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Study on correlation of inspiratory pulmonary function parameters with anthropometric parameters and analysis of pattern of inspiratory parameters at various age points in Indian Children

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ABSTRACT

The prevalence of lung diseases is increasing globally. Mortality, morbidity and respiratory disability are a growing health concern. The pulmonary function test is an accurate tool for detecting airway and lung abnormalities. Early diagnosis of respiratory disease is key to preventing mortality and morbidity. The current study has evaluated the relation of the anthropometric parameters and inspiratory parameters of pulmonary function test and also analyzed its behaviour over the growing age in Indian children. The current study included 2109 school-aged children aged 6 to 15. The height, weight, body mass index and body surface area were recorded. The spirometry was performed in accordance with the protocols. The parameters of the inspiratory flow volume loop were recorded. This study observed a good relation between the anthropometric parameters and inspiratory lung function parameters and the parameters were higher in males than in females. The behaviour of these parameters at various points of growing age was analyzed. This study revealed geographical, gender wise variation in the inspiratory parameters. The study also revealed different patterns of lung growth in boys and girls. Hence this study recommends to include inspiratory parameter assessment in the routine assessment of respiratory patients for early and accurate diagnosis of lung pathology in young children.

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a growing health concern across the globe which is affecting 210 million people (Rajkumar *et al.*, 2017). The burden of COPD in India is increasing day by day (Rajkumar *et al.*, 2017). In India, COPD contributes to 75·6% of the chronic respiratory disease disability adjusted life years (DALYs). The prevalence of COPD has increased from 3.3% to 4.2% (Salvi *et al.*, 2018). The mortality, morbidity and disability related to respiratory diseases are increasing over decades. Although it is a chronic respiratory disease, it can be easily preventable &

curable to a good extent (Rajkumar *et al.*, 2017). The pulmonary function test (PFT) done by spirometry is one of the reliable tools to diagnose airway abnormalities. Early diagnosis is most important for reduction in mortality & morbidity associated with respiratory disease. The Spirometry procedure involves recording of patient's inspiratory and expiratory efforts. The efforts are expressed in graphical as well as statistical form (Mahler, 2019). The evaluation of expiratory and inspiratory parameters is important for accurate diagnosis & deciding the severity of the diseases.

Peak inspiratory flow rate (PIFR), forced inspiratory volume in 1 second (FIV1), Forced Inspiratory Vital Capacity (FIVC), Forced inspiratory flow at 25% of FIVC (FIF25%), Forced inspiratory flow at 50% of FIVC (FIF50%), and Forced inspiratory flow at 75% of FIVC (FIF75%) are useful in diagnosing airway abnormalities. Many authors have highlighted the importance of these parameters in clinical practice (Ghosh *et al.*, 2017; Visser *et al.*, 2010; Sterner *et al.*, 2009). The success of the inhaled drug in COPD patients depends on the PIFR values as it is the measure of a patient's inspiratory effort (Ghosh *et al.*, 2017), whereas bronchodilator reversibility can also be assessed by FIV_1. The use of these inspiratory parameters in COPD diagnosis improves accuracy (Visser *et al.*, 2010). Also, the various types of intra and extra thoracic obstructions can be diagnosed by analyzing inspiratory lung function parameters (Owens *et al.*, 1983; Modrykamien *et al.*, 2009). For diagnosing the abnormality, it's important to understand relation of these parameters with height, weight, and age.

The expiratory portion of flow volume loop of spirometry has received great attention from researchers (Koopman *et al.*, 2011; Sudeep *et al.*, 2021). However, this is not the situation of the inspiratory parameters. There is a dearth of studies on understanding inspiratory parameters (Vilozni *et al.*, 2009) its relation with anthropometric parameters and its behaviour over growing age. Hence, this study was designed to understand the relation between anthropometric parameters and inspiratory lung function parameters and to analyze the pattern of inspiratory parameters at various age points in Indian children.

MATERIALS AND METHODS

The study was conducted in eight primary & secondary schools located in the Latur & Beed districts of Maharashtra, India. 1377 healthy boys and 732 healthy girls were randomly selected from schools. A healthy child is defined as a child who has a normal BMI and is free from cardiac/respiratory/metabolic/spinal diseases and the Written permission was obtained from the authorities of the school to carry out the study. The ethical committee approval was received by the institute. Every child's parents received a form with questions about their child's health status and medical history. The parents were asked to fill in the forms. The subjects were recruited for study after getting a dually filled form & consent from parents. The registered medical practitioner carried out the examination to rule out the exclusion criteria. The age, weight, height, body mass index (BMI), body surface area (BSA) were recorded. The selected children were divided into small groups of 10. Detailed instructions and explanation about recording of PFT were given to every group. After demonstration & adequate practice, the PFT was recorded as per the task force of European respiratory society & American thoracic society guideline (American Thoracic Society, 1995). The PIFR, FIVC, PIFR, FIV1, FIF 25%, FIF50%, FIF 75% were recorded for analysis.

Statistical Analysis

The mean, the standard deviation was calculated by descriptive statistics. To understand the relation of anthropometric parameters with PFT parameter, Pearson's correlation test was used in the current study. P value was considered significant if it was less than 0.05. IBM SPSS package 23 was used for statistical analysis.

RESULTS AND DISCUSSION

Results

The mean, the standard deviation of anthropometric parameters was calculated by descriptive statistics in females and for males. Table 1 is depicting overall descriptive of anthropometric parameters of male & female population of study. The mean values of height, weight, age, BMI, BSA were higher in males than in females. Table 2 is depicting overall descriptive of inspirator parameters of male & female population of study.

Age-wise trend of lung function

A gradual, steady increase was noted in female children in FIV1, & FIVC as age advanced from 6-14 years & a slight fall in these values was noted at the age of 15 years, which was statistically non-significant. Figure 1 is depicting overall trend of inspiratory PFT parameters in relation with growing age in female population. The PIFR showed an initial gradual increase followed by a slight decrease at 10 years & then a rise up to 14 years. A slight decrease was noted at 15 years in PIFR. Both the falls

Table 1: Gender wise Descriptive Statistics for Anthropometric Parameters

Parameter	Girls		Boys	
	Mean	SD	Mean	SD
Age	11.201	3.087	11.978	2.783
Weight	33.639	8.174	35.711	10.880
Height	142.022	15.621	146.542	16.930
BMI	16.490	1.793	16.224	1.627
BSA	1.147	0.185	1.289	0.218

Female n=732, Male n=1377

Table 2: Gender wise comparision of Mean values of PFT parameter

PFT Parameter	Girls		Boys	
	Mean	SD	Mean	SD
FIVC	1.535	0.532	1.700	0.665
PIFR	2.105	0.844	2.397	1.182
FIV1	2.566	0.854	2.967	1.201
FIF25%	1.575	0.969	1.718	1.187
FIF50%	1.846	0.948	2.067	1.248
FIF75%	1.925	0.904	2.110	1.179

Table 3: Pearson's Correlation coefficient for Anthropometric Parameters and PFT Parameters (Females)

PFT Parameter	Age	Weight	Height	BMI	BSA
FIVC	.398**	.464**	.364**	.287**	.370**
PIFR	.489**	.504**	.449**	.388**	.431**
FIV1	.543**	.644**	.522**	.503**	.483**
FIF25%	.392**	.489**	.380**	.446**	.354**
FIF50%	.402**	FIF75%	.387**	.455**	.354**
FIF75%	.458**	.536**	.427**	.488**	.376**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4: Pearson's Correlation coefficient showing Correlation between Anthropometric Parameters and PFT Parameters (Males)

PFT Parameter	Age	Weight	Height	BMI	BSA
FIVC	.595**	.702**	.549**	.484**	.503**
PIFR	.553**	.644**	.532**	.459**	.485**
FIV1	.633**	.798**	.617**	.539**	.531**
FIF25%	.323**	.438**	.333**	.277**	.284**
FIF50%	.436**	.536**	.436**	.322**	.390**
FIF75%	.466**	.574**	.458**	.406**	.429**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

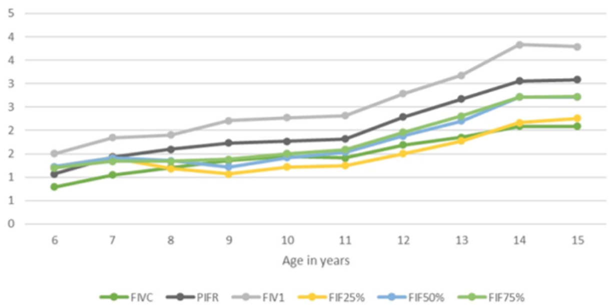

Figure 1: Behaviour of Inspiratory flow parameters at various age points in female children

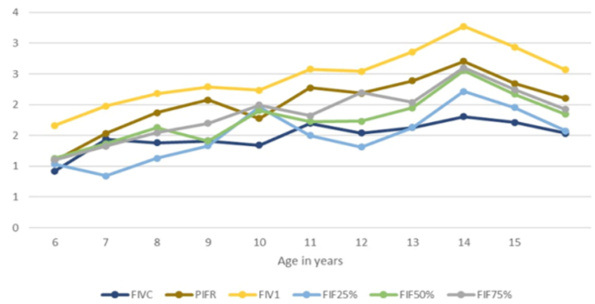

Figure 2: Behaviour of Inspiratory flow parameters at various age points in male children

were statistically non-significant.In female children, FIF 25% increased gradually and steadily from 6 to 12 years of age. Slight decrease at the age of 12 & then a steady rise till 14 was observed followed by a small fall at 15 years of age. This fall was statistically non-significant. FIF75% of female children showed an initial gradual increase until the age of ten years.

Figure 2 is depicting overall trend of inspiratory PFT parameters in relation with growing age in male population. In male children, a gradual, steady increase was noted in PIFR, FIV1 & FIVC as age advanced. The minimum value was noted at the age of 6 years, whereas the maximum at 15 years. FIF25% & FIF50% showed an initial rise at 6 years followed by a small decrease at 08 years & then a steady rise till 15. The fall at age 8 was statistically non-significant. FIF50% showed an initial rise & slight fall 9 years age & after 9 years it showed a gradual steady rise. The fall in the values was statistically non-significant.

Correlation in female populations

In females for FIVC, the highest correlation was observed with weight followed by age, height, BSA & BMI. All the independent parameters showed a significant weak correlation with FIVC. For PIFR, the highest correlation was observed with weight followed by age, height, BSA & BMI. Weight showed a moderate correlation whereas all other parameters showed a significant weak correlation. For FIV1, the highest correlation was observed with weight followed by age, height, BMI & BSA. Weight, age, height, and BMI all had a moderate correlation, but BSA had a significant weak correlation. For FIF25%, FIF50%, FIF 75%, the highest correlation was observed with weight, followed by BMI, age, height & BSA. All independent parameters showed a significant weak correlation. Table 3 is depicting relation of inspiratory PFT parameters in relation with growing anthropometric parameters in female population.

Correlation in male populations

In males for FIVC, the highest correlation was observed with weight followed by age, height, BSA, BMI. Weight showed a strong correlation whereas age, height, BSA showed moderate correlation. The BMI showed a weak correlation with FIVC. For PIFR, the highest correlation was observed with weight followed by age, height, BSA & BMI. Weight, age, and height all had a moderate correlation, whereas BMI and BSA had a significant but weak correlation. For FIV1, the highest correlation was observed with weight followed by age, height, BMI, BSA. Weight showed a strong correlation, whereas all other independent parameters showed moderate correlation. For FIF25%, the highest correlation was observed with weight followed by height, age, BMI, BSA. All independent parameters showed a significant weak correlation. For FIF50%, the highest correlation was observed with weight, followed by age, height, BSA & BMI. Weight showed a moderate correlation whereas all independent parameters showed a significant weak correlation. For FIF 75%, the highest correlation was observed with weight, followed by age, height, BSA & BMI. Weight showed a moderate correlation whereas all independent parameters showed a significant weak correlation. Table 4 is depicting relation of inspiratory PFT parameters in relation with growing anthropometric parameters in male population.

Discussion

The current study was designed to understand the relation of inspiratory parameters of lung function with age, height, weight, sex, BMI & BSA, and understand the pattern of these parameters at various age points. This study showed the positive correlation of inspiratory lung function parameters with weight, height, age, BMI & BSA. Among all anthropometric parameters, weight, height & age were the most independent variables and had shown higher coefficients of correlation. We observed that the lung function parameters increase as age, height, weight, BMI & BSA increase in both genders. The work done by other researchers supports our findings (Schrader *et al.*, 1984; Sliman *et al.*, 1982).

The current study has observed the linear relation of PFT parameters with age & lung function was higher in boys. This finding was supported by many authors (Dickman *et al.*, 1971; Rosenthal *et al.*, 1993). The current study also observed that gender differences in lung function become wider in both genders from 14 years & above. Probably this pattern could be because of the differences in growth in terms of height in boys & girls. Probably no significant increase in height took place in girls after puberty.

The current study also evaluated the inspiratory lung function parameter trends concerning age in boys & girls to understand lung function behaviour concerning growing age. In a comparison of inspiratory parameters & age in both genders, the current study found slightly different trends in the male & female population. The male population had a gradual steady rise in all inspiratory PFT parameters from 6 years age to 15 years except FIF 25% & FIF 50% which had slight decreases at the age of 8 & 9 years respectively & then a steady rise up to 15 years.

The female population of the current study had a steady rise in FIVC from 6 years to 14 years & slight falls at the age of 15 years. FIFR, FIF25%, FIF 50% & FIF 75% had a slight fall at the age of 10,12,8 & 10 years respectively and then a steady rise up to 14 years, followed by a fall at 15 years age. In the female population, all the inspiratory PFT parameters had a slight fall at the age of 15 years. The fall in the parameters was statistically non-significant. A slight decrease at 15 years in all parameters in females can be a result of two basic factors. The first is the chest adiposity & the second the breathing pattern.

The age of 14-15 is the age of puberty in most Indian girls (Khadilkar and Stanhope, 2006; Khadgawat *et al.*, 2016). The changes taking place in hormones start affecting many systems. It also affects the adiposity in the female body. With puberty, the chest adiposity starts to increase. Increased chest adiposity along with changes occurring in the respiratory muscles and rib cage will lead to breathing pattern changes in females. The breathing pattern in both genders in children is primarily abdominal, which changes to costal breathing in females just before onset of puberty (Grivas *et al.*, 1991; Hibbert *et al.*, 1984). The transition from abdominal breathing pattern to thoracic abdominal breathing pattern in girls takes place once puberty is achieved (Guyton and Hau, 2006). The pattern is not developed properly in females at the age of 15 years, hence the amount of air drawn into the lungs gets slightly affected. This change in breathing pattern would have contributed to a slight decrease in lung function values in females after 14 years in the current study. On the contrary, the boys had shown a steady increase in all PFT parameters except FIF 25% & FIF50%.

In boys, FIF 25% & FIF50% showed a slight fall at the age of 8 & 9 years respectively & then a steady rise up to 15 years. In girls, a slight fall in the FIFR, FIF 25%, FIF 50% & FIF 75% was noted between the age of 8-12. Such changes took place only in inspiratory flow parameters in both genders. The variation in inspiratory flow parameters in both genders can be explained by the differences in the airways in the female population. Mostly in very young children, the larger airways like trachea are shorter & wider in females, whereas in boys it is longer and smaller. Hence, girls have higher flow rates than boys due to shorter & wider trachea (Grivas *et al.*, 1991; Guyton and Hau, 2006). The air will easily enter & leave the lungs. As age increases, the growth of lungs starts, which includes the growth of airways & lung parenchyma. The changes will take place in the trachea. The length of the trachea increases in girls with growing age, which results in a slight decrease in flow rates. In boys, the size of the trachea increases & the trachea becomes wider, which increases the flow rates. The changes taking place in airways in relation to the lung parenchyma, chest dimensions are consequences of unequal growth (Quanjer *et al.*, 2008). This in-proportionate growth in the lung resulted in alternate slight rise & fall in inspiratory flow parameters in girls of the current study (Grivas *et al.*, 1991; Quanjer *et al.*, 2008). The study of Jordanian children also observed a fall in PFT values at the age of 5 years in girls (Sliman *et al.*, 1982). Differences in lung function behaviour concerning growing age and discontinuity in the pattern noted in the current study were supported by the following authors. Puberty, the lung function & height relation in the pubertal stage was the reason for the discontinuity (Dickman *et al.*, 1971; Quanjer *et al.*, 2008).

In girls at the age of 13 years, the sitting-height or leg-length ratio reaches a minimum value, whereas in boys it reaches a minimum at the age of 15 years. In adulthood, this ratio increases slightly and then it gets stabilized. This makes it clear that increase in standing height & leg length doesn't occur simultaneously. The leg length increases more than standing height. The lungs are present in the trunk. The lung volumes, the standing height & their interrelationship are subjected to change in relation to the time during the growing years, which suggests that growth of central & peripheral parts of the body is not proportionate, resulting in lower PFT parameter values in both sexes as compared to pre-puberty values (Quanjer *et al.*, 2008).

The boys of the United Kingdom and Kerala had higher PIFR values than our boys (Rosenthal *et al.*, 1993; Nair *et al.*, 1997). Kerala boys with heights ranging from 120 cm to 140 cm had higher PIF 25%, PIF 50%, and PIF 75% values than our boys, whereas Kerala boys taller than 140 cm had lower values (Nair *et al.*, 1997).

CONCLUSION

Anthropometric parameters correlate well with the inspiratory parameters. The pattern of lung growth varies gender-wise. Hence, prediction equations shall be derived for both genders separately. The geographic variation in lung function exists hence population-specific equations shall be utilized for the assessment of lung function. Recording of inspiratory parameters of the flow volume loop shall be an integral part of the assessment of respiratory patients. The outcome of this study will help in early & accurate diagnosis of airway obstruction & restriction in children suffering from respiratory diseases.

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Conflict of Interest

The authors declare that there is no conflict of interest for this study.

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