REFERENCE VALUE FOR CHEST EXPANSION IN HEALTHY ADOLESCENT BETWEEN 10–19 YEAR AGE GROUP: A CROSS SECTIONAL STUDY

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Abstract: Background- Chest expansion serves as a vital aspect in assessing respiratory health, offering insights into rib cage mobility and lung volume. The measurement, typically taken as the difference between thoracic girth during maximal inspiration and expiration, aids in diagnosing various thoracic and pulmonary conditions. Differential breathing patterns between genders emphasize the importance of considering thoraco-abdominal and abdomino-thoracic breathing dynamics. The biomechanics of chest movement, characterized by pump handle and bucket handle motions, highlight the intricate interplay of costal joints in facilitating respiration. Assessment of chest expansion at multiple levels - axillary, mammary, and xiphoid process ensures comprehensive evaluation, while avoiding reliance on soft tissue landmarks prone to variability.

Furthermore, lifestyle factors and age-related changes significantly impact chest expansion. Age-related calcification of cartilage and reduced lung compliance further emphasize the importance of considering age, weight, and height in chest expansion evaluations. It is important to know the reference values of chest expansion of healthy adolescent population for precise interpretation.
So, the present study was undertaken to find out reference value for chest expansion in healthy adolescent between 10 – 19 year age group.

Methodology-Ethical approval was obtained. A cross sectional study was carried out in 300 healthy adolescent population between the age group of 10 - 19 year without H/O any cardiac/respiratory illness, musculoskeletal or neurological diseases, spinal deviations, cough and cold. Chest expansion measurements were assessed in sitting position at three levels – axillary, mammary and xiphoid process, using an non- elastic measuring tape. It was taken as thoracic circumference at the end of maximum inspiration and expiration. The best of those three readings at each level was taken into consideration.

Result- The statistical analysis demonstrated that the reference value for 10–14 year age group at axillary level is 2.5cm(0.98 inch) – 6.0 cm(2.36 inch) , mammary level is 2.4 cm (0.94 inch) – 6.0 cm (2.36 inch), xiphoid level is 2.5cm (0.98 inch) – 5.6cm (2.20 inch) and the reference value for 15–19 year age group at axillary level is 3.0cm(1.18 inch) – 6.8 cm (2.67 inch) , mammary level is 3.0 cm (1.18 inch) – 7.0cm (2.75 inch) , xiphoid process level is 3.0cm (1.18 inch) – 7.0cm (2.75 inch) .

Conclusion- This study concludes that across all three levels (axillary, mammary, xiphoid), there is a consistent pattern of increased chest expansion from the 10-14 year age group to the 15-19 year age group. There is a consistent pattern of males having higher chest expansion values compared to females. In the older age group (15-19 year), there is a significant negative correlation between BMI and chest expansion whereas in the younger age group (10-14 year), there is no significant correlation between BMI and chest expansion at any level.

Keywords: Chest Expansion, Reference Value, Healthy, Adolescent Population, Body Mass Index, Correlation

INTRODUCTION

Chest expansion is commonly measured as the difference between the thoracic girth measurement after maximal inspiration and at the end of expiration.[1] Chest expansion may be used to measure rib cage mobility and was found to be related to lung volume.[1] Evaluation of chest expansion is important step in physical examination of respiratory system and can give an important idea about chest wall pathology, different disorders in the thoracic cage or in the lung itself, treatment effectiveness, progression of respiratory disease by detection of any limitation of chest expansion.

When breathing normally, inspiration occurs actively and expiration passively. [1] Females have predominately thoraco-abdominal breathing whereas males have abdomino -thoracic breathing. [2] Movements of the ribs occur at the cost - transverse and the cost - vertebral joints. The orientation of the joints varies in the upper and lower ribs. The pump handle movement, predominant in upper thorax, occurs on inspiration and there is an increase in the antero - posterior diameter of thorax. In the bucket handle movement there is an increase in transverse diameter of lower thorax [1]. The transverse diameter of thorax is greater than the antero - posterior diameter giving it an ellipsoid shape with the ratio 7:5. [1] There are different biomechanical movement occurring at different level so therefore upper, middle and lower chest movement should be assessed .[2] So chest expansion should be measured at axillary, mammary and xiphoid. [3] Soft tissue landmark is avoided because it varies with the individual. [2] The tape measure, method of measuring expansion at three level is reliable and useful in clinical settings. [4]

Chest expansion movement in sitting position had an improvement in the rib cage compartment of the chest wall, whereas in the supine position there was superior enhancement in the part of the abdomen relative to other body position. [5] To assess the maximal range of motion in the chest, patient should be instructed not only to "breathe in /out'', but also instructed to "make yourself as big / small as possible''. [6]Age wise there is difference in the chest expansion in both males and females. It is also seen that the chest expansion declines with the Age. This can be attributed to the aging process. Calcification of the costo - chondral cartilage and loss of 6 elasticity of the connective tissue reduces the compliance of the thoracic cage. Reduction of lung compliance due to aging reduces chest expansion. [2]

In the recent years, due to unhealthy lifestyle habit such as physical inactivity, imbalanced diet, alcohol consumption, stress, smoking etc., the overall global incidence of non-communicable diseases such as obesity, hypertension, diabetes mellitus, metabolic syndrome, cardiovascular diseases, cancer and stroke is on the rise. Obesity adversely affects the respiratory system by causing a decrease in both, the lung as well as chest wall compliance. As the adiposity in the lower thoracic and upper abdominal region increases, there is reduction in the normal excursion of diaphragm. This leads to reduced lung volumes leading to increased work of breathing. [7] Hence age, weight & height should be considered while comparing chest expansion of an individual.

NEED OF STUDY

Considering the importance of chest expansion as a diagnostic tool in clinical setting, the interpretation is dependent on reference values or normative data drawn from the normal individuals to detect variation from normal. There is a lack of reference data on chest expansion due to which the values derived from other population are used for reference .Comparison of the patient with wrong population data will not lead to accurate diagnosis. It is a non – invasive, easy, cost effective, beside clinical method to assess lung function.

Even though a study has been done on reference value for chest expansion in healthy adolescent population but it did not aimed to establish relation of age, height, and weight with chest expansion. There is no study found for reference values of chest expansion for adolescent age group.

Since 16% of population between the age group of 10 – 19 years are growing population. It is an important stage of human development and time for laying foundation of good health, so finding reference value of chest expansion for this age group will helping in ruling out any lung pathology or respiratory & thus work productivity & efficiency will be improved.More & more studies will help in finding out the accurate data.

AIM

To find out the reference value for chest expansion in healthy adolescent between the age group of 10 – 19 year age group.

OBJECTIVE

1. To study the reference value for chest expansion in healthy adolescent population between age group of 10 – 19 year by using tape measure method.
2. To study the difference in chest expansion values of males & females.
3. To study relation of body mass index with chest expansion.

METHODOLOGY AND MATERIALS

a) Study type – Cross – sectional study
b) Sampling technique – Convenient sampling
b) Sample size – 300
c) Study duration – 6 months
d) Study area – Pune pcmc
e) Weighing Scale
f) Tape measure
g) Non elastic measuring Tape

h) Table
i) Chair
j) Consent form
k) Pen/ pencil

INCLUSION CRITERIA

Individuals who will give written informed consent letter.
Individuals between the age group of 10 year – 19 year.
Healthy individuals.

EXCLUSION CRITERIA

Individuals those who have any history of addiction.
Individuals with known respiratory conditions and respiratory infections such as asthma, chronic obstructive pulmonary disease (COPD), bronchitis, pneumonia or any other chronic respiratory illness.
Individuals with musculoskeletal abnormalities affecting the chest wall, such as scoliosis, pectus excavatum, or other deformities.
Individuals with recent chest trauma or surgery.
Individuals with neuromuscular disorders affecting chest wall mobility, such as muscular dystrophy or spinal cord injuries.
Individuals with cognitive or communication impairments, that may affect their ability to understand and comply with measurement instructions.

OUTCOME MEASURE

Measurement of chest expansion in (cm) by using tape measure method.

PROCEDURE

Ethical committee clearance was obtained and permission was taken from the department. 300 Subjects were selected according to the inclusion and exclusion criteria. Subjects were explained about the procedure and informed assent was taken from the teacher for subject of age group 10 – 14 year & consent was taken from subject of age group 15 – 19 year before starting the procedure. Subject's chest expansion was taken in sitting position with feet apart and the upper limb at the sides with the shoulder slightly abducted, elbow in flexion, wrist extended and placed on the iliac crest and thumb abducted. The chest expansion was taken as thoracic circumference at the end of inspiration then thoracic circumference at the end of expiration. Three readings at axilla, mammary and Xiphoid process was recorded using a non – elastic measuring tape. The best of those three readings was documented as final normative value for that level. Data was recorded and analyzed. The results were analyzed and documented

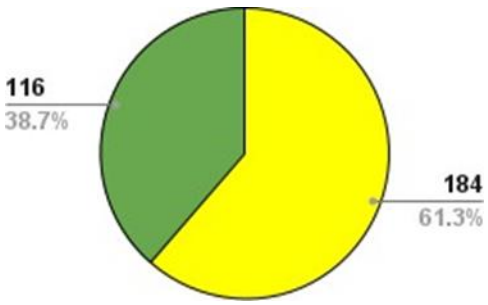
STATISTICAL ANALYSIS & RESULT

Total 300 subject participated.

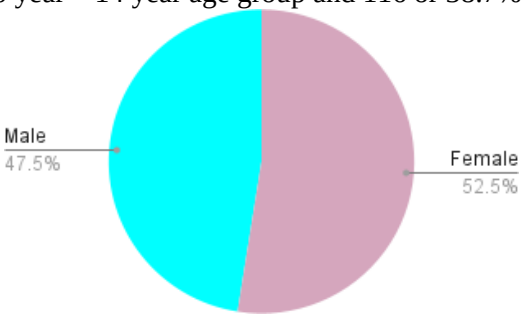
Table 1: Age and Gender Distribution.

Age Group	Participant	Percentage
10 – 14 year (early adolescent)	184	61.3%
15-19 year (late adolescent)	116	38.7%

Gender	Participants	Percentage
Male	142	47.5%
Female	157	52.5%



Interpretation: The above pie chart shows the % of study population in particular age group. It depicts that 184 or 61.3% participants belongs to 10 year – 14 year age group and 116 or 38.7% belongs to 15 year – 19 year age group



Interpretation: The above pie chart shows the gender wise distribution. It depicts that study population consisted of 47.5 % male participants & 52.5 % female participant in the age group 10 year – 19 year.

Table 2:- Reference Value (Upper & Lower limit) for chest expansion of the age group 10 – 14 year (early adolescent) & 15 – 19 year (late adolescent) at axilla , mammary & xiphoid level

Sr. No.	Level	10 – 14 year (early adolescent)				15 – 19 year (late adolescent)			
		Mean	Std. Dev.	Lower limit	Upper limit	Mean	Std. Dev.	Lower limit	Upper limit
1.	Axillary	3.7902	1.0684	2.5 cm	6.0 cm	4.776	1.1635	3.0 cm	6.8 cm
2.	Mammary	3.8592	1.1009	2.4 cm	6.0 cm	4.8491	1.2428	3.0 cm	7.0 cm
3.	xiphoid	3.7951	1.0492	2.5 cm	5.6 cm	4.6828	1.2475	3.0 cm	7.0 cm

Interpretation :- Across all three levels (axilla, mammary, xiphoid), there is a statistically significant increased chest expansion from the 10-14 age group to the 15-19 age group.
This reflects the normal growth and development of the chest wall during adolescence

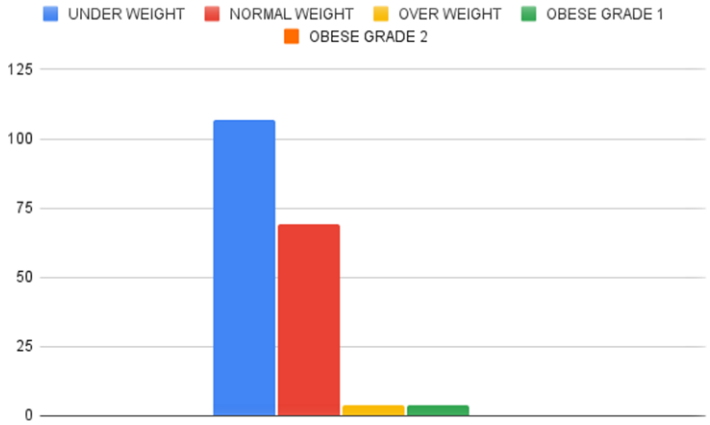
Table 3: Difference in the chest expansion values of male & female of the age group 10 – 19 year.

Sr. No.	Level	Median Chest Expansion		Mann Whitney Test
		Male	Female	P value
1.	Axillary	4.5	4.0	< 0.001
2.	Mammary	4.5	4.0	< 0.001
3.	Xiphoid	4.5	4.0	< 0.001

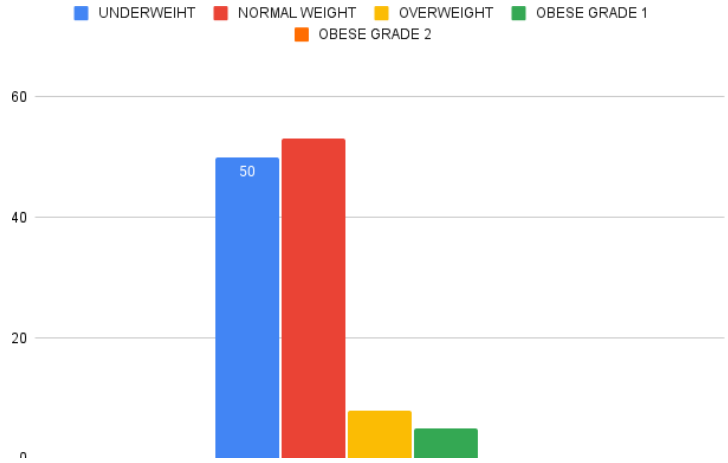
Interpretation: Across all three variables (axilla, mammary, and xyphoid), there is a statistically significant difference in chest expansion between males and females. Males tend to have higher chest expansion measurements compared to females.

Table 4: BMI and Age category distribution

BMI Category (kg / m2)	Age Category	
	10 – 14 year	15 – 19 year
Underweight (< 18.5) kg / m2	107	50
Normal (18.5 to 24.9) kg / m2	69	53
Overweight (25.0 to 29.9) kg / m2	4	8
Obese grade 1 (30.0 to 34.9) kg / m2	4	5
Obese grade 2 (35.0 to 39.9) kg / m2	0	0



Age : 10 – 14 year



Age : 15 – 19 year

Table 5: Correlation between chest expansion and body mass index for 10 – 14 year and 15 – 19 year age group.

Sr. No.	Level	10 – 14 year		15 – 19 year	
		Correlation coefficient r	Significance level	Correlation coefficient r	Significance level
1.	Axillary	-0.03355	P = 0.6512	-0.3064	P = 0.0008
2.	Mammary	-0.07781	P = 0.2938	-0.1996	P = 0.0317
3.	Xyphoid	-0.1189	P = 0.1079	-0.3373	P = 0.0002

Interpretation: In the older age group (15-19 years), there is a significant negative correlation between BMI and chest expansion at all three levels (axilla, mammary, xiphoid), indicating that higher BMI is associated with lower chest expansion. In the younger age group (10-14 years), there is no significant correlation between BMI and chest expansion at any level.

DISCUSSION

This study aimed to establish reference values for chest expansion in healthy adolescents aged 10 to 19 years. The establishment of reference values for chest expansion in healthy adolescents aged 10-19 years represents a significant contribution to the field of respiratory assessment. By providing clinicians with normative data, this study facilitates the early detection and management of respiratory issues in adolescents, ultimately improving patient outcomes and healthcare delivery.

The study adopts a cross-sectional design with a convenient sampling technique, aiming to recruit 300 healthy adolescents from Pune PCMC, India. Adolescents between 10 and 19 years of age were included, and individuals with respiratory diseases or spinal deformities were excluded. Chest expansion was measured at axillary, mammary and xiphoid level using a non- elastic tape measure method.[3] Soft tissue landmark is avoided because it varies with the

individual. [2] The tape measure, method of measuring expansion at three level is reliable and useful in clinical settings. [4]

A noteworthy aspect of the methodology is the division of adolescents into early (10-14 years) and late (15-19 year) stages. Early adolescence is characterized by rapid growth and development, while late adolescence is marked by the completion of physical growth and the onset of maturity. Separating the age groups allows for a better understanding of chest expansion patterns across different developmental stages within adolescence.

The statistical analysis demonstrated that the reference value for 10–14 year age group at axillary level is 2.5cm(0.98 inch) – 6.0 cm(2.36 inch) , mammary level is 2.4 cm (0.94 inch) – 6.0 cm (2.36 inch), xiphoid level is 2.5cm (0.98 inch) – 5.6cm (2.20 inch) and the reference value for 15–19 year age group at axillary level is 3.0cm(1.18 inch) – 6.8 cm (2.67 inch) , mammary level is 3.0 cm (1.18 inch) – 7.0cm (2.75 inch) , xiphoid level is 3.0cm (1.18 inch) – 7.0cm (2.75 inch) . Across all three levels (axillary, mammary, xiphoid), there is a consistent pattern of increased chest expansion from the 10-14 age group to the 15-19 age group. This reflects the normal growth and development of the chest wall during adolescence. The study "Age-related changes in chest wall volumes and pulmonary function indices" by G.L. da Silva et al., published in the Brazilian Journal of Physical Therapy in 2013, concludes that there are age-related changes in chest wall volumes and pulmonary function indices. As age increases, there is a tendency for chest wall volumes to increase, suggesting an increase in chest expansion with age. [10]

Additionally, gender differences were observed, with males generally exhibiting higher chest expansion values compared to females. In the study "Sex Differences in Various Anthropometric Parameters in Relation to Chest Expansion among Medical Students" by Bhagath Kumar Potu et al., published in the Indian Journal of Physiology and Pharmacology in 2011, it was found that male medical students generally exhibited greater chest expansion compared to female medical students. This indicates a sex difference in chest expansion among the participants. [11] Furthermore, there was a negative correlation between BMI and chest expansion in 15- 19 year age group (late adolescent) , suggesting that higher BMI was associated with lower chest expansion and in the younger age group (10-14 years), there is no significant correlation between BMI and chest expansion at any level. In late adolescence (15-19 years), higher BMI may limit chest expansion due to increased fat deposition around the chest, sedentary lifestyles reducing respiratory muscle training, and obesity-related factors like reduced lung compliance. In contrast, in the younger age group (10-14 years), BMI may not significantly affect chest expansion as growth dominates BMI changes, and higher physical activity levels promote uniform development of respiratory muscles.

Also in the study "Correlation of Body Mass Index with Peak Expiratory Flow Rate and Chest Expansion in Adolescents" by Dr. Neeta M. Mandovra et al., published in the Journal of Clinical and Diagnostic Research in 2017, it is concluded that there is a negative correlation between Body Mass Index (BMI) and both peak expiratory flow rate and chest expansion in healthy adolescents. This suggests that as BMI increases, peak expiratory flow rate and chest expansion tend to decrease in this age group. [12]

This study provides valuable insights for physiotherapists and researchers, offering reference values for assessing chest expansion in children aged 10 to 19 years. Utilizing non-invasive, cost-effective bedside clinical methods such as chest expansion assessment can offer a superior approach to evaluating lung function. The normative values established in this study can aid in monitoring disease severity and progression, enhancing clinical management strategies.

CONCLUSION

The study concludes that the reference value for 10 – 14 year age group at axillary level is 2.5cm (0.98 inch) – 6.0 cm (2.36 inch) , mammary level is 2.4 cm (0.94 inch) – 6.0 cm (2.36 inch), xiphoid level is 2.5cm (0.98 inch) – 5.6cm (2.20 inch) and the reference value for 15 – 19 year age group at axillary level is 3.0cm (1.18 inch) – 6.8 cm (2.67 inch) , mammary level is 3.0 cm (1.18 inch) – 7.0cm (2.75 inch) , xiphoid level is 3.0cm (1.18 inch) – 7.0cm (2.75 inch). Across all three levels (axillary, mammary, xiphoid), there is a consistent pattern of increased chest expansion from the 10-14 age group to the 15-19 age group. This reflects the normal growth and development of the chest wall during adolescence.

The study also concludes that there is a consistent pattern of males having higher chest expansion values compared to females.

In the older age group (15-19 year), there is a significant negative correlation between BMI and chest expansion indicating that higher BMI is associated with lower chest expansion whereas in the younger age group (10-14 year), there is no significant correlation between BMI and chest expansion at any level.

LIMITATION OF STUDY

Chest expansion measurement were taken while participants were clothed due to time constraint and unavailability of space to maintain participant privacy, potentially leading to inaccuracies due to variation in clothing thickness and tightness.

Tape measure was used instead of a stadiometer for height measurement because of inability to mount it on wall at different locations where the study was conducted. There is possibility of measurement error, as it relies on manual placement and alignment, which may not always be precise.
The unequal representation existed between the categories i.e.; unequal numbers of participants included in the 10-14-year & 15-19-year age groups and in male & female distribution, potentially affecting the generalizability of the findings.
The study was conducted in only a few schools within the (PCMC) area, thereby lacking representation from all divisions within the region.
Factors such as physical activity levels, muscle mass distribution, and individual body composition can also play a role in determining chest expansion beyond BMI alone.The ideal sampling method being stratified random sampling for the study can be used to ensure representation from distinct age groups, reduce variability, enhance precision and generalizability, and facilitate efficient statistical analysis; however, due to limitations, convenient sampling was utilized instead.

FUTURE SCOPE OF STUDY

Future research should focus on refining measurement techniques for accurate assessments of chest expansion and height while including larger, diverse sample populations to enhance generalizability.
Longitudinal studies tracking individuals over time can provide insights into the dynamic relationship between BMI and chest expansion.
Exploring additional variables like physical activity levels and body composition beyond BMI alone would deepen our understanding of respiratory function in adolescents. Additionally, expanding research to diverse geographic locations would shed light on how environmental and cultural factors influence BMI and chest expansion patterns.

CLINICAL IMPLICATION

This study establishes reference values for chest expansion in healthy adolescents aged 10 to 19, aiding respiratory assessment and clinical practice. These values have clinical significance, enabling healthcare professionals to diagnose respiratory disorders, monitor disease progression, and assess treatment effectiveness accurately. Considering gender-specific differences and BMI's influence on chest expansion enhances respiratory evaluations, improving patient care.
Knowing how BMI relates to chest expansion can help healthcare professionals create specific treatments for adolescents with breathing problems, making sure they get better care and have better results.

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