Reliability and Reproducibility of Chest Wall Expansion Measurement in Young Healthy Adults

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Abstract

Objective: The purposes of this study were to (1) evaluate the reliability and reproducibility of chest expansion (CE) measurement on 2 different levels and (2) observe relationships between upper and lower CE measurements and lung function.

Methods: Fifty-three healthy subjects aged between 18 and 39 years were recruited. Chest expansion measurements were taken with a cloth tape measure at 2 levels of the rib cage (upper and lower). Reproducibility of the measurement was measured for 2 physiotherapists and on 2 different days. Lung function (ie, forced expiratory volume in 1 second [FEV1], forced vital capacity (FVC), vital capacity and, inspiratory capacity) was measured for all subjects by a spirometer (MEC Pocket-spiro USB100, Medical Electronic Construction, Brussels, Belgium).

Results: Upper CE was less than lower CE (5.4 cm and 6.4 cm, respectively; $P < .001$). Intrarater and interrater reliability were good for upper and lower CE. Reproducibility between physiotherapists was verified for both CE measurements. Reproducibility between days was only verified for upper CE. Sex influenced lower CE. Upper and lower CE values were correlated ($r = 0.747$; $P < .01$). Lower and upper CE were significantly and positively correlated with all lung function parameters and inspiratory muscle strength (moderately and weakly, respectively) except to inspiratory capacity for upper CE ($P = .051$) and for FEV1/FVC for both CE measurements.

Conclusion: Upper and lower CE measurements showed good intra- and interrater reliability and reproducibility in healthy subjects. Although both measurements were correlated with lung functions (ie, FEV1, FVC, and vital capacity), the findings of this study showed that upper CE measurements may be more useful in clinical practice to evaluate chest mobility and to give indirect information on lung volume function and inspiratory muscle strength.
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Introduction

Patients with respiratory problems may present with abnormalities in chest biomechanics or with physical alterations of the chest wall such as chest stiffness.[1] Rib cage mobility might be decreased[2] as a consequence of airway obstruction in some respiratory diseases such as chronic obstructive pulmonary disease (COPD) and asthma. Valuable, simple, inexpensive, and reproducible methods of evaluation are needed to observe these alterations.

Moll described the measurement of chest expansion (CE) in 1972.[3] This measurement has been used in evaluation of patients with different disease conditions (eg, ankylosing spondylitis,[4,5] asthma,[6] COPD,[6] and thoracic scoliosis[7,8]) and has been used to measure the effect of different physical treatments such as respiratory muscle stretching[9] and respiratory muscle endurance training.[10]

Chest expansion may be used to measure rib cage mobility and was found to be related to lung volume.[2]

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Traditionally, CE is calculated by measuring the difference between thoracic girth after maximal inspiration and at the end of maximal expiration.[11] Several anatomical markers have been used to measure upper and lower CE which has contributed to differences in interpretation. These include the fourth intercostal space,[3,5,12] fifth thoracic vertebrae and axillary line,[2] and the 10th thoracic vertebrae and xiphoid process.[13]

Even though CE has been regularly mentioned in the literature, its measurement properties have been poorly investigated. Moreover, no standardization of measurement procedure seems to exist. Chest expansion seems to be heterogeneous, varying with diseases and comprising between 4 cm^3 and 7 $cm^{14,15}$ in healthy subjects. The normal range of CE tends to decline with age (decline up to 50%-60% between ages 15 and 75 years) and to be 20% greater in men.[3]

At present, there are no studies that combine analysis of the reliability and reproducibility evaluation of upper and lower CE and the relationship of both measurements with lung function parameters and inspiratory muscle strength in a group of healthy subjects. Therefore, the primary aim of this study was to evaluate inter- and intrarater reliability and reproducibility of CE measurement on 2 different levels and the relationship between upper and lower CE measurements and lung function (ie, forced expiratory volume in 1 second [FEV1], forced vital capacity [FVC], vital capacity [VC], and inspiratory capacity [IC]).

Methods

Subjects

For this preliminary study, 53 healthy subjects between 18 and 39 years old were recruited from among the staff of the pulmonology unit of the hospital. The inclusion criteria were as follows: body mass index within normal values (ie, 19-25 kg/m^2), absence of respiratory or neuromuscular disease, musculoskeletal disorders, or another situation-altering respiratory mechanics. Exclusion criteria included being incapable of allowing measurements and inability to follow instructions. Subjects were asked about smoking and sports habits. Subjects were arbitrarily considered to be physically active if they were exercising for more than 2 hours per week. A written informed consent was obtained from all participants and the experiment was approved by the Institutional Medical Ethics Committee of Cliniques universitaires Saint-Luc before the beginning of the study in 2010.

CE Measurement

Chest expansion was measured with a cloth tape at 2 different levels of the rib cage (Fig 1). The anatomical marks for upper thoracic expansion were the third intercostal space, the middle of the clavicular line, and spinous process of the fifth thoracic vertebrae. The anatomical marks for lower thoracic expansion were the xiphoid process and spinous process of the 10th thoracic vertebrae. A measurement was performed on the subjects by 2 different physiotherapists (E1 or E2) on 2 separate days (T1 cycle and T2). When performing the measurements, each physiotherapist was alone with the patient. The other physiotherapist was blinded. The assessor was blinded when analyzing the results.

The breathing instructions given to the subjects were standardized. Before the thoracic measurement, subjects were asked "to inhale slowly through the nose and to push against the tape measure to expand the lungs as much as you can." Then the participants were asked "to breathe out completely through the mouth." Measurements were taken at the end of a complete inspiration and expiration cycle.

Measurements were taken with the participants in standing position with their arms along the body. The physiotherapists placed the "0" of the cloth tape measure on the appropriate vertebrae. The cloth tape was held with an index finger between the participant's body and the cloth tape (Fig 1), without generating any deformation or cutaneous folds. The inspiratory diameter was subtracted from the expiratory diameter to calculate the CE value.

Intra- and interrater reliabilities were evaluated by repeated measurement by 1 physiotherapist on 2 separate days (E1T1 vs E1T2) and by 2 physiotherapists on the same day (E1T1 vs E2T1). Reproducibility was evaluated for lower and upper CE separately: CE measurement was compared between 2 physiotherapists on the same day (E1T1 vs E2T1) and for 1 physiotherapist on the same day (E1T1 vs E2T2).

Lung Function

Lung function was measured by a spirometer following the American Thoracic Society and European Respiratory Society guidelines[16] using the MEC Pocket-spiro USB100 (Medical Electronic Construction, Brussels, Belgium). Measurements were made of VC, FVC, FEV1, IC. Patients were seated for all measurements and at least 3 maneuvers were performed for each. Predicted values for lung function parameters were calculated according to European Community for Coal and Steel.[17] Three measurements were recorded in the same order for each participant: static measures (ie, VC and IC), dynamic measures (ie, FEV1, FVC, and FEV1/FVC), and maximal inspiratory pressure. Before any lung function measurement, instructions and a demonstration were given to the participants.

Statistical Analyses

Statistical analyses were performed with SPSS 20.0 (IBM-SPSS Inc, Armonk, NY). Values were expressed by mean and standard deviation.