Original Article

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Lean Body Mass Can Predict Lung Function in Underweight and Normal Weight Sedentary Female Young Adults

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Background: A previous cross-sectional study found reduced lung function among over weight and obese students in Zanjan city. However, there is no reliable evidence about the respiratory function of underweight and normal weight students. The objective of this study was to evaluate lung function and develop prediction equations in underweight and normal weight female young adults residing in Soltanieh city near Zanjan.

Materials and Methods: A cross sectional study was conducted on underweight (n=29, mean age=16±0.84 years) and normal weight (n=38, mean age=15.9±0.86 years) sedentary female young adults. Fat mass (FM) was measured by Omron Body Fat Monitor FB-3002. Lean body mass (LBM), waist to hip ratio (WHR), body mass index (BMI) and waist circumference (WC) were calculated. Maximum oxygen uptake was calculated using Queen's College step test. Forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) were recorded, using Spirolab III spirometer. Independent t test, Pearson's correlation test and stepwise linear regression analysis were used for data analysis.

Results: FVC and FEV1 were significantly lower than the reference values in both groups (P<0.05). LBM was significantly correlated with FVC and FEV1 in underweight and normal weight groups (P<0.05). Regression equations were derived to predict FVC and FEV1 using LBM.

Conclusion: This study suggests that dynamic lung functions are poor in underweight and normal weight sedentary female young adults residing in Soltanieh city and LBM plays a significant role in their lung function.

Key words: Underweight, Normal weight, Lung function

INTRODUCTION

Lung function is often assessed by measuring FEV1 and FVC (1). A low FEV1 is related to all-cause mortality and cardiovascular mortality (2), while a low FVC is associated with higher risk of developing diabetes (3) and myocardial infarction (4). Our previous study showed that FVC and FEV1 were significantly lower than reference values in overweight and obese male students in Zanjan city with sedentary life styles (5). It is known as a fact that underweight and normal weight individuals with sedentary life styles have reduced FVC and FEV1 and poor respiratory muscles (6). In Zanjan, especially in rural areas, spirometric screening of lung function is rarely done at elementary and high school levels, due to the lack of equipment and experienced experts. As a result, there is no dada available about the spirometric characteristics of underweight and normal weight young adults. Therefore, it seemed necessary to assess the non-spirometric measures, which can perfectly reflect lung function in these subjects.

Physical fitness tests are generally accepted and widely used methods to determine health related physical fitness components in high school students (7). Body composition (FM and LBM) (8) and cardio respiratory fitness (maximal oxygen uptake=VO_{2max}) (9) are among these components, which can be measured by simple field tests. Association of body fat mass (FM) and its distribution [waist to hip ratio (WHR) and waist circumference (WC)] with pulmonary dysfunction has been reported by longitudinal and cross sectional studies in overweight and obsess people (10). Other studies have reported positive correlation of cardiorespiratory fitness (VO_{2max}, measured by field test) and lung function (11). Despite these facts, at least in case of underweight and normal weight female young adults living in Soltanieh city, there are no data specifically addressing the relationship of body composition, fat distribution and cardiorespiratory fitness with respiratory function. Also, we do not know which of these variables can predict respiratory function.

The aim of this study was to assess the relationship of body composition (FM, LBM), fat distribution (WHR, WC) and VO_{2max} with FVC and FEV1 in young female young adults with sedentary life styles residing in Soltanieh city.

MATERIAL AND METHODS

Subjects: Data were collected using the physical activity questionnaire and WHO classification for BMI. Study subjects were 38 normal weight (BMI=18.5-24.99) and 29 underweight (BMI<18.50) physically inactive female young adults (15-17 years) who were studying in high schools of Soltanieh in 2012. This study was approved by the ethics committee of Soltanieh Education Organization. All subjects were informed about the experiments before giving their informed consent. Healthy underweight and normal weight female young adults with sedentary life styles were included in this study. The exclusion criteria were asthma, respiratory illness, musculoskeletal disorders and taking medications interfering with respiratory function.

Measurements

Standing height was measured using a flexible tape fixed to the wall and recorded to the nearest 0.1cm. Body weight was measured with an electronic scale, with subjects wearing light indoor clothing and recorded to the nearest 100 gr. BMI (kg/m^2) was also calculated. WC, which is a measure of central obesity, was measured with a tape measure in centimeters as the average of measurements made after inspiration and after expiration at the midpoint between the lowest rib and the iliac crest. WHR was determined as the ratio of WC and the circumference of the hips at the trochanter major (12).

Body composition measurements: Body FM was measured using bioelectrical impedance analysis (BIA) by Omron BF-300 (Omron Corp., Kyoto, Japan) (13). LBM was then estimated using the difference of body weight and FM.

Spirometric measurements: Lung function (FVC, FEV1) was measured using Spirolab III (Medical International Research, Roma, Italy) according to the guidelines of the American Thorax Society (ATS) and European Respiratory Society (ERS) (14). Before each measurement, the spirometer was calibrated. Subjects rested for 15 minutes before measurements and were briefed about the procedure. After appropriate placement of mouthpiece and nose clip, a powerful, quick, forced expiration challenge was done right after maximum forced inhalation. By doing at least three technically appropriate measurements, the highest value was recorded as the baseline value. All volumes were reported in Body Temperature and Pressure Saturated (BTPS) (14). ECCS set of equations were used by Spirolab III to calculate reference values according to the ERS guidelines (14). All tests were done by an experienced technician.

Queen's College step test: Queen's College step test was used to calculate VO_{2max}. Participants were required to step up and down on a 16.25 in / 41.3 cm step with both feet continuously for 3 minutes. They stepped at a rate of 22 steps per minute. It was important to keep a steady step rate according to a metronome rhythm (the subjects used a four-step cadence, 'up-up-down-down' for 3 minutes). At the end of the test subjects rested for 5 seconds and then their heart rates were counted for 15 seconds. The obtained heart rate was multiplied by 4 to give the beats per minute (bpm), which was used for VO_{2max} calculation using the equation below (15).

Women: VO_{2max} (ml/kg/min) = 65.81 - 0.1847 x heart rate (bpm)

Statistical analysis: SPSS version 19 was used for data analysis. The data were presented as mean± SD. Because of the non-probability sampling technique (purposive sampling) applied for sample selection, the normality test was performed using Kolmogorov-Smirnov test (Table 1). Independent t test was applied to compare the measured respiratory values with the reference values. Pearson's correlation test was used to determine the relationship between the study variables. Then the relationship between BMI, FM, WHR, WC, LBM and VO_{2max} (as independent variables) and FVC and FEV1 (as the dependent variables) was analyzed using the stepwise linear regression analysis. Level of significance was set at $P< 0.05$.

RESULTS

Characteristics of the study subjects are presented in Table 1. Statistical analysis showed that baseline FVC and FEV1 were significantly lower than the reference values in the normal weight and underweight groups ($P<0.05$) (Table1).

Table1. Characteristics of the study groups, comparison of the respiratory indices with reference values and the results of normality tests.

variable	Group: Under weight(n=29)	Group: Normal weight(n=38)	K-S: P	K-S: Z
Age(year)	16±.84	15.9±0.86	0.644	0.740
BMI(kg/m^2)	17.28±1.02	21.21± 1.67	0.777	0.659
WHR	0.71± 0.05	0.73± 0.05	0.944	0.527
WC(cm)	61.28± 3.0	68.13± 5.7	0.461	0.853
FM(kg)	7.80± 2.63	12.79± 2.92	0.769	0.665
FFM(kg)	37.46± 3.4	40.682± 4.5	0.809	0.639
VO_{2max}(ml/kg/min)	40.11± 2.76	40.66± 2.79	0.768	0.665
FVC_{base}(liter)	2.78± 0.38	2.88± 0.34	0.912	0.561
$FVC_{reference}$(liter)	3.254±0.39*	3.18± 0.36*		
$FEV1_{base}$(liter)	2.76± 0.36	2.83±0.32	0.644	0.740
$FEV1_{reference}$(liter)	3.25±0.39*	2.71± 0.30*		

BMI=body mass index: WHR=waist to hip ratio: WC=waist circumference: FM: fat mass: LBM=lean body mass: VO_{2max}= maximal oxygen uptake: FVC=forced vital capacity: FEV1= forced expiratory volume in 1 second:*=p<0.05. k-s= Kolmogorov-Smirnov test. Z and p= p value and z for k-s test

Pearson's analysis in the underweight and normal weight groups showed that correlations of FVC-LBM (underweight: r=.637, P=0.00; normal weight: r=.323, P=0.048) and FEV1- LBM (underweight: r=.668, P=0.00. normal weight: r=.390, P=0.016) were significantly positive (Table 2); while other variables (WHR, WC, FM, LBM and VO_{2max}) were not correlated with FVC or FEV1 (Table 2).

Table 2 Pearson correlations of FVC and FEV1 versus body composition, fat distribution and cardiorespiratory variables.

	Underweight(n=29)				Normal weight(n=38)			
	FVC		FEV1		FVC		FEV1	
Variable	R	P	r	p	r	p	r	p
LBM	0.637	0.00*	0.668	0.00*	0.323	0.048*	0.390	0.016*
VO_{2max}	0.253	0.186	0.192	0.318	0.269	0.102	0.302	0.065
WHR	0.337	0.074	0.345	0.067	0.276	0.094	0.241	0.198
WC	0.367	0.050	0.317	0.093	0.187	0.217	0.217	0.191
FM	0.286	0.133	0.317	0.094	0.171	0.3O5	0.232	0.162
BMI	-0.052	0.790	-0.42	0.833	0.066	0.69	0.110	0.511

BMI=body mass index: WHR=waist to hip ratio: WC=waist circumference: FM: fat mass: LBM=lean body mass: VO_{2max}= maximal oxygen uptake: FVC=forced vital capacity: FEV1= forced expiratory volume in 1 second:*=p<0.05

In normal weight and underweight groups, the stepwise linear regression analysis revealed that LBM is a significant independent factor explaining the variances in FVC (underweight: R=.503, P=0.00. normal weight: R=.323.P=.048) and FEV1 (underweight: R=.668, P=0.00. normal weight: R=.390, P=0.016). As shown in Table 3, LBM can be a significant predictor of FVC and FEV1 for underweight and normal weight female young adults with a sedentary life style. Accordingly, the FVC and FEV1 can be predicted from the following regression equations:

Underweight

FVC=0.070(LMB) +0.154

FEV1=0.71 (LBM) +0.117

Normal weight

FVC=0.024(LMB) +1.892

FEV1=0.028(LBM) +1.71

Table3. Linier regression between FVC, FEV1 (as dependent variables) and LBM (as independent variable) in the underweight and normal weight girls.

Group		Variable	Beta coefficients	F	P	R	R^2
Underweight n=29	FVC	Constant	0.154	18.44	0.00*	0.637	0.406
		Lean body mass	0.070				
	FEV1	Constant	0.117	21.781	0.00*	0.668	0.447
		Lean body mass	0.71				
Normal weight n=38	FVC	Constant	1.892	4.199	0.048*	0.323	0.104
		Lean body mass	0.024				
	FEV1	Constant	1.71	6.450	0.016*	0.390	0.152
		Lean body mass	0.028				

FVC=forced vital capacity: FEV1= forced expiratory volume in 1 second:*=p<0.05

DISCUSSION

In our study, the mean spirometric indices in underweight and normal weight female young adults were significantly lower than the predicted values. This can be attributed, in part, to the negative effects of sedentary life style (16) and poor nutrition (17) on these parameters. Follow-up studies described an association between the level of physical activity and respiratory function (16). FVC and FEV1 are strong indicators of lung function, and decline due to sedentary life style (16). Research indicates that men who remained active during the follow-up period (19 months) showed 50 ml improvement in their FEV1 and 70 ml in their FVC; whereas subjects who remained sedentary had 30 and 20 ml reduction in their FEV1 and FVC, respectively (18). Underweight and normal weight female young adults in this study had sedentary life styles, which may arise from misunderstandings about physical activity for females in the rural areas. Highly active and energy-demanding lifestyle accounts for the higher levels of VO_{2max} in young subjects (19). In this study, VO_{2max} in underweight and normal weight groups was 40.1±2 and 40.6±2.7 ml/kg/min, respectively, which are rated below the average compared to the reference value for VO_{2max} (20). This may be an indicator of low physical activity and its negative effects on lung function. In Sistan-Baluchistan, high prevalence of underweight among high school female young adults has been reported to be due to malnutrition and micronutrient deficiencies (21). There is no reliable study about the prevalence of underweight in Zanjan Province. But with respect to the poor economical status of most rural areas, we may state that malnutrition probably plays a role in this regard. Under-nutrition can reduce skeletal and respiratory muscle mass, which results in reduced FVC and FEV in underweight and normal people (10).

Non-significant correlations were found between BMI, FEV1 and FEV1 in the underweight and normal weight groups. The present results are different from those of other populations. In an underweight Indian population, BMI had a significant, positive correlation with FVC and FEV1 in males as well as in females (22). In reviewing the literature, no data was found on the lack of association or negative association between BMI and lung function in underweight and normal weight individuals. We did not find any report consistent with our results. It is therefore difficult to explain the obtained results, but it might be related to the opposite effects of BMI components (FM and LBM) on lung function, which at the same time tend to decrease and increase respiratory function.

Fat mass (FM) showed positive but less than significant correlations with FVC and FEV1 in underweight and normal weight groups. In previous studies, body FM was associated with lower lung function in overweight and obsess men and women (23). Presumably, this contradiction is due to different subjects in these studies (normal weight and underweight versus overweight and obsess). Pralhadrao et al, (22) and Shah et al. (24) reported positive but significant associations between FM and lung function in underweight and normal weight subjects, which, to some extent, confirm our results. In this study, FM was directly linked with LBM in underweight and normal weight groups and the latter was significantly correlated with lung function (data not presented). Therefore, it seems that positive effect of FM on FVC and FVE1 was because of its relation with LBM in our underweight and normal weight subjects.

Our results did not show significant correlations of WHR and WC (both indicators of central adiposity) with respiratory indices in the two groups. A number of studies have reported an inverse correlation between these indices and fat distribution and respiratory function. In a Scottish cross-sectional survey of 865 men and 971 women aged 25–64 years, Chen et al. (25) found that WC was inversely associated with FVC and FEV1. In a British cohort study of 9674 men and 11,876 women aged 45–79 years, Canoy et al. (26) found significant associations of WHR with FVC and FEV1 in both men and women. These conflicting results may be due to differences between subjects in our experiment (underweight, normal weight) and those of other studies (overweight, obese). Increased WHR and WC are indicators of abdominal fat deposition and can lead to lung function deterioration in both mildly obese and morbidly obese individuals, because of the limited diaphragm descent and lung expansion (26). This finding is in agreement with the findings of Wannamethee et al. who showed that central fat deposition was not related to lung function in the lean and normal weight persons, in whom central fat deposition was less marked (27). According to the WHO classification, subjects of this study with WHR of less than 0.85 and WC of less than 80 cm (Table 1) were considered not having abdominal obesity (28). A possible explanation for lack of correlation between abdominal obesity and lung function may be the lack of adequate abdominal fat deposition in subjects.

The results of this study did not show any significant correlations between VO_{2max} (calculated by Queen's step test) and respiratory indices in underweight and normal weight groups (Table 2). These results differ from those of Afzalpour et al. reporting positive correlations between VO_{2max} (measured by Storer-Davis protocol) and pulmonary function (FVC and FEV1) in normal weight and overweight young females (29) and Babb et al. reporting, positive association of VO_{2max} (measured by a computerized, breath-by-breath system) and maximal expiratory follow in healthy men (30). Most studies on VO_{2max} and lung function estimated VO2max via treadmill or cycle ergometry protocols (29). To the best of our knowledge, this study was the first to use Queen's step test for this purpose. This discrepancy may be due to different VO_{2max} protocols. There are conflicting results about the validity of Queen's step test. Chatterjee et al. reported a poor agreement with the direct method for Queen's step test (31). While results of one study showed that Queen exercise tests were valid for estimation of VO_{2max} in male elite karate competitors (32). This remains to be studied in the future. To our knowledge, estimation of VO_{2max} by Queen's step test could influence VO_{2max} and in turn its relation with FVC and FEV1.

The current study found that LMB was significantly and positively correlated with FVC and FEV1 in underweight and normal weight groups (Table 2). These findings are consistent with those of Santana et al (33), and Shah et al. (24) who found direct correlations between LBM and lung function in old men, underweight COPD patients and underweight boys, respectively. LBM is a representative of muscle mass and a relation between muscle mass and lung function has been postulated (34). In patients with COPD and low body weight (<80% of usual body weight), a significant association was observed between respiratory muscle strength and fat-free mass measured by dual-energy x-ray absorptiometry (DXA) (33). Based on this observation and with respect to the observed correlation between LBM and lung function in this study, it may be stated that reduced EVC and FEV1 may be due to reduced skeletal and consequently respiratory muscle mass in our subjects. The probable cause of low dynamic lung function in underweight group may be lower level of physical activity and malnutrition. In prolonged under-nutrition, energy is utilized at the expense of muscle protein leading to respiratory and diaphragm muscle atrophy (24). We believe that the reduced lung function in the normal weight group is probably the consequent of sedentary life style and malnutrition, which can decrease muscle mass and increase fat mass, respectively.

Based on the results of stepwise regression analysis in Table 3, LBM was significantly (P<0.05) correlated with FVC (underweight: R=.637, normal weight: R= .323) and FEV1 (underweight: R=.668 .normal weight: R=.390) in the two groups. Therefore, prediction equations were developed for FVC and FEV1 on the basis of the LMB in underweight and normal weight female young adults with a sedentary life style. This finding is in agreement with that of Raju et al. showing that LBM is an independent variable for lung function prediction in Indian boys. On the contrary, studies conducted on Western populations have used height, sitting height, stature, FFM/stature and %body fat as independent variables for prediction of ventilatory functions (34). These differences can be explained in part by the difference in ethnicity of subjects.

In this study, LBM was found to be a significant indicator of lung function in sedentary underweight and to a lesser extent in normal weight female young adults. Our study developed predictive equations for FVC and FEV1 using linear regression analysis for underweight and normal weight sedentary female young adults living in Soltanieh. Small sample size and being unable to use net muscle mass instead of LBM were the limitations of this study. Our results need to be confirmed in a larger group in future using net muscle mass index.

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