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Research Article

Effect of Body Composition on Ventilation Parameters in a Group of Young Sudanese Females

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Abstract

Background: Lung Function Test helps (LFT) in the diagnosis and follow up of patients with pulmonary or cardiac diseases. Ignoring BMI and body composition during interpretation of LFT results may lead to wrong diagnosis and unnecessary use of drugs. **Objective**: This study was conducted to test the hypothesis that differences in body composition between individuals can explain some of the features of LFT that are explained by variations in age, sex, and height only. **Methods**: This observational analytical cross sectional study which included 150 young adult females. Those with history of amenorrhea, smoking, asthma or cardiac disease were excluded. Anthropometric measurements including: BMI, waist circumference (WC) and body fat percent calculated from skinfold thickness measurements were done. Dynamic spirometric tests were performed using digital spirometer; FEV_1, FVC, FEV_1% were measured. **Results**: Both obese and underweight subjects had a significant reduction in FEV_1 (P = .002) and FVC (P = .004) compared to normal ones. FEV_1% was significantly higher in the overweight and obese group compared to the other two groups (P = .02). Body weight, BMI, and WC had significant positive correlation with FEV_1 and FEV_1% in young healthy females. **Conclusion:** Increase in BMI, body weight, WC and body fat showed positive significant correlation with FEV_1% and may give a restrictive pattern in LFT. Underweight subjects may show significant reduction in lung function if their BMI is not considered.

Keywords: FEV_1, FVC, FEV_1%, BMI, waist circumference, Body fat %, obesity

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الملخص

الخلفية: اختبار وظيفة الرئة يساعد في تشخيص ومتابعة المرضى الذين يعانون من أمراض رئوية أو قلبية. تجاهل مؤشر حجم كتلة الجسم وتكوين الجسم أثناء تفسير نتائج اختبار وظيفة الرئة قد يؤدي إلى التشخيص الخاطئ والاستخدام غير الضروري للأدوية.

الهدف: أجريت هذه الدراسة لاختبار الفرضية القائلة بأن الاختلافات في تكوين الجسم بين الأفراد يمكن أن تفسر ملامح اختبار وظيفة الرئة التي يتم تفسيرها من خلال الاختلافات في العمر والجنس والارتفاع فقط.

الطريقة: : هذه دراسة رصدية تحليلية مقطعية والتي شملت ١٥٠ من الإناث الشابات البالغات. واستبعدت من يعانين من تاريخ انقطاع الطمث والتدخين والربو أو أمراض القلب. القياسات الأنثروبومترية بما في ذلك: مؤشر كتلة الجسم، محيط الخصر ونسبة الدهون في الجسم محسوبة من قياسات سماكة الجلد. تم إجراء اختبارات قياس التنفس الديناميكي باستخدام مقياس التنفس الرقمي؛ تم قياس FEV١، FEV١ ،FVC٪.

النتائج: كان لكل من السمنة ونقص الوزن في المدروسات انخفاض كبير في FEV١ (P = ٠٠٢.) و FVC (P = ٠٠٤.) مقارنة مع تلك العادية. وكان FEV١٪ أعلى بكثير في مجموعة زيادة الوزن والبدانة مقارنة مع المجموعتين الأخريتين (P= ٠,٠٢). وزن الجسم، مؤشر كتلة الجسم، ومحيط الخصر كان على علاقة إيجابية كبيرة مع FEV١ و FEV١٪ في الإناث الصحيحات.

الخلاصة: إن الزيادة في مؤشر كتلة الجسم، وزن الجسم، محيط الخصر ونسبة الدهون في الجسم كانت على علاقة إيجابية كبيرة مع FEV١٪ ويمكن أن تعطي نمطا انحصاريا في اختبار وظيفة الرئة. الاناث مع نقص الوزن قد تظهر انخفاضا كبيرا في وظائف الرئة إذا لم يتم النظر في مؤشر كتلة الجسم.

1. Introduction

Assessment of the lung functions (LF) helps in the diagnosis and management of patients with pulmonary or cardiac diseases. Lung volume measurements made during forced expiration are interpreted by comparing them with the expected values given the age, height and sex of the patient. Body mass index (BMI) is rarely used. This may lead to wrong diagnosis, unnecessary use of drugs, and failure to detect significant improvement in FEV_1(forced expiratory volume in the first second) [1]. Racial or ethnic differences in lung volumes have been reported. USA Blacks were found to have lower lung volumes than Whites. The differences in the body size and shape were suggested to be the reason for these differences in spirometric findings [2].

Obesity is known to affect the LF and may increase the effect of an existing airway disease [3]. Obese subjects may have a decrease in lung volume and expiratory flow rates [4] and may experience dyspnea at rest [5, 6]. Some studies found that BMI has a strong positive association with risk of adult-onset asthma [5–8]. Other studies showed that obese individuals can have dyspnea but not airway obstruction [6, 9]. Many obese subjects were using bronchodilators without evidence of airflow obstruction [6]. Jones and Nzekwu found that BMI has significant effects on all lung volumes [10]. It has been observed that BMI improved the predictions for both volumes and flows, regardless of sex. BMI or body weight (BW) gain has been related to the decrease in FEV_1 and forced vital capacity (FVC) in adults [11–13].

The addition of waist circumference (WC) to BMI improved the prediction of health risk than BMI alone [14]. Chen et al. reported that WC, but not BMI, is negatively associated with LF [15]. Some studies suggest that upper body fat distribution [16, 17] and abdominal adiposity [18] are better predictors of LF than BW or BMI. Body fat distribution also affects the LF [17]. Fat% and fat free mass (FFM) index improved the descriptions of FVC and of changes in FEV_1 and FVC [14].

This study was conducted to test the hypothesis that differences in body composition between individuals can explain some of the features of LFT that are explained by variations in age, sex, and height only.

2. Materials and Methods

This study is an observational analytical cross sectional study, done on 150 young female university students. The main objective of the study was to determine the effect of overweight and obesity on the ventilatory parameters (FEV_1, FVC, FEV_1%). The secondary objectives were: to determine the effect of BMI on each of the ventilatory parameters, and to verify the relation between BMI, percentage of body fat and waist circumference and each of the ventilatory parameters.

Subjects were volunteers from the practical groups who considered themselves healthy with no history of amenorrhea, smoking, asthma or cardiac disease. Their age was between 17-23 years. All subjects had completed a questionnaire personal data and additional questions on smoking, history of asthma, other respiratory or cardiovascular disease, or any other disease that can affect the lung function. Each subject underwent complete physical examination to exclude any abnormality and signed an informed consent. Dynamic spirometric tests and anthropometric measurements including: BW, height, BMI, WC, skinfold thickness were done.

Weight (kg): was measured to the nearest 100 g using standardized digital weight scale (Beurer, Germany) with the subject in standing position wearing light clothes and without shoes.

Standing height (m) was measured without shoes with the subject's back to avertical standardized height scale (Seca, Germany) to the nearest mm. Then **BMI** (kg/m^2) was calculated as a ratio between body weight (kg) and squared height (m^2).

Waist circumference (cm) was measured using a tape to the nearest 0.1 cm at the end of a normal expiration from exposed relaxed abdomen, at the level of the umbilicus in standing position.

Body composition was estimated using three steps:

(a) **Skinfold thickness** was measured in mm using Holtain skinfold caliper (Crymych Company, United Kingdom) from the triceps and subscapular region to the nearest 1 mm [19] by the same investigator.

(b) **Body fat % (BF%)**: using the method of Paríková and Bůžková [20], BF% was calculated from the triceps and subscapular skinfold separately as follows:

$$y_1 = 4.019 + 0.894\, x_1$$
$$y_1 = 2.333 + 0.988\, x_2$$

Where y_1 = BF% of the body weight; x_1 triceps skinfold (mm); x_2 subscapular skinfold (mm).

(c) **Fat Free Mass** (**FFM)** (kg) was calculated from the body weight and BF%.

Dynamic spirometric tests were performed using Electronic spirometer (Chest Corporation, Japan) in the sitting position and with a nose clips. First subjects were instructed in the FVC maneuver then the appropriate technique was demonstrated by the investigator. Each subject inhale from FRC and then insert the breathing tube into her mouth, making sure her lips are sealed around the mouthpiece before starting the FVC maneuver. The subject must have a complete inhalation before beginning the forced exhalation. Each subject attempted to perform at least three acceptable FVC maneuvers according to the ATS (American Thoracic Society) acceptability and reproducibility criteria [21]. The highest result was used for statistical analysis. FEV_1, FVC, and FEV_1% were measured.

Data analysis: Data was saved and analyzed using SPSS version 10. Subjects were classified into 3 BMI groups: underweight, normal and obese (include both overweight and obese BMI > 25 kg/m^2) according to WHO classification [22]. Descriptive statistics were calculated for all the variables according to BMI classes. Correlations of body measurements with ventilatory parameters were done using Pearson Correlation. To verify the effect of BMI class on the ventilatory parameters their mean values was compared between underweight, normal, obese groups using analysis of multiple variances (ANOVA) Test.

3. Results

This study included 150 young healthy females. Subjects were classified according to BMI class into 3 groups underweight, normal, obese (include both overweight and

Variables	Mean ± SE		
	Underweight (N = 54)	Normal BMI (N = 64)	Overweight & obese (N = 32)
Height (m)	1.62 ± 0 .01	1.6 ± 0 .01	1.61 ± .02
Weight (kg)	47.9 ± 1.6	61.1 ± 1.3	75.1 ± 1.1
BMI (kg/m^2)	18.2 ± 0.5	22.5 ± 0.4	29.0 ± 0.5
Waist circumference(cm)	64.4 ± 0.9	71.7 ± 0.8	80.9 ± 1.1
Triceps skinfold(mm)	12.8 ± 0.7	18.1 ± 0.6	26.4 ± 0.9
Fat % (t)	15.4 ± 0.6	20.2 ± 0.5	27.7 ± 0.8
Subscapular skinfold(mm)	13.5 ± 0.7	17.7 ± 0.6	28.0 ± 0.9
Fat % (s)	15.7 ± 0.7	19.8 ± 0.6	30.0 ± 0.9
FFM (t) (kg)	40.6 ± 0.7	47.5 ± 0.6	55.0 ± 0.8
FFM (s) (kg)	40.5 ± 0.6	47.7 ± 0.6	53.0 ± 0.8
FEV_1 (L)	2.592 ± .059	2.856 ± .053	2.781 ± .075
FVC (L)	3.139 ± .069	3.418 ± .061	3.202 ± .088
FEV_1%	82.63 ± .72	83.68 ± .64	85.59 ± .93

Table 1: Anthropometric and Spirometric Measurements According to BMI Class. *FFM: fat free mass, (t): calculated using triceps skinfold, (s): calculated using subscapular skinfold.

obese BMI > 25kg/m^2) according to WHO classification [22]. Table 1 shows means of anthropometric and spirometric measurements in different to BMI classes.

To assess the effect of anthropometric measurement on lung function test (LFT) parameters Pearson correlation was done (table 2). BMI and WC showed significant positive correlation with FEV_1((P = .016) and (P = .003) respectively),and FEV_1% ((P = .005) and (P < .005) respectively). Body fat % showed a highly significant positive association with FEV_1% (P = 0.002).

To determine the effect of overweight and obesity in lung function test ANOVA test was done to compare the means of the three BMI groups. Underweight subjects had a significantly lower FEV1 than normal BMI and obese subjects (P = 0.03) (Figure 2). FVC was significantly higher in normal BMI subjects compared to the other two groups (P = 0.01). There was no significant difference between underweight and obese subjects in FVC (Figure ??). FEV_1% was significantly higher in the overweight and obese group compared to the other two groups (P = .02).

Body Measurements	FEV1	FVC	FEV1%
Weight	0.294 (P = .000)*	.184 (P = .024) *	.231 (P = .005) *
BMI	.196 (P = .016) *	.084 (P = .306)	.229 (P = .005) *
waist circumference	.245 (P = .003) *	.107 (P = .191)	.309 (P = .000) *
Fat % t	.064 (P = .438)	-.010 (P = .899)	.191 (P = .020) *
Fat % s	.067 (P = .414)	-.025 (P = .764)	.248 (P = .002) *
FFM- t	.392 (P = .000) *	.289 (P = .000) *	.189 (P = .021) *
FFM- s	.407 (P = .000) *	.318 (P = .000) *	.139 (P = .090)

Table 2: Correlations between Body Measurements and Lung Function Parameters. * P values (<0.05 is significant, <0.005 is highly significant). (-) indicates negative correlation.

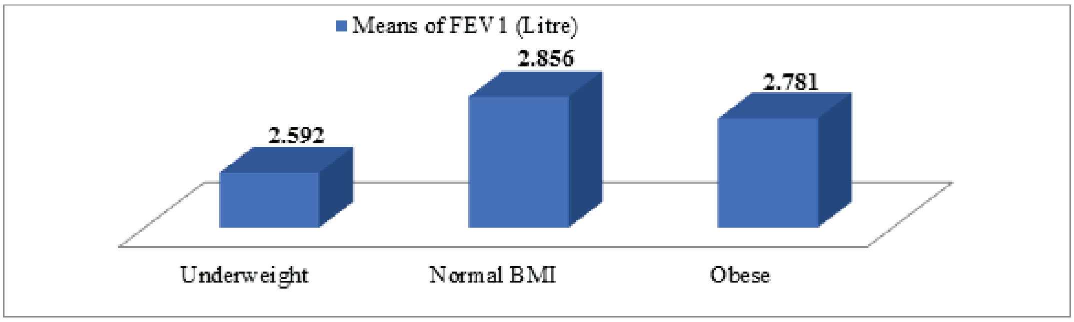

Figure 1: Means of FEV_1 in Different BMI Groups.

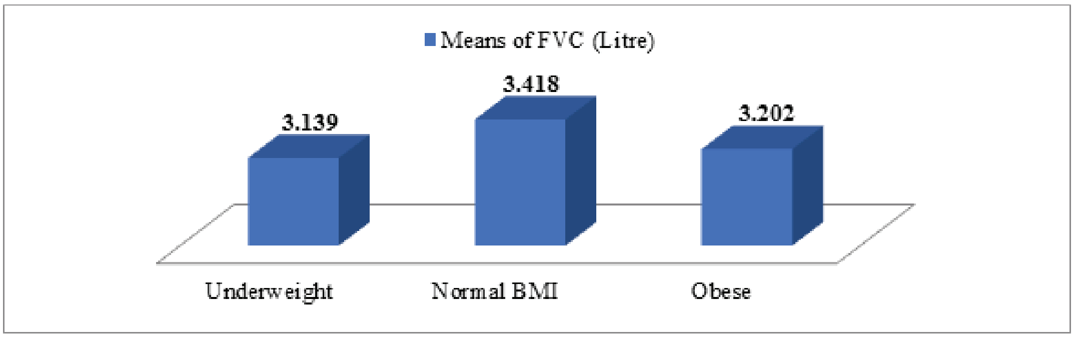

Figure 2: Means of FVC in Different BMI Groups.

4. Discussion

In this study obese subjects had the highest mean of BF %, but they also had the highest mean of FFM as well (table 1). The increase in BW in the study group could be explained partially by the physical growth involving skeletal frame, muscles and fat. This means that subjects in the obese group were overfed females with excessive energy intake and minimal exercise, therefore they deposited more fat. They had a good nutritional status which leads to development of good muscle bulk (more FFM).

4.1. Effect of Body Composition on Ventilation Parameters

We found that the subgroup with normal BMI had the highest mean of both FEV_1 and FVC, while underweight ones had the lowest mean of both FEV_1 and FVC. Well-developed muscles especially of the chest wall are expected to influence all forced expiratory parameters. Being underweight with small muscle bulk may reduce the lung volumes.

FVC showed a significant positive association with BW (P = .02). The increase in BW in this young females group reflects increase in both muscle bulk and body fat with predominant effect of muscle bulk on LF. Contrary to expectations FVC had no significant association with BMI in the present sample. The effect of BMI may be clearer in older age group. BF% showed a negative correlation with FVC but it was not significant. The present results agreed partially with Lazarus et al results who found that adjusted FVC was not significantly associated with BMI, but was negatively associated with BF% in men and women [17]. Therefore, it was justified to look for the FFM and its correlation with LF parameters because: the number of overweight and obese is too small to show the effect of increased BMI or body fat on LF. FVC showed positive correlation with BW and not with BMI. In addition, underweight had the lowest FVC. From the previous results muscle mass is more likely to affect the lung parameters. The results showed a highly positive association between FFM and FVC (P = .000) as shown in table 2; which agrees with Lazarus et al results [17]. In Cotes et al study, this association was insignificant in women but not for women who perform much exercise [14].

Unlike the results of Chen et al in which WC, but not BMI, is negatively associated with LF [15]; there was no association between WC and FVC in this sample. This is most probably due to the opposing effects of fat and muscle in these young females.

FEV_1 had highly significant positive association with BW, FFM and WC ($P < .005$); and a positive significant association with BMI (P = .01). This can be explained by the effect of the good muscle bulk on forced expiration.

FEV_1 % had a highly significant positive correlation with BW and BMI (P = .005), because these measures caused a significant increase in FEV_1 and a slight or no increase in FVC (table 2). In contrary to Heather et al results which showed a negative association between WC and FEV_1 % [18], there was a highly significant positive correlation between them in this study ($P < .005$). The increase in WC in these young females was associated with the increase in muscles mass (causing increase FEV_1) as well as fat (causing insignificant effect on FVC) and therefore a positive association with FEV_1 %. In addition, there was a positive highly significant association between FEV_1 % and BF% calculated from the subscapular skinfold (P = .002) and triceps skinfold (P = .02). FEV_1% was significantly higher in the overweight and obese group compared to the other two groups (P = .02). Thus, results of LFT in healthy obese persons may give a restrictive pattern. This may be due to the mechanical load impeding expansion of the chest wall during inspiration. Future studies may yield more conclusive results if more sensitive estimates of muscle mass are employed in different age group.

4.2. Effect of BMI on Ventilation Parameters

In this study BMI class had a significant effect on FEV_1 (P = .004), FVC (P = .008) and on FEV_1 % (P = .04). Underweight subjects had significantly lower FEV_1 compared to normal BMI and obese subjects. There was no significant difference in FEV_1 between obese and normal BMI subjects, which support the hypothesis that the effect of increase muscle mass is likely to offsets the effect of fatness on FEV_1.

In agreement with previous studies which have demonstrated that a rise in BMI lowers FEV_1 and FVC [12, 13]; this study showed that FVC was significantly reduced in the obese and underweight group compared to normal BMI subjects ($P < .05$). There was no significant difference in FVC between obese and underweight subjects. This means that both obese and underweight had a significant reduction in FVC compared to normal weight females.

5. Conclusion

The higher FEV_1% in the overweight and obese group compared to the other two groups and the positive association of body fat, body weight, WC and high BMI with FEV_1% suggests that obese subjects may show a restrictive pattern in LFT. On the other hand, underweight subjects may have a significant reduction in lung function. We suggest that more anthropometric measurements should be taken into account for the assessment of lung function.

6. Ethics Approval

This study was approved by the Department of Physiology-Faculty of Medicine- University of Khartoum. Each participant signed an informed consent form.

7. Competing Interests

No areas of competing interest of this study.

8. Acknowledgements

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9. The Author Contributions

1. Study concept and design: Professor Mohammed Yousif Sukkar.
2. Collection of data: Dr. Nouralsalhin Abdalhamid Alaagib.
3. Analysis and interpretation of data Professor Mohammed Yousif Sukkar and Dr. Nouralsalhin Abdalhamid Alaagib.

10. Availability of Data and Material

Data is available in Excel form and can be provided when requested.

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