

Impact of Physical Activity on Pulmonary Function and Respiratory Muscle Strength in Obese Young Adults

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Abstract

Physical inactivity is a crucial contributor to the obesity epidemic. Previous studies demonstrated that physical inactivity and obesity have been linked with the impairments of pulmonary and respiratory muscle function. However, the impact of physical activity (PA) on pulmonary and respiratory muscle function in obese young adults remains unclear. The study aimed to compare pulmonary and respiratory muscle function between physically inactive and active obese young adults. Obese young adults (BMI ≥ 25 kg/m²) aged between 18 - 25 years old were included. They were classified into 2 groups, physically inactive obese (IO, n = 16) and active obese (AO, n = 14) groups according to the metabolic equivalent of task (MET) obtained from the global physical activity questionnaire (GPAQ). Then, pulmonary and respiratory muscle function were measured. The results showed that there were no differences in baseline data between groups. The AO group showed significantly higher forced expiratory volume in 1 second (FEV₁) (2.90 ± 0.55 vs 3.40 ± 0.79 , $p = 0.04$), and maximal inspiratory pressure (MIP) (96.25 ± 6.18 vs 124.50 ± 12.28 , $p = 0.01$) than those IO group. There were no differences between the groups in regard to FVC, FEV₁/FVC ratio, %FVC, %FEV₁, MVV, %MVV and maximum expiratory pressure (MEP) (all $p > 0.05$). In addition, FEV₁ ($r = 0.43$, $p = 0.01$) and MIP ($r = 0.40$, $p = 0.03$) were positively moderately correlated with MET. Higher in FEV₁ and MIP which observed in physically active obese young adults indicate that regular PA appears to be beneficial to pulmonary function and inspiratory muscle strength in obese individuals.

Keywords: Obesity, Physical activity, Physical inactivity, Pulmonary function, Respiratory muscle strength, Lung function, FVC, FEV₁

Introduction

Regular physical activity (PA) is important towards a healthy living thus prevent and manage non-communicable diseases such as heart disease, stroke, diabetes and several cancers [1]. Previous studies have shown that young adults do not meet the global recommended levels of physically activity and risk for obesity [2,3]. The World Health Organization (WHO) recommends that adults age 18 and older participate in at least 150 min of moderate-intensity or 75 min of vigorous-intensity PA each week. However, the evidence has shown that 23 % of men and 32 % of women over the age of 18 do not meet this recommendation [1]. Additionally, WHO recently reported that 650 million adults and adolescents were overweight, a number that is expected to rise to 1 billion by 2025 [4]. Obesity is not only a significant contributor to the development of the metabolic syndrome, but it is also closely associated with lung conditions such as obstructive sleep apnea (OSA) and chronic obstructive pulmonary disease. (COPD) [5]. Obesity has several detrimental effects on pulmonary and respiratory muscle function, including changes to breathing mechanics, the thoracic cage and diaphragm are compressed by extra adipose tissue in the abdominal cavity and chest wall. As a result, there is less diaphragmatic displacement, less lung and chest wall compliance, and more elastic recoil. These changes lead to a reduction in lung volumes and an overuse of the inspiratory muscles [6]. Many studies have reported that obesity has been linked with reduced forced vital capacity (FVC) and forced expiratory volume in the 1 second (FEV₁) [7,8]. Moreover, a decline in respiratory muscle strength and endurance, and exercise intolerance were reported [6,9]. In contrast, a higher cardiorespiratory fitness (CRF) observed in obese children is linked to a greater FEV₁/FVC ratio [10]. In line with a recent study which revealed that obese youths with higher level of PA had improved respiratory function [11]. The latter 2 findings suggest the important of PA on pulmonary and respiratory muscle function in obese young people. However, only few studies have investigated the influence of PA

on pulmonary function and respiratory muscle strength in obese young adults. The present study aims to compare pulmonary and respiratory muscle function between physically active and inactive obese young adults.

Materials and methods

Study design

This study was an ex post facto design. The study protocol was approved by the committee for research in humans, the Faculty of Associated Medical Sciences, Chiang Mai University (No. AMSEC-63EX-007). All subjects signed on informed consent before the enrollment of this study.

Study populations

The G*Power program version 3.1 was used to determine the participant numbers. We used the MIP results from a pilot study ($n = 8/\text{group}$), which showed a mean \pm SD of the physically active and inactive obese groups, 124.50 ± 34.75 and 95.37 ± 25.99 , respectively, with effect size 0.95, power of 0.8 and an alpha level of 0.05. Therefore, a total sample size of 30 participants was required.

Inclusion criteria were obese young adults (age 18 - 25) and $\text{BMI} \geq 25 \text{ kg/m}^2$, according to the Regional Office for the Western Pacific (WPRO) standard [12]. Exclusion criteria included a history of any respiratory disease, smoking ≥ 10 packs a year or having quit less than a year prior, clinical cardiovascular diseases, taking medication that affected outcome measurement.

Thirty participants were divided into 2 groups according to the metabolic equivalents (MET) value obtained from the global physical activity questionnaire (GPAQ); the physically inactive obese group (IO; $n = 16$) (< 600 MET minute per week) and physically active obese group (AO; $n = 14$) (≥ 600 MET minutes per week).

Anthropometrics

Body mass and body composition were measured using an electrical impedance device (Tanita BC-418, Tokyo, Japan). The BMI was computed by dividing the weight (kg) by the height's square (m^2). The waist and hip circumferences were assessed using the buttocks' width and the umbilicus' level, respectively.

Physical activity assessment

The level of PA of each participant was measured using the GPAQ which was developed by WHO [13]. The test consists of 16 questions (P1 - P16) that assess sedentary behavior as well as 3 types of PA, including activity at work, travel to and from places and recreational activities. Then, the total time spent in physical activity, intensity and frequency during a typical week were recorded. The following MET values were assigned in accordance with WHO recommendations for calculating a person's overall energy expenditure using GPAQ. The PA was classified according to the following criteria: High (at least 3,000 MET minute per week), moderate (at least 600 MET minute per week), and low (A person not meeting any of the criteria mentioned above falls in this category). High to moderate and low PA levels among the participants are categorized as the "physically active" and the "physically inactive" group, respectively [14].

Pulmonary function test

Pulmonary function, including FVC, FEV_1 , FEV_1/FVC ratio, and the maximal voluntary ventilation (MVV), were evaluated using the CHESTGRAPH HI-105 spirometer (Chest MI, Inc, Tokyo, Japan). All values were reported as percentages (%). All participants perform spirometry according to the American Thoracic Society /European Respiratory Society (ATS/ERS) standard protocols [15].

Respiratory muscle strength

MIP and MEP, which representing the strength of the inspiratory and expiratory muscle [16], were measured using micro RPM portable manometer (MICRO Medical®, Rochester Kent, UK), according to the standardized procedure [17]. Briefly, subjects were instructed to perform maximal inspiratory effort and held for 1 s for MIP and maximal expiratory effort and maintained for 1 s for MEP. The greatest value was determined after 3 trials with a 1-min gap between each. The assessments of respiratory function were performed in a random sequence, with enough time between each maneuver for rest. All outcome variables were assessed by blinded assessors.

Statistical analysis

All data were expressed as Mean \pm SD. Data were analyzed using SPSS version 22.0 (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY). The normality of data was analyzed using the Shapiro-wilk test. Differences in general characteristics across groups were analyzed using the independent t-tests. Gender data was analyzed using a chi-squared test. The association between MET and respiratory function, FEV₁ and MIP were analyzed using Pearson's correlation coefficient. For all comparisons, *p*-value < 0.05 was considered as statistically significant.

Results and discussion

A total of 30 obese young adults (IO = 16 and AO = 14) with a mean age of 21.83 \pm 1.41 years were recruited. The baseline characteristics of participants are shown in **Table 1**. There were no differences in age, gender, anthropometric variables and body composition among groups. However, the MET obtained from the GPAQ questionnaire of the AO group was significantly higher than the IO group (*p* < 0.05).

Table 1 General characteristics of young adults included in the study.

Parameters	Inactive obese (n = 16)	Active obese (n = 14)	<i>p</i> -value
Age (year)	21.13 \pm 1.59	20.46 \pm 1.19	0.58
Gender (Male/female)	11/5	3/11	0.08
Height (m)	1.65 \pm 0.07	1.70 \pm 0.09	0.64
Body mass (kg)	85.61 \pm 19.99	90.24 \pm 16.73	0.29
BMI (kg/m ²)	31.02 \pm 6.59	30.85 \pm 5.19	0.49
Waist circumference (cm)	97.73 \pm 20.59	100.80 \pm 12.10	0.52
Hip circumference (cm)	112.56 \pm 12.65	112.57 \pm 9.76	0.55
Waist hip ratio	0.86 \pm 0.08	0.89 \pm 0.07	0.88
Total body fat (%)	39.64 \pm 8.07	33.90 \pm 10.54	0.16
MET-minutes per week	266.87 \pm 145.00	2125.78 \pm 1383.32	< 0.001*

Data are represented as mean \pm SD; MET: Metabolic equivalents value

*Statistically significant data (*p* < 0.05).

The results of pulmonary function and respiratory muscle strength are shown in **Table 2**. The data demonstrated that the FVC, FEV₁/FVC ratio, %FVC, %FEV₁, MVV, %MVV and MEP were not significantly different between groups. Meanwhile, the AO group exhibited a significantly higher value of FEV₁ and MIP (*p* < 0.05) than the IO group.

Table 2 Comparison of pulmonary function and respiratory muscle strength between physically inactive and active obese groups.

Variables	Inactive obese (n = 16)	Active obese (n = 14)	<i>p</i> -value
FVC (L)	3.57 \pm 0.81	3.95 \pm 0.89	0.21
FVC %	99.49 \pm 15.64	98.65 \pm 12.61	0.87
FEV ₁ (L)	2.90 \pm 0.55	3.40 \pm 0.79	0.04*
FEV ₁ %	85.33 \pm 13.21	85.90 \pm 13.62	0.91
FEV ₁ /FVC (%)	86.78 \pm 4.86	86.66 \pm 9.19	0.96
MVV (L)	76.94 \pm 8.30	104.99 \pm 9.13	0.08
MVV %	60.85 \pm 19.59	66.68 \pm 17.75	0.51
MIP (cmH ₂ O)	96.25 \pm 6.18	124.50 \pm 12.28	0.01*
MEP (cmH ₂ O)	97.20 \pm 14.69	90.77 \pm 13.13	0.26

Data are represented as mean \pm SD; FVC: Forced vital capacity; %FVC: Percentage of predicted forced vital capacity; FEV₁: Forced expiratory volume in 1 s; %FEV₁: Percentage of predicted forced expiratory volume in 1 s; MVV: Maximum voluntary ventilation; %MVV: Percentage of predicted maximum voluntary ventilation; MIP: Maximal inspiratory pressure; MEP: Maximal expiratory pressure.

*Statistically significant data (*p* < 0.05).

In addition, the correlation between PA, respiratory function and inspiratory muscle strength were made by Pearson's correlation analysis. The result showed that FEV₁ ($r = 0.43, p = 0.01$) and MIP ($r = 0.40, p = 0.03$) were positively correlated with MET, as depicted in **Figures 1(A) - 1(B)**, respectively.

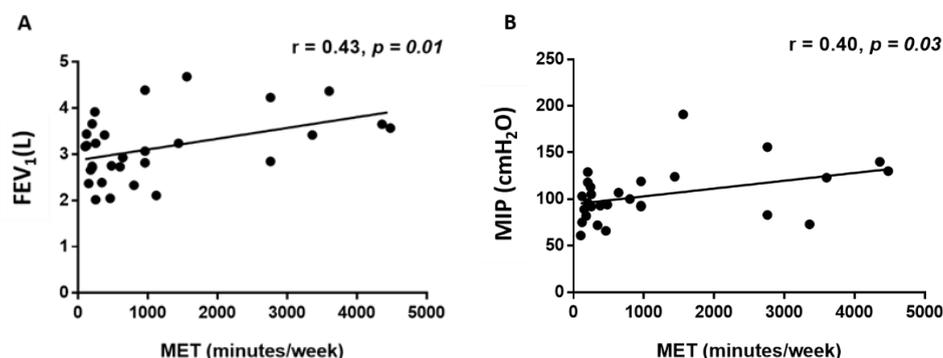


Figure 1 Correlation between metabolic equivalents value (MET-minutes per week) and FEV₁ (A) and MIP (B).

The major findings from this study demonstrated that obese young adults who are physically active had higher FEV₁ and MIP than those of physically inactive, but no differences in the other pulmonary and respiratory muscle variables. Moreover, the positive correlations between MET and FEV₁ and MIP were observed.

Earlier studies demonstrated that increased weight and BMI are linked to a reduction in lung volume, which results in reduced FVC and FEV₁ in adults [18]. In contrast, the results of this study revealed that all pulmonary function variables of both groups were within the normal range according to the interpretation of ATS/ERS. However, the lower value of FEV₁ was observed only in the physically inactive obese group. This result was consistent with previous studies which demonstrated that low PA levels were associated with low FEV₁ and FVC [19,20]. Similar to the study of Nguyen *et al.* [11], overweight/obese young adults with physically active had higher FVC and FEV₁ than those with moderate BMI. Moreover, daily vigorous PA has been found to be associated with the age-related decline in FEV₁ and FVC in adults [21,22]. Consistent to our physically active participants who had moderate to vigorous activity, but we did not observe the different of FVC in this study.

Furthermore, previous study showed that respiratory muscle strength was significantly low in elderly with sedentary lifestyle [23]. Similar to these results, we found the decline of MIP in physically inactive obese individual. Moreover, significant associations between MET and FEV₁ and MIP were found in this study. Although the exact mechanism by which physical inactivity may affect FEV₁ remains unknown, the relationship between respiratory muscle force and FEV₁ has been studied extensively [24]. Possible explanations for reduced FEV₁ in the current study could be due to the outcome of inspiratory muscle weakening caused by our individual's sedentary lifestyles and higher BMI. In addition, numerous studies have found that obesity associated with low grade systemic inflammation and reduced lung function in young adults [25,26]. Possible mechanisms by which PA enhances pulmonary function include its anti-inflammatory effects [27].

The strengths of this study are controlling for potential confounding factors, such as age, body mass, height and BMI. There are some limitations of the study. Due to the small sample size and individuals who were solely from Chiang Mai province, our study's conclusions might not be applicable to other racial or geographic groups. Another limitation included the usage of a questionnaire method for collecting data on PA and sedentary behavior. Considering that this study is merely cross-sectional, caution should be used when interpreting our data. In addition, our study results need to be confirmed in a larger group in future studies. Moreover, in addition to improving respiratory function, PA might provide additional benefits on cardiovascular fitness in obese young adults. Future clinical studies are needed to confirm these findings.

Conclusions

Higher values of FEV₁ and MIP observed in obese young adults who physically active compared to physically inactive individuals, suggesting the benefit of PA to maintain pulmonary function and inspiratory muscle strength.

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