# Differential effects of physical activity on cognitive and motor performance in obese young adults (#122472)

First submission

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### BASIC REPORTING

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The structure of the article should conform to an acceptable format of 'standard sections' (see our Instructions for Authors for our suggested format). Significant departures in structure should be made only if they significantly improve clarity or conform to a discipline-specific custom.

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All appropriate raw data have been made available in accordance with our Data Sharing policy.

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Research question well defined, relevant & meaningful. It is stated how research fills an identified knowledge gap.

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The investigation must have been conducted rigorously and to a high technical standard. The research must have been conducted in conformity with the prevailing ethical standards in the field.

Methods described with sufficient detail & information to replicate.

Methods should be described with sufficient information to be reproducible by another investigator.

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Decisions are not made based on any subjective determination of impact, degree of advance, novelty or being of interest to only a niche audience. We will also consider studies with null findings. Replication studies will be considered provided the rationale for the replication, and how it adds value to the literature, is clearly described. Please note that studies that are redundant or derivative of existing work will not be considered. Examples of "acceptable" replication may include software validation and verification, i.e. comparisons of performance, efficiency, accuracy or computational resource usage.

All underlying data have been provided; they are robust, statistically sound, & controlled.

The data on which the conclusions are based must be provided or made available in an acceptable discipline-specific repository. The data should be robust, statistically sound, and controlled.

Conclusions are well stated, linked to original research question & limited to supporting results.

The conclusions should be appropriately stated, should be connected to the original question investigated, and should be limited to those supported by the results. In particular, claims of a causative relationship should be supported by a well-controlled experimental intervention. Correlation is not causation.

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# Differential effects of physical activity on cognitive and motor performance in obese young adults

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The rising prevalence of obesity among young adults presents significant health challenges, particularly due to its adverse effects on cognitive function and physical mobility. This study examined the effects of physical activity on cognitive performance and gait speed in obese individuals aged 18 to 25 years. Seventy-six participants were categorized as either physically active or sedentary based on the Global Physical Activity Questionnaire. Anthropometric data were collected. Cognitive assessments included the Trail Making Test, Stroop Color Word Test, Hand Reaction Time Test, and Logical Memory Test. Gait speed was evaluated using the 10-meter walk test. The physically active group showed significantly better results in logical memory, executive function, and all Stroop test conditions ($p < 0.05$). No group differences were found in reaction time, Stroop interference score, or gait speed ($p > 0.05$). These findings suggest that higher physical activity levels are linked to better cognitive performance, highlighting the value of promoting physical activity in young adults with obesity. The lack of observed differences in gait speed and reaction time may indicate that these functions are less sensitive to early changes or require longer periods of inactivity to decline in this population.

# Differential Effects of Physical Activity on Cognitive and Motor Performance in Obese Young Adults

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Total word count: 2126

Abstract word count: 193

Number of tables: 2

Number of figures: 2

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**Abstract**

The rising prevalence of obesity among young adults presents significant health challenges, particularly due to its adverse effects on cognitive function and physical mobility. This cross-sectional study examined the effects of physical activity on cognitive performance and gait speed in obese individuals aged 18 to 25 years. Seventy-six participants were categorized as either physically active or sedentary based on the Global Physical Activity Questionnaire. Anthropometric data were collected. Cognitive assessments included the Trail Making Test, Stroop Color Word Test, Hand Reaction Time Test, and Logical Memory Test. Gait speed was evaluated using the 10-meter walk test. The physically active group showed significantly better results in logical memory, executive function, and all Stroop test conditions ($p < 0.05$). No group differences were found in reaction time, Stroop interference score, or gait speed ($p > 0.05$). These findings suggest that higher physical activity levels are linked to better cognitive performance, highlighting the value of promoting physical activity in young adults with obesity. The lack of observed differences in gait speed and reaction time may indicate that these functions are less sensitive to early changes or require longer periods of inactivity to decline in this population.

Please identify that/if all particpants completed the study

**Keywords:** executive function, gait speed, reaction time, sedentary behavior, youth obesity

## Introduction

Obesity is a significant global health issue linked not only to metabolic and cardiovascular diseases but also to cognitive decline (Costache *et al.* 2023). Emerging evidence indicates that excess adiposity negatively affects cognitive domains such as executive function, working memory, and processing speed, while also contributing to physical limitations, including reduced mobility and slower gait speed (Berbegal *et al.* 2022, Lentoor 2022, Vakula *et al.* 2022). Gait speed serves as a comprehensive, non-invasive biomarker that reflects neuromuscular coordination, cardiovascular health, and cognitive functioning. It predicts functional independence in older adults and serves as an early indicator of declining health in midlife (Rasmussen *et al.* 2019a, 2019b). The mechanisms connecting obesity to cognitive and motor impairments include chronic low-grade inflammation, insulin resistance, oxidative stress, and cerebrovascular dysfunction (Farruggia and Small 2019, Huang *et al.* 2024, Naomi *et al.* 2023). These concerns are particularly relevant given the rising prevalence of obesity among young adults, a population traditionally considered at low risk for such functional decline. Early identification of modifiable factors, such as physical activity (PA), that can protect against these effects is therefore critical.

PA has well-documented protective effects on both cognitive and physical health. It enhances cerebral blood flow, promotes neurogenesis, improves synaptic plasticity, and reduces systemic inflammation (Ben-Zeev *et al.* 2022, Latino and Tafuri 2024). Prior study demonstrated that moderate PA improved both cognitive and physical performance in older adults with initially low levels of activity (Galle *et al.* 2023). Additionally, PA interventions have been shown to enhance cognitive function and academic performance in adolescents with obesity (Martin *et al.* 2018). PA also helps maintain gait speed, which is crucial for physical

tense does not match

independence and overall quality of life (Nascimento *et al.* 2022). While these benefits are well established in older adults, research on the cognitive and motor benefits of PA in obese young adults is still limited. Previous study reported that both total PA levels and cognitive function were significantly lower in adolescents with obesity compared to their non-obese peers (Thummasorn *et al.* 2022). Importantly, few studies have examined whether PA can simultaneously mitigate both cognitive and motor impairments in young adults at risk due to obesity. Most existing research has evaluated these outcomes independently or within mixed-age populations, leaving a gap in understanding the specific impact of PA in obese young adults. Moreover, practical motor function indicators such as gait speed and hand reaction time have not been thoroughly examined in relation to habitual PA levels in this demographic. Therefore, the present study aims to evaluate the effects of PA on cognitive performance and gait speed in obese young adults by comparing sedentary and physically active individuals. We hypothesized that the physically active group would demonstrate superior executive function, memory, and cognitive flexibility, as well as faster gait speed and shorter hand reaction times compared to their sedentary counterparts.

## Materials and methods

### Study design

This observational cross-sectional study was approved by the Committee for Research in Humans, Faculty of Associated Medical Sciences, Chiang Mai University, in accordance with the Declaration of Helsinki (Approval No. AMSEC-67EX-104). All participants provided written informed consent prior to participation. The study was conducted at the Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, with participant recruitment and assessments carried out between December 2024 and May 2025.

But, what is the duration of the participant observation specifically, and at what point/s was your intervention?

**Study participants**

The required sample size for this study was determined using G*Power software (version 3.1). The calculation was based on gait velocity outcomes from a preliminary investigation involving seven participants per group. The mean gait velocities for the physically active and sedentary obese groups were 1.71 ± 0.16 m/s and 1.82 ± 0.17 m/s, respectively. Based on an effect size of 0.66, a statistical power of 0.80, and a significance level of 0.05, a total of 76 participants was required. Eligibility criteria included young adults aged 18–25 years who were classified as obese, defined by a body mass index (BMI) ≥ 25 kg/m² according to the World

According to the WHO, obsesity is defined with a BMI at or above 30. Please change verbiage, or value

Health Organization (WHO) Asian BMI classification (Pan and Yeh 2008). Participants were excluded if they had major comorbidities or conditions that could interfere with testing or confound the results, including acute or chronic illnesses, neurological or musculoskeletal disorders, psychiatric or mood disorders (e.g., depression), and visual or hearing impairments.

**Procedure**

A total of 76 participants was recruited for the study, with matching based on sex and BMI. PA levels were assessed using Global Physical Activity Questionnaire (GPAQ), from which metabolic equivalents (MET-minutes/week) were calculated based on participant's self-reported data. According to the MET values derived from the GPAQ, participants were categorized into two distinct groups: the sedentary obese group (n = 38), which reported fewer than 600 MET-minutes per week, and the physically active obese group (n = 38), which reported 600 MET-minutes per week or more. Anthropometric measurements, including body mass,

did you evaluate true body composition? if not, why, and might there be an implication?

stature, waist circumference (WC), and hip circumference (HC), were recorded. Body composition was assessed using a bioelectrical impedance analyzer (Tanita BC-418, Tokyo, Japan). Body mass index (BMI) was calculated by dividing body weight (kg) by the square of height ($m^2$). All participants underwent cognitive assessments and a 10-meter walk test to evaluate gait speed. The study protocol is illustrated in **Figure 1**.

**Cognitive assessment**

***Trail making test (TMT)***

The TMT was used to evaluate executive function and consists of two components: TMT-A and TMT-B. In TMT-A, participants connected numbers sequentially from 1 to 25. In TMT-B, they alternated between numbers and letters in sequence. Performance was measured by the time taken to complete each part. The difference in completion time between TMT-B and TMT-A (B–A) was used as an index of executive function (Tombaugh 2004).

***Stroop color and word test (SCWT)***

The SCWT evaluates the ability to inhibit cognitive interference, which occurs when processing one aspect of a stimulus affects the simultaneous processing of another. In this test, the number of correct responses in the word (W), color (C), and color-word (CW) conditions within 45 seconds was recorded. The interference score (IG) was calculated using the formula: $IG = CW - [(W \times C)/(W + C)]$. A lower IG score indicates greater difficulty with interference inhibition (Scarpina and Tagini 2017).

***Hand reaction time (HRT)***

The evaluation of processing speed was performed utilizing a HRT test, using a portable electronic timer. Participants were seated and placed their dominant index finger on the right button of a modified computer mouse. Following the presentation of a red-light stimulus, participants were obligated to press the button with maximum rapidity. The average reaction time, quantified in seconds, was computed over the duration of ten trials (Lord *et al.* 2003).

***Logical memory test (LM)***

The delayed recall component of the Logical Memory (LM) test was used to assess episodic memory. Participants listened to two short narrative passages read aloud and were instructed to remember as many details as possible. Following a 30-minute delay, they were asked to recall each story as accurately as possible. Higher scores on the delayed recall task indicate better episodic memory performance (Ahn *et al.* 2019).

**Gait speed assessment**

The timed 10-meter walk test (TMW) was used to assess gait speed. Each participant began walking from a point 2 meters before the designated start line. Timing began as they crossed the start line and stopped at the 10-meter endpoint. The additional 2 meters at the beginning and end of the walkway minimized the effects of acceleration and deceleration. The test was conducted twice on the same day, and the average time was used for analysis (Kim *et al.* 2021).

**Statistical analysis**

Data were expressed as mean ± standard deviation (SD). Statistical analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was applied to assess the normality of the data distribution. Independent t-tests were used to evaluate group differences in participant's general characteristics, cognitive function, and gait speed. The chi-squared test was employed to analyze gender distribution. A *p*-value of less than 0.05 was considered statistically significant.

## Results

The general characteristics of the participants are shown in **Table 1**. There were no significant differences between the sedentary obese and physically active obese groups in terms of age, gender, BMI, body mass, height, WC, HC, waist-to-hip ratio, and body fat percentage. However, the physically active obese group reported significantly higher MET-minutes per week on the GPAQ compared to the sedentary obese group ($p < 0.01$).

A comparison of cognitive performance between the sedentary and physically active obese groups is presented in **Table 2**. The physically active obese group demonstrated significantly better performance in several cognitive tasks compared to their sedentary counterparts. The TMT B-A time was significantly lower in the physically active group than in the sedentary group ($p$ <0.05). Similarly, the LM scores were significantly higher in the physically active group compared to the sedentary group (p <0.05). In the SCWT, the number of correct answers in the W condition, C condition, and CW condition were all significantly higher in the physically active group ($p < 0.05$). However, no significant differences were observed between the two groups in hand reaction time, IG score, or gait speed ($p$ >0.05**, Figure 2**). These results indicate that PA may positively influence executive function, memory, and cognitive flexibility in obese individuals, while reaction time and gait speed remain unaffected.

## Discussion

Our findings reveal that individuals who engaged in higher levels of PA demonstrated significantly better cognitive performance in executive function, episodic memory, and cognitive flexibility compared to their sedentary counterparts. However, no significant differences were observed in gait speed, hand reaction time, or IG score.

The superior performance on the TMT B-A among physically active participants suggests enhanced executive functioning, including cognitive flexibility and task-switching ability (Fischetti *et al.* 2024, Shi *et al.* 2022). This finding aligns with previous research linking PA to improved prefrontal cortex activity, mediated by elevated levels of brain-derived neurotrophic factor (BDNF) and increased cerebral blood flow (Lukkahatai *et al.* 2025, Tari *et al.* 2025). The higher LM scores observed in the physically active group further support the cognitive benefits of regular PA, consistent with studies associating moderate-to-vigorous activity with enhanced memory and increased hippocampal volume, particularly in individuals with overweight or obesity (Machida *et al.* 2022, Migueles *et al.* 2020). Although physically active participants showed improved performance in all Stroop conditions, the IG value did not differ significantly between groups. The IG score is specifically designed to assess interference inhibition by mathematically adjusting for abilities in word reading and color naming (Scarpina and Tagini 2017). In the present study, improvements in W, C, and CW conditions occurred proportionally, which may explain the lack of observed enhancement in interference inhibition as calculated by the IG formula. These findings suggest that while PA may improve general processing speed and accuracy, it may not sufficiently enhance the ability to inhibit cognitive interference.

Previous studies have suggested that inhibitory control may require more intensive, targeted cognitive or resistance training interventions to yield measurable improvements (Dhir *et al.* 2021, Lin *et al.* 2024). Contrary to our hypothesis, no group differences were observed in gait speed or hand reaction time. This may be attributed to the relatively young age and preserved functional status of participants. In young adults, both neuromuscular and cardiovascular systems are typically well-maintained, which may lead to a ceiling effect that obscures potential benefits of PA on basic motor functions (Tan *et al.* 2024, Youssef *et al.* 2024).

Furthermore, prior research indicates that complex or fine motor adaptations often require prolonged or highly specific training to manifest (Krzysztofik *et al.* 2025, Lehmann *et al.* 2022, van Vliet *et al.* 2023). Another possible explanation for the absence of differences in gait speed is that obesity-related mobility impairments may not yet be clinically evident in early adulthood. Subclinical reductions in neuromuscular efficiency or cardiorespiratory capacity may have been too subtle to affect gait performance, especially in the absence of overt functional decline (Iyer *et al.* 2024, Koinis *et al.* 2024).

A key strength of this study is the control of potential confounding variables, including BMI, waist circumference, and body fat percentage, which were comparable across groups. This enhances the interpretation that PA level, rather than body composition, was associated with improved cognitive outcomes. However, some limitations should be acknowledged. First, PA was assessed using GPAQ, a self-report instrument subject to recall bias. Future research should incorporate objective measures such as accelerometry for greater accuracy. Second, the cross-sectional design limits causal inference. Longitudinal or intervention studies are needed to determine whether cognitive benefits are sustained over time.

## Conclusions

This study underscores the importance of PA as a neuroprotective strategy in obese young adults. While basic motor outcomes, such as gait speed, may remain intact, the cognitive benefits of PA are evident. Future research should explore whether these early cognitive improvements translate into long-term preservation of functional independence and healthspan.

## Acknowledgements

The authors would like to sincerely thank the Faculty of Associated Medical Sciences, Chiang Mai University, for providing the facilities and equipment used in this study.

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## Figure legends

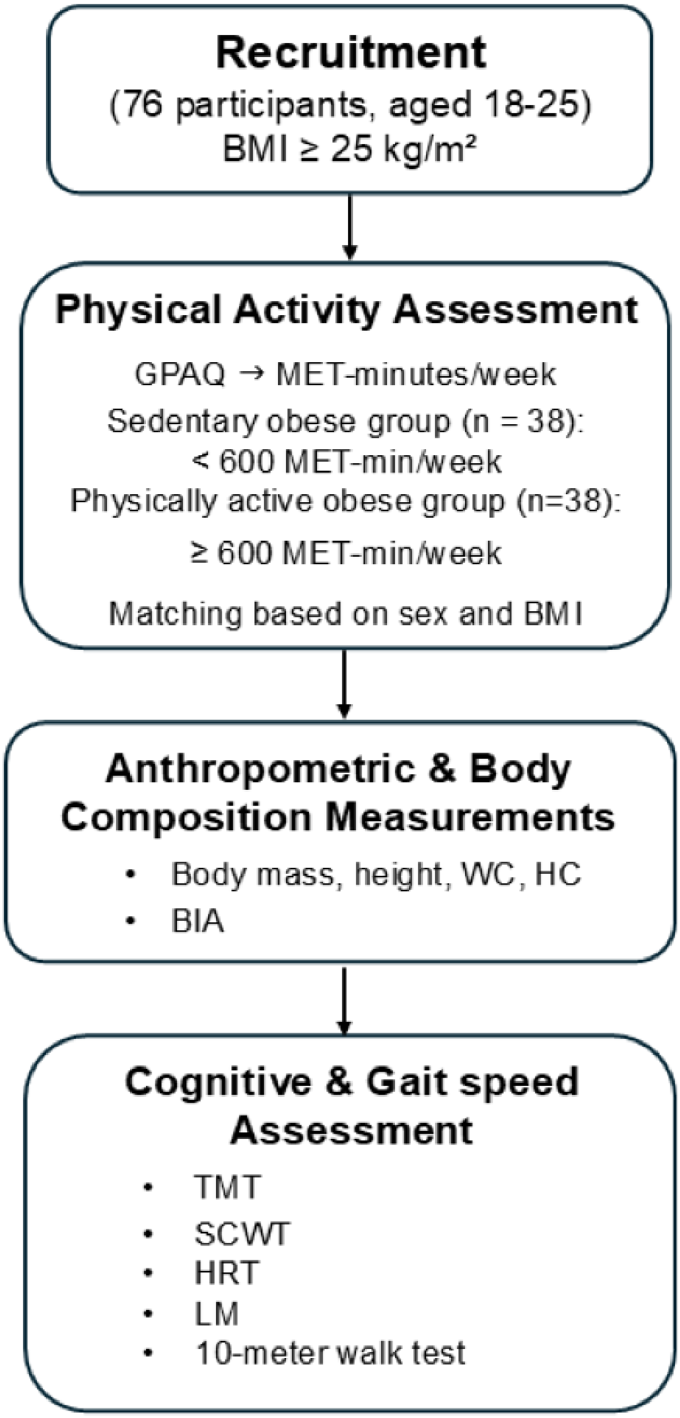
**Figure 1** Flowchart of the study methodology. GPAQ: global physical activity questionnaire; MET: metabolic equivalent task; WC: waist circumference; HC: hip circumference; BMI: body mass index; BIA: bioelectrical impedance analyzer; TMT: trail making test; SCWT: Stroop color-word test; HRT: hand reaction time test; LM: Logical memory test.

**Figure 2** Comparison of gait speed between sedentary and physically active obese groups.

# Figure 1

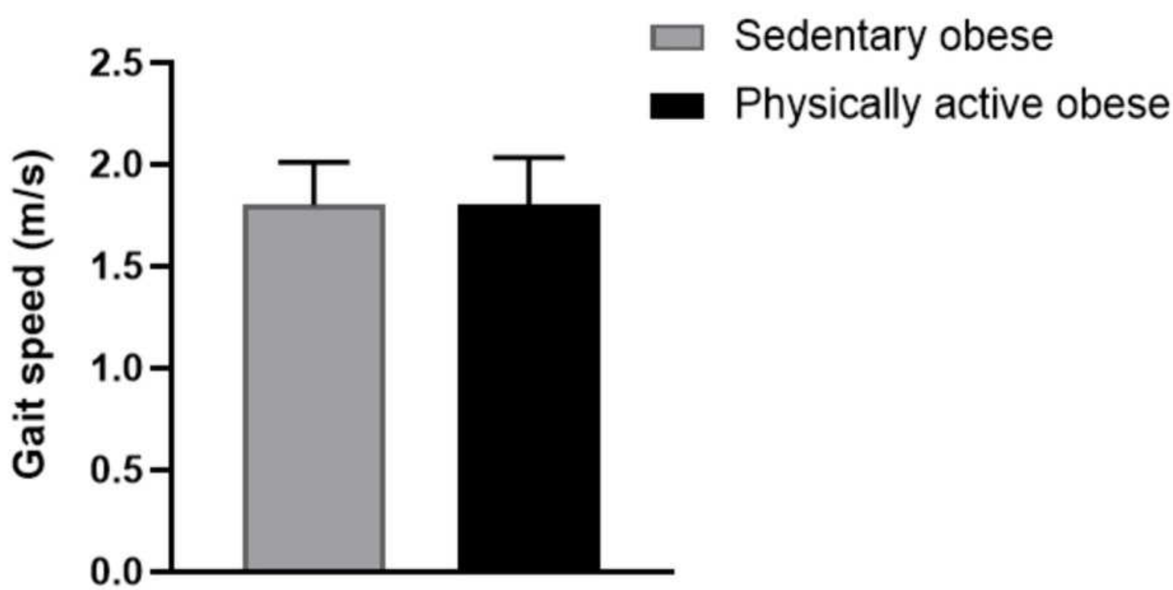
Figure 1. Flowchart of the study methodology

GPAQ: global physical activity questionnaire; MET: metabolic equivalent task; WC: waist circumference; HC: hip circumference; BMI: body mass index; BIA: bioelectrical impedance analyzer; TMT: trail making test; SCWT: Stroop color-word test; HRT: hand reaction time test; LM: Logical memory test.


Recruitment
(76 participants, aged 18-25)
BMI ≥ 25 kg/m²
Physical Activity Assessment
GPAQ → MET-minutes/week
Sedentary obese group (n = 38):
< 600 MET-min/week
Physically active obese group (n=38):
≥ 600 MET-min/week
Matching based on sex and BMI
Anthropometric & Body Composition Measurements
Body mass, height, WC, HC
BIA
Cognitive & Gait speed Assessment
TMT
SCWT
HRT
LM
10-meter walk test

# Figure 2

Figure 2. Comparison of gait speed between sedentary and physically active obese groups



## Table 1(on next page)

Table 1.General characteristics of participants

Data are represented as mean ± standard deviation (SD). MET; metabolic equivalent task.

BMI: body mass index. * Statistically significant data ($P < 0.05$).

**Table 1 General characteristics of participants**

| Variables | Sedentary obese (n=38) | Physically Active obese (n=38) | P-value |
|---|---|---|---|
| Age (year) | 21.18 ± 1.29 | 20.73 ± 1.65 | 0.19 |
| Gender (Male/female) | 13/25 | 13/25 | 1.00 |
| Body mass (kg) | 85.01 ± 18.58 | 83.80 ± 11.43 | 0.73 |
| Height (m) | 1.65 ± 0.09 | 1.66 ± 0.08 | 0.44 |
| BMI ($kg/m^2$) | 30.94 ± 5.73 | 30.01 ± 3.19 | 0.38 |
| Waist circumference | 97.97 ± 14.29 | 95.59 ± 9.95 | 0.40 |
| Hip circumference | 110.51 ± 12.40 | 108.87 ± 8.43 | 0.50 |
| Waist hip ratio | 0.88 ± 0.06 | 0.87 ± 0.08 | 0.72 |
| Body fat percentage (%) | 38.85 ± 9.00 | 37.51 ± 8.37 | 0.50 |
| MET-minutes per week | 187.36 ± 186.07 | 2570.00 ± 1796.61* | **< 0.01** |

Data are represented as mean ± standard deviation (SD). MET; metabolic equivalent task. BMI: body mass index. * Statistically significant data ($P < 0.05$).

## Table 2(on next page)

Table 2. Comparison of cognitive performance between the sedentary and physically active obese group

Data are represented as mean ± standard deviation (SD). TMT B-A trail making test B-A, W names of colors printed in black, C names different color patches, C names different color-words, CW names color-word, where color-word are printed in an incongruous color ink (name the color of the ink instead of reading the word). *$p < 0.05$ VS. the sedentary obese group

**Table 2 Comparison of cognitive performance between the sedentary and physically active obese group**

| Variables | Sedentary obese (n=38) | Physically active obese (n=38) | P-value |
|---|---|---|---|
| TMT B-A (sec) | 51.68 ± 19.54 | 40.59 ± 15.84* | **< 0.01** |
| Logical memory test (score) | 18.44 ± 6.90 | 21.31 ± 5.09* | **0.04** |
| Hand reaction time test (sec) | 0.246 ± 0.03 | 0.249 ± 0.05 | 0.77 |
| Correct answer in W condition | 98.63 ± 13.67 | 105.76 ± 15.84* | **0.03** |
| Correct answer in C condition | 71.44 ± 10.55 | 78.07 ± 11.83* | **0.01** |
| Correct answer in CW condition | 43.97 ± 9.59 | 49.52 ± 10.07* | **0.01** |
| Interference score | 2.65 ± 7.04 | 4.79 ± 9.07 | 0.25 |

Data are represented as mean ± standard deviation (SD). TMT B-A trail making test B-A, W names of colors printed in black, C names different color patches, C names different color-words, CW names color-word, where color-word are printed in an incongruous color ink (name the color of the ink instead of reading the word). *$p < 0.05$ VS. the sedentary obese group