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Original Research Article

Evaluation of Pulmonary Function Parameters in Relation to Physiological Variables

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Abstract:

Background: Pulmonary functional tests (PFTs) are crucial diagnostic methods, which measures the lung functionality and respiratory mechanics in numerical values. Respiratory health and disease are best understood in terms of their physiological nature and differences between individuals.

Aim: To assess the parameters of pulmonary functioning and physiological changes of the same in response to the age, sex, height, and weight of healthy adults.

Methodology: A cross-sectional observational study was undertaken on 100 healthy participants of the age 18–50 years of age with the Department of Physiology, Netaji Subhas Medical College and Hospital, Jamshedpur. It was measured by standardized procedures for spirometric parameters (such as FVC, FEV_1, FEV_1/ FVC ratio, PEFR, and FEF 25–75 percent). The SPSS version 27 was used to analyze the data and Pearson coefficient and regression were used to evaluate the correlations.

Results: Males exhibited significantly higher FVC, FEV_1, PEFR, and FEF25–75% values than females ($p<0.001$), while FEV_1/FVC ratio showed no gender difference. Height and weight were strong positive predictors of FVC, whereas age had a negative influence. BMI was not significantly correlated with lung function.

Conclusion: Pulmonary function is significantly influenced by gender, height, weight, and age, but not by BMI. These findings highlight the importance of considering anthropometric and demographic variables for accurate interpretation of PFTs.

Keywords: Pulmonary Function Tests, Spirometry, FVC, FEV_1, Anthropometry, Lung Function.

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Introduction

Pulmonary function tests (PFTs) are very useful diagnostic tools which provide quantitative measurements of lung functioning and respiratory mechanics [1]. They are used to determine the physiological state of the respiratory system, determine the presence of pulmonary pathologies, the course of disease, and the efficiency of treatment procedures. Respiratory system is a significant component of the homeostasis as it is the location where the gaseous exchange occurs between the external environment and the blood, that is why the right quantities of oxygen and carbon dioxide reach the organism, and the carbon dioxide is also released [2]. Disruption of this system, either structurally or functionally can result in impairment of the pulmonary functioning which can be objectively tested in combination of well-standardized tests which are also known as pulmonary function tests in a broader sense. These tests are a foundation in the clinical respiratory medicine and aid clinicians to differentiate between obstructive and restrictive pulmonary diseases, evaluate the ventilatory capacity, and understand mechanical properties of the lungs and the thoracic cage.

Breathing is a complicated process in human beings which is a combination of ventilation, diffusion, perfusion and regulation [3]. These tests of pulmonary functioning have a basis on the knowledge of these processes. The breathing of air in and out of the lungs, that is also known as ventilation, is dependent on the elasticity of the lung tissue, resistance of the airways, and the output of the respiratory muscles.

Diffusion process is a process by which gases are transported between the alveolar-capillary membrane which is dictated by the pressure gradient and thickness of the membrane. Perfusion relates to the pulmonary circulation of blood where it takes in deoxygenated blood of the right ventricles into the lungs to be oxygenated [4]. The interaction between these processes offers an appropriate exchange of gases and arterial blood gas homeostasis. Any disturbance of these physiological processes can be reflected in the variation of the values of the pulmonary tests of the functioning that is why the PFTs are not only diagnostic but also indicating of the underlying pathophysiological changes.

The PFTs are physiologically grounded that is deep rooted in the law of physics and gas dynamics. As an example, the most common pulmonary functionality test is spirometry that determines airflow and lung volume with forced inspiration and expiration of air that provides the information about airway resistance and lung compliance [5]. Some of the parameters are Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV 1), which particularly work well to draw a line between obstructive disease, such as chronic obstructive pulmonary disease (COPD), and restrictive diseases such as pulmonary fibrosis [6]. The use of FEV 1 to FEV 1 ratio is disproportionate in obstructive disease and proportional in restrictive diseases and the implications of airways resistance changes are compensated by relatively normal FEV 1/FVC ratio [7]. Similarly, pleasures are utilized in establishing the elasticity of both lungs and the chest wall by using pleasures like Total Lung Capacity (TLC), Residual Volume (RV) and Functional Residual Capacity (FRC). The other significant test that is referred to as Diffusing Capacity of the Lungs of Carbon Monoxide (DLCO) is the measurement of the effectiveness of exchange of gases across the alveolar-capillary barrier, which is used as a marker of the inability to conduct diffusion in diseases like emphysema or interstitial lung disease.

Also, lung functions are examined, which is important in occupational health, sports medicine, preoperative examination and epidemiology [8]. They would be useful in determining the impact of environmental exposures to dust, fumes, and toxins on the lung performance, and also the degree of fitness to vigorous physical activities or surgery. The reliability and reproducibility of PFTs has been enhanced over the last few years owing to standardization of these tests by different organizations such as the American Thoracic Society (ATS) and the European Respiratory Society (ERS) in different clinical settings. There is also the creation of advanced computerized spirometers and body plethysmographs due to the technological advancements that can measure the lung mechanics, airway resistance, and the volumes of gas correctly and real-time. More opportunities to test pulmonary function through portable equipment also have been developed to make it available in both local and field-testing locations, thus providing the possibility to screen a large population.

The physiological idea of pulmonary functional testing is essential to the adequate explanation of the results. The respiratory system has many parts that work together to ensure that the system functions properly and these are the lungs as well as the quality of the airways, the thoracic cage, respiratory muscles and the neuronal control systems. In this way, the interpretation of PFT requires a deep insight into the part that these factors contribute to the overall workings of breathing. To illustrate the case, lower fiberrosis lung compliance will result in less lung volumes; increased airway resistance will lead to airway asthma resulting in limit of flow and air trapping. Similarly, neuromuscular diseases may result into reduced maximal inspiratory and expiratory pressures thereby interfering with ventilatory efficiency. Thus, the pulmonary function test is the connection between clinical examination and physiological understanding of the tissue, in which multifaceted respiration mechanism is changed into measurable variables that guide diagnosis and treatment.

Methodology

Study Design: The present study was designed as a cross-sectional observational study aimed at assessing pulmonary function parameters and their physiological variations among healthy individuals. The study sought to evaluate the relationship between various physiological factors such as age, gender, height, and body weight with different spirometric parameters. This design was chosen to obtain baseline pulmonary function data from a defined population within a limited time frame.

Study Area: The study was conducted in the Department of Physiology, Netaji Subhas Medical College and Hospital, Jamshedpur, Jharkhand, India for five months. All pulmonary function tests were performed in the departmental laboratory using standardized spirometric equipment under controlled environmental conditions to ensure the accuracy and reliability of the measurements.

Study Participants: The study included healthy volunteers comprising medical students, hospital staff, and individuals attending routine health checkups at the institution. All participants were briefed about the purpose and procedure of the study, and written informed consent was obtained prior to data collection.

Inclusion Criteria

- Healthy individuals aged between 18 to 50 years.

- Non-smokers and non-alcoholics.
- Individuals with no history of respiratory, cardiovascular, or neuromuscular diseases.
- Participants willing to provide informed consent and cooperate during testing procedures.

Exclusion Criteria

- Individuals with any known respiratory disorders such as asthma, chronic obstructive pulmonary disease (COPD), or tuberculosis.
- Subjects with recent respiratory infections within the past four weeks.
- Individuals with cardiovascular abnormalities or neuromuscular impairments affecting respiration.
- Smokers and subjects with occupational exposure to respiratory irritants.
- Pregnant women and individuals unwilling to participate.

Sample Size: A total of 100 participants were included in the study based on the inclusion and exclusion criteria. The sample size was determined considering feasibility, availability of participants, and comparable previous studies evaluating pulmonary function in similar populations.

Procedure: All participants were instructed to report to the physiology laboratory in the morning hours to minimize diurnal variation in lung function. After explaining the procedure, anthropometric measurements including height, weight, and body mass index (BMI) were recorded. Pulmonary function tests were performed using a computerized spirometer following the American Thoracic Society (ATS) guidelines. Each participant was seated comfortably, and a nose clip was applied to prevent nasal leakage. The subject was then instructed to inhale deeply and exhale forcefully into the mouthpiece to obtain parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), FEV_1/FVC ratio, Peak Expiratory Flow Rate (PEFR), and Forced Expiratory Flow (FEF25–75%). Each maneuver was repeated at least three times to ensure reproducibility, and the best reading was taken for analysis. All instruments were calibrated before each session, and hygienic precautions such as the use of disposable mouthpieces were strictly followed.

Statistical Analysis: Data collected were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software version 27. Descriptive statistics such as mean and standard deviation were calculated for all variables. The relationship between pulmonary function parameters and anthropometric variables (age, height, weight, and BMI) was analyzed using Pearson's correlation coefficient. Differences between groups (e.g., male vs. female) were assessed using Student's t-test. A p-value of less than 0.05 was considered statistically significant.

Result

Table 1 shows the study sample of 100 individuals in terms of age and gender. Most of the respondents (45%), made the group of 18 25 years, consisting of 20 men and 25 women, which means that the female representation in this category is slightly higher. The age bracket 2635 years was 25 per cent of the participants with males (15) being more than females (10). The ages of participants were 36–45 years (18-percent of the sample, 10 males and 8 females). The lowest percentage (12) was recorded in the 46 50 years age group that comprised 7 males and 5 females. In general, the sample presented in the studies had an almost equal gender mix comprising of 52 males and 48 females and an adequate age and gender mix.

Table 1: Distribution of Study Participants According to Age and Gender (n = 100)

Age Group (Years)	Male (n)	Female (n)	Total (n)	Percentage (%)
18 – 25	20	25	45	45
26 – 35	15	10	25	25
36 – 45	10	8	18	18
46 – 50	7	5	12	12
Total	**52**	**48**	**100**	**100**

Table 2 gives the mean anthropometric value of the study participants, that is, 52 males and 48 females. Male and female participants were quite similar in age, with the mean of the total sample being 29.2 ± 8.0 years, and 29.8 (28.5) years, respectively. Males were also significantly taller but the mean height of 171.2 cm +/- 6.5 cm, and 159.3 cm +/- 5.8 cm in males and females respectively gave an overall mean height of 165.6 cm +/- 8.4 cm. On the same note, the body weight in males (68.4 ± 7.9 kg) was greater than that of females (59.8 ± 6.3 kg) and the overall average body weight was 64.3 ± 8.5 kg. Nonetheless, there was no significant difference in the mean Body Mass Index (BMI) between the two groups and the mean of BMI was 23.2 + 2.1 kg/m 2 and 23.5 + 2.4 kg/m 2, respectively, which means that there is no significant difference in the overall body structure between the two genders.

Table 2: Mean Anthropometric Characteristics of Study Participants (Mean ± SD)			
Parameter	**Male (n = 52)**	**Female (n = 48)**	**Total (n = 100)**
Age (years)	29.8 ± 8.2	28.5 ± 7.9	29.2 ± 8.0
Height (cm)	171.2 ± 6.5	159.3 ± 5.8	165.6 ± 8.4
Weight (kg)	68.4 ± 7.9	59.8 ± 6.3	64.3 ± 8.5
BMI (kg/m²)	23.2 ± 2.1	23.5 ± 2.4	23.3 ± 2.2

Table 3 shows the comparison of parameters of pulmonary function test (PFT) in male and female participants and the most significant gender-based differences could be observed in the majority of the measured parameters. The forced vital capacity (FVC) and the forced expiratory volume in a single second (FEV 1) were significantly better in males (4.25 ± 0.65 L and 3.58 ± 0.55 L, respectively) compared to females (3.12 ± 0.58 L and 2.89 ± 0.49 L), and the p-values were less than 0.001, which is a significant statistical value. Likewise, the Peak Expiratory Flow rate (PEFR) and forced expiratory flow between 25 and 75 per cent of FVC (FEF2575) was significantly higher in men (8.10 ± 1.05 L/sec and 4.01 ± 0.68 L/sec) compared to women (6.95 ± 0.92 L/sec and 3.42 ± 0.59 L/sec) with p-values of less than 0.001 and 0.00 Nevertheless, the difference in the FEV 1 / FVC ratio was not significant (p =0.142) even though the male gender has more absolute lung volumes and flow rates, but the relative capacity of the expiratory capacities between the two genders is still similar.

Table 3: Comparison of Pulmonary Function Test (PFT) Parameters Between Male and Female Participants			
Parameter	**Male (Mean ± SD)**	**Female (Mean ± SD)**	**p-value**
FVC (L)	4.25 ± 0.65	3.12 ± 0.58	<0.001
FEV_1 (L)	3.58 ± 0.55	2.89 ± 0.49	<0.001
FEV_1/FVC (%)	84.3 ± 4.7	85.9 ± 5.1	0.142
PEFR (L/sec)	8.10 ± 1.05	6.95 ± 0.92	<0.001
FEF25–75% (L/sec)	4.01 ± 0.68	3.42 ± 0.59	0.003

Table 4 presents correlation of pulmonary with the anthropometric variables in 100 individuals using parameters of pulmonary functions. The findings reveal that age was negatively correlated with all the parameters of pulmonary functions implying that lung functioning is on the downward trend with advancing age. Height was positively correlated with FVC (r = +0.612) and FEV1 (r = +0.583) meaning that taller people have higher lung volumes and expiratory capacities. Weight also showed positive relationship with FVC (r = +0.425) and FEV1 (r = +0.398) which means that body mass possesses a positive impact in lung function though not as potent as the height. Contrastingly, BMI only had weak correlations with all parameters indicating that it is not a very significant determinant of pulmonary functioning. The FEV 1/FVC was positively or negatively correlated with anthropometric variables, indicating that proportional lung capacity is not very directly related to body size or age. On the whole, height was found to have the most impact on the pulmonary functioning.

Table 4: Correlation of Pulmonary Function Parameters with Anthropometric Variables (n = 100)				
Parameter	**Age (r)**	**Height (r)**	**Weight (r)**	**BMI (r)**
FVC (L)	-0.218	+0.612	+0.425	0.192
FEV_1 (L)	-0.238	+0.583	+0.398	0.165
FEV_1/FVC (%)	0.065	-0.109	-0.085	-0.142
PEFR (L/sec)	-0.175	+0.529	+0.311	0.094
FEF25–75% (L/sec)	-0.284	+0.475	+0.283	0.101

Table 5 is the regression analysis that gives the predictors of Forced Vital Capacity (FVC). The findings show that age correlates negatively with FVC (β = -0.023, p = 0.014), which has shown that FVC is likely to be reduced with age. Height indicates a strong positive correlation with FVC (β = 0.048, p < 0.001), which means that the taller people tend to possess higher values of FVC. Weight also shows a strong positive correlation with FVC (β = 0.022, p = 0.034) so that greater body weight does not have a significant contribution to higher FVC figures. Nonetheless, BMI does not demonstrate any notable impact (β = 0.013, p = 0.386) implying that BMI may not be a predictor of FVC alone as compared to other variables. Altogether, height and weight become important positive predictors, whereas age has a negative effect on FVC.

Table 5: Regression Analysis Showing Predictors of Forced Vital Capacity (FVC)				
Independent Variable	**β Coefficient**	**Standard Error**	**t-value**	**p-value**
Age (years)	-0.023	0.009	-2.51	0.014
Height (cm)	0.048	0.011	4.36	<0.001
Weight (kg)	0.022	0.01	2.15	0.034
BMI (kg/m²)	0.013	0.015	0.87	0.386

Discussion

Our results showed that males were significantly higher than females in the values of FVC, FEV1, PEFR and FEF 25-75%, but the difference in FEV1/FVC ratio was not significant based on gender (we studied 100 participants). In our regression analysis, height and weight were found to be positive predictors of FVC, age had a negative effect and BMI did not significantly predict it. These results conform and are opposed by various previous researches of pulmonary functioning tests (PFTs) and their physiology.

To begin with, on the gender differences, our observation that males have higher absolute lung volumes and flow rates than females echoes earlier work. As an example, Choudhuri (2014) [9] was able to measure lower values of FVC, FEV1, PEFR, and maximal expiratory pressure in female subjects compared to males. Likewise, Heraganahally et al. (2022) [10] found that males had a larger mean FVC (difference 0.41 L) and FEV1 (difference 0.27 L) as compared to females with the same height and age, but there was no significant difference between the FEV1/FVC ratio. This trend helps us conclude that gender differences in lung functioning are caused by anatomical (size of thorax, volume of lungs, airways calibres) and not functional reasons. Conversely, some studies have reported that the FEV1/ FVC ratio varied among genders, which was not the case with ours. This strengthens the opinion that the proportionality of being able to exhale in the first second is similar between the sexes when measured as the ratio of total forced vital capacity.

Second, our positive correlation between height (and to a weaker extent weight) and FVC as well as FEV1 is well supported by the literature. Indicatively, Das et al. (2018) [11] found that height and age had a close relationship with FEV1 and FVC, but the ratio of the two was not highly height-related. They highlighted height as the anthropometric measurement with the highest predictability of the lung volumes and flows. FVC, FEV1 and PEFR have been observed in another study to have a positive correlation with height, age, and body surface area among children (Doctor et al., 2010) [12]. Our findings reflect these findings: taller subjects are less likely to have smaller lung volumes and ventilatory capacity. On the weight/anthropometry side we saw moderate positive correlation with weight but weak with BMI; this is also in line with the literature that demonstrates that weight can have an impact on lung volumes (probably through lean body mass/respiratory muscle strength) but BMI (which mixes fat and muscle) is a poor predictor of lung volumes.

Third, we observe that the relationship between age and all parameters of pulmonary functions (FVC, FEV1, flows) is negative, which is consistent with previously well-known findings. A thorough analysis conducted by Talaminos Barroso et al. (2018) has provided evidence that the age-related decrease in FVC and FEV1 is caused by the anatomical and mechanical factors (e.g., stiffness of the chest wall, loss of elastic recoil, reduced airway calibre). According to Thomas et al. (2019) [13], the healthy adult decline rate was 0.056 to 0.99 mL/year (median of 0.292 mL/year). These longitudinal trends are reflected in the negative age and PFT value relationship in our cross-sectional sample. In addition, according to regression studies (e.g., Sawane, 2019) [14], age-related decreases and height-related increments are predictable factors of PFTs. Our results that age is a significant negative predictor of FVC and height is an important positive predictor is, therefore, well-founded in the literature.

Fourth, we have resorted to the ratio FEV1/FVC: we did not find any significant gender variation but noted that height and weight were prognosticators of FVC and not BMI whereas the ratio did not change with gender. In a mathematical analysis, Gólczewski, Lubiński & Chciałowski (2012) [15] suggested that the age-dependence of FEV1 /FVC is mostly a statistical artefact: as FEV1 and FVC are highly correlated, and both decrease with age, the ratio inevitably decreases although the underlying physiology may remain constant. This helps us conclude that the difference in genders in terms of lung volumes could be attributed to the size of the organs as opposed to the change in airways functioning or proportional airways capacity. In that respect, our findings can be consistent with the idea that the FEV1/FVC ratio might be less anthropometric dependent and more obstructive-physiologic-dependent.

Lastly, when compared to the effects of obesity and BMI: Other studies demonstrate mixed effects although our BMI-PFT correlation was weak. Aggarwal (2017) [16] discovered that PFTs had an inverse correlation with the increasing BMI in both sexes; Satapathy et al. (2019) [17] discovered that BMI and FVC/FEV1 were inversely correlated among obese young people. BMI however did not significantly predict FVC in our study, maybe due to

the fact that our sample had similar levels of BMI among sexes and narrow extremes of obesity. It implies that BMI in morbid obesity can influence lung mechanics (through thoracic restriction, diaphragmatic loading) but the moderating effect of BMI on the moderate or homogenous levels of BMI population may not be so pronounced. It also justifies our conclusion that weight (lean mass), rather than BMI itself is a more predictive variable of lung volumes in healthy young adults.

Overall, our results on gender, height, weight, and age factors as determinants of pulmonary functions test are more or less congruent with the literature in general. It has an anatomical and morphological foundation of volume of the lungs (height and gender) and age-related degradation of the ventilatory capacity. The additional specificity of our study lies in the fact that BMI might be a weak predictor in a population with no severe cases of adiposity, and the ratio of FEV 1/ FVC does not change in relation to sex when the size of the anatomy is controlled. To improve prediction models in the future, longitudinal monitoring of the lung performance changes and the contribution of body composition (lean ves vs fat mass mass) could be used.

Conclusion

The current cross-sectional research proved that FVC, FEV_1, PEFR, and FEF25-75% parameters of pulmonary functioning were significantly greater in men than in females, but FEV_1/FVC was not significantly different between males and females. Height and weight became strong positive predictors of FVC other anthropometric variables whereas age showed negative correlation with it which showed progressive decrease in lung function with increasing age. BMI however was not a strong predictor of pulmonary performance; this implies that it has a weak predictive ability amongst the healthy population. This is because these findings highlighted that pulmonary functionality has a great dependence on the anatomical and physiological differences as far as gender, size of the body, and age are concerned as opposed to body mass index. PFTs therefore must be interpreted correctly taking note of these variables in order to come up with credible reference points of clinical assessment.

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