Original Research Article

The association between pulmonary function test and anthropometric measurements using bioelectric impedance analysis in adolescents

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ABSTRACT

Background: The development of pulmonary functions and growth of physical parameters i.e. height and weight are coexistent. These physical parameters are further affected by nutrition and physical activities of children. The aim of present study was to find correlation between pulmonary function test and anthropometric measurements using bioelectric impedance analysis in adolescence.

Methods: A cross sectional observational study conducted at Sanskar Madhmik Vidhyalay, Mayur Park, Aurangabad during July to December 2017. Adolescent between the age group between 11 to 18 years were enrolled in present study.

Results: Out of 138 total students 80 (57.97%) were male and 58 (42.02%) female. As per person correlation test analysis weight, height, Hip circumference and body surface area are found to be positively correlated to FVC, FEV1, PEFR and FEF25-75. As per person correlation test analysis total body fat, trunk subcutaneous fat and whole body subcutaneous fat are found to be negatively correlated to FVC, FEV1, PEFR and FEF25-75. Muscle mass and basal metabolic rate are found to be positively correlated to FVC, FEV1, PEFR and FEF25-75.

Conclusions: Total body fat, trunk subcutaneous fat and whole body subcutaneous fat are negatively correlated with pulmonary function test. The body fat percentage had a stronger correlation than BMI, thus suggesting that body fat percentage was a major determinant of the reduced pulmonary functions in both sexes.

Keywords: Total body fat, Lung function test, Body mass index

INTRODUCTION

The pulmonary function tests are considered as an essential part for evaluation of lung functions. PFTs are influenced by various factors like anthropometric, geographic, genetic, socioeconomic and life style. The development of pulmonary functions and growth of physical parameters i.e. height and weight are coexistent. These physical parameters are further affected by nutrition and physical activities of children.

During last few decades, PFTs have been evolved from the tool for physiological study to clinical investigation in assessing respiratory status of the patients. The development of pulmonary function and growth of physical parameters go hand in hand in children. Therefore measurement of lung functions is important for the evaluation of physical development and diseases. The prevalence of childhood pulmonary diseases especially bronchial asthma is increasing worldwide and this necessitates the need for establishing regression equations for predicting pulmonary function in children. Usually the values are compared with the standards obtained from healthy individuals of similar age and height. Development of pulmonary function is then described by means of regression equations usually employing sex, age and standing height as independent variables.
Obese and overweight people are at an increased risk of respiratory symptoms, such as breathlessness, particularly during exercise, even if they have no obvious respiratory illness. The association between obesity and asthma has also raised new concerns about whether the mechanical effects of obesity on the respiratory system contribute to airway dysfunction that could induce or worsen asthma. Although obesity-related lung function changes have been described in adults, there is a lack of data on such changes in children. The increase in childhood obesity is an emerging problem worldwide and directly contributes to obesity in adulthood; as a result, there is an increase in the incidence of fatal diseases such as cardiovascular disease, metabolic syndrome, dyslipidemia, diabetes mellitus, arterial hypertension, and even respiratory changes.

Anthropometric measurements are an important, widely applicable, noninvasive, and inexpensive technique for assessing body size, proportions, and composition. Differences in LF parameters (forced expiratory volume in 1 s [FEV1] and forced vital capacity [FVC]) are due in part to differences in body proportions as well as several other factors. Some evidence also suggest that psychosocial factors, and family problems, may influence truncal length and height in childhood.

**Aim and objectives**

**Aim**

To find correlation between pulmonary function test and anthropometric measurements using bioelectric impedance analysis in adolescence.

**Objective**

- To study relationship between anthropometric measurement like weight, height, body mass index (BMI) and pulmonary function test in adolescence.
- To study relationship between body fat percentage and Muscle mass with pulmonary function test in adolescence.

**METHODS**

**Study design**

Cross-sectional observational study.

**Study area**

Sanskar Madhmik Vidhyalay, Mayur Park Aurangabad.

**Inclusion criteria**

Inclusion criteria were adolescent between the age group between 11 to 18 years.

**Exclusion criteria**

Exclusion criteria were cardiorespiratory diseases; thoracic cage disorders; children with H/O bronchial asthma, COPD or allergic diseases; children on treatment of respiratory tract infection; smoking.

**Sampling method**

Purposive sampling

**Study instrument**

- Performa containing identifying data
- Bioelectric Impedance analysis - Karada scan

A complete spirogram was performed according to American Thoracic Society (ATS) guidelines by using a computerized spirometer. The test was carried out in a private and quiet room in a standing position with the nose clip held in position on the nose. The flow, volume/timed graph were taken out in accordance to the criteria based on the ATS. The subject was instructed to take a deep breath until the lung were full and then blow out through mouth as forcibly and as fast and as long as possible till the maximum capacity, sealing the lips tightly around a clean mouth piece. Best of the three acceptable curves was selected as the recording. Spirometric parameters recorded for analysis were forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), FEV1/FVC ratio, peak expiratory flow rate (PEFR), forced expiratory flow FEF25 - 75%.

**Anthropometric measurement**

**Weight:** It was measured without shoes with the help of weighing machine to the nearest 0.1 kg mark.

**Standing height:** It was measured against wall inscribed with measuring scale to the nearest centimeter.

**BMI:** Weight in kg/height in m²

**Chest circumference:** Measured at the level of nipple in mid-inspiration.

**Waist circumference:** Midpoint between lower margin of last palpable rib and top of iliac crest

**Hip circumference:** Measurement should be taken around widest portion of the buttocks.

**Waist to hip ratio:** Waist circumference/hip circumference

**Body surface area:** Mosteller formula- 

\[ \text{Body surface area} = \text{Mosteller formula} \times (\text{weight}/360). \]
Study period

July to December 2017.

Sample size

Sample size was calculated using statistical software for calculating Sample Size using Estimation of Sample Mean by considering confidence level of 95% and absolute precision of 1%. The mean of 89.95 with SD of 5.82.

M - Your guess of population M - 89.95
S - Standard deviation of M - 5.82
1-alpha - set level of confidence (value <1.0) - 0.95
Z1 - Z value associated with confidence - 1.96
d - Absolute precision (=value <M) - 1
n - Minimum sample size – 131.

RESULTS

Table 1 shows the demographic profile of the students studied, the students were from age group 12 to 16 of which 39.1% from age 15, 26.1% and 24.6% from 13 and 14 age group. Out of 138 total students 80 (57.97%) were male and 58 (42.02%) female. 65.2% of all were from nuclear, 22.5% from joint and 12.3% from three generation family. 37% students are living in overcrowded conditions.

| Particulars       | Numbers | Percentage (%) |
|-------------------|---------|----------------|
| Age               |         |                |
| 12                | 7       | 5.1            |
| 13                | 36      | 26.1           |
| 14                | 34      | 24.6           |
| 15                | 54      | 39.1           |
| 16                | 7       | 5.1            |
| Sex               |         |                |
| Male              | 80      | 57.97          |
| Female            | 58      | 42.02          |
| Type of family    |         |                |
| Nuclear family    | 90      | 65.2           |
| Joint family      | 31      | 22.5           |
| Three generation family | 17 | 12.3 |
| Religion          |         |                |
| Hindu             | 134     | 97.1           |
| Muslim            | 1       | 0.7            |
| Christian         | 0       | 0              |
| Other             | 3       | 2.2            |
| Type of house     |         |                |
| Kachha            | 2       | 1.4            |
| Pakka             | 136     | 98.6           |
| Overcrowding      |         |                |
| Yes               | 51      | 37.0           |
| No                | 87      | 63.0           |

Table 1: Demographic profile of students.

Table 2 shows the various anthropometric parametric Mean and Standard deviations in students. The mean weight was 47.88 kg and 43.20 kg in male and females respectively, height was 163.55 cm and 151.08 cm in male and female respectively.

Table 2: Anthropometric parameters in students.

| Sr. no. | Parameters               | Male (Mean±SD) | Female (Mean±SD) |
|---------|--------------------------|----------------|------------------|
| 1       | Weight                   | 47.88±8.64     | 43.20±6.79       |
| 2       | Height                   | 163.55±8.5     | 151.08±18.9      |
| 3       | Body mass index          | 17.85±2.63     | 18.26±2.57       |
| 4       | Chest circumference      | 29.34±2.62     | 29.49±2.16       |
| 5       | West circumference       | 27.01±2.88     | 26.96±2.65       |
| 6       | Hip circumference        | 33.66±2.49     | 33.50±2.80       |
| 7       | W/h ratio                | 0.79±0.60      | 0.80±0.05        |
| 8       | Body surface area        | 1.46±0.17      | 1.34±0.11        |

Table 3: Mean of body fat analysis as per bioelectric impedance analysis.

| Sr. no. | Parameters               | Male (Mean±SD) | Female (Mean±SD) |
|---------|--------------------------|----------------|------------------|
| 1       | Total body fat           | 14.62±4.30     | 22.53±3.59       |
| 2       | Trunk subcutaneous fat   | 8.16±2.80      | 14.66±3.62       |
| 3       | Whole body subcutaneous fat | 9.82±2.91 | 18.80±3.69       |
| 4       | Muscle mass              | 37.08±2.21     | 27.74±2.78       |
| 5       | Basal metabolic rate     | 1275±140.56    | 1033±100.02      |

Table 3 shows mean of body fat analysis as per bioelectric impedance analysis, all the total body fat, trunk subcutaneous fat and whole body subcutaneous fat was significantly higher in females than males, but muscle mass is more in males than females.

Table 4: Outcome of lung function test.

| Sr. no. | Parameters | Male (Mean±SD) | Female (Mean±SD) |
|---------|------------|----------------|------------------|
| 1       | FVC        | 2.67±0.67      | 2.05±0.52        |
| 2       | FEV1       | 2.55±0.61      | 1.98±0.47        |
| 3       | PEFR       | 6.10±1.28      | 4.79±0.99        |
| 4       | FEF 25-75  | 3.93±1.08      | 3.49±0.91        |

Table 5: Restriction of lung function test found in spirometry with its severity classification.

| Particulars        | Numbers | % |
|--------------------|---------|---|
| Restriction        | Yes     | 50 | 36.2 |
|                    | No      | 88 | 63.8 |
| Restriction        | Mild    | 18 | 36  |
| classification     | Moderate| 26 | 52  |
|                    | Sever   | 6  | 12  |
Table 5 shows the distribution lung function test in male and female students. It shows the mean and standard deviation of FVC (forced vital capacity), FEV1 (forced expiratory volume 1), PEFR (peak expiratory flow rate), FEF25-75 (forced expiratory flow between 25% and 75% expired volume (FEF25-75%)).

The difference between male and female for FVC and PEFR are statistically significant, but FEV1 and FEF25-75 are not significant.

As per person correlation test analysis weight, height, Hip circumference and body surface area are found to be positively correlated to FVC, FEV1, PEFR and FEF25-75 but chest circumference is positively correlated with FVC, FEV1 and PEFR. Waist to Hip ratio is found to be negatively correlated to FVC, FEV1, PEFR and FEF25-75. BMI and hip circumference are not correlated to FVC, FEV1, PEFR and FEF25-75.

Table 6: Relationship between anthropometric parameters with lung function test.

| Parameters               | FVC          | FEV1         | PEFR         | FEF 25-75   |
|--------------------------|--------------|--------------|--------------|-------------|
| 1. Weight                | r=0.436*     | r=0.427*     | r=0.405*     | r=0.260*    |
| 2. Height                | r=0.440*     | r=0.447*     | r=0.353*     | r=0.207*    |
| 3. BMI                   | r=0.071      | r=0.051      | r=0.091      | r=0.073     |
| 4. Chest circumference   | r=0.287*     | r=0.273*     | r=0.228*     | r=0.157*    |
| 5. Waist circumference   | r=0.062      | r=0.072      | r=0.030      | r=0.38      |
| 6. Hip circumference     | r=0.279*     | r=0.264*     | r=0.242*     | r=0.155     |
| 7. Waist/hip ratio       | r=0.385*     | r=0.385*     | r=0.288*     | r=0.220*    |
| 8. Body surface area     | r=0.529*     | r=0.525*     | r=0.486*     | r=0.309*    |

Table 7: Relationship between body fat distributions as per bioelectric impedance analysis with lung function test.

| Parameters                      | FVC          | FEV1         | PEFR         | FEF 25-75   |
|---------------------------------|--------------|--------------|--------------|-------------|
| Total body fat                  | r=0.409*     | r=0.430*     | r=0.434*     | r=0.230*    |
| Trunk subcutaneous fat          | r=0.372*     | r=0.388*     | r=0.398*     | r=0.201*    |
| Whole body subcutaneous fat     | r=0.425*     | r=0.440*     | r=0.436*     | r=0.214*    |
| Muscle mass                     | r=0.452*     | r=0.462*     | r=0.487*     | r=0.230*    |
| Basal metabolic rate            | r=0.582*     | r=0.577*     | r=0.571*     | r=0.325*    |

Table 8: Multiple regression equations for pulmonary function of adolescent.

| Parameters                      | Multiple regression equations                                                                 |
|---------------------------------|---------------------------------------------------------------------------------------------|
| FVC (liter)                     | 0.157 + 0.043 × Weight (kg) + 0.014 × Height (cm) - 0.063 × CC (cm)                          |
|                                 | 2.682 - 0.089 × BMI + 0.169 × CC (cm) - 4.542 × W/H ratio                                  |
|                                 | - 1.391 - 0.064 × BMI + 0.027 × MM + 2.884 × BSA                                           |
|                                 | 1.464 - 0.052 × TBF + 0.003 × MM + 0.039 × weight (kg)                                    |
|                                 | 0.345 - 0.087 × BMI + 0.003 × BMR + 0.005 × TBF                                            |
|                                 | 3.358 - 0.048 × TBF + 0.202 × Trunk SF - 0.168 × WBFS                                     |
| FEV1 (liter)                    | 0.332 + 0.039 × Weight (kg) + 0.013 × Height (cm) - 0.062 × CC (cm)                       |
|                                 | 2.593 - 0.087 × BMI + 0.155 × CC (cm) - 4.077 × W/H ratio                                  |
|                                 | - 1.064 - 0.067 × BMI + 0.023 × MM + 2.702 × BSA                                           |
|                                 | 1.781 - 0.054 × TBF - 0.003 × MM + 0.035 × weight (kg)                                    |
|                                 | 0.554 - 0.077 × BMI + 0.003 × BMR + 0.001 × TBF                                            |
|                                 | 3.246 - 0.055 × TBF + 0.184 × Trunk SF - 0.143 × WBFS                                     |
| PEFR (liter/sec)                | 3.970 + 0.105 × Weight (kg) + 0.017 × Height (cm) - 0.203 × CC (cm)                       |
|                                 | 6.146 - 0.09 × BMI + 0.219 × CC(cm) - 6.78 × W/H ratio                                    |
|                                 | - 2.579 - 0.005 × BMI + 0.098 × MM + 3.513 × BSA                                           |
|                                 | 2.723 + 0.081 × TBF - 0.035 × MM + 0.068 × weight (kg)                                    |
|                                 | 2.484 + 0.037 × BMI + 0.003 × BMR - 0.079 × TBF                                            |
|                                 | 7.572 - 0.128 × TBF + 0.295 × Trunk SF - 0.216 × WBFS                                     |
| FEF25-75% (liter)               | 2.879 + 0.050 × Weight (kg) + 0.007 × Height (cm) - 0.087 × CC (cm)                       |
|                                 | 4.487 - 0.034 × BMI + 0.106 × CC (cm) - 4.068 × W/H ratio                                  |
|                                 | 0.421 - 0.040 × BMI + 0.021 × MM + 2.375 × BSA                                            |
|                                 | 4.467 - 0.076 × TBF - 0.034 × MM + 0.039 × weight(kg)                                    |
|                                 | 2.357 + 0.040 × BMI + 0.001 × BMR - 0.040 × TBF                                            |
|                                 | 4.775 - 0.106 × TBF + 0.116 × Trunk SF - 0.029 × WBFS                                     |
As per person correlation test analysis total body fat, trunk subcutaneous fat and whole body subcutaneous fat are found to be negatively correlated to FVC, FEV1, PEF and FEF25-75. Muscle mass and basal metabolic rate are found to be positively correlated to FVC, FEV1, PEF and FEF25-75.

**CONCLUSION**

Weight, height, hip circumference and body surface area are the strong determinants of pulmonary function test. Total body fat, trunk subcutaneous fat and whole body subcutaneous fat are negatively correlated with pulmonary function test. The body fat percentage had a stronger correlation than BMI, thus suggesting that body fat percentage was a major determinant of the reduced pulmonary functions in both sexes.

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**Conflict of interest:** None declared

**Ethical approval:** The study was approved by the Institutional Ethics Committee

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