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ASSESSMENT OF PULMONARY FUNCTION IN HEALTHY STUDENTS AGED 19 TO 25 YEARS IN THE NATIONAL CAPITAL DISTRICT, PAPUA NEW GUINEA.

Majella P. NORRIE and Shalon TAUFA

Discipline of Physiology, Division of Basic Medical Sciences, School of Medicine and Health Sciences, University of Papua New Guinea.

Correspondence Author: Dr. Shalon Taufa: shalontaufa@gmail.com.

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ABSTRACT:

Pulmonary function tests are among the groups of tests that can be used for assessing the physical status of healthy individuals. This prospective observational cross-sectional study assessed the pulmonary function of healthy students aged 19 to 25 years in higher learning institutions in the National Capital District, Papua New Guinea. A total of 156 students volunteered to participate in the study. Of these, 116 (74.4%) students were randomly selected and requested to complete a pretested questionnaire before assessing their pulmonary function. A computerised spirometer, SpiroUSB, run with Spida5 software was used to determine the parameters FEV_1, FVC, FEV_1/FVC, PEF and FEF_{25-75}. After analysis of the 116 questionnaires and implementing the American Thoracic Society guidelines and criteria for assessing the spirometry results, the data obtained from 77 (66.4%) students were suitable for analysis. Of these 77 students, 34 (44.2%) were males and 43 (55.8%) were females. The mean FEV_1 for the male students (3.70 ± 0.43L) was significantly higher (p = 0.001, 2-tailed) than that for the female students (2.91 ± 0.39L); the mean FVC for males (4.18 ± 0.54L) was also significantly higher (p = 0.001) than that for the females (3.25 ± 0.53L). The PEF and FEF_{25-75} also showed significantly higher (p = 0.001) results for males compared to the females. The FEV_1/FVC, however showed no statistically significant (p = 0.275) difference between the values obtained for the male and female students. Strong inverse statistically significant correlation was found between the Body Mass Index of male students in the overweight category and their FEF_{25-75} (rho = -0.695, p = 0.004).

The data indicated that gender was a significant determinant of lung function with the male students showing greater mean values for FEV_1, FVC, PEF and FEF_{25-75}, suggesting greater lung volumes compared to the female students.

KEY WORDS: *Pulmonary function, Students, National Capital District*

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INTRODUCTION:

Pulmonary function tests (PFT) are carried out to objectively assess the pulmonary function status of an individual [1]. The PFT provide good indication of the health status of an individual. In a study begun in 1960 by Shunemann et al [2], FEV_1 expressed as the normal percent predicted (FEV_1% pred) proved to correlate well with the longevity of life.

PFT using a spirometer have been shown to be efficient in clinical use for diagnosing and managing respiratory disease, like monitoring patients who have asthma and chronic obstructive pulmonary disease (COPD) [1, 3, 4]. Factors such as gender, age, height and ethnicity have been proven to impact on the results obtained in PFT [5 – 8].

In the Oceania Region including Papua New Guinea (PNG) very limited studies have been done to identify lung function determinants and the amplitude of their effects. There is no published set reference range for spirometry lung volumes in PNG. Some studies carried out in PNG on apparently healthy individuals have compared betel nut chewers with non – chewers, smokers to non – smokers and highlanders to coastals [9, 10]. Datta and Yanga showed that betel nut chewing and smoking are detrimental to lung function [9]. Anderson et al [10] showed that New Guineans from the highlands had larger FEV_1 and FVC values than those from the coast. However, there is still a great need for more research on the pulmonary function among healthy Papua New Guineans.

One of the major objectives of the present study was to assess and compare the pulmonary function of healthy male and female students of similar age group in higher institutions in the National Capital District Papua New Guinea.

SUBJECTS AND METHODS:

The study was carried out in the National Capital District (NCD) PNG and was conducted between April and June 2013. Three institutions of higher learning in NCD were selected because of their proximity, convenience, accessibility by road and assumed willingness of the students to participate in the study. The institutions were, the Taurama and Waigani campuses of the University of Papua New Guinea (UPNG), the Port Moresby Business College (PBC) located at 6-mile, and the Don Bosco Technological Institute (DBTI) located at East Boroko.

The sample size was calculated using a design effect of one, a relative precision of 10%, and confidence level of 95 per cent and predicted non-response rate of 20 per cent [11]. A sample size of 150 students was considered appropriate for this study because of the rigid criteria for inclusion.

This was a prospective observational cross-sectional study. All the students in the three institutions were eligible for enrolment in the study. Students in the three institutions were invited to participate through posters and fliers posted on notice boards and also by announcements made during their regular lectures and practical classes. Simple random sampling was used for selecting the participants among the students that volunteered. However, final approval for a selected student to participate in the study was based on the inclusion criteria, which was determined by the exclusion criteria indicated in a questionnaire.

A self-designed pre-tested questionnaire was used to collect demographic data and other information. Each selected student was requested to read and sign an informed consent form before completing the questionnaire. Students with history of chronic cough, recurrent respiratory tract infection, chest or spinal deformity, asthma, emphysema, COPD, TB or cardiac illness were excluded from the study.

The weight of each student was taken to the nearest 0.1kg using an electronic scale. The height was measured using a standard stadiometer to the nearest 0.1cm with the student standing erect and upright. The body mass index (BMI) for each student was calculated as appropriate.

Pulmonary function tests were carried out only in the morning (between 8.00am to 12.00 noon) to reduce circadian rhythm variation in the data [12]. The tests were done using a computerised spirometer, SpiroUSB model run with Spida5 software [13]. The spirometer was calibrated each morning according to the protocol in the manufacturer's instruction manual [13].

The procedure was explained and demonstrated to each of the students before allowing them to proceed with the test. For each student, the test was repeated until three "good blows" gave acceptable recordings. Testing was stopped if a student did not wish to continue or if after 8 attempts failed to give sufficient number of acceptable recordings. The three "good blows" measured had to be within 150ml of each other to satisfy reproducibility criteria [14]. The best of the three acceptable manoeuvres was recorded as the final result. Spirometry tests were assessed using the American Thoracic Society (ATS) guidelines and criteria [6, 13, 14].

The pulmonary function parameters recorded for each student were: Forced Expiratory Volume in one second (FEV_1), Forced Vital Capacity (FVC), FEV_1/FVC, Peak Expiratory Flow (PEF) and Forced Expiratory Flow 25% and 75% (FEF_{25-75}).

Statistical analysis of the data was carried out using Microsoft XP Excel Data Package and the Statistical Package for Social Sciences (SPSS) Version 20. The Shapiro-Wilks test was used to assess normality of data. Student's T-tests and Mann-Whitney U tests were used as appropriate. P-value of <0.5 was considered as significant.

Ethical clearance and permission were obtained from the Ethics and Research Grant Committee of the School of Medicine and Health Sciences (SMHS) University of Papua New Guinea (UPNG). Consent was obtained from all the institutional heads including permission for the setting up of the instrument to be carried out in secure areas in their institutions. Signed informed consent was obtained from each student.

RESULTS:

A total of 156 students volunteered to participate in the study. Of these, 116 (74.4%) students were randomly selected and requested to complete a pretested questionnaire before performing the spirometry.

After analysis of the 116 questionnaires and implementing the American Thoracic Society guidelines and criteria for assessing the spirometry results, a total of 39 (33.6%) students were excluded, because they did not fulfil the inclusion criteria. The reasons for exclusion of these 39 students are presented in Table 1. The reasons for failure to meet ATS criteria included insufficient number of blows (failure to give three good blows after eight or more attempts) and greater than 150 ml variations between blows for FEV_1 or FVC values.

Of the 77 students whose questionnaires and spirometry results were selected for analysis 34 (44.2%) were males and 43 (55.8%) were females. No specific reasons can be given for higher number of female students compared to male students that participated in this study.

The Mean age of the female students was 22±1.6 years (Mean ± SD) and for the male students was 22±1.5 years.

The anthropometric data and BMI classification for the male and female students are presented in Table 2. Although the male students were on average slightly taller and heavier than the female students, the differences were not statistically significant.

The WHO recommended categories for BMI was used to classify the BMI status which is an indication of the nutritional status of individuals [15]. None of the male students were underweight compared to 9.3% among the female students.

Table 1: Reasons for exclusion

Reason for Exclusion	Number (%) Excluded
Discrepancies in answers in the questionnaire.	2 (1.7%)
Spirometry results showing signs of mild-moderate restriction.	3 (2.6%)
Outside age range of 19-25 years.	7 (6.0%)
History of Lung/Cardiac Disease/Injury only.	14 (12.1%)
ATS Criteria not met only.	6 (5.2%)
Both ATS Criteria not met and History of Disease.	7 (6.0%)
Total (%) Excluded	39 (33.6%)

Table 2: Anthropometric data and BMI categories of male and female students

Parameters	Males (n = 34)	Females (n = 43)	
Height (cm)			
Mean	167.4	160.4	*P = 0.001*
Standard deviation (SD)	6.1	5.3	
Range (cm)	156.0-177.0	148.0-172.0	
Median (cm)	167.0	161.0	*P = 0.001*
Weight (kg)			
Mean	69.4	60.1	*P = 0.001*
SD	10.5	7.9	
Range (kg)	48.0-96.0	48.2-78.3	
Median (kg)	70.5	60.5	*P = 0.001*
BMI (kg/m2)			
Mean	24.7	23.4	*P = 0.093*
SD	3.2	3.4	
Range	19.5-31.7	17.1-30.8	
Median	24.4	23.5	*P = 0.741*

BMI (kg/m2)	Nutritional status	Males (n = 34)	Females (n = 43)
<18.5	Underweight	0	4 (9.3%)
18.5 – 24.9	Normal	18 (52.9%)	26 (60.5%)
25.0 – 29.9	Overweight	15 (44.1%)	12 (27.9%)
≥30	Obese	1 (2.9%)	1 (2.3%)

Table 3. Summary statistics of the Pulmonary Function Indices for the male and female students.

Parameters	FEV_1 (Litres)		FVC (Litres)		PEF (Litres/min)		FEV_1/FVC (%)		FEF_{25-75} (Litres/sec)	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Mean	3.70	2.91	4.18	3.25	595.1	453.8	88.9	90.1	4.85	3.87
SD	0.43	0.39	0.54	0.53	99.7	72.1	4.2	4.6	1.03	0.73
Range	2.87-4.51	2.35 - 3.79	3.23 - 5.52	2.56 - 4.81	415.0 - 785.0	326.0 - 655.0	79.0 - 96.0	75.0 - 99.0	2.50 - 6.54	2.58 - 5.77
95% CI	3.55 - 3.85	2.79 - 3.03	3.99 - 4.37	3.09 - 3.41	560.4 - 629.9	431.6 - 476.0	87.4 - 90.3	88.7-91.5	4.49 - 4.80	3.65 - 4.10
Median	3.77	2.82	4.18	3.10	598.5	458.0	89.0	91.0	4.80	3.84
IQR	3.45 - 3.97	2.63 - 3.28	3.74 - 4.55	2.86 - 3.64	519.5 - 650.8	398.0 - 499.0	86.8 - 92.0	86.0 - 93.0	4.26 - 5.49	3.41-4.39
Mann Whitney	*P=0.001*		*P=0.001*		*P=0.001*		*P=0.275*		*P=0.001*	

95% CI: 95% Confidence Interval; IQR: Interquartile Range

Table 3 shows the summary statistics of the pulmonary function indices for the male and female students. The Shapiro-Wilk test for normality of distribution indicated that the FEV_1 results for the males were normally distributed (p = 0.553, df = 34) but not normally distributed for the females (p = 0.025, df = 43). Similar distributions were obtained for some of the other parameters. The Mann-Whitney U and Student's-T tests show that the mean FEV_1 for the male students (3.70 ± 0.43L) was significantly higher (p = 0.001; 2-tailed) than that for the female students (2.91 ± 0.39L).

The mean FVC for the male students (4.18 ±0.54L) was significantly higher (p = 0.001; 2-tailed) than the mean (3.25 ± 0.53L) for the female students. Tests for normality of distribution of the PEF results for both male and female students indicated that both were normally distributed (males, p = 0.42, df = 34; females, p = 0.274, df = 43). A statistically significant difference was obtained when the PEF results was compared between the males and the females (p = 0.001, 2-tailed).

The mean FEV_1/FVC% for the male students was 88.9 ± 4.2% and for the female students was 90.1 ± 4.6%. There was no statistically significant difference (p = 0.275) between the values obtained for the male and female students.

The mean FEF_{25-75} for the male students was 4.85 ± 1.03L/sec and for the female students was 3.87 ± 0.73L/sec. Comparison of the results indicated that the mean FEF_{25-75} for the male students was significantly higher (p = 0.001) than the mean for the female students.

The non-parametric data (median values and Interquartile ranges) for the pulmonary function tests parameters are presented in Table 3.

The coefficients of correlation between BMI and spirometry parameters for male and female students are presented in Table 4.

For the male students with normal BMI, the Spearman's rho indicated strong positive statistically significant linear correlation between BMI and FEV_1, BMI and FVC, and also BMI and FEF_{25-75}. For the female students with normal BMI, the spearman's rho shows very weak inverse non-statistically significant correlation between BMI and FEV_1, BMI and FVC, and BMI and FEF_{25-75}.

The male students in the BMI overweight category, Spearman's rho indicates weak inverse correlation that was not statistically significant, between BMI and FEV_1, BMI and FVC. However, a strong inverse statistically significant correlation was obtained between BMI and FEF_{25-75}. For the female students in the overweight BMI categories, Spearman's rho shows weak inverse non-statistically significant correlations between BMI and FEV_1, and also BMI and FEF_{25-75}, but a weak linear non-statistically significant relationship between BMI and FVC.

Table 4: **Coefficients of correlation between body mass index (BMI) and spirometry parameters for male and female students**

	Normal		Overweight	
Correlation between	**Spearman's rho**		**Spearman's rho**	
	Males	**Females**	**Males**	**Females**
BMI and FEV1	0.609 (p=0.007)	-0.074 (p=0.720)	-0.202 (p=0.471)	-0.225 (p=0.483)
BMI and FVC	0.491 (p=0.039)	-0.006 (p=0.976)	-0.111 (p=0.693)	0.035 (p=0.914)
BMI and FEF25 – 75	0.689 (p=0.002)	-0.218 (p=0.284)	-0.695 (p=0.004)	-0.403 (p=162)

Coefficient of correlation: Spearman's rho
P < 0.05 indicates statistical significance.

DISCUSSION:

In the present study the rigid screening procedures that included the exclusion criteria and implementation of the ATS Guidelines reduced the total number of 116 randomly selected students to the sample size of 77 (66.4%) students. The anthropometric measurements revealed that the mean height and weight for the male students (167.4 ± 6.1cm and 69.4 ± 10.5kg) were significantly greater than those for the female students (160.4 ± 5.3cm and 60.1 ± 7.9kg) respectively. These results support the findings reported in the PNG National Nutritional Survey (PNG NNS) conducted in 2005 [16]. According to the PNG NNS 2005, the mean height (164.9 ± 7.3cm) and weight (61.1 ± 7.5kg) of males in the 20-29.9 years age group were greater than the mean height (154.5 ± 5.3cm) and weight (54.1 ± 8.7kg) of their female counterparts in the same age group [16]. Body Mass Index results however showed no significant difference across gender. Statistical tests for normality of distribution showed that some of the spirometry parameters of interest had normal distributions for both male and female results, except the FEV_1 and FVC, where only the male groups had normal distributions. No specific reasons can be given for the skewed FEV_1 and FVC results obtained for the female students. Comparison of spirometry results obtained for male and female students revealed significant differences between the genders for FEV_1, FVC, FEF_{25-75} and PEF. FEV_1/FVC% was the same across the gender groups. Because FVC is a measure of lung size it is possible to suggest that the male students have larger lung volume than the female students of the same age group in the present study. This may be a result of a genetically greater thoracic size, which allows for greater expansion and development of the lungs.

FEV_1 is a measure of both lung size and airway resistance. Our results suggest smaller lung volumes and/or narrower airways in the female students compared to the male students. FEV_1/FVC% was not different among males and females (89 ± 4% and 90 ± 5% respectively); therefore the difference of FVC in the two groups was proportionate to the difference of their FEV_1. A narrowing of the airways would have resulted in lowering of the FEV_1 only and not the FVC. Thus, the smaller mean FEV_1 seen in the female students is more likely to be a result of a smaller lung volume rather than narrower airways.

PEF is dependent on effort and lung volume [14]. The PEF results may also imply larger lung size in the male compared to the female students.

Mean height was significantly higher in males compared to females. Therefore, this difference in anthropometry could have contributed to the difference in spirometry since height is known to be a significant determinant of measured lung volumes and capacities.

Even though few studies have focused on comparing male and female spirometry, review of the findings of numerous studies focusing on other variables show consistently that males have higher mean values than females of similar age groups. Schwartz et al [17] reported that males tended to outperform females with the same anthropometric characteristics in all age groups, except in the height range of 130 to 160cm, where female flow and volumes were superior. Pellegrino et al [18] also stated that for the same standing height, young males have greater lung function values than young females; while Neder et al [19] found that males presented with higher total lung capacity values than females in all age groups with the exception of the 50-59 year group where the height difference was the lowest.

Obesity is becoming a greater burden on health systems in the Pacific as a result of changes in diet and lifestyle [20, 21]. The effects of weight gain on body systems have been extensively studied [22]. Obese individuals frequently complain of respiratory symptoms [23,24]. Various studies have investigated correlation between BMI and various lung volumes [25-27]. Jones et al demonstrated significant linear relationships between BMI and vital capacity and total lung capacity [26]. On the other hand, functional residual capacity and expiratory reserve volume decreased exponentially with increasing BMI [26]. Park et al found no BMI correlation with FVC and FEV_1 in males while a positive correlation was found between BMI and FVC and FEV_1 in females [27]. Results of a work by Jaltade and co-workers showed mean values of FVC, FEV_1 and FEF_{25-75} were lower in overweight subjects than normal weight subjects [25].

In our present study, there was a statistically significant positive correlation between BMI and FEV_1, FVC and FEF_{25-75} for male students with normal BMI, while a negative correlation was observed for FEF_{25-75} in overweight BMI male students. Results for the females showed no significant correlation between BMI and the spirometry parameters. The results in our present study were similar to those reported by Jones et al [26], but different from those reported by Park et al [27].

Our results suggest that BMI does not have much of an effect on airway diameter and therefore on forced expiratory volumes. Much of the reduced lung function seen in obesity may be attributed to the burden of weight (fat build up) placed on the respiratory pump and the airways. In less heavy individuals the burden may not be great enough to exert an obvious effect, possibly explaining why we did not find any effects of BMI on lung function in our results.

However, the negative correlation between BMI and FEF_{25-75} for the overweight male students hint at an increased risk of developing asthma in this group since FEF_{25-75} may be reduced in obstructive lung disease [18].

CONCLUSION:

Our findings indicate that gender was a significant determinant of lung function with the male group showing greater mean values for FEV_1, FVC, PEF and FEF_{25-75}. These suggest greater lung volumes in the male students compared to the female students. Negative correlation was found between FEF_{25-75} and being overweight in the male group. It is hoped that these results may serve as baseline data and set the stage for further detailed research in assessing the normal pulmonary function among the various age groups in PNG.

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