An Evaluation of the Pulmonary Function Tests and their Association with Age and Body Mass Index (BMI) in the Southern Angami Population

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Abstract

Among the many variables in the human body form and function, pulmonary function is a major biological variable affected by gender, age, body composition, as well as the geographical location of a population. Pulmonary function tests (PFTs) are an essential tool for monitoring patients with known respiratory disease or for determining cases of pulmonary disorders, chronic obstructive pulmonary diseases (COPD), obstructive lung diseases, etc. Women are found to have a lower lung capacity than men. This paper evaluates the differences in the PFTs between the males and the females, and various age groups. Additionally, an evaluation between age and body mass index (BMI) with pulmonary function tests is also made to find out if there are any significant relationships.

Introduction

Age and gender differences in the human body form or functions are quite evident, and studies are most often carried out on the basis of these two variables. Leaving aside population differences even among the same gender or age groups, differences are often observed. Among the many variables in the human body form and function, pulmonary function is a major biological variable affected by gender, age, body composition, as well as the geographical location of a population as evident from several studies (Choudhuri & Choudhuri, 2014; Behera, *et.al.*, 2014; Cotes, *et.al.*, 2001; Frisancho, 1969).

Pulmonary Function Tests (PFTs) are an essential tool for monitoring patients with known respiratory disease or for determining cases of pulmonary disorders, chronic obstructive pulmonary diseases (COPD), obstructive lung diseases, etc., (Johnson & Theurer, 2014). It has become a part of routine health examination in respiratory, occupational, sports medicine and public health screening. Although they do not provide a diagnosis per se, different patterns of abnormalities are seen in various respiratory diseases, which helps to establish a diagnosis. Spirometry is the most frequently used measure of lung function and is a measure of volume against time. It is a simple and quick procedure to carry out (Ranu, *et.al*., 2011).

The lungs undergo a phase of growth and maturation during the first two decades of life and achieve maximal lung function around the age of 20 years in females and 25 years in males. Lung function remains steady with very minimal change from age 20 to 35 years, and starts declining thereafter (Sharma & Goodwin, 2006). Women are found to have a lower lung capacity than men, *i.e*., about 20% (Fulambarker, *et.al*., 2004). Another study reported that the volume of adult female lungs is typically 10–12% smaller than that of males who have the same height and age (Bellemare, *et.al*., 2003).

The reduced physiological capacity evident with ageing may affect the ability to perform many tasks, potentially affecting also the quality of life. This reduction is generally due to the dilation of alveoli, decrease in the air exchange surface of the lung and loss of supporting tissues for peripheral airways (Santana, *et.al.*, 2001). With the advancing age, the human body also tends to accumulate more amount of fat-mass (FM) while there is a decline in the fat-free mass (FFM), and that low FFM reduces forced expiratory volume (FEV_1), and reflects reduction in respiratory muscle mass (Santana, *et.al.*, 2001; Wannamethee, *et.al*., 2005).

Keeping in focus the trends of research, this study is taken up to evaluate the differences in the PFTs between the males and the females, and various age groups. Additionally, an evaluation between age and body mass index (BMI) with pulmonary function tests will be made to find out if there are any significant relationships.

Materials and Methods

The data for the study was collected from among 317 individuals, all of whom were within the age group of 21 to 60 years. Among these, males totaled 163 and females 154. A detailed explanation of the purpose of the study was given and, informed consent of each participant was obtained. All were healthy adults who had not faced any kind of illness one month prior to the day of investigation. The measurements were taken when the participants were at rest, and had no physical activity one hour prior. The socio-economic status and occupation also varies widely among the individuals. However, no attempt has been made to exclude those individuals engaged in the habit of tobacco use. Nevertheless, among the females, lactating and pregnant women were excluded in the study.

The Spirometer SP10 manufactured by Contec Medical Systems Co., Ltd., Qinhuangdao, China was used for the measurement of the PFTs. Forced vital capacity (FVC), FEV_1 and peak expiratory flow (PEF) were measured. FEV_1/FVC ratio, also called Tiffeneau-Pinelli index was obtained later from the observed measurements. An anthropometer and a weighing machine were used to obtain the height and weight of the individuals respectively.

Analysis of the obtained data was carried out using the IBM (International Business Machines Corporation) SPSS software (version 23.0.0.0). The physical characteristics and the parameters of the FPTs are presented as mean ± standard deviation) SD. Independent-samples t-test was used to assess the level of significance between the males and the females as well as between age groups. Pearson's correlation coefficient was used to assess the relationship between age and BMI with PFTs.

RESULTS AND DISCUSSION

The mean value of the observed variables and their SD are presented in table 1. It is observed that the mean values of all the variables are higher among the males. The lung capacity of the females were also significantly lesser than that of the males. This can be attributed to the fact that males are taller and more muscular in terms of body proportions. Some other factors contributing to these differences may include sex hormones or anatomical differences between the genders and socio-cultural factors (Alghadir, *et.al.*, 2012; Fulambarker, *et.al.*, 2004). Independent-samples t-test applied showed significant gender-difference in all PFTs except for FEV_1/FVC which showed no significance ($p>0.05$). A similar study among the adults has also shown the same result where FEV_1/FVC was found to have no significance between the gender groups (Jagia & Hegde, 2014). The analysis has also shown the similar result with another study where age and BMI showed no statistical significance between the males and the females (Behera, *et.al.*, 214).

Table 1: Characteristics of the measurements

Variables	**Males (n=163) Mean±SD**	**Females (n=154) Mean±SD**	**p**
Age (in years)	35.81±10.61	35.25±10.04	0.636
Height (in cm)	166.37±5.82	154.28±5.52	0.001*
Weight (in kg)	64.4±11.26	54.54±9.88	0.001*
BMI (kg/m^2)	23.23±3.65	22.89±3.79	0.405
FVC (in L)	3.42±0.71	2.42±0.41	0.001*
FEV_1 (in L)	2.66±0.77	1.83±0.54	0.001*
PEF (in L/min)	250.89±101.12	165.75±62.62	0.001*
FEV_1/FVC	77.95±15.85	75.54±19.46	0.226

*$p<0.05$

Correlation analysis was performed to determine if there are any significant relationships between age and BMI with the PFTs. The results given in table no. 2 show that age has a negative correlation with all PFT variables. An increase in age is associated with the reduction in

PFT values. FVC and FEV_1 showed significant correlation in both the gender groups while PEF showed a significant correlation only in the males. Age has shown no significant correlation with FEV_1/FVC in both the males and females. Santana, *et.al.,* (2001) also reported no significant relationship between age and FEV_1/FVC. While it has also shown that age and FVC has no significant correlation, this study has shown otherwise.

Correlation analysis performed between BMI and PFTs presented in table no. 3 also showed that BMI also has a negative correlation with all of the PFT variables in both the male and female group, although none of the variables was found to be statistically significant. The fact that both age and BMI correlates negatively only contributes to the fact that, with aging, the human body tends to accumulate more FM and therefore an increase in BMI is likely to be observed resulting in the corresponding decrease in subsequent PFT values. A study by Behera, *et.al.,* (2014) showed that the FEV_1/FVC ratio has a positive low correlation and was not significantly associated with BMI in both males and females. While their study consisted of only 60 subjects in the age group of 20–60 years, this study has 317 subjects in the age group 21–60 years. Therefore, the difference in result could be because of the sample size for the similar age group considered in both the studies.

Table 2: Correlation of age with PFTs

Variables	**Males (n=163)**		**Females (n=154)**	
	R	**p**	**r**	**p**
FVC (in L)	-0.467	0.001*	-0.302	0.001*
FEV_1 (in L)	-0.422	0.001*	-0.197	0.014*
PEF (in L/min)	-0.339	0.001*	-0.06	0.459
FEV_1/FVC	-0.136	0.083	-0.023	0.118

*p<0.05

Table 3: Correlation of BMI with PFTs

Variables	Males (n=163)		Females (n=154)	
	R	p	r	p
FVC (in L)	-0.058	0.462	-0.087	0.283
FEV_1 (in L)	-0.073	0.354	-0.001	0.99
PEF (in L/min)	-0.022	0.781	-0.015	0.854
FEV_1/FVC	-0.052	0.509	-0.064	0.43

*p<0.05

Age Group Difference in the PFTs

The correlation analysis has shown a negative relationship between age and PFTs. An increase in age was associated with decreasing PFT values. Therefore, an analysis of the PFTs divided into 4 age groups (21-30 years, 31-40 years, 41-50 years, 51-60 years) are presented from table 4 - 6 to give a detailed account of the differences in values between age groups as well as gender.

The results obtained from each group (table 4 – 6) have shown a gradual decline in the PFT values for a given age group. The findings also showed an increased value for PEF in the females, and the value for FEV_1/FVC showed an increased value for both the males and the females in the age group 31–40 years respectively. This could well be attributed to the differences in the ratio of sample size between the males and females as well as age groups. A more detailed study with similar sample size in each age group is required to understand better the pattern of variations. Nevertheless, males and females showed significant differences for PFTs in all age groups. However, from 51–60 years, significant difference is not observed between the males and the females, and no significant difference is also found for FEV_1/FVC in all the age groups. Other studies have also shown corresponding decline in PFT values with increasing age (Phatak, *et.al*., 2002; Sharma & Goodwin, 2006; Behera, *et.al*., 2014)).

Table 4: FVC in males and females divided into a decade age group

Age group	Males Mean±SD	Females Mean±SD	p
21 – 30	3.71±0.66	2.54±0.44	0.001*
31 – 40	3.57±0.58	2.39±0.38	0.001*
41 - 50	3.05±0.59	2.31±0.34	0.001*
51 - 60	2.73±0.61	2.17±0.36	0.007

*p<0.05

Table 5: FEV_1 in males and females divided into a decade age group

Age group	Males Mean±SD	Females Mean±SD	p
21 – 30	2.92±0.71	1.91±0.51	0.001*
31 – 40	2.89±0.71	1.88±0.54	0.001*
41 - 50	2.17±0.65	1.72±0.54	0.003*
51 - 60	2.07±0.61	1.59±0.57	0.38

*p<0.05

Table 5: PEF in males and females divided into a decade age group

Age group	Males Mean±SD	Females Mean±SD	p
21 – 30	277.03±101.32	167.94±64.66	0.001*
31 – 40	275.85±103.91	170.91±54.66	0.001*
41 - 50	199.42±69.89	161.22±70.93	0.033*
51 - 60	188.53±76.69	147.71±55.37	0.127

*p<0.05

Table 6: FEV_1/FVC in males and females divided into a decade age group

Age group	Males Mean±SD	Females Mean±SD	p
21 – 30	78.83±14.39	74.47±17.93	0.145
31 – 40	81.29±16.09	78.51±21.02	0.461
41 - 50	71.64±18.04	74.54±19.82	0.543
51 - 60	75.84±14.12	72.66±21.15	0.609

*$p<0.05$

Conclusion

Age generally has a huge impact on the human body form and function because of the process of growth and developmental processes taking place. Morphological, physiological, anatomical and metabolic changes associated with the growth and developmental processes are bound to change the body form and function. This study was aimed at determining the values of the PFTs among the adult Angami population in the age group of 21–60 years. A total of 317 individuals comprising of 163 males and 154 females were measured for the purpose of the study. Age, height, weight, BMI, FVC, FEV_1, PEF and FEV_1/FVC were the considered variables.

The data for each of the variables showed a normal distribution in both the male and female groups. The results of the study have shown that males have significantly higher values of PFTs as compared to the females. Even among the four age groups, males have higher PFT values than the females of the same age group. The values of the PFTs are also found to decrease with the increase in age in both males and females. Age correlates negatively with PFTs. BMI, which is a very important measure of the overall body mass, is also found to be negatively correlated with the PFTs. It is also evident from various other studies that a decline in the values of PFT is associated with an increase in age and BMI respectively. This study has also provided a result which is in conformity with established studies.

Nevertheless, one main drawback of this study which must be mentioned is the inclusion of all tobacco users grouped together with the non-users. No attempt has been made to exclude those individuals in this study.

The results can be summed up as follows:

- Males have higher PFT values than the females in all the age groups
- Significant difference of FEV_1/FVC is absent between the male and female group.
- Age and BMI showed negative correlation with the PFTs.
- FEV_1/FVC shows an increased value from 31 – 40 years in both the males and females.

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