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The effects of obesity on spirometric variables following a sub-maximal exercise challenge

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ABSTRACT

The combined effects of obesity and exercise on respiratory system have not been investigated in subjects with normal resting spirometry.The objective was to recognizethe exercise-related breathing issues in non-asthmatic obese individuals, pre and post asub-maximal challenge. Our hypothesis was examined on thirteen age-matched obese (BMI≥35) and ten normal-weight (BMI≤25) males who did not do any type of sport whatsoever. Pulmonary function tests (PFTs) were performed at baseline and 30 minutes after exercise at 5, 10, 20 and 30-mint post-challenge time points. All subjects completed the sub-maximal exercise challenge for 8 minutes.Exercise intensity was determined based on HRpeak, in relation to VO2max values. Baseline spirometry revealed no difference between the two groups.A significant reduction was observed in values for proximal airways($p<0.05$), however, no significant difference was observed between OG and NWG in post-challenge percent change in FEV1.The results showeda significant difference in spirometry from pre- to post-exercise time points in the high-BMI subjects ($p<0.05$). FEV1/FVC ratio increased significantly in OG ($p<0.05$). It seems that obesity and exercise are concomitantly affecting PFT results. Obesity has a considerable impact on spirometry variables which are thought to be boosted by exercise in subjects with normal airway function. The share of obesity and exercise effects on respiratory system can be independently, though not preciselyproved.

Keywords: obese; respiratory system; exercise; spirometry
Abbreviations*: OG = obese group; NWG = normal-weight group*

INTRODUCTION

Today, obesity is considered as a major health issue. A steady trend of increasing obesity has been observed over the past several decades [1].Different body compositions, especially obesity may affect the respiratory system to variousdegrees [2]and cause changes in the respiratory system during and after physical activity [3]. Several studies have demonstrated a reduction in lung compliance in obese individuals [4]which appears to be exponentially related to BMI[5].

In many studies [6,7], it has been observed that the percentage and distribution of body fat may have significant effects on pulmonary function. In fact, increasing body fat percentage decreases the activity of the respiratory muscles and causes a general decrease in the dynamic compatibility of the lungs and in lung capacity [8].In the same line, numerous investigations [9,10,7]have suggested that increasing fat percentage, especially in the upper body,plays a more effective role in such a decrease. Obesity may be associated with a reduction in vital capacity (VC) and Forced Expiratory Volume in one second (FEV1) depending upon the age, type of body fat distribution [11] and severity of obesity.

In addition, exercise seems to be another exacerbating factor that influencesthe respiratory system in terms of airway resistance and compliance features [12,13]. Increased fat mass may negativelybe associated with resting, during [14,15] and post-challenge [16] spirometric lung function. Lean and obese subjects, also develop expiratory flow limitation at peak exercise [17],however,these physiological changes are more pronounced in obese subjects, as compared to normal weight subjects.

Although the association between obesity and pulmonary function has been extensively reported in several studies [1,2,3], little, if any, attention has been given to healthy and non-athlete obese men's pulmonary function following an exercise challenge. However, unknown exercise-related respiratory difficulties can be a potential discouraging factor among obese people who are going to participate in fitness programs.It is currently hardly known as far as obese subjects with a normal FEV1/FVC ratioare concerned, whether exercise deterioratestheirspirometric results, orobesity-related conditions aid exercise to develop its effects on the respiratory system.

MATERIALS AND METHODS

Study population

13non-athlete obese and 10 normal-weight subjects (control group) were screened for havinga BMI respectively greater than 35 kg/m^2 and lower than 25 kg/m^2. The subject's clinical records and other relevant data were reviewed to identify those with any possible underlying disease that could have affected their pulmonary function. Obese individuals were assessed for not having hypertension. All details of the study were explained to the volunteers after the written consent was obtained.

Measurements

Body weight and height were measured with barefootsubjects wearing thin clothing. BMI was calculated as body weight/$height^2$. All subjects underwent PFTs in four interval time points following an exercise challenge in accordance with the American Thoracic Society guidelines [18]. FVC was measured by forced exhaling into spirometry lasting maximally for 6 seconds. Two reproducible maneuvers within 3% of each other were performed before exercise and the best maneuver was used to calculate post-challenge falls in FEV1 [12].Since any drastic change in temperature influences the airway caliber [2], exercise challenge and PFTs from pre to post exercise were performed atambient temperature of 20˚C (Celsius) and RH <30.Ten percent fall in FEV1 was considered as a significant reduction in spirometry indices [19,20,12].

Exercise challenge

All subjects completed a recommended-8-minutes-running on treadmill. During the first 2 minutes, exercise was at such intensity that the heart rate would reach at least to 80% to 90% of the predicted maximum heart rate, and during the remaining six minutes it should continue at this heart rate[21]. VO_2max index was assessed by modified Bruce test [22]. To consider the intensity prescribed for the obese subjects, OG's Predicted HRpeak was assessed in relation toVO_2max values[23,24]. For obese individuals, the equation 200-0.5 × Age was used [24].

All subjects wore wireless heart rate monitors to verify exercise intensity (Polar Vantage XL; Finland). The protocol of the study was accredited by the scientific board of the Physical Education Department of ShahidChamran University of Ahvaz.

Statistical analysis

Descriptive statistics of the baseline lung function were calculated for spirometry tests. The values were expressed as the mean ± SD. (SPSS 16; Chicago, IL). One way analysis with repeated measures on the last factor test was used to compare post-exercise values with baseline data. Respiratory parameters between two groups were analyzed using an Independent T test. Pearson product–moment correlations were used to identify relationships between spirometry results.The significance level was defined as $P \leq 0.05$.

RESULTS AND DISCUSSION

Relation between spirometry variables

Strong correlations were found between the pre and post exercise percentage change values for spirometry in OG and NWG. The percentage of change in FVC significantly correlated with that of FEV1 (OG, r = 0.49; NWG, r = 0.55; P<0.05), FEF_{50} (OG, r =0. 69; NWG, r = 0.76; P<0.05) and FEF_{25-75} (OG, r = 0.56; NWG, r = 0.63; P<0.05). Peak decrease in FVC significantly correlated with peak increase in FEV1/ FVC (OG; r = -0.77; P<0.05).

Baseline lung function

Mean resting lung function values from spirometry are presented in Table1. Resting values appeared not to be significantly different between OG and NWG. All normal-weight and obese subjects' resting values fell within normal expectations. Great- but statistically non-significant- fall was observed in resting OG's PEF (Table 1). In addition, no significant difference was observed between OG and NWG at baseline peak percentage change in FEV1/ FVC ratio.

Table1.Subject's Characteristics and Spirometry values at Baseline

Obese (n=13)	leans (n=10)	P value	
Age, yr	26.37±6.5	27.70±7.68	.163
Height, cm	174±13	177±16	.365
Weight, kg	123.5±11.5	73.62±9.2	<.001
BMI, kg/m^2	36.67±6.3	23.5±7.8	<.001
VO_2max,mL/ (kg.min)	28.4±7.2	31.64±6.12	.129
FVC, %predicted	95. 91 (± 4.12)	99.27 (± 5.15)	.337
FEV_1, %predicted	97. 83 (± 7.1)	100.62 (± 6.13)	.433
$FEF_{25-75\%}$, %predicted	94. 94 (± 4.67)	96.13 (± 3.99)	.129
$FEF_{50\%}$, %predicted	94. 91 (±8. 38)	97.80 (±9. 60)	.112
PEF, %predicted	100 (±12. 39)	109.2 (±6. 90)	.106
FVC, L	4.14 (±. 59)	4.89 (±. 44)	.704
FEV1, L	3.97 (±. 72)	4.33 (±. 60)	.462
$FEF_{25-75\%}$, L/s	4.13 (±. 87)	4.54 (±. 73)	.143
$FEF_{50\%}$, L/s	3.91 (±. 97)	4.47 (±. 76)	.156
PEF, L/s	6.13 (±. 86)	6.99 (±. 58)	.398
FEV_1/FVC ratio, %	83. 70 (± 6.2)	81.00 (± 7.5)	.342

Abbreviation; *BMI=Body Mass Index FEV_1=Forced Expiratory Volume in the first second; FVC=Forced Vital Capacity; $FEF_{25-75\%}$= Forced Expiratory Flow at 25-75 percent; $FEF_{50\%}$=Forced Expiratory Flow at 50 percent; PEF=Peak Expiratory Flow; VO_2max= Maximum Oxygen Consumption.*

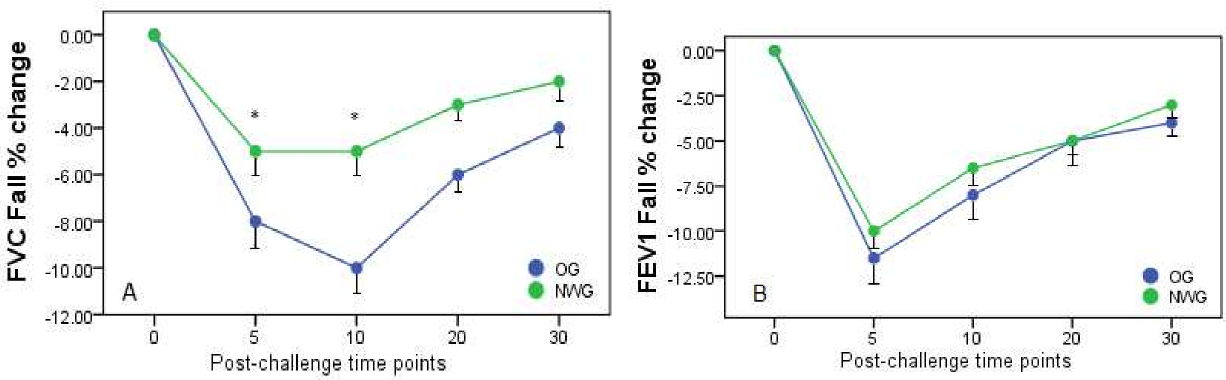
All data are shown as mean (SD).

P<. 01

Post exercise lung function

Mean post exercise lung function values from spirometry for 30-min after exercise in 5 and 10 min intervals are shown in figure 1 through3.No significant difference in VE was found between OG and NWG (117.37 L/min and 122.74 L/min respectively) during the challenge. Peak heart rate during the challenge was 180±13 and 169±15 beats/min for NWG and OG respectively. OG had a significant decrease in pulmonary function indices following the exercise on treadmill. The FEV1/FVC ratio was significantly greater for OG at 10-min after challenge (P<0.05).

Post-challenge maneuvers were normal for NWG except for FEV1at 5-min after exercise (P>0.05). Significant differences were observed between OG and NWG, in post-challenge forced expiratory maneuvers(P>0.05), (figure 1). From 20 through 30 minutes after challenge subjects slowly returned to their baseline values.



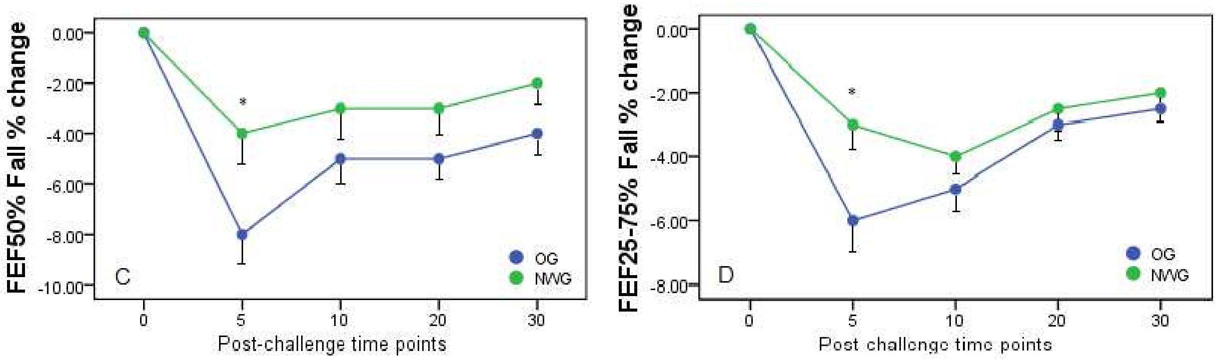


Figure1. Post-challenge percentage change in FVC (A), FEV1 (B), FEF$_{50\%}$ (C), and FEF$_{25-75\%}$ (D) from baseline until 30 min after exercise in 5 and 10-min intervals. Values were significantly greater for OG (P<0.05), except for FEV1. Values are presented as mean ± SE.

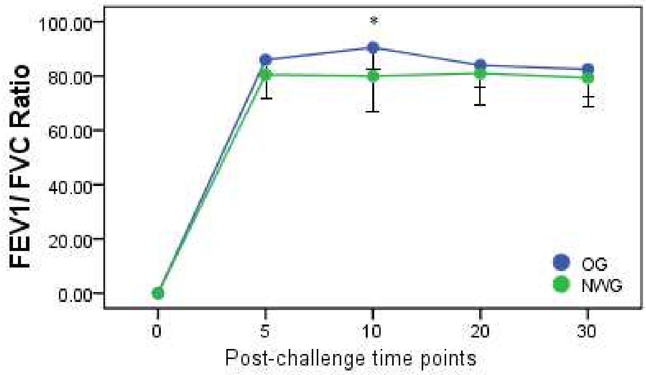


Figure 2.post-challenge serial changes in FEV1/FVC ratio, calculated from the forced vital capacity maneuver. The ratio was significantly different at 5-min after exercise (P<0.05). Values are presented as ± SE.

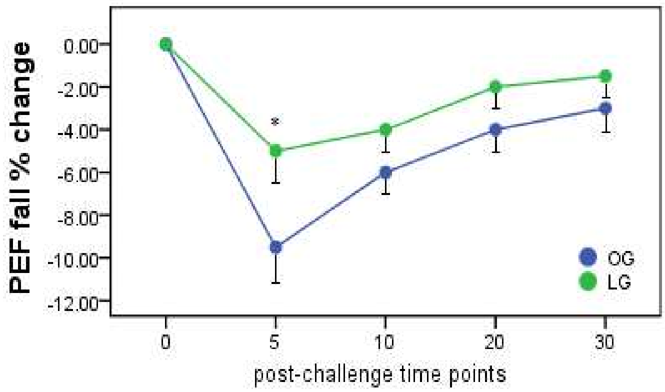


Figure3. post-challenge serial changes in PEF. Values were significantly greater for OG at 5-min after exercise (P<0.05). Values are presented as ± SE

In the present study, we compared spirometry parameters in obese and normal-weight subjects and examined whether pulmonary function in obese subjects was affected following a sub-maximal challenge. Eight minutes of exercise while running on the treadmill with 80-90% HRpeak was considered as a suitable challenge for inducingairwayhyperresponsiveness.To eliminate any possible pulmonary issue, the subjects were selected based on the criteria of having a well preserved FEV1/FVC ratio.

Our results of baseline spirometry values in OG are in conformity with the findings of other [25,1]studies which have established a non-significant difference between non-asthmatic lean and obese men's spirometry data. In this study, post-challenge FEV1 as an exercise bronchial provocation criterion, was meaningfully differentfrom the baseline measures. This is not unexpected as Evans et al[2]and Moradi et al [16] found a post-challenge peak fall in FEV1 in non-athletic subjects in room temperature.

Many studies have shown that lung volumes decrease as body weight increases [26,27,28,3]. One study [29] showed that the RLV (Residual Lung Volume) temporarily increased during recovery from a maximal treadmill test by 21% after 5minutes. Increased RLV, preventing complete exhalation, causes FVC to decrease. Our data suggest a significant difference in FVC between OG and NWG at 5-min and 10-min post-challenge time points ($p>0.05$) ;(figure1, A).

In contrast to NWG, where large airways were affected by exercise; in OG, exercise imposed its powerful influence on distal airways. According to our findings, it seems that the most remarkable influence of obesity following a sub-maximal exercise is on expiratory flow. the greatest reduction was reported in FEF_{50} and FEF_{25-75} in the obese group (figure 1, C and D).

Obesity and exercise can independently affect different parts of the respiratory system. Intense exercise heavily influences airway resistance [30, 31, 2] and obesity specifically abdominal and chest wall fat pushing in on the rib cage and lungs and abdominal load pushing up on the diaphragm and its downward motion [2] alter the mechanical properties of the lungs.Yap, et al [32]found that spirometry parameters are highly dependent on mechanical properties of the lungs.

In addition, exercise-related effects may be attributed to some factors such as the closure of some peripheral airways, increase in thoracic blood volume and dilated lungsthat leads to a reduction in dynamic compliance and an inevitable reduction in peak expiratory flow (figure 3).

Obesity is known to causea restrictive ventilatory deficit, but the combination of obesityand physical activity has been attributed to mixed obstructive and restrictive pulmonaryabnormalities [33]. Our results are therefore limited to spirometry measurements that make it difficult todifferentiate between the contributions from obesity and exercise in obese individuals.All the same, the exact percentage of this influence, individually, remains obscure to the researchers. It seems supposedly that exercise boosts the redundant effects of obesity in terms of spirometry indices. Exerciseseems to only affect airway resistance, but increase in FEV1/FVC ratio is thought to occur because of peripheral airway obstruction which in turn stems from obesity [27]. No significant difference in peak fall of FEV1 between two groups suggests that obesity may not influence large airway resistance. The implication is that while obesity may affect small airway function, it may not affect large airways [34].

CONCLUSION

Obesity with the exercise intervention may affect all pulmonary system compartments.We recommend, therefore, that appropriate pulmonary function testing is required when fitness experts need subjecting obese individuals to exercise therapy.

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