Determination of Reference Equation for Chest Expansion in Healthy Indian Children

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ABSTRACT

BACKGROUND

Measurement of chest expansion is commonly done in physical examination of patients as it gives reliable idea about the rib cage mobility & capacity of lungs along with thorax to expand. Chest expansion values are reduced in diseases and it can be used to check progression of the diseases. In India there is lack of reference data on chest expansion due to which the values derived from other population are used for reference in India. Comparison of the patient with wrong population data will create misinformation & wrong diagnosis. This study was designed to establish reference value for expansion of chest in healthy Indian children, understand relation of age, height, and weight with chest circumference & compare these values with published global values.

METHODS

Chest expansion & circumference of chest was measured in 229 boys and 226 girls aged 6 – 15 years. The study was conducted in Mumbai metropolitan region and Navi - Mumbai. Standing height, weight, age, sitting chest circumference and chest expansion were recorded. Chest expansion was measured at three different levels i.e. axillary, mammary and xiphoid. The correlation coefficient was used to understand relation of age, weight, height with chest expansion & chest circumference. The prediction equation was derived for both genders separately by multivariate regression.

RESULTS

Significant positive correlation of chest circumference was observed with age and weight and negative correlation with height. Chest expansion was higher in males as compared to females. Chest expansion had shown positive correlation with age, height and weight. Pearson correlation coefficients were 0.927, 0.885 & - 0.337 respectively. Different prediction equations were drawn for males and females for expansion of chest at all three levels. Significant difference was noted in values of this study and global values.

CONCLUSIONS

Gender wise differences exist in chest expansion values. Males have higher values than females. Hence gender specific equations are needed for estimation of chest expansion.

KEY WORDS

Chest Circumference, Indian Children, Chest Expansion, Prediction Equation

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BACKGROUND

The chest expansion measurement is one of the simple methods which gives good information about person's capacity of chest mobility, capacity of lung and thorax to expand.[1] Hence measurement of chest expansion is done routinely in assessment of respiratory patients in clinical set up. This makes the thoracic expansion measurement done with measuring tape a reliable objective outcome measure in respiratory patients.[2] As this measurement of chest expansion is used as a diagnostic tool in clinical practice, the reference value derived from the normal population is important.[3]

Chest expansion has value in assessing respiratory patients like chronic obstructive pulmonary disease (COPD), asthma and also to check progression of diseases. Children being vulnerable population at risk of developing asthma & other respiratory diseases. Asthma affects both children and adults. It is estimated that people of all ages and all ethnic backgrounds suffering from asthma have reached up to 300 million. Childhood asthma is one of the common factors responsible for loss of school days which will result in academic loss and opportunity to socially interact.[4,5]

It's a common practice to compare the chest expansion value with reference values which is derived from other population. In India at most of the centres unpublished reference values are used traditionally for comparison of chest expansion. There is huge variation in practice to use reference values. Physiotherapy interventions given in the form of breathing exercises, lung expansion therapy, thoracic expansion exercises are designed to improve the lung & thoracic expansion.[6] Wrong selection of reference data will result in wrong diagnosis which will result in wrong treatment. Hence there is a need to establish local data set for chest expansion in this region. This study was designed to establish reference value for expansion of chest in healthy Indian children, understand relation of age, height, and weight with chest circumference & compare these values with published global values.

METHODS

A cross sectional observational study was conducted in 455 normal subjects aged between 6 and 15 years in Mumbai metropolitan region and Navi Mumbai. Study duration was from 6.02.2019 to 18.11.2020. A simple random sampling technique was used. A healthy child was defined as the one who was free from cardiac / respiratory / metabolic / rib cage / spinal deformity and had normal BMI from 5th to 95th percentile.

Children whose parents / guardians were unable to give written consent to participate in the study, children who refused to participate in the study, children with acute respiratory diseases / bronchial asthma / cardiac diseases / metabolic disorder, with any family history of bronchial asthma / bronchiectasis / cystic fibrosis / or any other respiratory diseases and with any rib cage deformity / cardiac / metabolic disorders, Children with BMI below 5th & above 95th percentile were excluded from study.

Based on the literature data, in the reference study, the sample size was calculated with 80 % power value and 5 % level of significance. SAS 9.1.3 statistical software was used to calculate sample size. Total 229 healthy Indian boys and 226 girls aged 6 to 15 years who met with the inclusion criteria, were recruited in this study.

Written consent was taken from parents / guardians after explaining the benefit, risks and procedure of the study. The detailed medical examination of all selected subjects was carried out to rule out any underlying heart, lung, other systemic diseases as well as chest / spine deformities and other medical abnormalities by registered medical practitioner.

Medical research council questionnaire for respiratory symptoms was used to screen subjects. Standing height, weight, age, sitting chest circumference and chest expansion were recorded in the subject's record sheet. The age was measured in years, height in centimetres and weight in kilograms.

The stadiometer was used to measure height. The weight was measured with the digital weighing machine. Chest circumference and chest expansion measurements were taken in sitting position with both hands - on waist. Flexible measuring tape, weighing scale, data recording sheet, pen and paper were used to record the values. An introductory explanation of chest expansion procedure, inspiration and expiration was given to the subjects. After training, measurement was taken.

All subjects were tested in sitting position with hands resting on their waist. After a practical demonstration the subjects were asked to take deep breath and then blow out fully. The difference between full inspiration and full expiration was noted using flexible measuring tape in centimetres. Chest expansion was measured at three levels i.e. axillary, mammary and xiphoid.[7] Total 3 trials were taken and the best out of 3 values of chest expansion was recorded.

Statistical Analysis

The mean & SD values were obtained by descriptive statistics. Pearson's correlation test was used to understand the relation of parameters under study. The prediction model was developed by multivariate regression analysis which was tested by diagnostic F test & ANOVA test.

RESULTS

The present study was undertaken to establish reference values for chest expansion in healthy Indian children. The study included 455 subjects out of which 226 were females and 229 were males. Multivariate regression analysis was done for developing prediction equation model for chest Expansion.

Diagnostic F test & ANOVA was done for checking model acceptance. The mean values were obtained by descriptive statistics. (See Table 1). The males had higher mean values of chest expansion than females (See Table 2)

Age	Height	Weight	Chest Circumference	CE1	CE2	CE3
10.45363 ± 2.61	95.33053 ±47.08	31.89934 ±11.57	77.24813 ±6.05	5.20989 ±1.11	4.724615 ±1.0	4.38022 ±1.10
Sample 455						

Table 1. Demographic Data (Mean)

Gender	Mean CE1	Mean CE2	Mean CE3
Male	5.334061	4.962882	4.644105
Female	5.084071	4.483186	4.112832

Table 2. Chest Expansion Comparison Male & Female

	Age	Weight	Height
Chest circumference	.927**	.667**	.630**

Table 3. Pearson's Correlation Coefficient Anthropometric Parameters and Chest Circumference

**. Correlation is significant at the 0.01 level (2 - tailed).

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
CE1	(Constant)	4.358	.596		7.310	.000
	Age	.271	.043	.694	6.299	.000
	Height	-.016	.007	-.294	- 2.323	.021
	Weight	.010	.010	.124	1.098	.274
	Axillary Chest Expansion (CE1) = 4.358 + 0.271(Age) - 0.016(Height)					
CE2	(Constant)	3.196	.598		5.344	.000
	Age	.230	.043	.585	5.335	.000
	Height	-.007	.007	-.121	-.959	.339
	Weight	.008	.010	.097	.861	.390
	Mammary Level Chest Expansion (CE2) = 3.196 + 0.230(Age)					
CE3	(Constant)	2.827	.623		4.540	.000
	Age	.268	.045	.661	5.952	.000
	Height	-.007	.007	-.121	-.953	.341
	Weight	-.001	.010	-.015	-.129	.898
	Xiphoid Level Chest Expansion (CE3) = 2.827 + 0.268(AGE)					

Table 4. Prediction Equation of Chest Expansion for Males

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
CE1	(Constant)	5.407	.691		7.821	.000
	Age	.262	.048	.575	5.408	.000
	Height	-.033	.008	-.489	- 4.256	.000
	Weight	.046	.012	.429	3.841	.000
	Axillary Level Chest Expansion (CE1) = 5.407 + 0.262(AGE) - 0.033(HEIGHT) + 0.046(WEIGHT)					
CE2	(Constant)	4.273	.660		6.473	.000
	Age	.182	.046	.449	3.941	.000
	Height	-.020	.007	-.329	- 2.673	.008
	Weight	.032	.012	.335	2.803	.006
	Mammary Level Chest Expansion (CE2) = 4.273 + 0.182(AGE) - 0.020 (HEIGHT) + 0.032(WEIGHT)					
CE3	(Constant)	3.271	.707		4.628	.000
	Age	.166	.049	.405	3.347	.001
	Height	-.009	.008	-.143	- 1.095	.275
	Weight	.010	.012	.099	.776	.438
	Xiphoid Level Chest Expansion (CE3) = 3.271 + 0.166(AGE)					

Table 5. Prediction Equation of Chest Expansion for Females

Author	Country	Age Group Studied	Axillary	Mammary	Xiphoid
O. Ye. Pashkova, K. P. Lysenko [9]	Ukraine	11 to 17 years	NA	4.67± 0.12 cm	NA
Esssraa A. Bataweel, Alaa I. Ibrahim [15]	Saudi Arabia	6 to 11 years	NA	2.8 cm	NA
Agenor Gracia Junior et al [12]	Brazil	9 to 10 years	5.7±1.6 cm	NA	4.5±1.1 cm
Katrina Neumannova et al [8]	Czech Republic	10 to 14 years	NA	Female - 6.9±1.7 cm Male - 7.4±1.7 cm	Female - 6.4±1.6 cm Male - 6.5±1.8 cm
Raphella oliveira E. da Silva et al [1]	Brazil	7 to 11 years	4.75±1.56 cm	NA	5.00±1.56 cm
Sousa RCM et al [13]	Brazil	9 to 12 years	NA	5.0 (3.9 - 6.5)	NA
Current study	India	6 to 15 years	Male - 5.33±1.04 Female - 5.08±1.17	Male - 4.96±1.05 Female - 4.48±1.04	Male - 4.64±1.08 Female - 4.11±1.05

Table 6. Comparison between Reference Value of Chest Expansion of Our Study with Other Global Values

NA: not available

High positive correlation of chest circumference was noted with age & weight whereas low negative correlation was observed with height. Pearson correlation coefficients were 0.927, 0.885 & - 0.337 respectively. All correlations were significant at the level of 0.01. (See Table 3).

In our study, prediction equation was derived for chest expansion for males and females respectively through regression. In males, axillary level chest expansion had best significance with age and height, the mammary level chest expansion had best significance with age, whereas the xiphoid level chest expansion had best significance with age (See Table 4). In females, axillary & mammary level chest expansion had best significance with age, height and weight, whereas xiphoid level chest expansion had best significance with age (See Table 5).

Diagnostic F test & ANOVA was significant for all prediction models. Difference was noted in values of chest expansion obtained in our study when compared to other studies (See Table 6). Reference value of chest expansion at axillary level in our study was less than study done in Brazil on age group of 9 to 10 years[8] & age group of 7 to 11 years.[9] Reference value of chest expansion at mammary level in our study was comparable to study done in Ukraine,[8] it was lower than normal children of Turkey,[10] Czech Republic on age group of 10 to 14 years,[11] Brazil 9 to 12 years,[12] normal children of Korea[13] and more than Saudi Arabia on age group of 6 to 11 years.[14] Reference value of chest expansion at xiphoid level in our study was comparable to study done in Brazil on age group of 9 to 10 years,[15] less than study done in Czech Republic on

age group of 10 to 14 years,[12] Brazil on age group of 7 to 11 years.[1]

The multivariate regression model derived to predict chest expansion value was as follows -

Prediction equation for males was

1. CE1 = 4.358 + 0.271 (Age) - 0.016 (Height)
2. CE2 = 3.196 + 0.230 (Age)
3. CE3 = 2.827 + 0.268 (Age)

Prediction equation for females was

1. CE1 = 5.407 + 0.262 (Age) - 0.033 (Height) + 0.046(Weight)
2. CE2 = 4.273 + 0.182 (Age) - 0.020 (Height) + 0.032(Weight)

CE3 = 3.271 + 0.166 (Age)

DISCUSSION

The study attempted to establish reference value for expansion of chest in healthy Indian children. Chest expansion now has been accepted as a simple and reliable way of assessment. There is no study done in India to determine reference value of chest expansion in children of age 6 to 15 years.

Chest Expansion, Chest Circumference and Age

In current study, chest expansion, chest circumference increased as the age increased. Axillary level chest expansion was greater than mammary and xiphoid level chest expansion in both genders at all ages. This can be probably explained by the breathing pattern. The apical breathing is predominantly seen in this population. The respiratory system, diaphragm & breathing pattern is not completely developed in this age group. Changes in orientation of ribs occur with increasing age in this population.[1,16-18] The ossification of ribs completes as age increases along with increase in rib length & development of costal cartilages.

Chest Circumference and Height

Current study shows low negative correlation of chest circumference with height. The lung function parameters increase linearly with height & age until at 10 years in females and 12 years in males where growth spurts in adolescents take place. In adolescence age group, the relation of lung function & height is not liner as the increase in height in this group is mostly because of increased leg length & less of increase in thoracic size or length.[4–6] Hence, parameters of lung function proportionally increase to chest & trunk dimension instead of height.[19,20]

Chest Expansion and Height

In current study, weak to moderate positive correlation was noted between chest expansion and height which was more in males than females. A good correlation was reported between thoracic mobility and height which was more prominent in boys than girls. Findings of current study matched with study done in Brazil.[1]

Chest Circumference and Weight

In current study, positive correlation of chest circumference with weight was reported. There is increase in chest circumference as there is increase in weight. This can be contributed by increase in lean body mass as well as fat free mass of the body in this age group. As the body of the children grows, there is increase in lean body mass which can reflect as increase in dimension of the chest wall.[21] Chest dimension increase is also related to increase in fat free mass.

CONCLUSIONS

Gender wise differences are present in chest circumference & chest expansion. Males have higher values than females. Hence for accurate estimation of chest expansion equations derived separately for males & females have to be used. There is significant positive correlation of chest circumference & chest expansion with weight & age, whereas height has negative correlation in 6 - 15 years age group. In males, axillary level chest expansion had best significance with age and height. mammary & xiphoid level chest expansion had best significance with age. In females, axillary & mammary level chest expansion had best significance with age, height and weight whereas xiphoid level chest expansion had best significance with age. This study has generated normative data of chest expansion & statistical prediction models which can be used for areas with similar socio-ethnic, environmental background. Use of this data & equations can prevent misdiagnosis, miss-interpretation in this population. There are differences in reference values derived from international population, hence use of such data in India shall not be encouraged.

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