Comparing the 6-minute Walk Test Performance and Estimated Maximal Oxygen Consumption Between Physically Active and Inactive Obese Young Adults

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RESEARCH

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ABSTRACT

Physical inactivity and a decline in cardiorespiratory fitness (CRF) are well-known risk factors for cardiovascular disease. Furthermore, evidence suggests a correlation between obesity and diminished CRF level. However, the influence of physical activity (PA) on the CRF level of obese young adults remains unclear. The aim of this study is to compare the performance of the six-minute walk test (6MWT) in physically active and inactive obese young adults aged 18-25 years. Fifty-six participants were included and classified into two groups based on their level of PA, assessed using the Global Physical Activity Questionnaire (GPAQ). These groups consisted of physically active obese participants (PAO; n = 28) and physically inactive obese participants (PIO; n = 28). All participants underwent a 6MWT, during which baseline demographic, anthropometric, dyspnea, and clinical data were recorded. Following the 6MWT, clinical data and the 6-min walking distance (6MWD) were evaluated, and the estimated maximal oxygen consumption (VO_2max) was subsequently calculated. The findings indicated that following the 6MWT, there were no statistically significant differences between the groups in terms of heart rate, systolic blood pressure, diastolic blood pressure, oxygen saturation and dyspnea (all $p > 0.05$). Nevertheless, the PAO group exhibited a greater 6MWD and VO_2max compared to the PIO group ($p < 0.05$). The results suggest that physically active obese young adults have a greater 6MWD and VO_2max compared to their inactive counterparts. This implies that consistent PA could provide cardiovascular fitness benefits for obese individuals.

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INTRODUCTION

The prevalence of obesity among young adults has significantly increased in recent years, contributing to a growing concern for public health (Poobalan and Aucott, 2016). Alarmingly, over 340 million children and adolescents were overweight or obese (World Health Organization, 2021b). Excess weight contributes to escalating healthcare costs and causes over 2.8 million deaths annually (World Health Organization, 2021a). Obesity is closely linked to an elevated risk of cardiovascular diseases, metabolic disorders and reduced quality of life of individuals (Powell-Wiley et al., 2021). A critical determinant of these health outcomes is cardiorespiratory fitness (CRF), reflecting the ability of the cardiovascular and respiratory systems to supply oxygen to working muscles during physical activity (PA) (Ross et al., 2016). Numerous studies have established a clear connection between obesity and diminished CRF in a wide range of individuals (Miller et al., 2012; Oliveira and Guedes, 2016; Kaze et al., 2022). Obesity and CRF independently predict cardiovascular and all-cause mortality (Katzmarzyk et al., 2004; Sui et al., 2007). Excess weight can impact the heart through established risk factors like dyslipidemia, hypertension, glucose intolerance and inflammatory markers, along with unidentified mechanisms (Poirier et al., 2006). Prior research consistently demonstrates that engaging in PA leads to various health benefits, including improved cardiovascular function and enhanced respiratory capacity (Wisnieski et al., 2019; Nystoriak and Bhatnagar, 2018; Fuertes et al., 2018). PA enhances cardiovascular health through systemic actions, involving the metabolism of neurons and various systems such as endocrine and immunological functions (Lavie et al., 2019; Kramer, 2020). The WHO has recommended performing at least 150 minutes of moderate-intensity PA or 75 minutes of vigorous-intensity PA weekly for adults aged 18 and above (Bull et al., 2020). Current data reveals that 23% of men and 32% of women in this age group are not meeting these activity guidelines (World Health Organization, 2017).

The six-minute walk test (6MWT), a submaximal and field exercise assessment, serves as a simple, safe and widely utilized measure of functional capacity, providing valuable insights into an individual's cardiorespiratory fitness (Mänttäri et al., 2018). Moreover, the 6MWT has received validation across various populations, including asymptomatic individuals (Giannitsi et al., 2019; Holland et al., 2014; Halliday et al., 2020). Additionally, research has shown that the distance covered during the 6MWT reliably predicts laboratory measured maximal oxygen consumption (VO_2max) (Mänttäri et al., 2018; Jalili et al., 2018). VO_2max represents the highest rate at which an individual's body can utilize oxygen during intense exercise. This measurement reflects the efficiency of the cardiovascular and respiratory systems in delivering oxygen to the muscles engaged in the activity and utilizing it for energy production (Bassett and Howley, 2000). Previous studies have demonstrated that an elevated BMI negatively impacts CRF by reducing 6-min walking distance (6MWD) and VO_2max in both children and adolescents (Shah et al., 2022; Setty et al., 2013). However, few studies that have explored the interaction between PA, CRF, and obesity in young adults (Nataraj et al., 2022). The potential link between regular PA and improved cardiovascular and respiratory health in obese young adults remains insufficiently investigated. Additionally, this research might offer effective and feasible strategies for promoting and integrating regular PA into interventions for this specific demographic. Therefore, the current study aims to compare functional capacity and estimated VO_2max from the 6MWT in both physically active and inactive obese young adults. We hypothesized that obese young adults who engage in PA would demonstrate a higher 6MWD and VO_2max compared to their sedentary counterparts.

MATERIAL AND METHODS

STUDY DESIGN

The study was an observational cross-sectional design and received approval from the Committee for Research in Humans, Faculty of Associated Medical Sciences, Chiang Mai University, in compliance with the Declaration of Helsinki (Approval No. AMSEC-63-EX-100). Informed consent was obtained from all subjects before their enrollment in the study.

STUDY PARTICIPANTS

The number of participants for the study was determined using the G*Power program (version 3.1). Our calculations were based on estimated VO_2max results obtained from a pilot study, which included 10 participants per group. In the physically active and inactive obese groups, the mean ± SD for estimated VO_2max was 29.98 ± 3.73 ml/kg/min and 27.28 ± 4.14 ml/kg/min, respectively. With an effect size of 0.68, a power of 0.8 and an alpha level of 0.05, it was determined that a total sample size of 56 participants would be required.

Eligible participants for this study included individuals aged 18 to 25 who were classified as obese with a body mass index (BMI) greater than or equal to 27.5 kg/m^2, in accordance with the WHO Asian BMI cut points (WHO Expert Consultation, 2004). Participants with a history of respiratory disease or neuromuscular disorders, lower limb fractures, those who had smoked more than 10 packs a year or had quit smoking within the past year, individuals with clinical cardiovascular diseases, those taking medications that could impact the outcome measurement and those with difficulties completing the protocol tests were excluded from the study.

Fifty-six volunteers were enrolled in this study. The participants were matched for sex, age, height and body mass. We assessed the PA of the participants using the Global Physical Activity Questionnaire (GPAQ). Based on the metabolic equivalents values (MET) obtained from GPAQ, the volunteers were divided into two groups. The first group consisted of physically inactive obese individuals (PIO; n = 28), who reported less than 600 MET minutes per week. The second group comprised physically active obese individuals (PAO; n = 28), who reported 600 MET minutes per week or more. Anthropometric data, including body mass, height and waist circumference (WC) were collected and measured. BMI was computed by dividing the weight (kg) by the square of the height (m^2). All participants completed a 6MWT, during which we recorded baseline demographic, anthropometric, dyspnea and clinical data. After the 6MWT, we assessed clinical data and the 6-min walk distance (6MWD) and then calculated the estimated VO_2max. The study protocol is shown in Figure 1.

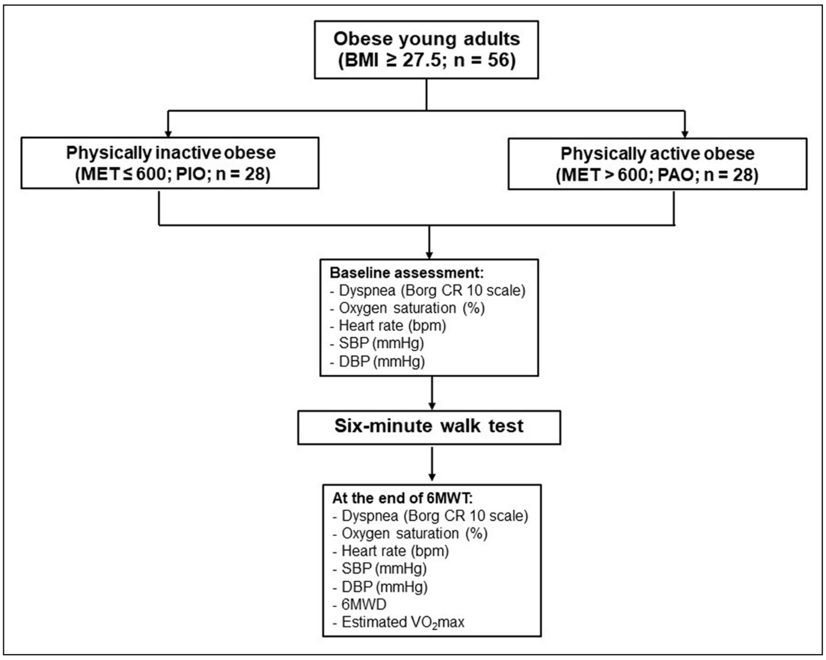

Figure 1 The experimental protocol of the study. BMI: body mass index; MET: metabolic equivalents values; SBP: systolic blood pressure; DBP: diastolic blood pressure; 6MWD: six-minute walk distance; VO_2max: maximal oxygen consumption; PIO: physically inactive obese; PAO: physically active obese.

PHYSICAL ACTIVITY ASSESSMENT

The GPAQ comprises 16 questions designed to assess an individual's PA in three domains: work, transportation, and leisure time, as well as the duration of sedentary behavior (World Health Organization, 2005). To calculate overall energy expenditure, the GPAQ uses MET values, as recommended by the WHO (World Health Organization, 2005). Participant's PA was classified into three categories: high (at least 3000 MET-minutes per week), moderate (at least 600 MET-minutes per week), and low (those not meeting the criteria for high or moderate PA) (Nguyen et al., 2021). Individuals with high to moderate levels of PA were categorized as "physically active," while those with lower activity levels were assigned to the "physically inactive" group (Nguyen et al., 2021).

SIX-MINUTE WALK TEST (6MWT)

The 6MWT was conducted following the established guidelines of the American Thoracic Society (ATS) (ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002). In brief, the examination occurred within a defined corridor of 30 meters in length with a firm surface, enclosed walls and markings at each meter. Two cones were placed to indicate the turning point of the walk. The individual is required to sit calmly in a chair, positioned close to the starting point, for a minimum of 10 minutes before performing the test. Throughout this period, assess for any contraindications, measure baseline parameters such as heart rate (HR), blood pressure (BP), and oxygen saturation (SpO2), and utilize the Borg CR10 (graded 1-10) scale to evaluate dyspnea. Participants were given standard instructions to walk both safely and as far as possible within a 6-minute duration. The examiner, walking alongside them, provided instructions and standard time updates every minute. At the end of the test, immediately record the post-walk Borg CR10, SpO2, HR, and BP, respectively. The distance covered in 6 minutes was recorded as 6MWD. Anthropometric factors and the outcomes of the 6MWT were used to calculate the estimated VO_2max using the equation formulated by Burr et al. (Burr et al., 2011). The calculations for VO_2max are as follows: VO_2max (ml/kg/min) = 70.161 + (0.023 × 6MWT [m]) – (0.276 × weight [kg]) – (6.79 × sex, where male = 0, female = 1) – (0.193 × resting HR [beats per minute]) – (0.191 × age [y]).

STATISTICAL ANALYSIS

The data were presented as Mean ± standard deviations (SD). Data analysis was performed using SPSS version 22.0 (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY). The normal distribution of the data was assessed using the Shapiro-Wilk test. The differences in general characteristics among the groups were analyzed using independent t-tests. A chi-squared test was used to assess gender data. Statistical significance was defined as *p*-values < 0.05.

RESULTS

Out of the 56 eligible subjects for the study classified as obese, the average age was 20.42 ± 1.45 years and the average BMI was 32.54 ± 3.60 kg/m². The anthropometric and demographic characteristics of participants are shown in Table 1. The Shapiro-Wilk test results showed a normal distribution for all outcome measures ($p > 0.05$). Consequently, independent t-tests were used to analyze statistical differences between groups.

PARAMETERS	PHYSICALLY INACTIVE OBESE (PIO, n = 28)	PHYSICALLY ACTIVE OBESE (PAO, n = 28)	P-VALUE
Age (year)	20.64 ± 1.49	20.21 ± 1.39	0.27
Gender (Male/female)	14/14	14/14	1.00
Height (m)	1.66 ± 0.08	1.69 ± 0.07	0.20
Body mass (kg)	95.41 ± 14.88	90.07 ± 10.73	0.13
BMI (kg/m²)	33.37 ± 3.58	31.74 ± 3.50	0.10
Waist circumference	108.51 ± 10.85	104.39 ± 11.43	0.17
MET minutes per week	187.43 ± 194.96	4129.25 ± 4465.05*	**<0.001**

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

Data are represented as mean ± standard deviation (SD). MET: metabolic equivalents value.

* Statistically significant data ($p < 0.05$) by independent t-test.

An independent t-test showed that no statistically significant differences were observed among the groups in terms of age, height, body mass, BMI, and WC (Table 1, $p > 0.05$). The difference in gender was assessed by a chi-squared test, which found that there were no significant differences between the groups (Table 1, $p > 0.05$). Additionally, the MET value from the GPAQ questionnaire was significantly higher in the PAO group than in the PIO group ($p < 0.05$). Table 2 summarizes the clinical characteristics of the study population prior to the 6MWT. At the baseline, there were no differences in dyspnea, SpO2, heart rate, and BP among the groups.

Every participant successfully completed 6MWT, with no need for breaks or experiencing any interruptions during the test. After the 6MWT, there were no group differences in dyspnea, SpO2, heart rate, or BP (Table 3, $p > 0.05$). Furthermore, our results revealed that the PAO group had a longer 6MWD and a higher estimated VO_2max after completing the 6MWT compared to the PIO group (Table 3, $p < 0.05$).

Table 2 Comparison of physiologic variables between physically inactive and active obese groups at the baseline.

PARAMETERS	PHYSICALLY INACTIVE OBESE (PIO, n = 28)	PHYSICALLY ACTIVE OBESE (PAO, n = 28)	P-VALUE
Dyspnea (Borg CR10 scale)	0.14 ± 0.57	0.16 ± 0.59	0.90
Oxygen saturation (%)	98.03 ± 0.74	98.03 ± 0.42	1.00
Heart rate (beat/min)	83.28 ± 9.88	85.89 ± 10.30	0.33
Systolic blood pressure (mmHg)	120.00 ± 14.21	120.96 ± 12.36	0.78
Diastolic blood pressure (mmHg)	79.78 ± 8.69	79.92 ± 8.67	0.95

Data are represented as mean ± standard deviation (SD).

* Statistically significant data ($p < 0.05$) by independent t-test.

Table 3 Comparison of physiologic variables between physically inactive and active obese groups at the end of 6MWT.

PARAMETERS	PHYSICALLY INACTIVE OBESE (PIO, n = 28)	PHYSICALLY ACTIVE OBESE (PAO, n = 28)	P-VALUE
Dyspnea (Borg CR10 scale)	2.08 ± 1.18	1.76 ± 1.50	0.37
Oxygen saturation (%)	98.10 ± 0.68	98.10 ± .049	1.00
Heart rate (beat/min)	100.92 ± 12.57	98.00 ± 24.21	0.57
Systolic blood pressure (mmHg)	133.89 ± 17.43	135.67 ± 14.56	0.67
Diastolic blood pressure (mmHg)	84.85 ± 10.98	81.03 ± 8.82	0.15
6 MWD (meter)	425.68 ± 36.68	**475.82 ± 62.49***	**<0.01**
Estimated VO_2max (ml/kg/min)	31.18 ± 4.36	**33.64 ± 2.94***	**0.02**

Data are represented as mean ± standard deviation (SD). 6MWD: six-minute walk distance; VO_2max: maximal oxygen consumption.

* Statistically significant data ($p < 0.05$) by independent t-test.

DISCUSSION

The findings of this study revealed that physically active obese young individuals had a significantly greater 6MWD and higher estimated VO_2max from the 6MWT compared to their inactive counterparts, with no differences in other physiological variables.

Previous studies have demonstrated an association between increased weight status and reduced duration of moderate-to-vigorous intensity physical activity (MVPA) (Cassidy et al., 2017; Danielsen et al., 2022). Other studies have provided evidence that higher body weight and BMI are linked to reduced 6MWD when compared to healthy individuals (Beriault et al., 2009, de Souza et al., 2009). Obese youth consistently exhibit poorer performance in weight-bearing activities such as walking and running, as well as reduced CRF when compared to their non-obese counterparts (Tsiros et al., 2011).

In this study, the physically inactive obese group had a shorter 6MWD (425.68 ± 36.68 m) compared to the physically active obese group (475.82 ± 62.49 m). In line with previous research, it was determined that a 6MWD of 511 meters or less emerged as the strongest predictor of physical inactivity (Sperandio et al., 2016). Sedentary behavior among obese individuals negatively impacts heart rate variability, respiratory, and cardiovascular health, potentially contributing to the observed shorter 6MWD (Leite et al., 2019). Despite a significant increase in walking distance compared to the inactive obese group, no differences in heart rate, dyspnea, and blood pressure were found. Both groups displayed comparable physiological responses, with the variation in walking distance attributed to the engagement of all three systems-respiratory, circulatory, and muscular during walking (Pathare et al., 2012). The group with higher PA levels appeared to have more effectively trained these systems, leading to superior test performance and emphasizing the importance of regular PA in optimizing overall functional outcomes.

A recent study found that the 6MWT accurately predicted the VO_2max of relatively young and healthy participants (Hong et al., 2019). Inactive obese individuals in our study exhibited lower estimated VO_2max. Positive effects of PA were noted, including increased forced expiratory volume in 1 second (FEV1) and maximal inspiratory pressure (MIP) in obese subjects (Sa-nguanmoo et al., 2023). Higher PA levels were also linked to greater forced vital capacity (FVC) and correlated with an extended 6MWD, suggesting that the relationship between increased PA, prolonged 6MWD, and higher VO_2max may result from improved lung function and reduced breathing workload during activities such as walking (Almeida et al., 2019). Engaging in regular PA significantly contributes to enhancing key physiological and functional parameters related to cardiovascular and respiratory health in obese young adults, emphasizing the potential benefits of physical activity interventions for their well-being, with implications for health promotion, risk reduction, quality of life enhancement, and personalized health interventions.

Our study has notable strengths, including control of confounding variables such as age, gender, body mass, height and BMI. Additionally, the 6MWT was consistently administered under controlled conditions. However, limitations must be considered. Our cross-sectional study observed the impact of PA on CRF in obese young individuals but does not facilitate the identification of underlying mechanisms. Additionally, relying on self-reported physical activity levels introduces potential recall errors and subjective biases. Furthermore, the exclusive recruitment of participants from Chiang Mai University may restrict the generalizability of our findings. To enhance applicability, future research should explore multicenter studies nationwide. Caution is advised when applying these results to clinical practice. To confirm these findings, additional clinical studies will be required.

CONCLUSION

In summary, participating in PA has a positive effect on the 6MWT performance, especially 6MWD and VO_2max in obese young adults. Therefore, promoting regular PA could potentially yield beneficial results for cardiovascular fitness in this population.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Conceptualization: PS, BC, AP, KJ, MP, WS; Investigation and data collection: PS, KJ, MP, WS; Data analysis: PS; Data interpretation: PS, BC; drafting and revising manuscript: PS and BC. All authors reviewed the article and approved the submitted version.

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