathic Association	Japan	2015
Reliability and Reproducibility of Chest Wall Expansion Measurement in Young Healthy Adults	Journal of Manipulative and Physiological Therapeutics	Belgium	2016
Comparison between the measurements of thoracoabdominal cirtometry performed in dorsal decubitus and orthostatism	Fisioterapia e Pesquisa	Brazil	2013

Continued..

Reliability of the measurement of thoracic cirtometry as an evaluation method in healthy individuals	Revista Movimenta	Brazil	2016
Thoracic mobility: reliability of cirtometry	Life Style Journal	Brazil	2018
Precision and accuracy of cirtometry in healthy adults	Jornal Brasil Pneumologia	Brazil	2007
Analysis of chest mobility and respiratory muscle strength in young adults	EFDeportes.com, Revista Digital	Argentina	2012

Source: research data.

The characteristics of the studies included in the review regarding cirtometry are presented in Table 2.

Table 2 – Characteristics of the studies included in the scoping review

Author Year	Type of Study	Partici-pants sex and age	Measures and resour-ces	Points evalua-ted	Comple-tion of the technique	Position	Comparison	Results in cm and volume
	Cross-sectional study	N = 137 70 men and 70 women from 18 to 25 years old	Mobility - cirtometry	Axillary, xiphoid, basal and umbilical	Maximum inspira-tion for maximum expiration	Orthos-tatic	Axillary, xiphoid, basal and umbilical region	The avera-ge thoracic mobility in the four regions is around 3 to 7 cm
Bezerra et al. 2012	Descriptive study	N= 50 25 men 25 women being 36 sedentary and 14 active from 25 ± 0.59 years	Cirtometry and ovacuometry	Axillary, xiphoid and abdominal (basal)	Maximum inspira-tion for maximum expiration	Orthos-tatic	Cirtometry and mano-vacuometry (Pimáx and Pemáx) between the sexes and active and sedentary.	The axillary and xiphoid amplitude values were around 4-7 cm. Muscle strength in active men has an influen-ce on lung capacity and volume
Pedrini et al. 2013	Cross-sectional study	N = 30 13 men and 17 women with an average age of 27.8±4.4 years	Mobility - cirtometry	Axillary, xiphoid and umbilical	Maximum inspira-tion for maximum expiration	Dorsal decubitus and in orthostatic position	Axillary, xiphoid and umbilical in orthostatic and dorsal decubitus	Abdominal mobility in orthostatic was lower (2.79±1.79), while in dorsal decubitus (4.25 ± 2.08 cm).
Adachi et al. 2015	Observational and cross-sectional study	N= 132 132 women from 65 to 80 years old	Mobility - cirtometry Pulmonary function - spirometry	Axillary, xiphoid and basal	Maximum inspira-tion for maximum expiration	Not described	The rela-tionship among chest wall mobility, respiratory function and age	There was a significant difference in the axillary region and respiratory function. The reduction of CVF followed that of thoracic mobility.

Continued...

Silva et al. 2016	Observational and cross-sectional study	N = 23 17 women and 6 men from 18 to 30 years old	Mobility - cirtometry	Axillary, xiphoid and umbilical	Maximum inspiration for maximum expiration	Orthostatic	Thoracic mobility intra-evaluator and inter-evaluator compared	Among the techniques, the values were significant for males and females in all regions evaluated.
Caldeira et al. 2007	Cross-sectional study	N= 40 9 men and 31 women with age between 21 to 50 years	Mobility - cirtometry	Axillary, xiphoid and umbilical	Rest for maximum inspiration for maximum expiration	Dorsal decubitus	Intra-evaluator and inter-evaluator compared thoracic mobility and corelated cirtometry and plethysmography	Presence of significant differences, making the technique reproductive and reliable
Debouche et al. 2016	Cross-sectional study	N= 53 27 men and 26 women with age between 18 to 39 years	Mobility - cirtometry Pulmonary function - spirometry	3rd intercostal space and xiphoid process.	Maximum inspiration for maximum expiration	Orthostatic	Superior and inferior thoracic mobility compared intra-evaluator and inter-evaluator and pulmonary function	The upper region had expansibility of 5.4cm and the lower region was 6.4cm
Carpes et al. 2018	Cross-sectional study	N = 23 women from 19 to 30 years	Mobility - cirtometry	Axillary, xiphoid and basal	Maximum inspiration for maximum expiration	Sedestation	Mobility through intra- and inter-evaluators technique	Little variability among evaluators

Source: research data.

Lehmkuhl *et al.*¹⁰ assessed in their study the thoracic mobility through cirtometry by measuring axillary, xiphoid, basal and umbilical regions in 70 men and 70 women in the orthostatic position. They concluded that normal values for a young adult are around 3 to 7 cm of displacement and that the inclusion of the umbilical region provides data of the abdominal compartment. However, the lack of standardization entails different ways of performing the technique, leading to different results for interpretation. Further, they suggest that cirtometry should be performed more carefully. But they did not specify the criteria for measuring the measures.

On the other hand, Carpes *et al.*¹² through the inter-evaluator and intra-evaluator technique, the pulmonary expansibility was measured in the position of sedestation in the axillary, xiphoid and basal regions. The authors suggest that the criteria that can be standardized to assist the reproducibility of the technique are the evaluator's voice command and the management of the tape measure, since the physical structure and intrinsic factors of the individuals cannot be modified. Thus, the authors indicate that even if the technique is performed by individuals with little practice, provided that it is performed in a methodical and standardized way, it is reliable. They observed that there was good reproducibility intra and extra-evaluators, and that the training of the method did not influence the results of the respiratory coefficient, which is given by the difference of a maximum inspiration between a maximum expiration.

Divergent from the authors mentioned earlier, Pedrini *et al.*⁸ chose to evaluate and compare the axillary, xiphoid and umbilical regions in the dorsal decubitus and in orthostatic position. In addition, they recommend that cirtometry should be performed in orthostatism for evaluation of patients who refer to orthopnea. Finally, they concluded that there was no significant difference when the axillary and basal regions are compared. This fact can be justified due to the structural formation of the chest that maintained the support in both postures. However, in the umbilical region there was a significant reduction of 34.35% in mobility obtained in orthostatism compared to that obtained in dorsal decubitus position. There was a reduction in mobility in this posture, due to the alteration of compliance of the abdominal compartment, caused by the alteration of body positioning, which was the main factor responsible for the variation of abdominal mobility.

On the other hand, Bezerra *et al.*¹⁸ evaluated the expansibility in the axillary, xiphoid and basal region in the orthostatic position in 25 men and 25 women, comparing between active and sedentary individuals and between the sexes. Regarding cirtometry, regardless of sex and physical conditioning, the expansibility of the axillary and xiphoid region varies from 4-7 cm of displacement, being considered larger when compared to the measurement of the basal region. This fact can be explained by the action of the accessory muscles of inspiration, whose most of the insertions are in

the chest, justifying the reduced expansion of the abdomen compared to the chest.

In the study by Adachi *et al.*¹⁹ in elderly women, participants were divided into 4 groups according to age group. They evaluated pulmonary function through spirometry and thoracic mobility using cirtometry. They chose to measure the axillary, xiphoid and basal regions. They compared the differences in the thoracic wall and spirometric parameters among women in the four age groups. Significant differences were found in the axillary region and pulmonary functionality according to age, as a result of the aging process, which causes physiological changes in the lungs, upper airways, decreased respiratory muscle function and chest wall complacence. The results suggest that decreased thoracic wall mobility accompanied the decrease in forced vital capacity. Thus, they concluded that cirtometry and spirometry are useful methods to evaluate thoracic function and expandability in the elderly. However, they did not address the displacement/expansibility values of cirtometry in relation to the volume and capacity values of pulmonary function.

Silva *et al.*¹¹ evaluated the mobility of the axillary, xiphoid and umbilical region by cirtometry comparing intra-evaluator and inter-evaluator techniques in the orthostatic position. Regarding intra-evaluator reliability, cirtometry is considered reproducible. However, in inter-evaluators reliability there was a significant difference, however, it was not higher than 1.8cm on average. This fact was due to the type of approach of the evaluators such as verbal command, positioning of the tape and even in relation to the respiratory properties of the participant in the case of mobility. In short, the study found that cirtometry is a reproducible technique obtaining accurate measurements.

However, Caldeira *et al.*⁹ in their study evaluated thoracic expansibility through cirtometry, axillary, xiphoid and umbilical points in dorsal decubitus and compared using intra-evaluator and inter-evaluator techniques. They also correlated the measurements measured by cirtometry with the pulmonary volumes measured with the plethymography. They obtained the following results: Intra-examiner reliability is considered adequate, however, in the analysis of inter-evaluators reliability there are significant differences of no more than 2.8cm displacement. Further, the authors conclude that cirtometry is not an accurate technique for measuring pulmonary volumes such as plethymography.

Although, Debouche *et al.*²⁰ assessed mobility through cirtometry in the third intercostal space and xiphoid process, compared upper and lower thoracic mobility through interevaluator and intra-evaluator techniques in the orthostatic position. They correlated cirtometry with pulmonary functionality measured through spirometry. The upper region had expansibility of 5.4cm and the lower region was 6.4cm In addition, cirtometry is a technique with good reproducibility and reliability. The authors conclude that the measurement of the upper region is useful to evaluate thoracic expandability

and provide indirect information on respiratory muscle function, volume and strength.

4 Conclusion

This study mapped in the literature studies which addressed the effectiveness of the cirtometry technique in the evaluation of pulmonary expansion in healthy adults and the elderly. It was found that cirtometry is a precise, reproducible and reliable technique for the measurement of the chest mobility reflecting the pulmonary expansibility. In addition, it can indirectly evaluate muscle strength and respiratory function. Standardization of the technique is essential to provide reliable values. However, consensus lacks that it is an accurate technique for providing data on lung volumes, normal values for adult and older adult statistics than on the degree of lung expansibility

References

1. Rondeli RR, Souza LM, Domingues M, Malaguti C, Corso SD. Mobilidade torácica (pela cirtometria de tórax) e sua relação com a função pulmonar em pacientes com doença pulmonar obstrutiva crônica e controles saudáveis. *Rev Ter Man* 2009;7(31):154-60.
2. Rodrigues, CP Alves LA, Matsuo T, Gonçalves AG, Hayashi D. Efeito de um programa de exercícios direcionados à mobilidade torácica na DPOC. *Fisioter Mov* 2012;25(2):343-9. doi: 10.1590/S0103-51502012000200012
3. Tascua C, Schusterb R, Alvarenga LFC. Força muscular respiratória e mobilidade torácica em portadores de doença de parkinson. *Rev Atenção Saúde* 2014;12(42):5-10. doi: 10.13037/rbcs.vol12n42.2275
4. Pascotini FS, Fedosse E, Ramos MC, Ribeiro VV, Trevisan MR. Força muscular respiratória, função pulmonar e expansibilidade toracoabdominal em idosos e sua relação com o estado nutricional. *Fisioter Pesq* 2016;23(4):416-22. doi: 10.1590/1809-2950/16843223042016
5. Veloso AP, Cusmanich KG. Evaluation of the thoracoabdominal mobility of obese subjects in pre-bariatric surgery. *Arq Bras Cir Dig* 2016;29:39-42. doi: 10.1590/0102-6720201600S10011.
6. Jesus LT, Baltieri L, Oliveira LG, Angeli LR, Antonio AP, Pazzianotto-Forti EM. Efeitos do método Pilates sobre a função pulmonar, a mobilidade toracoabdominal e a força muscular respiratória: ensaio clínico não randomizado, placebo-controlado. *Fisioter Pesq* 2015;22(3):213-22. doi: 10.590/1809-2950/12658022032015
7. Moreira WEM, Cassimiro MS, Sales ACM, Pires RLCC, Carvalho PMM. Comparação do pico de fluxo expiratório e a cirtometria torácica entre idosas, antes e após a realização de fisioterapia respiratória. *Rev Bras Ciênc Saúde* 2020;24:141-52. doi 10.22478/ufpb.2317-6032.2020v24nSupl. 2.39669
8. Pedrini A, Gonçalves MA, Leal BE, Yamaguti WPS, Paulin E. Comparação entre as medidas de cirtometria tóraco-abdominal realizadas em decúbito dorsal e em ortostatismo. *Fisioter Pesq* 2013;20(4):373-8. doi: <https://>

doi.org/10.1590/S1809-29502013000400012

9. Caldeira VS, Starling CCD, Britto RR, Martins JA, Sampaio RF, Parreira VF. Precisão e acurácia da cirtometria em adultos saudáveis. *J Bras Pneumol*. 2007;33(5). doi: <https://doi.org/10.1590/S1806-37132007000500006>
10. Lehmkuhl E, Neves FM, Panizzi EA, Pamplona CMA, Kerkoski E. A mobilidade torácica avaliada em diferentes regiões através da técnica de cirtometria em indivíduos saudáveis. *Rev Univap* 2004;1589-1592.
11. Silva LP, Alves JÁ, Póvoa TIR, Silva-Hamu TCD. Confiabilidade da mensuração da cirtometria torácica como método de avaliação em indivíduos saudáveis. *Rev Mov* 2016;9(3):451-9.
12. Carpes MF, Simon KM, Souza AR, Santos GV, Castr AAM, Dittrich R. Mobilidade torácica: confiabilidade da cirtometria. *Lifestyle J* 2018;1(5):61-75. doi: <http://dx.doi.org/10.19141/2237-3756>
13. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implementation Scie* 2010;5:69.
14. Armstrong R, Hall BJ, Doyle J, Waters E. Scoping the scope' of a cochrane review. *J Public Health (Oxf)* 2011;33(1):147-50. doi: 10.1093/pubmed/fdr015
15. Peters MDJ. Scoping Reviews. In: Aromataris E, Munn Z. Joanna Briggs Institute Reviewer's Manual. 2017. Available from <https://reviewersmanual.joannabriggs.org/>
16. Alexander L, Aromataris E, Barber N, Barker MUNN Z. JBI Manual for Evidence Synthesis. JBI, 2020. doi: <https://doi.org/10.46658/JBIMES-20-01>
17. Page MJ, Mckenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al*. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372. doi: 10.1136/bmj.n71.
18. Bezerra RO, Santos-Júnior FFU, Campos NG. Análise da mobilidade da caixa torácica e da força muscular respiratória em adultos jovens. *EFDeportes* 2012;17(175):1-1.
19. Adachi D, Yamada M, Nishiguchi S, Fukutani N, Hotta T, Tashiro Y, Morino S, *et al*. Age-related decline in chest wall mobility: a cross-sectional study among community-dwelling elderly women. *J Am Osteopath Assoc* 2015;115(6):384-9. doi: 10.7556/jaoa.2015.079.
20. Debouche S., Pitance L, Robert A, Liistro G, Reychler G. Reliability and reproducibility of chest wall expansion measurement in young healthy adults. *J Manipulative Physiol Ther* 2016;39(6):443-9. doi: 10.1016/j.jmpt.2016.05.004.