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RESEARCH ARTICLE

Relationship between Anthropometric Variables and Lung Function Parameters among Apparently Healthy Adults in a Nigerian University

John Jeneviv Nene[1*], Nwosu Chiamaka Justina[1], Okezue Obinna Chinedu[1], Anyachukwu Canice Chukwudi[1], John Davidson Okwudili[2,3] and Mgbeojedo Ukamaka Gloria[1]

[1]Department of Medical Rehabilitation, University of Nigeria Enugu Campus, Nigeria

[2]Department of Physiotherapy, Alex Ekwueme Federal Teaching Hospital, Nigeria

[3]Department of Physiotherapy, Evangel University, Nigeria

***Corresponding author:** *John Jeneviv Nene, Faculty of Health Sciences and Technology, Department of Medical Rehabilitation, University of Nigeria Enugu Campus, Nigeria, Tel: +2348038781954*

Abstract

Background: Lung function reportedly differs between ethnic groups in infants, children and adults. More so, a reduction in lung function has health implications that go beyond diagnosable lung disease. As a result, it is imperative to understand the circumstances that can cause variations in lung function. This study investigated the relationship between anthropometric variables and lung function (LF) parameters of apparently healthy adults.

Methods: This cross-sectional survey involved two hundred and two (76 males, 126 females) apparently healthy adults who were recruited using a purposive sampling technique. The participant's LF parameters: Forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC) and peak expiratory flow rate (PEFR) were assessed using a micro plus spirometer. Anthropometric variables: Chest circumference, body mass index, waist to hip ratio and percentage body fat were measured using standardized procedures. Spearman rank correlation was used to determine the relationship between variables. ANOVA and Independent t-test were used to compare the mean value of LF parameters across age groups and gender respectively. Point of significant difference was determined using the bonferroni post-hoc analysis.

Results: A significant positive correlation was observed between FVC and waist to hip ratio ($r = 0.283$, $p = 0.000$), chest circumference ($r = 0.420$, $p = 0.000$); and a significant negative correlation between FVC and percentage body fat ($r = -0.223$, $p = 0.001$). FEV1 had a significant positive correlation with body mass index ($r = 0.175$, $p = 0.013$), waist to hip ratio ($r = 0.160$, $p = 0.023$), and chest circumference ($r = 0.363$, $p = 0.000$). PEFR had a significant positive correlation with waist circumference ($r = 0.157$, $p = 0.025$) while FEV1/FVC had a significant positive correlation with percentage body fat ($r = 0.147$, $p = 0.037$). Significant difference in FVC and FEV1 across the different age groups was observed ($p < 0.05$). The exact point of significance difference occurred within the age range of 21-25 years as compared to the age range of 16-20 years. Significant gender differences in FVC, FEV1 and FEV1/FVC were observed ($p < 0.05$).

Conclusion: Anthropometric indices influence the lung function parameters of adults and should be considered in the interpretation of lung values of apparently healthy individuals.

Keywords

Anthropometry, Lung function, Adults

Introduction

Lung function test also referred to as pulmonary function test is performed to ascertain how well the lung works and also to make a proper diagnosis of a pulmonary condition [1,2]. Apart from diagnosing pathology in the lungs, lung function tests are used to objectively monitor the progression or course of respiratory diseases. They provide a better understanding of functional changes in the lungs by diagnosing and monitoring rehabilitative

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outcomes or the course of diseases that affects lung function [1]. Deviation from normal values of these tests can form a basis for the diagnosis and assessment of chronic ventilatory diseases [3].

Lung function parameters commonly used for the estimation of lung function are forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and peak expiratory flow rate (PEFR). Forced vital capacity is the maximum volume of air that can be expelled from the lungs after maximal inspiration; FEV_1 is the maximum volume of air that can be forced out of the lungs in one second after maximal inspiration while FEV_1/FVC is the percentage of the total vital capacity exhaled in the first second. Peak expiratory flow rate is the maximum velocity of airflow during a forced expiration after maximal inspiration. Several techniques are utilized in the measurement of lung function including body plethysmography, nitrogen washout, gas dilution, radiographic imaging, and spirometry [4]. However, spirometers are portable and are frequently used in clinical practice unlike other instruments which require trained personnel and are not readily available. Advancement in technology has resulted in portable flow sensing spirometers which can automatically display several parameters and store the results.

Anthropometry has been defined as body measurements used as an index of physiological development and nutritional status [5]. Human body dimensions including anthropometric variables have been reported to have a great impact on lung function [6,7]. Differences in lung function parameters in normal individuals has also been attributed to ethnic origin, physical activity level, environmental factors, tobacco smoking, age, sex, socioeconomic status and habitat [8,9]. Hence, lung function parameters reportedly differ between ethnic groups in infants, children and adults [2,10]; and the test values are interpreted by comparison with a reference or predicted value derived from a normal population. Consequently, ethnic-specific predicted values should be used while interpreting the lung function parameters of individuals.

However, despite the observed influence of ethnicity on lung function parameters; there is still paucity of studies on lung function parameters in sub-Saharan Africa, especially in Nigeria. It is also unknown if this reported ethnic variation in lung function parameters has a relationship with anthropometric variables. In addition, there are limited studies on lung function parameters among young adults in this region even though the respiratory system reportedly undergoes various structural, physiological, and immunological changes with age. Hence, this study sought to evaluate the relationship between anthropometric variables and lung function parameters among apparently healthy undergraduate students in Enugu, south-east Nigeria.

Methods

Research design

A cross-sectional correlation research design.

Ethical consideration

Ethical approval was sought and obtained from the Institutional Research and Ethics Committee. Participants read and signed an informed consent form which is in line with the Helsinki declaration format.

Participants

Two hundred and two apparently healthy adults aged 16-30 years who are students of the University of Nigeria, Enugu Campus were recruited for this study. Participants for this study were recruited using a purposive sampling technique. Prior to participant recruitment, student's information was obtained from the student's database and they were invited to partake in the study through text messages, what's app messages and e-mails. The researcher explained the purpose of the study to the students and emphasized that participation was voluntary. Students who declared interest in participation were screened to determine their eligibility. Exclusion criteria included: History of cardiopulmonary or respiratory disease, signs and symptoms of respiratory disease, smokers, recent thoracic or abdominal surgery, and acute disorders affecting test performance such as nausea and vomiting.

Instruments

Micro plus spirometer (micro medicals limited, SKU 208, England): This was used to measure the lung function parameters (FVC, FVC_1, and PEFR) of the participants. It is a portable handheld electronic spirometer with a disposable mouthpiece connected to the main unit. It also has memory storage and a display screen for displaying the result of measurements. It is widely used for respiratory function measurements, respiratory monitoring, and diagnosis.

Height scale (Ayron 226, USA): A height meter calibrated in centimeter was used to measure the heights of the participants to the nearest 0.1 cm.

A weighing scale (Secca 287, Germany): This was used to obtain the weight of the participants to the nearest 0.1kg.

Tape measure: A non-elastic tape measure (Model: HD2020, Shanghai Kearing Stationary Co., Ltd, Shanghai, China) of range 0-150 centimeters was used to measure the chest, waist and hip circumference to the nearest 0.1 cm.

Fat Analyser (Beurer, Germany): This was used to determine the percentage body fat of the participants.

Procedure

Height of each participant was measured using a height meter. The participants were instructed to stand bare-footed in an upright position on the platform of the height meter. The researcher checked that the feet did not come off the floor and that the position of the head was upright. The horizontal projection of the height meter was placed on the vertex of the participants, crushing the hair as much as possible. The readings were read off by the researcher to the nearest 0.1 centimeter [11].

The weight of the participants were taken in minimal clothing. Participants were instructed to stand barefooted on the platform of the weighing scale with the feet apart and weight evenly distributed. The researcher checked that the reading of the scale was on zero. The reading was recorded to the nearest 0.1 kg.

The waist circumference measurement was taken at the level of the narrowest point between the lower costal (10th rib) border and the iliac crest [11]. In the absence of any obvious narrowing, the measurement was taken at the mid-point between the lower costal border (10th rib) border and the iliac crest [11]. The measurement was taken with the participants arms abducted. The stub of the tape and the housing were both held with the researcher's right hand while the left hand was used to adjust the level of the tape at the back to the adjudged level of the narrowest point [11]. The measurement was taken at the end of a normal expiration to the nearest 0.1 cm.

The measurement of hip circumference was taken with the participants in standing position, the arms folded across the thorax, the feet together and the gluteal muscles relaxed [11]. The researcher passed the tape around the hips from the side. The stub of the tape and the housing were held with the researcher's right hand while the left hand was used to adjust the tape at the back to the level of the greatest posterior protuberance of the buttocks. The tape was adjusted with the researcher ensuring that it does not excessively indent the skin, and the readings were read off to the nearest 0.1 cm.

Body mass index (BMI) in kg/m^2: This was computed from the readings of the weight and the height of the participants using the formula: BMI = $\frac{weight}{height^2}$

Waist to hip ratio (WHR) was calculated using the formula: $\frac{weight\ circumference}{hip\ circumference}$

The chest circumference measurement was taken at the thoracic region at the level of the mesosternal. The participants were instructed to abduct the arms to the horizontal position so as to allow the tape to be passed around the thorax. The stub of the tape and the housing were held with the right hand while the left hand was used to adjust the level of the tape at the back to the level of the mesosternal [11]. The participants were instructed to lower their arms to the relaxed position with the arms slightly abducted and the measurement is taken at the end of a normal expiration (end tidal).

To measure the percentage body fat, the participants were asked to stand barefooted in minimal clothing on the platform of the body fat analyzer. The following variables were imputed into the body fat analyzer (Height, weight, age and physical activity level) and the percentage body fat readings were taken from the display unit of the body fat analyzer.

Lung function was measured in accordance with the National Health and Nutrition Examination Survey (NANHES) spirometry procedure [12]. The breathing protocols were taken with the participants in a relaxed and upright sitting position. The participants were instructed to breathe in and out in a relaxed position, breathe in as much as possible and breathe out as fast as and as long as possible (forced expiration) through the mouthpiece into the spirometer. The values of FVC, FEV_1 and PEFR were computed by the spirometer and were read off from the display screen. The protocol was repeated three times in a session for each of the participants with 1-2 minutes interval of rest and the best of the three results with less than 5% deviation from the other readings was taken.

Data analysis

Descriptive statistics of mean and standard deviation was used to present the results. Pearson's product moment correlation was used to determine the relationship between anthropometric variables and lung function parameters. One way analysis of variance (ANOVA) was used to determine the difference in mean of FVC, FEV_1, FEV_1/FVC and PEFR across age groups studied. Point of significant difference was determined using the bonferroni post-hoc analysis. Independent-t-test was used to compare the difference in the mean of FVC, FEV_1, FEV_1/FVC and PEFR value across gender. Alpha level was set at $p < 0.05$. All data were analyzed using SPSS for windows version 23.0.

Results

A total of 202 young adults (76 males and 126 females) participated in the study. Majority of the participants were aged 21-25 years (114 (56.4%)) and a great number were 200 level students (70 (34.7%)). Table 1 shows the mean value of anthropometric and lung function variables of the participants**.** There was a significant positive correlation between FVC and waist to hip ratio ($r = 0.283$, $p = 0.000$), chest circumference($r = 0.420$, $p = 0.000$); and a significant negative correlation between FVC and percentage body fat ($r = -0.223$, $p = 0.001$) (Table 2). FEV_1 had a significant positive correlation with body mass index ($r = 0.175$, $p = 0.013$), waist to hip ratio ($r = 0.160$, $p = 0.023$), and chest circumference (r =

Table 1: Anthropometric and lung function variables of the participants.

Variable	Mean	SD
BMI	22.56	2.88
WC	75.83	8.35
HC	93.96	7.99
WHR	0.81	0.47
CC	85.49	7.12
PBF	24.16	7.63
FVC	2.36	0.88
FEV_1	1.86	0.75
FEV_1/FVC	0.81	0.18
PEFR	157.48	81.49

SD: Standard deviation; BMI: Body mass index; WC: Waist circumference; HC: Hip circumference; WHR: Waist hip ratio; CC: Chest circumference; PBF: Percentage body fat; FVC: Forced vital capacity; FEV_1: Forced expiratory volume in one second; PEFR: peak expiratory flow rate

0.363, p = 0.000) (Table 2). Also, PEFR had a significant positive correlation with waist circumference (r = 0.157, p = 0.025) while FEV1/FVC had a significant positive correlation with percentage body fat (r = 0.147, p = 0.037) (Table 2). Table 3 shows a significant difference in FVC and FEV_1 across the different age groups ($p < 0.05$). The exact point of significance difference was observed to be within the age range of 21-25 years as compared to the age range of 16-20 years (Table 4). Table 5 showed that there was a significant difference in FVC, FEV_1 and FEV_1/FVC across gender ($p < 0.05$).

Discussion

The positive correlation observed between waist circumference, waist to hip ratio, chest circumference and FVC, as well as the negative correlation of percentage body fat with FVC, is in tandem with previous studies. It has been reported that chest circumference has an

Table 2: Relationship between anthropometric variables and lung function parameters.

Variable		FVC	FEV_1	FEV_1/FVC	PEFR
BMI	R	0.116	0.175	0.022	0.127
	p-value	0.102	0.013*	0.770	0.073
WC	R	0.246	0.250	-0.032	0.157
	p-value	0.000*	0.000*	0.647	0.025*
HC	R	0.118	0.160	0.024	0.098
	p-value	0.096	0.023*	0.731	0.166
WHR	R	0.283	0.221	-0.106	0.123
	p-value	0.000*	0.002*	0.134	0.080
CC	R	0.420	0.363	-0.086	0.236
	p-value	0.000*	0.000*	0.222	0.001*
PBF	R	-0.223	-0.069	0.147	0.000
	p-value	0.001*	0.326	0.037*	0.996

*correlation is significant at $P < 0.05$

BMI: Body mass index; WC: Waist circumference; HC: Hip circumference; WHR: Waist hip ratio; CC: Chest circumference; PBF: Percentage body fat; FVC: Forced vital capacity; FEV1: Forced expiratory volume in one second; PEFR: Peak expiratory flow rate

Table 3: Age group differences in the lung function values.

Variable	Age group	Mean ± SD	p-value	F-value
FVC	16-20	2.17 ± 0.82	0.043*	3.21
	21-25	2.49 ± 0.89		
	26-30	2.47 ± 1.00		
FEV1	16-20	1.67 ± 0.67	0.017*	4.14
	21-25	1.98 ± 0.79		
	26-30	1.94 ± 0.52		
FEV1/FVC	16-20	0.79 ± 0.18	0.756	0.28
	21-25	0.81 ± 0.18		
	26-30	0.82 ± 0.18		
PEFR	16-20	141.64 ± 69.70	0.079	2.57
	21-25	168.60 ± 89.59		
	26-30	153.09 ± 50.01		

*correlation is significant at $P < 0.05$

FVC: Forced vital capacity; FEV1: Forced expiratory volume in one second: PEFR: Peak expiratory flow rate; SD: Standard deviation

Table 4: Post hoc analysis of mean difference in FVC and FEV1 across the three age groups.

Variable	Age	Age	p-value	MD
FVC	16-20	21-25	0.040*	-0.321
		26-30	0.856	-0.301
	21-25	16-20	0.040*	0.321
		26-30	1.000	0.020
	26-30	16-20	0.856	0.301
		21-25	1.000	-0.020
FEV1	16-20	21-25	0.014*	-0.309
		26-30	0.767	-0.270
	21-25	16-20	0.014*	0.309
		26-30	1.000	0.039
	26-30	16-20	0.767	0.270
		21-25	1.000	-0.039

FVC: Forced vital capacity; FEV1: Forced expiratory volume in one second; MD: Mean difference

*significant at P ≤ 0.05.

Table 5: Gender differences in the lung function values.

Variable	Sex	Mean ± SD	t-value	p-value
FVC	Male	2.88 ± 0.9	6.89	0.000*
	Female	2.05 ± 0.70		
FEV1	Male	2.18 ± 0.83	4.59	0.000*
	Female	1.67 ± 0.62		
FEV1/FVC	Male	0.76 ± 0.19	-2.64	0.009*
	Female	0.83 ± 0.17		
PEFR	Male	171.62 ± 91.98	1.83	0.070
	Female	148.94 ± 73.53		

*significant at P < 0.05

FVC: Forced vital capacity; FEV1: Forced expiratory volume 1; PEFR: Peak expiratory flow rate; MD: Mean difference; SD: Standard deviation

influence on FVC of individuals [13,14]. In addition, Mohammed, et al. also reported that FVC significantly positively correlated with waist circumference and chest circumference [2]. However, this was expected because the waist and chest circumference involve measurements taken around the thoracic region and an increase in the readings observed in these areas may likely influence the capacity of the thoracic cage. Furthermore, an increase in chest circumference increases the descent of the diaphragm during inspiration thereby increasing the volume of inspired air and FVC of the individual. On the other hand, waist circumference negatively correlated with FVC and FEV1 in another study, which disagrees with the findings of this study [15]. This observation may be attributed to difference in populations studied as their own study involved normal, underweight and obese individuals. The negative correlation observed between FVC and percentage body fat in this study may be attributed to a possibility of reduction in diffusing capacity, low ventilator muscle endurance and airway narrowing of the participants as the percentage body fat increased [16]. However, body mass index showed no significant correlation with FVC in this study. This finding is inconsistent with findings of a study which revealed a negative correlation between body mass index and FVC in healthy Indian young adults [17]. Disparity in the findings of these studies could likely be as a result of difference in the race of the populations studied.

The positive correlation observed between body mass index, waist to hip ratio, and FEV_1 in this study contrasts the findings of several studies which observed a significant negative correlation between body mass index and FEV1 in healthy young adult Indians in Madras [17-19]. The observed differences in the findings could be as a result of differences in the population studied as lung function parameters have been reported to differ in individuals from different race, ethnicities and in different geographical locations. Also, the positive correlation observed in this study between chest circumference and FEV_1 is in tandem with the findings of Mohammed, et al. who also reported a significant positive correlation between chest circumference and FEV_1 in children despite the age differences in the populations studied [2]. In addition, studies have also reported that chest circumference influences FEV1 in individuals [13,14]. This is expected because as the chest circumference of an individual increases, there is likely going to be an increase in the volume of inspired air and a resultant increase in FEV1.

Furthermore, the positive correlation observed between PEFR and waist circumference in this study is consistent with findings of a study which reported a significant increase in PEFR with an increase in height, weight and waist circumference of children despite the age differences in populations studied [1]. On the contrary, another research study observed a significant negative correlation between waist circumference and PEFR [20]. The difference between the two studies could have been due to discrepancies in the participant's waist circumference values. Moreover, it has been reported that increased abdominal adiposity restricts the descent of the diaphragm, limits lung expansion and increases the thoracic pressure, thereby leading to low lung volumes [17].

The observed significant difference in FVC and FEV_1 across the different age groups studied may have resulted from differences in body composition of the different age groups studied which is sufficient to induce changes in lung functions [16].

The FVC and FEV_1 of the males were significantly greater than that of the females while the FEV_1/FVC of the female participants was significantly greater than that of the males. Considering these differences, the male and female participants were significantly different in all the lung function parameters with the exception of

PEFR. This finding is in agreement with Singh, et al. who reported that the mean FVC was approximately 28% lower in females than males [21]. Also, Balasubramaniam, et al. reported that FVC and FEV1 were slightly lower in females in a study carried out in young adults [10]. This finding could be linked to the greater respiratory muscle strength and greater compliance in males compared to females [18]. Men and women also reportedly differ in the age they reach the maximal values of lung function indices [22]. Females reach their maximal values earlier, at approximately16 to 18 years, whereas male lung volumes usually continue to increase until the age of 25 or more. Thus, muscle growth in males is much greater than in females and it continues beyond puberty in males, reaching a maximum at around the age of 25, especially with training.

Conclusion

Anthropometric variables of individuals should be considered in the interpretation of their lung function parameters. Also, demographic characteristics such as the age and gender of an individual should be put into consideration as they may affect the lung function parameters. Encouraging participation in exercise is essential in promoting lung function as abdominal adiposity has been reported to influence lung function values. Further studies should incorporate waist to hip ratio and percentage body fat to observe their relationship with lung function parameters as there are limited studies in this area. Ultimately, more rigorous research is needed in sub-Saharan Africa to substantiate or validate the possible influence of race/ethnicity on the relationship of some anthropometric parameters (percentage body fat, body mass index and waist to hip ratio) with lung function parameters as observed in this study.

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