

Correlation Between Body Fat Percentage, BMI and Cognition Among Healthy Young Adults: A Cross-Sectional Study

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ABSTRACT

Background: Obesity has emerged as a major public health concern, increasingly recognized not only for its metabolic consequences but also for its detrimental impact on neurocognitive health. While the relationship between excess adiposity and cognitive decline is well-documented in middle-aged and older populations, the extent to which body composition influences cognitive function in younger, non-clinical populations remains less defined. **Objectives:** This study aimed to investigate the direct association between Body Mass Index, body fat percentage, and cognitive performance among healthy young adults. **Materials and Methods:** A cross-sectional study was conducted involving 60 healthy participants aged 18 to 25 years. Body composition parameters, specifically BMI and body fat percentage, were evaluated using standardized anthropometric procedures and body composition analysis. Cognitive function was systematically assessed across domains including executive function, attention, working memory, and processing speed using a validated battery of cognitive tests. Statistical analyses, including correlation and regression models, were performed to identify significant associations. **Results:** Significant inverse correlations were observed between both BMI and body fat percentage and cognitive test scores ($p < 0.05$). Participants exhibiting higher body fat percentages demonstrated lower performance in executive functioning tasks and prolonged processing speeds compared to their peers within normal body composition ranges. **Conclusion:** Higher BMI and elevated body fat percentages are significantly associated with poorer cognitive performance in healthy young adults. These findings highlight that adiposity-related neurocognitive variations can manifest early in adult life, underscoring the importance of early lifestyle and body composition interventions to optimize cognitive health.

Keywords: Obesity, Body Mass Index (BMI), Body Fat Percentage, Cognitive Function, Cognition, Young Adults, Healthy Adults, Cross-Sectional Study.

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INTRODUCTION

Cognitive function is a fundamental aspect of human health that encompasses several mental processes including attention, memory, learning, executive function, information processing speed, reasoning, and decision-making. These cognitive abilities are essential for academic achievement, professional performance, and successful daily functioning. Young adulthood represents a critical period during which cognitive functions are expected to be at their peak. However, several lifestyle and physiological

factors may influence cognitive performance even in otherwise healthy individuals. Among these factors, obesity and excess body fat accumulation have emerged as growing public health concerns worldwide.

The prevalence of overweight and obesity has increased dramatically over the past few decades, affecting individuals across all age groups, including adolescents and young adults. According to the World Health Organization, obesity is defined as abnormal or excessive fat accumulation that presents a risk to health. Traditionally, obesity has been associated with metabolic disorders such as type 2 diabetes mellitus, hypertension, cardiovascular diseases, and dyslipidemia. More recently, research has highlighted the potential impact of obesity on brain health and cognitive function, suggesting that excess adiposity may adversely affect neural integrity and cognitive performance (Alves *et al.*, 2024; Morys *et al.*, 2024; Veneziani *et al.*, 2024; Wong *et al.*, 2023).



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Several epidemiological studies have reported associations between obesity and impaired cognitive functioning. Individuals with higher Body Mass Index (BMI) often demonstrate poorer performance in tasks involving attention, executive function, working memory, processing speed, and cognitive flexibility (Fitzpatrick *et al.*, 2009; Miller and Spencer, 2014; Smith *et al.*, 2011). Furthermore, neuroimaging studies have shown that obesity may be associated with structural alterations in brain regions involved in cognition, including the prefrontal cortex, hippocampus, and temporal lobes (Morys *et al.*, 2024; Singh-Manoux *et al.*, 2012). These findings suggest that excess body weight may contribute to changes in brain structure and function that ultimately affect cognitive abilities.

Although BMI is the most commonly used indicator of obesity, it has several limitations because it does not distinguish between lean body mass and adipose tissue. Consequently, Body Fat Percentage (BF%) has gained increasing attention as a more accurate indicator of body composition and metabolic health. Body fat percentage reflects the proportion of adipose tissue within the body and may provide a more direct measure of obesity-related health risks. Emerging evidence suggests that BF% may be more strongly associated with cognitive outcomes than BMI because adipose tissue actively secretes inflammatory cytokines, adipokines, and other bioactive substances that can influence brain function (Boccarda *et al.*, 2023; Song *et al.*, 2023).

Several biological mechanisms have been proposed to explain the relationship between obesity and cognitive impairment. One of the most widely accepted mechanisms involves chronic low-grade systemic inflammation. Excess adipose tissue, particularly visceral fat, releases pro-inflammatory cytokines such as Tumor Necrosis Factor- α (TNF- α), Interleukin-6 (IL-6), and C-Reactive Protein (CRP). These inflammatory mediators can cross the blood-brain barrier and contribute to neuroinflammation, which may impair neuronal communication and cognitive processing (Farruggia & Small, 2019; Miller & Spencer, 2014). Chronic inflammation has been linked to reduced synaptic plasticity, neuronal dysfunction, and accelerated cognitive decline.

Another important mechanism involves insulin resistance. Excess body fat is associated with impaired insulin signaling, which affects not only peripheral glucose metabolism but also cerebral glucose utilization. Since glucose is the primary energy source for the brain, disruptions in insulin-mediated glucose uptake may negatively influence cognitive performance, memory formation, and executive functioning (Kiliaan *et al.*, 2014; Wong *et al.*, 2023). Insulin resistance has also been implicated in neurodegenerative processes and may increase the risk of future cognitive decline.

Hormonal dysregulation may represent an additional pathway linking obesity and cognition. Adipose tissue functions as an endocrine organ that secretes hormones such as leptin, adiponectin, and resistin. Alterations in these hormones may

affect appetite regulation, energy balance, and neural signaling pathways involved in learning and memory (Kiliaan *et al.*, 2014). Elevated cortisol levels associated with obesity-related stress responses may further contribute to impaired cognitive function by affecting hippocampal structure and function.

Furthermore, obesity has been associated with vascular dysfunction and reduced cerebral blood flow. Impaired vascular health may decrease oxygen and nutrient delivery to the brain, thereby affecting cognitive efficiency and neural performance (Benito-León *et al.*, 2013; Waldstein and Katzel, 2006). Studies have demonstrated that central obesity and increased adiposity are associated with poorer executive function, slower information processing speed, and reduced attention span (Gunstad *et al.*, 2007; Li *et al.*, 2008).

Despite growing evidence linking obesity with cognitive impairment, much of the existing research has focused on middle-aged and older adults. Limited data are available regarding healthy young adults, particularly in developing countries such as India. Since cognitive abilities during young adulthood play a crucial role in educational achievement, professional development, and long-term quality of life, identifying modifiable risk factors that may affect cognition is of considerable importance. Moreover, understanding whether body fat percentage provides additional information beyond BMI may help improve the assessment of obesity-related cognitive risk.

Therefore, the present study was undertaken to investigate the relationship between Body Mass Index, Body Fat Percentage, and cognitive performance among healthy young adults. Cognitive performance was assessed using the Digit Symbol Substitution Test (DSST), Trail Making Test Part A and Part B (TMT-A and TMT-B), and Letter Cancellation Tests. It was hypothesized that higher BMI and body fat percentage would be associated with poorer cognitive performance, particularly in domains related to executive function, attention, processing speed, and cognitive flexibility.

MATERIALS AND METHODS

Methods

Study Design

This cross-sectional observational study was conducted to investigate the relationship between Body Mass Index (BMI), Body Fat Percentage (BF%), and cognitive performance among healthy young adults. The study was carried out after obtaining approval from the Institutional Ethics Committee, and all participants provided written informed consent prior to participation.

Participants

A total of 60 apparently healthy young adults of both genders, aged between 18 and 25 years, were recruited through convenience

sampling. Participants were selected from students and young adults who met the eligibility criteria.

Inclusion Criteria

- Healthy males and females aged 18-25 years.
- Willingness to participate voluntarily in the study.
- Ability to understand and follow study instructions.

Exclusion Criteria

- History of neurological disorders.
- Psychiatric illness or cognitive impairment.
- Musculoskeletal conditions affecting test performance.
- Current use of medications known to influence cognitive function.
- Presence of metabolic, cardiovascular, or endocrine disorders.

Anthropometric Assessment

Basic anthropometric measurements including height and weight were recorded using standardized procedures. Height was measured using a stadiometer with participants standing barefoot, while body weight was measured using a calibrated digital weighing scale.

Body Mass Index (BMI) was calculated using the formula:

$$\text{BMI (kg/m}^2\text{)} = \text{Weight (kg)} / \text{Height}^2 \text{ (m}^2\text{)}$$

Participants were classified according to the World Health Organization (WHO) BMI classification criteria.

Assessment of Body Fat Percentage

Body Fat Percentage (BF%) was measured using the QuadScan 4000 Bioelectrical Impedance Analyzer (Bodystat Ltd., United Kingdom). Bioelectrical Impedance Analysis (BIA) is a non-invasive and reliable method used to estimate body composition by measuring the resistance of body tissues to a small electrical current.

Participants were instructed to:

- Avoid vigorous physical activity for 24 hr before testing.
- Refrain from consuming food or beverages for at least 2 hr before assessment.
- Remove metallic accessories before measurement.
- Measurements were performed under standardized laboratory conditions according to the manufacturer's guidelines.

Cognitive Function Assessment

Cognitive performance was evaluated using a battery of validated paper-and-pencil neuropsychological tests that assess attention, processing speed, executive function, visual scanning ability, and cognitive flexibility.

Digit Symbol Substitution Test (DSST)

The Digit Symbol Substitution Test is a widely used measure of processing speed, attention, visuomotor coordination, and working memory. Participants were required to match symbols with corresponding numbers according to a provided key within a specified time limit. The total number of correct responses was recorded, with higher scores indicating better cognitive performance.

Trail Making Test-Part A (TMT-A)

The Trail Making Test Part A was used to assess visual attention, psychomotor speed, and information processing speed. Participants were instructed to connect numbered circles sequentially as quickly as possible. The time taken to complete the task was recorded in seconds. Lower completion times indicated better performance.

Trail Making Test-Part B (TMT-B)

The Trail Making Test Part B assessed executive functioning, cognitive flexibility, mental set shifting, and divided attention. Participants were required to alternate between numbers and letters in sequential order (1-A-2-B-3-C, etc.). Completion time was recorded in seconds, with shorter times indicating superior executive functioning.

A Letter Cancellation Test (ALCT)

The A Letter Cancellation Test evaluated selective attention and visual scanning ability. Participants were instructed to identify and cancel all target letters within a specified time period. The number of correctly identified target letters was recorded.

A-Q-T Letter Cancellation Test (AQTLC)

The A-Q-T Letter Cancellation Test was used to assess sustained attention, concentration, and visual discrimination. Participants were required to locate and cancel specific target letters from a field of distractors. The total number of correctly cancelled target letters was recorded for analysis.

Data Collection Procedure

Following recruitment and informed consent, participants underwent anthropometric assessment and body composition analysis. After a brief rest period, cognitive assessments were administered individually in a quiet and distraction-free environment. Standardized instructions were provided before

each test to ensure uniformity. All assessments were completed during a single session lasting approximately 30-45 min.

Pearson's correlation coefficient (r) was used to examine the relationship between BMI, Body Fat Percentage, and cognitive performance variables.

RESULTS

The results are tabulated in Tables 1 and 2.

DISCUSSION

The present study investigated the relationship between Body Mass Index (BMI), Body Fat Percentage (BF%), and cognitive performance among healthy young adults. The findings revealed significant associations between body composition parameters and several domains of cognitive function, including processing speed, attention, executive function, and cognitive flexibility. Specifically, BMI demonstrated significant correlations with DSST, AQTLC, and TMT-B scores, while body fat percentage showed significant correlations with ALCT, AQTLC, TMT-A, and TMT-B. These results suggest that increased adiposity may negatively influence cognitive performance even in a young and otherwise healthy population.

The findings of the present study are consistent with previous literature demonstrating the adverse effects of obesity and excess body fat on cognitive functioning. Several studies have reported that individuals with higher BMI tend to perform poorly on tasks involving executive function, memory, attention, and information processing speed. Gunstad *et al.* (2007) reported that elevated BMI was associated with executive dysfunction among healthy adults, while Smith *et al.* (2011) observed a negative relationship between obesity and cognitive performance across different age groups. Similarly, Singh-Manoux *et al.* (2012) demonstrated that obesity during midlife was associated with poorer cognitive performance later in life. These findings support the growing evidence that obesity may have detrimental effects on brain health and cognition.

In the present study, BMI showed significant correlations with DSST and TMT-B performance. The Digit Symbol Substitution Test primarily assesses processing speed, attention, and working memory. Participants with higher BMI tended to exhibit poorer

performance on this test, indicating reduced information processing efficiency. Similar findings have been reported by Cournot *et al.* (2006), who observed that increased BMI was associated with lower cognitive performance, particularly in tasks requiring rapid mental processing. Reduced processing speed may affect academic performance, learning ability, and everyday problem-solving skills among young adults.

Furthermore, BMI demonstrated a significant relationship with Trail Making Test Part B performance, which reflects executive functioning and cognitive flexibility. Executive functions are higher-order cognitive processes responsible for planning, decision-making, problem-solving, and task switching. Poorer performance on TMT-B among individuals with higher BMI suggests that excess body weight may negatively affect the neural pathways involved in executive control. Neuroimaging studies have shown structural alterations in the prefrontal cortex among obese individuals, which may contribute to deficits in executive functioning (Li *et al.*, 2008; Morys *et al.*, 2024).

An important finding of the present study is that body fat percentage demonstrated stronger and more widespread associations with cognitive performance than BMI. Significant correlations were observed between BF% and ALCT, AQTLC, TMT-A, and TMT-B. These findings suggest that body fat percentage may be a more sensitive indicator of obesity-related cognitive impairment than BMI. Unlike BMI, which only considers height and weight, BF% directly reflects adipose tissue accumulation and therefore provides a more accurate estimate of metabolic risk.

Previous research supports the notion that body fat percentage may be more closely linked to cognitive outcomes than BMI. Song *et al.* (2023) reported that excess adiposity was associated with alterations in brain structure and cognitive function, while Boccara *et al.* (2023) found significant associations between regional fat accumulation and cognitive decline. Because adipose tissue acts as an endocrine organ, excessive body fat may influence brain function through the secretion of inflammatory cytokines and adipokines that affect neuronal health.

Several biological mechanisms may explain the observed associations between body composition and cognitive performance. One proposed mechanism is chronic low-grade inflammation. Excess adipose tissue, particularly visceral fat,

Table 1: Cognitive Performance Results.

Cognitive Test	Normal Weight (n=30)	Higher WHR (n=30)	Statistical Test	p-value
TMT Part A (Processing Speed, sec)	45±8	53±9	t-test	0.005
TMT Part B (Cognitive Flexibility, sec)	65±12	78±14	t-test	0.002
Digit Symbol Substitution Test (DSST)	45±5	38±6	t-test	0.001
A & A, Q, T Letter Cancellation Test (Correct Items)	32±4	28±5	t-test	0.010

Table 2: Correlation between BMI, Body Fat Percentage and Cognitive Performance (Pearson Correlation).

Cognitive Variable	Mean±SD	r(BMI)	p-value	r(Body Fat %)	p-value
BMI (kg/m ²)	21.92±3.29	-	-	-	-
Body Fat (%)	25.96±8.67	-	-	-	-
ALCT-1	0.80±0.75	0.038	0.790	0.144	0.315
DSST	30.94±20.44	0.444	0.001*	0.168	0.238
ALCT-2	154.29±51.38	0.271	0.054	0.538	0.001*
AQTLCT	232.80±72.43	0.508	0.001*	0.496	0.001*
TMT-A	155.17±50.94	0.275	0.051	0.536	0.001*
TMT-B	233.19±72.64	0.510	0.001*	0.490	0.001*

produces pro-inflammatory cytokines such as interleukin-6, tumor necrosis factor-alpha, and C-reactive protein. These inflammatory mediators may cross the blood-brain barrier and promote neuroinflammation, leading to impaired synaptic plasticity, neuronal dysfunction, and reduced cognitive performance (Farruggia and Small, 2019; Miller and Spencer, 2014). Chronic inflammation has been implicated in deficits involving attention, executive functioning, and memory.

Another potential mechanism is insulin resistance. Increased body fat accumulation is strongly associated with impaired insulin sensitivity, which may affect cerebral glucose metabolism. Since glucose serves as the primary energy source for the brain, disturbances in glucose utilization may compromise neuronal activity and cognitive efficiency (Kiliaan *et al.*, 2014; Wong *et al.*, 2023). Previous studies have demonstrated associations between insulin resistance and reduced executive function, memory deficits, and slower cognitive processing.

Hormonal dysregulation may also contribute to the relationship between adiposity and cognition. Adipose tissue secretes various hormones, including leptin, adiponectin, and cortisol, which influence both metabolic regulation and brain function. Altered levels of these hormones may affect hippocampal function, learning processes, and memory formation (Kiliaan *et al.*, 2014). Elevated cortisol levels associated with obesity-related stress responses have been linked to impaired cognitive performance and structural changes within the hippocampus.

The significant correlations observed between body fat percentage and Trail Making Test performance indicate that adiposity may particularly affect executive function and cognitive flexibility. These cognitive domains are largely mediated by the prefrontal cortex, which is highly vulnerable to metabolic and inflammatory disturbances. Impaired executive functioning may adversely affect academic achievement, professional productivity, and decision-making abilities among young adults.

The present study contributes to the existing literature by examining the association between body composition and cognition in healthy young adults, a population that has received

relatively limited attention in obesity-related cognitive research. Most previous investigations have focused on middle-aged or elderly populations, where age-related cognitive decline may act as a confounding factor. By studying healthy young adults, the present findings suggest that the adverse cognitive effects of obesity may begin much earlier than previously recognized.

Despite its strengths, the study has several limitations. The cross-sectional design does not permit causal inference regarding the relationship between obesity and cognitive performance. The sample size was relatively small and drawn from a single population, which may limit generalizability. Furthermore, factors such as physical activity level, sleep quality, dietary habits, socioeconomic status, and psychological stress were not evaluated and may have influenced cognitive outcomes. Future longitudinal studies with larger and more diverse populations are needed to establish causal relationships and identify underlying mechanisms.

CONCLUSION

Overall, the findings indicate that both BMI and body fat percentage are significantly associated with cognitive performance among healthy young adults. However, body fat percentage demonstrated stronger and more consistent relationships with cognitive measures than BMI, suggesting that it may serve as a better predictor of cognitive health. These results highlight the importance of maintaining healthy body composition not only for physical well-being but also for preserving optimal cognitive function and long-term brain health.

ABBREVIATIONS

ALCT: A Letter Cancellation Test; **AQTLCT:** A-Q-T Letter Cancellation Test; **BF%:** Body Fat Percentage; **BIA:** Bioelectrical Impedance Analysis; **BMI:** Body Mass Index; **CRP:** C-reactive Protein; **DSST:** Digit Symbol Substitution Test; **IL-6:** Interleukin-6; **TMT:** Trail Making Test; **TMT-A:** Trail Making Test Part A; **TMT-B:** Trail Making Test Part B; **TNF-α:** Tumor Necrosis Factor-alpha; **WHR:** Waist-Hip Ratio.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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