ORIGINAL ARTICLE

RELATIONSHIP BETWEEN BODY CIRCUMFERENCES AND LUNG FUNCTION TESTS AMONG UNDERGRADUATE STUDENTS OF A NIGERIAN UNIVERSITY

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Background: The purpose of this study was to find out the relationship among some anthropometric variables and lung functional capacities of the undergraduate students in Obafemi Awolowo University (OAU), Nigeria**. Method:** This study was undertaken at the Department of Physical and Health Education, Faculty of Education, OAU, Ile Ife, Nigeria. One hundred and forty students (90 males and 50 females) of OAU participated in the study. Anthropometric variables measured were, height, weight and body circumferences at the waist, hip, thigh, calf, arm, and forearm a standard protocol. Spirometry was used to measure Tidal Volume (TV), Expiratory Reserve Volume (ERV), Inspiratory Capacity (IC), Vital Capacity (VC), and Total Lung Capacity (TLC). Data were analysed using descriptive statistics, independent *t*-test, and Pearson Product Moment Correlation. **Results:** There was a significant negative correlation between VC and weight (r= -0.190, p<0.05), thigh circumference (r= -0.241, p<0.001), WHR (r= 0.260, p<0.001), but a significant positive correlation between VC and height (r= 0.330, p<0.001), wrist (r= 0.300, p<0.001) and forearm circumference (r= 0.202, p<0.05). TLC had positive significant correlation with height (r= 0.643, p<0.001), forearm circumference (r= 0.176, p<0.05), and wrist circumference (r= 0.441, p<0.001), but negative significant correlation with BMI (r= -0.244, p<0.001). **Conclusion:** An increase in WHR and weight may reduce the VC and TLC. TLC could be reduced by an increase in BMI and a tall individual may have enhanced VC and TLC.

Keywords: Lung Functions, Body Mass Index, Body circumference, Spirometry

INTRODUCTION

During the past few decades lung function tests evolved from simple tools for physiologic study to those of clinical investigations in assessing respiratory status. Lung function tests have also become a part of routine health examination in respiratory, occupational, and sports medicine and in public health screening.[1] Some studies reported inverse associations between lung function, especially forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC), and some anthropometric measures of central adiposity such as the waist circumference (WC) and waist-to-hip ratio (WHR).[2,3] Many studies also examined the relationship between obesity (using body mass index, BMI) and lung function tests (FEV_1 and FVC). Body mass index showed weak associations with diminished lung function at both extremes of the BMI distribution (thin or obese).[4,5] In the past few years, it was also suggested that these factors may have distinct effects on pulmonary function.[4,6–9]

Whitrow and Seeromanie[10], found that differences in upper body segment explained more of the ethnic differences in lung function of pupils aged 11–13 years than standing height, particularly among Black Caribbeans/African subjects. Raju *et al*[1] also reported that height had a strong significant relationship with FEV_1 and FVC in healthy school girls aged between 5 and 15 years.

Although several studies reported a significant relationship among anthropometric parameters, FEV_1 and FEV, there is paucity of data on relationships among anthropometric parameters, TV, VC, and TLC, especially in adult Nigerians. The purpose of this study was to establish a relationship among anthropometric parameters and TV, VC and TLC in undergraduate students of OAU, Ile Ife, Nigeria.

MATERIAL AND METHODS

A descriptive research method was used in this study. The population consisted of male and female undergraduate students of Obafemi Awolowo University, Ile-Ife, Nigeria. Sample of convenience was used to select 140 student volunteers including 90 males and 50 females. The age ranged from 18 to 30 years. Informed consent was obtained from all subjects. Ethical clearance was also obtained from Ethic and Research Committee of OAU Teaching Hospitals Complex, Ile Ife. The age and sex of each participant were recorded. Anthropometric parameters measured were: height, weight and body circumferences. Body circumferences were measured

at waist, hip, thigh, calf, arm, forearm and wrist, using the protocol of Marfell-Jones[11].

The lung volumes were measured as described by Guyton and Hall[12]. The equipment consisted of a spirometer with pen recorder, recording drum with chart, three-way stop cock, two-way respiratory valve, nose-clip and mouthpiece. The procedure was as explained by Ajayi[13]. Four normal respiratory movements were recorded. At the end of normal expiration, the subject inhaled maximally and was then asked to exhale maximally.

The spirogram was used to calculate Tidal Volume, Expiratory Reserve Volume, Inspiratory Capacity (IC), Vital capacity (VC) Inspiratory Reserve Volume (IRV), and Functional Residual Capacity (FRC).

RESULTS

One-hundred-and-forty (90 male and 50 female) students participated in the study. Table-1 shows physical characteristics of participants. There were significant differences between height of male and female participants, also waist to hip ratio of males was significantly higher than that of females. Table-2 compared the body circumference of male and female participants while Table-3 gives a summary of relationship between lung functions and anthropometrics parameters. There was a significant correlation between height and total lung capacity; waist to hip ratio was significantly correlated with total lung capacity and increase in wrist circumference significantly correlated with total lung capacity.

Table-1: Physical Characteristics of the participants (Mean±SD) (n=140)

Variables	Male (n=90)	Female (n=50)	Total (n=140)	*p*
Age (Yr)	24.44±3.82	22.76±2.80	23.83±3.57	0.007*
Height (m)	1.73±0.06	1.65±2.80	1.70±0.08	0.000*
Weight (Kg)	64.50±10.28	60.48±9.39	63.05±10.12	0.024*
BMI (Kg/m^2)	21.48±3.34	22.36±3.62	21.80±3.49	0.156
Waist circumference (Cm)	80.70±24.62	74.74±8.33	78.55±20.48	0.100
WHR	0.87±0.06	0.80±0.06	0.85±0.07	0.000*
Frame Size	10.20±0.52	10.32±0.60	10.24±0.55	0.217
VC (ml)	3150.4±333.68	2604±328.82	2958±422	0.000*
ERV (ml)	1028.00±331.76	984.12±169.26	1012.2±84.26	0.385
TV (ml)	5265.7±276. 76	4382.0±168.80	4947.8±228.78	0.028*
IRV (ml)	1504.9±339.37	1319.6±386.75	1438.3±366.78	0.004*
IC (ml)	2027.9±288.39	1745.3±331.16	1926.3±332.42	0.000*
FRC (ml)	2339.4±374 .47	2430.2±268.85	2500.1±343.3	0.072
TLC (ml)	4661.9±373.22	4050.0±368.55	4441.8±473.18	0.000*

*Significant

Table-2: Comparison of Body Circumferences of males and females participants (Mean±SD) (n=140)

Variables	Male	Female	Total	*t*	*p*
Waist circumference (Cm)	80.69±24.63	74.74±8.53	78.55±20.44	2.499	0.100
Hip Circumference (Cm)	92.73±28.05	93.23±9.70	92.91±23.13	2.257	0.904
Arm circumference (Cm)	27.79±2.77	26.89±3.47	27.49±3.06	1.992	0.093
Forearm Circumference (Cm)	53.06±55.85	25.03±4.17	42.98±40.06	45.05	0.001*
Thigh circumference (Cm)	51.69±5.25	51.01±4.89	52.90±5.68	2.809	0.042*
Calf Circumference (Cm)	34.48±3.17	34.88±3.00	34.63±3.11	0.381	0.472
Wrist Circumference (Cm)	17.03±0.97	15.99±0.90	16.66±1.06	0.295	0.000*

*Significant

Table-3: **Correlation matrix showing relationship between Lung Functions and anthropometrics parameters (n=140)**

Variables	VC	ERV	TV	IRV	IC	RV	FRC	TLC
Age	0.036	0.044	0.126	-0.068	0.018	0.156	0.121	0.094
Height	0.330*	0.035	0.007	0.164	0.193*	0.882*	0.509*	0.643*
Weight	-0.190*	0.009	0.397*	-0.148	0.110	0.327*	0.186*	0.125
BMI	-0.190*	-0.014	0.382*	-0.230*	0.007	-0.188*	0.114	-0.244*
Waist Circumference	0.031	-0.119	0.239*	-0.010	0.165	0.091	-0.049	0.002
Hip Circumference	-0.063	-0.118	0.193*	-0.037	0.101	0.072	0.058	0.027
Waist-Hip Ratio	-0.252*	-0.047	0.151	0.079	-0.199*	0.088	0.009	-0.260*
Arm Circumference	-0.013	-0.073	0.143	0.006	0.113	0.206*	0.051	0.069
Fore Arm Circumference	0.202*	0.025	0.266*	-0.002	0.190*	-0.011	0.015	0.176*
Thigh Circumference	-0.241*	-0.033	0.130	-0.204*	-0.117	0.164	0.062	-0.150
Calf Circumference	-0.139	-0.115	0.013	-0.052	0.002	0.231*	0.030	-0.033
Wrist Circumference	0.300*	0.026	0.112	0.093	0.196*	0.437*	0.260*	0.441*
Frame Size	-0.080	0.006	-0.119	0.018	-0.077	0.233*	0.131	0.020

*Significant

DISCUSSION

The physical characteristics of the participants of this study indicated that the mean BMI was 21.45 Kg/m^2±2.94 for males and 22.36 Kg/m^2±3.62 for females. World Health Organization[14] proposed BMI between 18.5 Kg/m^2 and 24.9 Kg/m^2 to be normal for average men and women. Hence an average participant in this study was within normal range of BMI. The mean waist circumference for male and female was below 100 Cm for male and 88 Cm for female which would have been indicative of a strong health risk especially for insulin resistance.[15,16] The mean waist to hip ratio of male participants in this study was 0.87 ±0.06 and that of female was 0.80±0.06. Bray and Gray[17] recommended that a waist to hip ratio of 0.85–0.90 for males and 0.75 to 0.83 for females is normal. The mean percent body fat for male participants in this study was 14.20±5.49. ACE[18] suggested that a percent body fat between 8% and 15% for an adult male was to be considered optimal. Participants in this study fit into this range. The reasons for the optimal level of adiposity in the participants of this study might be due partly to the rigours of academic and partly to the distance that the students should have to trek daily from the hostels to the academic area. These activities will continually increase metabolism which will not allow accumulation of adiposity. Regarding the frame size, male participants in this study are of medium frame 10.14±0.72 while the mean value for female was 10.32±0.60. Report from the study of Grant *et al*[19], suggested that a frame size of between 10.4–9.6 and 10.9–9.9 should be considered to be of medium size for male and female respectively.

Considering the lung functions of the participants, the higher lung function values of males than females (except for the FRC) was supported by literatures.[20,21] Hopkins and Harms[21] explained that relative to body size, women have a lower diffusing capacity for carbon monoxide, smaller airway diameter, and smaller lung volumes than men. Harms and Rosenkranz[22] also reported that women tend to show reduced lung size, decreased maximal expiratory flow rates, reduced airway diameter, and a smaller diffusion surface than age- and height-matched men. Ovarian hormones, namely progesterone and oestrogen, are known to modify and influence the pulmonary system. These differences may have an effect on airway responsiveness, ventilation, respiratory muscle work, and pulmonary gas exchange during exercise. The significant positive correlation of some lung capacities especially VC, FRC and TLC with height in this study have been corroborated with some previous studies.[1,9,23] The correlation of weight with TV and FRC was inline with the study of Deshpande *et al*.[24] There was significant positive correlation between pulmonary functions and anthropometric parameters like height, weight and upper segment of the body.[24] Body weight was understood to have an important effect on lung volume and flow rates and may be of importance in accounting for the disparities observed between African, American, and Caucasians regarding lung functions values.[25] It was observed that there was a positive correlation between wrist circumference and VC, FRC and TLC. There is paucity of data to support this, however, frame size is a ratio height to wrist circumference which invariably determines the body size.[26,27] There was a negative correlation between thigh circumference and vital capacity in this study. Thigh circumference is a measure of body density and a useful indicator of adiposity or lean body mass.[28]

The significant correlation between VC, TLC and BMI in our study is inline with the work of Galal.[29] BMI at baseline and weight gain were significantly related to pulmonary function. Body mass index showed weak negative associations with diminished lung function at both extremes of the BMI distribution (i.e., thin or obese) as reported by Maiolo[4] this was inline with the findings of this study. The significant inverse correlation between WHR and VC and TLC in this study was inline with the work of Cotes *et al*.[2]

CONCLUSION

A tall individual may have a higher vital capacity, FRC and TLC. An increase in WHR may decrease the VC and TLC. Increase in weight may lead to increased TV. TLC may reduce due to an increase in BMI.

REFERENCES

1 Raju PS, Prasad KVV, Ramana VY, Murthy KJR. Pulmonary function tests in Indian girls —prediction equations. Indian J Pediatr 2004;71(10):893–7.

2 Cotes J, D Chinn and J Reed. Body mass, fat percentage, and fat free mass as reference variables for lung function: Effects on terms for age and sex. Thorax 2001;56:839–44.

3 Chen R, Tunstall-Pedoe H, Bolton-Smith C, Hannah MK, Morrison C. Association of dietary antioxidants and waist circumference with pulmonary function and airway obstruction. Am J Epidemiol 2001;153:157–63.

4 Maiolo C, Mohamed EI, Carbonelli MG. Body composition and respiratory function. Acta Diabetol 2003;40:S32–8.

5 Lazarus R, Gore CJ, Booth M, Owen N. Effects of body composition and fat distribution on ventilatory function in adults. Am J Clin Nutr 1998;68:35–41.

6 Santana H, Zoico E, Turcato E, Tosoni P, Bissoli L. Relation between body composition, fat distribution, and lung function in elderly men. Am J Clin Nut 2001;73:827–21.

7 Amara CE, Koval JJ, Paterson DH, Cunningham DA. Lung function in older humans: The contribution of body composition, physical activity and smoking. Ann Human Biol 2001;28:522–36.

8 Mohamed EI, Maiolo C, Iacopino L, Pepe M, Daniele ND, Lorenzo AD. The impact of body-weight components on forced spirometry in health Italians. Lung 2002;180:149–59.

9 Cotes JM, Dabb JM, Hall AM, Heywood C, Lawrence KM. Sitting height, fat-free mass and body fat as reference variables for lung functions in healthy British children comparison with stature. Ann Hum Biol 1979;6:307–14.

10 Whitrow MJ, Seeromanie H. Ethnic differences in adolescent lung function anthropometric, socioeconomic, and psychosocial factors. Am J Respir Crit Care Med 2008;177(11):1262–7.

11 Marfell-Jones MT, Stewart A, Carter L. Skinfolds measurements and girth circumference. In: International Standard for Anthropometric Assessment. South Africa: International Society for the Advancement of Kinanthropometry (ISAK) Publication 2006;p. 67, 80.

12 Guyton AC, Hall JE (Eds). Textbook of Medical Physiology, 11th ed. Elsevier-Saunders 2006;p. 220.

13 Ajayi AA. Respiratory Function Test. Experimental Physiology and Workbook. Department of Physiology, University of Lagos, Nigeria 2004;p. 29–30.

14 WHO expert consultation. Appropriate body mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363(9403):57–63.

15 Aronne LJ. Classification of obesity and assessment of obesity-related health risks. Obes Res 2002;10:105–15.

16 Klein S, Allison DB, Heymsfield SB, Kelley DE, Leibel RL, Nonas C, Kahn R. Waist circumference and cardiometabolic risk a consensus statement from shaping America's health: Association for weight management and obesity prevention, NAASO, the obesity society: The American society for nutrition and the American diabetes association. Diabetes Care 2007;30:1647–52. doi: 10.2337/dc07-9921

17 Bray GA, Gray DS. Obesity Part I: Pathogenesis: Breadth as a frame size standard on nutritional assessment. West Med J 1988;149:429–41.

18 American Council on Exercise (ACE). What are the guidelines for percentage of body fat loss? Ask the Expert Blog December 2, 2009.

19 Grant JP, Luster PB, Thurlow J. Current technique of nutritional assessment. Surg Clin North Am 1981;61:437–63.

20 Elein, Glenn. "Volume of Human Lungs" 2009. http://hypertextbook.com/facts/2001/Lauren Calabrese.shtml

21 Hopkins SR, Harms CA. Gender and pulmonary gas exchanged during exercise. Exer Sport Sci Rev 2004;32(2):50–6.

22 Harms CA, Rosenkranz S. Sex differences in pulmonary function during exercise. Med Sci Sports Exerc 2008;40:664–8.

23 Whittaker AL, Sutton AJ, Beardsmore CS. Are ethnic differences in lung function explained by chest size? Arch Dis Child Fetal Neonatal Ed 2005;90:F423–F428.

24 Deshpande JN, Dahat HB, Shirole CD, Pandc AH. Pulmonary functions and their correlation with anthropometric parameters in rural children. Indian J Pediatr 1983;50:375–8.

25 Chamber EC, Heshka S, Haiffakari LY, Xiong Y, Wang J. Truncal adiposity and lung functioning in older black women. Lung 2008;186:13–7.

26 Martin AD. An anatomical basis for assessing human body composition: Evidence from 25 dissections (Unpublished doctoral dissertation). Burnaby, British Columbia: Simon Fraser University: 1984.

27 Grant JP, Custer PB, Thurlow J. Current techniques of nutritional assessment. Surg Clin North Am 1981;61:437–8.

28 Callaway CW, Chumlea WC, Bouchard C, Himes JH, Lohman TG, Martin AD, *et al*. Circumference. In: Athropometric standardization reference manual by Lohman TG, Roche AF, Martorell Reyaldo. Human Kinetics Books, Champaign Illinois;1988.p. 49.

29 Galal MM. Abdominal and Total Body Adiposity Markers in Asthmatic Patients. J Med Sci 2009;2:59–69.

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