Original Article

Intrarater Reliability of Chest Expansion using Cloth Tape Measure Technique

Mohan V[1] , Dzulkifli NH[2], Justine M[3], Haron R[4], H LJ[5], Rathinam C[6]

Abstract

Objective: The Objective of this study was to determine the intrarater reliability of chest expansion at three different anatomical landmarks using a cloth tape measure among healthy peoples. ***Materials and Methods:*** 120 healthy male and female volunteers were evaluated on two occasions in different days. The measures consisted of chest expansion measurement at axilla, fourth intercostals and xiphoid levels. The measurements were taken in the standing position with the arms hanging sideways at all the three different anatomical landmarks. The test-retest reliability of the measurements was determined by intraclass correlation coefficient (ICC) and standard error of measurements (SEMs). ***Results:*** An acceptable reliability was determined by ICC values greater than than 0.85 and SEMs less than 5%. The mean age of the subjects was 21.93 years. ICC of all measures ranged between 0.95 to 0.97 and SEMs were 1.9%, 1.8%, 1.5% at the axillary, fourth intercostals and xiphoid level respectively. ***Conclusions:*** The findings of this study suggested that, the cloth tape measurement was reliable at all the three different anatomical landmarks of the chest wall. Therefore, this measurement technique could be used as an outcome measure for chest expansion in the management of cardiorespiratory conditions.

Key Words: intrarater reliability; chest expansion; axillary, fourth intercostals, xiphoid.

Introduction

Breathing is a physiological process that includes inspiration and expiration[1]. Neurological[2], neuro-musclular[3], cardiorespiratory[4] and other illnesses affects and alters breathing. When lungs expands and contracts it influences the mobility of the chest through the diaphragm and intercostals muscle attachments[5]. A change in the chest excursion because of restricted chest wall mobility has an impact on lung volumes and capacities in those conditions[2,3,4]. Such changes were objectively measured with spirometer which is uncommon to be used in the regular clinical practice. Therefore, the clinicians require a simple and inexpensive technique which is easy to learn and apply in their routine clinical practices. Cloth tape measurement (CTM) technique is a common practice employed to measure chest excursion by the health care professionals[6,7] and this has been used over a decade for objective measurement in various clinical conditions[6,7,8].However, measurement techniques at different levels warrant reliability testing of this technique.

The Chest wall excursion was measured with CTM at various anatomical landmarks to represent upper, middle and lower chest wall mobility. Fisher, Cawley & Holgate, 1990; Sahin et al., 2004, used the fourth intercostals space in ankylosing spondylitis and primary fibromyalgia respectively[9,10]. Ide et al., 2005, favored axillary and xiphoid level in chronic

1. Dr Vikram Mohan, MPT. Department of Physiotherapy, Faculty of Health Sciences, UniversitiTeknologi MARA, PuncakAlam, Selangor, Malaysia.
2. Nurul Hafizah Dzulkifli, BPT. Department of Physiotherapy, Faculty of Health Sciences, UniversitiTeknologi MARA, PuncakAlam, Selangor, Malaysia.
3. Maria Justine, PhD. Department of Physiotherapy, Faculty of Health Sciences, UniversitiTeknologi MARA, PuncakAlam, Selangor, Malaysia.
4. Rohani Haron, MSc. Department of Physiotherapy, Faculty of Health Sciences, UniversitiTeknologi MARA, PuncakAlam, Selangor, Malaysia.
5. Leonard Joseph H, MSPT. Physiotherapy Program, Faculty of Allied Health Sciences, UniversitiKebangsaan Malaysia, Kuala Lumpur, Malaysia.
6. Chandrasekar Rathinam, MPT. Physiotherapy department, Ida Darwin, Fulbourn, Cambridge, United Kingdom.

Corresponds to: Vikram Mohan, MPT, Lecturer in Physiotherapy, Department of Physiotherapy, Faculty of Health Sciences, Universiti Teknologi Mara, Puncak Alam Campus- 42300, Bandar Puncak Alam, Selangor Malaysia, *E-mail:* mohanvikram2001@yahoo.com

obstructive pulmonary diseases [11]. A reliability study by Bockenhauer, Chen, Julliard & Weedon, 2007 carried out on six healthy subjects showed intraclass coefficients (ICC) for upper and lower thoracic excursion ranged from 0.81 to 0.91 at upper thoracic and lower thoracic excursion measurements. ICCs were 0.99 and greater when inhalation and exhalation were considered separately [12]. Similarly, an intrarater reliability study carried on twenty-two subjects with ankylosing spondylitis and twenty five healthy subjects at the xiphoid showed ICCs was good (0.85 to 0.97) across the occasions [13]. The findings of the previous studies suggest that the reliability testing on CTM are performed on different populations and with small number of subjects. It indicates that a separate study on the reliability procedures on CTM will be beneficial for standardization of clinical practice.

The common landmarks proposed to measure chest wall mobility in the literature were in the xiphoid process, fourth intercostals, axillary, upper and lower thoracic levels to decide upper, middle and lower thoracic wall mobility respectively. Selecting these sites take over an advantage of representing different lobes' elasticity in the lungs. For instance, the axilla marks the upper lobe, the fourth intercostal space marks the right middle and left lingular lobe (Scot Irwin & Stephen Tecklin, 2004), while the xiphoid level notes both the lower lobes. The estimate technique proposed to measure chest excursion was by holding the tape measure horizontally at the xiphoid level by using a grid as a guide in two different arm position such as hands on head and arms at side [14]. Another way, recommended to measure upper thoracic excursion was assessed by placing the tape measure at the fifth thoracic spinous process and the third intercostals space at the midclavicular line [12]. Similarly, the tape measure was placed at the 10th thoracic spinous process and at the tip of the xiphoid process for the lower thoracic excursion with hand crossed technique for holding the tape [12]. Anatomic markers marked the reference points for tape placements [12].

Despite the advantage and the significance of using these landmarks to measure chest excursion, all these sites were not collectively measured in the routine clinical practice. This could be because of variations in measurement strategies and the intrarater

reliability values possibly confusing graduate students and novice clinicians while learning the measurement techniques [12, 13]. All the related existing studies use small sample size measured at one or two levels by the assessors with more experience or expert clinicians [12,13]. To our knowledge no study is available examining the intrarater reliability of CTM in chest wall excursion at three different sites collectively measured by the graduate students of health care profession while at training. Therefore, this study aims to address issues by researching the intrarater reliability of chest excursion measurement at the axillary, 4th intercostals and xiphoid levels using a cloth tape with larger samples assessed by the students while at training.

Methods
Study design
This study was a test-retest reliability design in determining chest expansion in three different anatomical levels among healthy peoples.
Subjects
Subjects were recruited from the faculty of health science program which comprised of 120 (60 males and 60 females) healthy people with a mean of 21.93 and standard deviation of 1.733. The criteria for selection used were as follows: being a volunteer, regardless of gender; being between the ages of 18 to 29; and presenting no signs and symptoms of respiratory disease and postural abnormalities. The Institutional ethics committee approved the study, and a written consent was obtained from each individual.

Experimental measurements
A final year student who was at training level measured thoracic circumference at peak inhalation and peak exhalation for each of the subjects on two occasions. To measure the readings in centimeters, the examiner used "Hands-crossed" technique with the help of cloth tape measure [12].

Initially the study subjects were asked to stand erect with arms at the side. Upper body for the male subjects was naked Haque M, Faruquee MH, Lahiry S, Tasnim S, Yasmin R, Yasmin N, Chaklader MA whereas female subjects wore a bra. A ballpoint pen marked the anatomical landmark such as fourth intercostal space and xiphoid . Examiner held the tape to make sure, the contour of the skin remained

unchanged.

Measurement of chest expansion was taken on two occasions. The examiner took measurements successively while the subjects held their breath during the inhalation and exhalation. One daytime period secured between the occassions

CTM held around the circumference of the chest at one of three levels. For the upper thoracic excursion, the tape measure was placed in the axillary region. For the midthoracic excursion and lower thoracic excursion, the tape measure was placed at the fourth intercostals and at the xiphoid process level. An average of three trials reading measured on each occasion and an assistant entered all the readings directly into the Microsoft excel data sheet . In order to minimize the errors the system of entering data into the Microsoft excel was adopted.

Data analysis

SPSS version 16.00 statistical packages analyzed the data. SPSS data sheet imported all averaged data from Microsoft excel spreadsheet. The test-retest variability was determined by an Intraclass correlation coefficient (ICC), Standard error of the mean (SEM) and through the standard error of measurement (SEMs) for all three levels of anatomical landmarks selected. The statistical significance was set at $P < 0.05$. SPSS statistical package earned the results of the ICC, and the calculation of SEMs values were gained from (Khamwong, Nosaka, Pirunsan, Paungmali, 2010) in order to know the precision of the measurement . The ICC values of 0.80-0.89, and greater than 0.90 were considered as good and high in reliability and SEMs value of less than 5 % is considered as reliable [16].

Results

Table I, shows the mean, standard deviation, SEM and SEMs for all measures. SEMs of all the anatomical landmarks were reliable as the values are less than 5 %. Intraclass correlation coefficient (ICC) a two-way mixed model employed for intrarater reliability.

Table I: Mean, Standard deviation (SD), Standar Error of Mean(SEM), Standard Error of Measurements (SEMs) of Chest expansion in cm on both occassions

	Mean	SD	SEM	SEMs
Axillary	2.8750	1.18849	.07672	0.26 (1.9%)
Fourth ICS	2.9658	1.36963	.08841	0.36 (1.8%)
Xiphoid	3.0685	1.46007	.09425	0.25 (1.5%)

As shown in Table II, the ICCs for the fourth intercostals measurement ranged from 0.90 to 0.95 across occasions with P <0.001 and axillary level, the ICCs ranged from 0.90 to 0.95 across occasions with P <0.001. Similiarly the ICCs for the xiphoid level chest expansion measurement ranged from 0.95 to 0.97 across occasions with P <0.001.

Discussion

This study used ICC, SEMs to assess the reliability of chest wall expansion at three anatomical levels of the chest in an attempt to use the measures to examine the effectiveness of an intervention in both clinical and research settings such as investigating the effect of chest and manual therapy intervention on the chest wall. The results showed that all the three levels of measurement were reliable (Table I, Table II).

Intrarater reliability measures the consistency of a tests' score respect to time and the evaluator. In this study cloth tape measurement considered as one of the inexpensive measures for objective measurement of chest expansion to measure the consistency. Chest expansion measurement scores are averaged for this study as suggested by Keating, therefore data are made to be more stable [17].

The results of the present study suggest that the cloth tape measure has relative test-retest reliability which is inconsistent with the study done by Bockenhauer et al., 2007, Sharma et al., 2004 [12,13]. The ICC for the present study across the occasions was 0.93 to 0.97 compared with (ICC = 0.81 to 0.84) (Bockenhauer et al., 2007) and (ICC = 0.85 to 0.97) [13]. However, these ICCs were obtained on xiphoid level and an upper and lower thoracic measurement. Therefore, the

study results are better for clinicians as well as novice clinicians to refer.

Helliwel and roberts also reached an agreement which was in conjunction with the current study that chest expansion was reliable [18,19]. However, direct agreement with the results of the present study was not possible because of the population, as all the studies are carried out on ankylosing spondylitis. But then this study was succeeded on young healthy population.

In the current study, the intrarater reliability measurement, were made with large number of samples with equal contribution of the genders, when compared to the earlier studies [12,13]. Therefore, it can be said this study contributes to high test-retest reliability when compared to other studies with small sample size. In contrast, Fisher et al, 1990, found the Chest expansion measurement was unreliable [9]. Even though it was inferred as unreliable measure, comparison with the present study was not possible as the levels of measurement and study population differs.

To measure of chest expansion in the present study we have included axillary, fourth intercostal space and xiphoid with the arms being positioned at the side. A previous trial showed fair to high reliability on arms at the side position (ICC= 0.78 to 0.96) and hands on head position (ICC=0.86 to 0.97) while measuring chest expansion (Sharma et al., 2004), but the later study was carried out only on xiphoid level to measure chest expansion. The study by Sharma, Senju & William, 2003, found no significant difference between groups on the chest expansion when two different arm positions were used [20]. So, the arm at side position was preferred while measuring chest expansion measurement protocol in the present study, as it was considered to be comfortable for the subjects.

About the levels of measurement earlier study done by Sharma, measured xiphoid level by positioning the arms above the head and on the sides and

Bockenhauer used third intercostals, fifth thoracic spinous process for measuring upper thoracic excursion and for the lower thoracic excursion the cloth tape measures are placed over the tenth thoracic spinous process and over the tip of xiphoid [12,13].Other few investigators have used armpits, xiphoid and fourth intercostal space as the landmark to place the tape measure [9,11]. But the present study used axillary, intercostals, tenth rib as the landmark to measure thoracic exursion as it will give upper, middle and lower thoracic expansion measurement. So, the authors recommend that these three anatomical landmarks utilized in the present study could be used by novice clinicians.

Literatures employed sitting and standing position for measuring chest expansion [11,13]. In order to simplify handling the measuring tape easier, standing position was preferred in this study. This posture allowed the positioning and the use of the tape measures alternatively and without the need to mobilize the subject during the collection, reducing the use of technical errors. Since the posture adopted was the same for all the three measurement landmarks, we can rule out the possibility that posture influenced the results.

Conclusions
The intrarater reliability proved to be high, with the highest reliability occurring with the xiphoid landmark when compared to fourth intercostals and axillary level. The high reliability found in the present study can be credited to anatomical landmarks selected with large sample size. Using the mean of three trials for data analysis may also have caused high reliability results. Further work, is underway to find out the interrater reliability using cloth tape measures with these sets of samples among novice clinicians.

Acknowledgments

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