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Research

Intrarater and Interrater Reliability of Chest Expansion in Healthy Children Between 5–12 years of Age Group: A cross-sectional observational study

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Abstract

Objective: The respiratory systems of adults and children differ anatomically and physiologically, which results in varying respiratory evaluation and treatment parameter values. An accessible clinical method for evaluating lung function at the bedside is the Chest Expansion (CE) examination. However, there isn't enough data in the literature to support the use of this assessment technique in the pediatric population. In order to ascertain the intrarater and interrater reliability of chest expansion in children aged 5 to 12, the current study was conducted.
Method: A Cross-sectional Observational study was done on 385 students between 5 to 12 years of age group& normal BMI were selected by convenient sampling method. Two independent investigators, both blinded, assessed the Chest expansion at 2nd, 4th, 6th intercostal spaces (ICS) using a non-elastic measuring tape with child in sitting position. An average of three such readings at each level were taken into consideration. These readings were taken at 3 timeframes. To assess interrater reliability CE was checked on the same day at 20-minute interval, by 2 independent assessors, and CE assessment was repeated after a weeks interval by one assessor to evaluate the intrarater reliability. The mean value of 3 repetitions was used to calculate the intraclass correlation coefficient ICC and Cronbach's Alpha by using the SPSS Software.
Result: The Cronbach's Alpha for both Intrarater and Interrater reliability was >0.8 for 2nd, 4th and 6th ICS.
Conclusion: Chest Expansion assessment in Healthy Children Between 5-12 years of Age Group has is an Excellent Intrarater and Interrater Reliability.

Keywords: Intrarater reliability, Interrater Reliability, Chest Expansion, Children, assessment techniques

INTRODUCTION

The morphological and physiological development of the lungs of the normal adult and pediatric respiratory systems differ. As unlike the elliptical shape seen in teenagers or adults, the cross-sectional shape of the thorax in infants is cylindrical [1,2]. The majority of the lung's alveolar growth happens in the first six months of life and is finished by the time an individual reaches the age of ten. With height grows, the quantity of alveoli increases [3]. Respiratory evaluation is an integral part of evaluation and treatment planning in adult as well as paediatric population but not concepts of it are similar in both of them. Chest wall mobility is important for effective lung expansion and subsequent ventilation. It reduces with many obstructive and restrictive lung diseases. Chest expansion is a respiratory assessment technique which is easy to use and gives an idea about the chest mobility and the capacity of lung to expand. It is and indirect way of estimation of lung volumes and capacities [4]

Chest expansion is a non-invasive method of lung function and chest mobility. Chest wall mobility refers to the ability of the rib cage and associated structures to move freely during breathing and other activities [5]. The chest wall consists of the ribs, sternum, and the muscles and connective tissue that support them. Healthy chest wall mobility is essential for efficient breathing. During inhalation, the chest wall expands outward and upward, allowing the lungs to fill with air. During exhalation, the chest wall contracts, helping to expel air from the lungs. Several factors can affect chest wall mobility, including muscle strength and flexibility, joint health, posture, and overall fitness level. Restricted chest wall mobility can lead to breathing difficulties, decreased lung function, and even pain or discomfort.

There are various assessment techniques used to assess the chest wall mobility such as - Visual inspection of the chest wall for asymmetry, deformities or abnormalities in posture and movement, Palpation to assess tenderness, muscle tightness or restricted movement in the chest wall and associated structures, Goniometer measurements of joint angles and range of motion of the thoracic spine and rib cage during various movements such as flexion, extension, lateral flexion and rotation, Tape measurements, Functional movement assessment, Manual therapy techniques which include the myofascial release, joint mobilizations and soft tissue massage, Breathing Pattern Assessment and Imaging studies such as X-ray, MRI or CT scans. However, using an inch tape is an easy and practical method for measuring chest expansion and chest mobility [6].

Normative values of chest expansion in paediatrics and adults are different too. Normative values of chest expansion among healthy young individuals of the age group 5 -12 years are known to be - 2nd Intercostal space - 1.027 inch+/- 0.143/ 2.5 cm, 4th Intercostal space- 1 inch+/- 0.140/2.5 cm, 6th Intercostal space- 1.7 inch+/- 0.286 / 4.25cm [7].

Intrarater reliability is defined as the consistency of data recorded by one rater over several trials. Essentially, it assesses the degree to which a single rater or observer provides consistent measurements when assessing the same individuals or phenomena multiple times. Whereas, Interrater reliability is defined as the measurement of the extent to which raters assign the same score to the same variable. Reliability is typically assessed using statistical measures such as intraclass correlation coefficient (ICC), Cohen's kappa coefficient, or Pearson correlation coefficient. These measures quantify the degree of agreement or consistency between repeated measurements made by the same Rater.

Reliability of the measurement technique is suggested by high intrarater and interrater reliability, which shows that measurements made by the same or different raters are consistent and reproducible over time. Any variability observed is likely to be caused by true differences in the phenomena being measured rather than measurement error.

Assessing reliability is essential in research and clinical practice to ensure that measurements are accurate, consistent, and reproducible, thereby increasing confidence in the validity of study findings or clinical assessments. Thus, the aim of the study is to check the reliability of the chest expansion in paediatric age group - in 5-12 years as this is an easy, bed side tool to determine lung function.

MATERIAL AND METHOD

Study design

This Cross sectional observational study by Convenience sampling was conducted in Community - In Schools in and around Pune city from march to April 2024 on 385 children after Institutional ethical clearance was done.

The ethical Clearance for this study was granted by Deccan Education Society’s Brijlal Jindal College of Physiotherapy, Pune Institutional Ethics Committee(PRN- EC/NEW/IND/2024/MH/0415) on 20th June 2023, Outward No: 331A/2023-24.

The study was also prospectively registered with Clinical Trial Registry of India.(CTRI Number- CTRI/2024/02/063391).

Healthy children between 5-12 years of age with normal BMI were included in study after ascent from parents. While those with H/O Cardiac, Respiratory, Musculoskeletal, Neurological diseases, Cognitive deficits, Any Abdominal / Thoracic surgery in past 1year, Spinal deviations, Thoracic cage deformities, Acute cough and cold, Fever were excluded from the study. A non-elastic inch tape was used for the study.

Procedure

The study protocol was explained to the participants and assent was taken from the parents and permission from the school was obtained for data collection. Age and sex of the participant were recorded. Anthropometric measurements like, height was taken using the non-elastic measuring tape and weight with the weighing machine with the participant wearing light clothes and without shoes.

The participant's chest expansion was assessed in sitting position with back erect and unsupported, feet supported on ground with shoulder width distance in them and the upper limbs at the sides with the shoulder slightly abducted, elbow in semi flexion, wrist extended and hand placed on the iliac crest with the thumb abducted.

The chest expansion was taken as the thoracic circumference at the end of complete exhalation and then thoracic circumference at the end slow and full/complete inspiration. This circumference was recorded at three levels/ Intercostal Space I.E. 2nd, 4th and 6th using the non-elastic measuring tape. The participants were instructed to breath in and out through nose and avoid forceful inspiration & exhalation also avoid use of neck muscles during this assessment. This was to avoid use of accessory muscle.

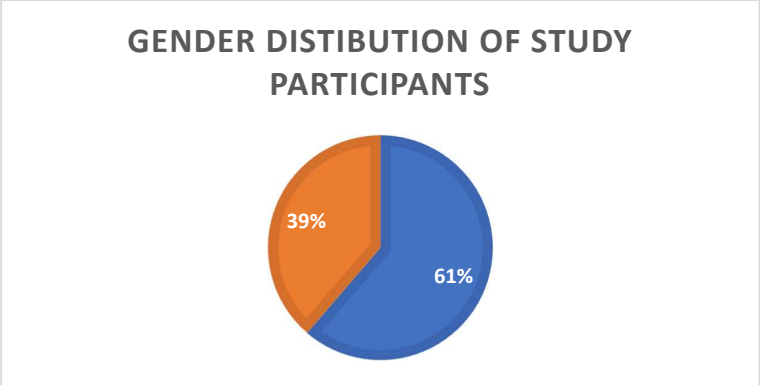
The three readings were recorded at three Intercostal Space I.E. 2nd, 4th and 6th with rest period of one minute. The average of the three values at each level was taken into consideration for statistical analysis of the data. For interrater reliability the raters were blinded, and CE was taken on the same student after a time interval of 20 minutes and for intrarater reliability, the chest expansion measurement was done twice by the same rater on the same population after gap of 7 days. Statistically the permissible window to collect the second measurement of the study was anytime 4 hours after the first measurement. Here the time interval chosen was 7 days after the first reading to get optimum result and to avoid recall bias.

RESULT

Statistics

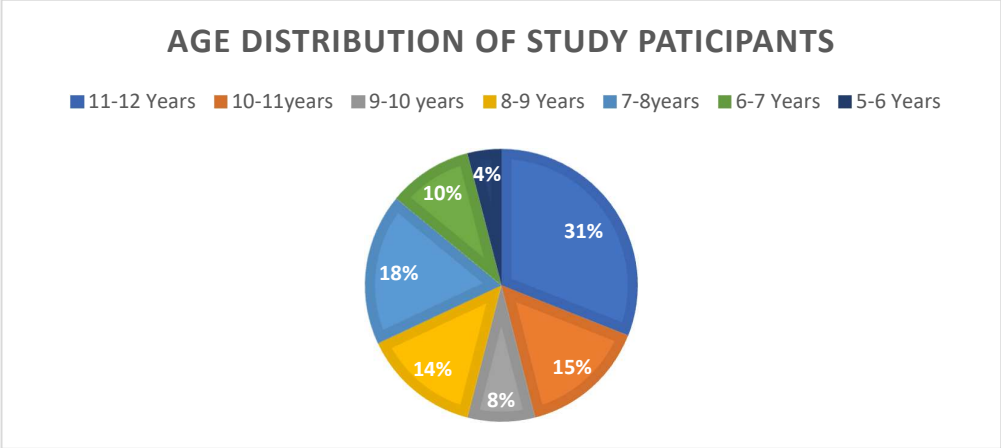
Sample size was calculated by formula S = (z2(d(1-d)) / e2) / 1+(z2(d(1-d)) / e2). The reliability was calculated using the SPSS Software. The values of chest expansion measurements at the second, fourth and sixth intercostal spaces of both days were compared. The Interclass correlation coefficient (ICC) was calculated, and the value of Cronbach's Alpha was used as the reliability tool.

study was done on 385 healthy children, as seen in graph 1; 236 boys (61%) and 149 girls (39%) were included.



Graph 1: Gender wise distribution of study participants

As seen in Graph 2; 31% of them were of 11-12 years of age, 15% were of 10-11 years of age, 8% were of 9-10 years of age, 14% were of 8-9 years of age, 18% were of 7- 8 years of age, 10% were of 6-7 years of age and 4% were of 5-6 years of age.



Graph 2: Age wise distribution of study participants

As seen in table 1 & 2 Chest expansion value at all the three level show excellent interrater and interrater reliability ICC & Cronbach's alpha> 0.85

Intrarater Reliabilty

Table 1: As seen in this table 2nd, 4th and 6th ICS has excellent intrarater reliability

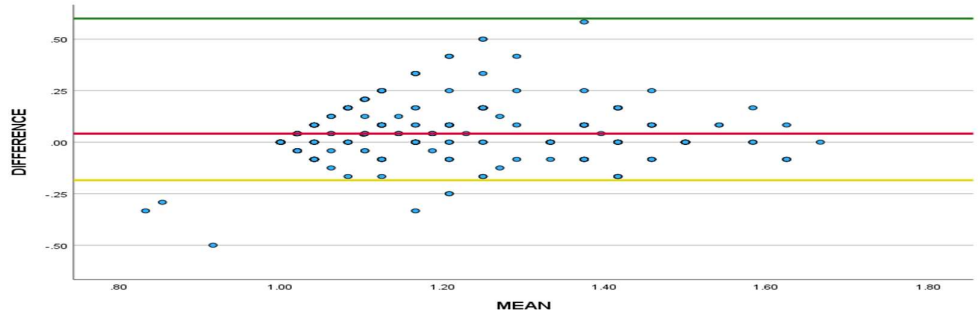
Intercostal Space	Mean (Inches)	SD (+/- in Inches)	ICC	Cronbach's Alpha
2ND ICS	Day 1 = 1.189 Day 7 = 1.147	Day 1 = 0.183 Day 7 = 0.169	0.876	0.878
4TH ICS	Day 1 = 1.499 Day 7 = 1.490	Day 1 = 0.188 Day 7 = 0.165	0.819	0.823
6TH ICS	Day 1 = 1.807 Day 7 = 1.649	Day 1 = 0.202 Day 7 = 0.158	0.924	0.940

Interrater Reliability

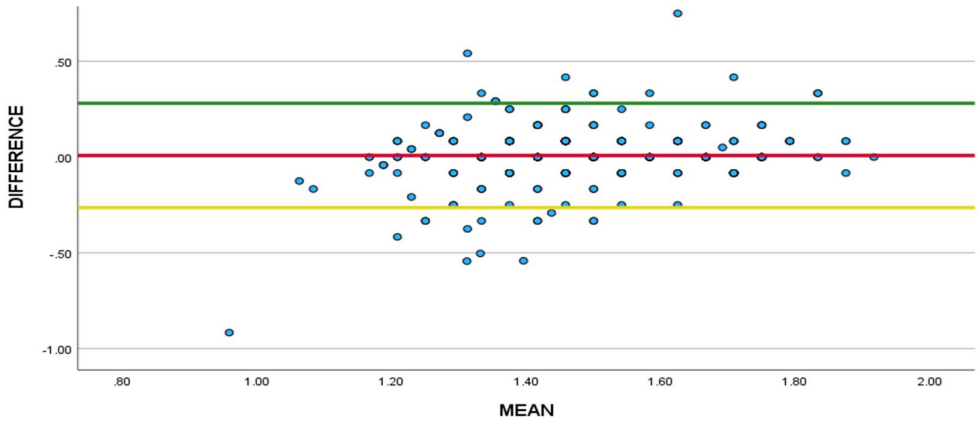
Table 2: As seen in this table excellent intrarater reliability can be seen at 2nd, 4th and 6th ICS

Intercostal Space	ICC – day 1 on inter and day 1 of intra examiner	Cronbach's Alpha – day 1 on inter and day 1 of intra examiner	ICC – day 1 on inter and day 7 of intra examiner	Cronbach's Alpha – day 1 on inter and day 7 of intra examiner
2ND ICS	0.998	0.998	0.815	0.815
4TH ICS	0.875	0.875	0.911	0.911
6TH ICS	0.999	0.999	0.995	0.995

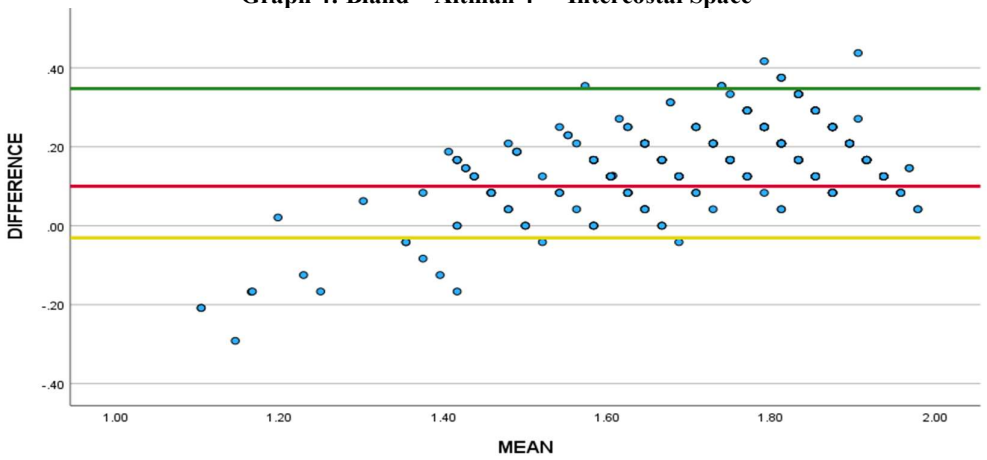
The Bland - Altman plots (Graph 3,4,5) also showed the agreement between different assays. The X-axis indicates the mean and the Y-axis indicates the difference between the measurements of the subject on both days .In this graph the Red line denotes the mean difference between the values measured on both days, the Green line denotes the upper limit and the Yellow line denotes the lower limit of the 95% confidence limits for the measurements.



Graph 3: Bland – Altman plot 2nd Intercostal Space



Graph 4: Bland – Altman 4th Intercostal Space



Graph 5: Bland – Altman 6th Intercostal Space

DISCUSSIONS

To our knowledge, this is the first study assessing Intra and interrater Reliability of chest expansion in Paediatric Population done on large cohort composed of girls and boys between the age group of 5-12 years. The finding of the study was the Statistically significant and excellent inter and intrarater reliability of this easy, quick, cost effective, bed side tool to evaluate chest mobility. Moll et al in 1972 described Chest expansion measurement using an inch tape that is a non-invasive, easy and an indirect tool to measure lung function [8]. Chest expansion assessment is the measurement of difference between the thoracic girth after maximal inspiration at the end of maximal expiration [9]. Anatomical reference landmarks for the upper chest expansion include the axillary line,

4th intercostal space and the 5th thoracic vertebrae and for the lower chest expansion include the xiphoid process and the 10th thoracic vertebrae [10].

Chest expansion in adult is variable and diverse between the healthy and diseased subjects ranging from 4-7 cms in healthy adults. The normal range of chest expansion decreases with age (50-60% between 15yrs and 75yrs) and 20% more in males compared to females [11]. Chest wall mobility assessment is a crucial to differentiate between normal and disease conditions like pulmonary diseases, Myasthenia Gravis, Fibromyalgia. The chest expansion assessment can also be used to assess the pre and post effects of medical and physiotherapeutic management [12]. It also helps to assess the progression of the various pulmonary, neurological, and musculoskeletal conditions affecting the chest wall mobility. A study conducted by Frédéric Lemaitre et al in 2013 suggests that Chest expansion measurements can also been used to assess the effects of treatment techniques like respiratory muscle endurance training and respiratory muscle stretching [13].

Another study entitled Effect of functional (aerobic) exercises on chest wall expansion and respiratory volumes in high school students conducted by Mohammad Mehdi et al suggested that the chest expansion measurements increased due to endurance training [14]. Thus, the chest expansion assessment method is used very widely in clinical and research fields to evaluate effectiveness of many pharmacological and non-pharmacological treatment techniques. The need of establishing intrarater and interrater reliability is further emphasized.

This study uses tape measurement, which is simple and cheap, to measure chest expansion. The study performed by Bockenhauer et.al has confirmed that the tape-measure method of measuring thoracic excursion at three levels is reliable in adults and useful in a clinical setting and the sitting position is recommended during assessment [15].

As seen in Graph 1 & 2, the study included 61% of boys and 39% of girls and the age distribution, of which 31% are of 11-12 years of age, 15% are of 10-11 years of age, 8% are of 9-10 years of age, 14% are of 8-9 years of age, 18% are of 7- 8 years of age, 10% are of 6-7 years of age and 4% are of 5-6 years of age. The total number of students for this study were 385 (N=385). Thus, finding of this study can be generalized to pediatric population and to both genders as the study participants is a representation of healthy children of specified age group:

Various intrarater studies were referred for statistical analysis. Intrarater Reliability of Chest Expansion using Cloth Tape Measure Technique conducted by Mohan, Dzulkifli, Justine, Haron and Rathinam calculated the chest expansion measurements at the three intercostal levels and average of the three values was considered. The test was repeated after a gap of 1 day. The reliability was found to be high at all three intercostal levels [8].

Similarly, Test-retest reliability of the functional reach test(FRT) and the hand grip strength test(HGST) in older adults using nursing home services conducted by Soraia Ferreira, Armando Raimundo and José Marmeleira. The study population was distributed into a group without cognitive impairment and a group with mild cognitive impairment and a 1-week test-retest was performed for the FRT and the HGST. Relative reliability was measured by the intraclass correlation coefficient, and the result was high reliability for both tests and absolute reliability by the standard error of measurement which was found to have good reliability [16].

Likewise, inter-rater and intra-rater reliability of the extended TUG test in elderly participants conducted by Juan José Bedoya-Belmonte, et al was referred. The data was analysed using the interclass correlation coefficient [17].

Correspondingly, Intra-Rater Reliability of Desktop Spirometry in Adults with Type 2 Diabetes Mellitus conducted by Minaxi Saini, Jaspreet Kaur was referred too. Paired t-test was used to compare the test-retest values of the variables. Absolute reliability was assessed through intraclass correlation (ICC), and relative reliability was analysed through standard error of measurement. The result concluded that the desktop spirometry had good reliability [18].

As seen in table no. 1 & 2 the value of the intra and interrater reliability coefficient (Cronbach' Alpha) for all the three intercostal spaces was >0.70, which indicates good reliability. Thus, chest expansion measurement at 3 intercostal space shows two and single individual's consistency of measurement. This can be seen in graph 3,4 & 5 too, it shows high level of agreement in the CE values assessed by the two assessors.

The study has no limitation as data was collected on expected sample size, girls and boys in equal distribution and standard procedure was followed to collect data and standard time gap was maintained for evaluation of chest expansion values by both investigators. This study would help clinicians, physiotherapist as well researchers assessing chest expansion in children at three levels for age group 5-12 years, as this assessment technique is found to be reliable.

Acknowledgment

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CONCLUSION

Chest Expansion assessment in Healthy Children Between 5-12 years of Age Group has is an Excellent Intrarater and Interrater Reliability. Assessing chest expansion by inch tape in children between 5-12 years of age is reliable technique and should be used in research and clinical settings as it is non-invasive, easy, cost effective, bed side clinical methods. This study proves the technique as reliable, superior, error free and the chest expansion should be used widely to monitor severity and progress of respiratory impairments.

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