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Association of body composition with cognitive function in healthy young adults.

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Abstract

Background: Body composition is a key determinant of health and has more recently been suggested to play a role in cognition. Increased adiposity and central obesity have been linked too many metabolic abnormalities that lower attention, memory, executive function, and processing speed. However, there is little evidence of this association in young and healthy adult. The purpose of this study was to examine the association between body composition and cognitive function in healthy young adults.

Materials and Methods: A cross-sectional study (n=85) was carried over undergraduate medical students aged 18-25 years at Sri Devaraj Urs Medical College, Kolar, Karnataka. Body composition was assessed using the Tanita BC-601 Body Composition Analyzer; and anthropometry included Body mass index (BMI) and Waist to hip ratio (WHR). Cognition was assessed by TMT, Six-Letter Cancellation Test (SLCT) and Digit Symbol Substitution Test (DSST). Analysis 2 Data were analysed using SPSS version 22.0 (IBM) Association was assessed by Pearson's correlation coefficient and Chi-square test, $p < 0.05$ has been considered statistically significant.

Results: Participants were 21.3 ± 1.6 years old, and 55.3% of the sample was female. Mean BMI was 23.4 ± 3.8 kg/m² and body fat percentage (BFP) was 24.8 ± 7.4%. Longer TMT completion times and higher SLCT and DSST scores were significantly associated with greater BMI, waist circumference, body fat rate and visceral fat ($p < 0.05$). In contrast, indicators of increased lean mass and total body water were positively associated with cognitive performance.

Conclusions: Results indicate an inverse relationship between higher adiposity and cognitive performance, while a direct relationship with higher muscle mass exists in healthy young adults. These results underline the importance of lifestyle changes aiming at a healthy body composition for facilitating cognitive health and an early preventive approach.

Keywords: Body composition; Cognitive function; Body mass index; Visceral fat; Muscle mass; Trail Making Test; Six-Letter Cancellation Test; Digit Symbol Substitution Test; Healthy young adults.

Introduction

Obesity has become an epidemic and one of the greatest global public health challenges in the twenty-first century - more than 1 billion people are overweight, including approximately 650 million adults with obesity. Over the last two decades, overweight and obesity rates have rapidly increased in the population of India largely due to urbanization, changes in diet patterns and a more sedentary lifestyle [1, 2]. Excess bodyweight is one among the important risk factors for several NCDs, which are responsible for 70% of global morbidity and mortality [2]. These include type-2 diabetes mellitus, hypertension, cardiovascular diseases and certain cancers.

Body composition is the relative constituent proportions of fat mass, skeletal muscle mass (per MMI), bone mass and body water in human beings. Unlike BMI, which evaluates adiposity in broad categories, assessment of body composition can help to better define nutritional and metabolic status due to the ability to separate fat from lean body mass [3]. The assessment of body composition is important because alterations in fat distribution, especially visceral adiposity, are closely associated with metabolic dysfunction related to obesity and chronic low-grade inflammation of a plethora of health functions.

This increase in evidence over the last few years has shown that, beyond physical health; obesity may have significant effects on cognitive function too. It is your cognitive function, which includes: attention and perception; memory (short-term, long-term); processing speed; executive function; problem-solving skills all of which are critical to academic achievement, work performance and life satisfaction. It should be noted that simple tests, including the Trail Making Test (TMT), Six-Letter Cancellation Test (SLCT) and Digit Symbol Substitution test(DSST), are routinely performed to evaluate these cognitive domains [4,5]. These alterations have previously been linked to deficits in executive function, working memory, attention and processing speed. Insulin Resistance, glucose dysmetabolism, leptin dysregulation as well as oxidative stress and endothelial dysfunction and systemic inflammation and alterations in adipokine secretion have been suggested to adversely affect neuronal integrity and synaptic plasticity [6,7]. Longitudinal studies also show that overweight/obesity in early adulthood increases the risk of cognitive decline/dementia later in life [8,9].

Between ages 20 and 25 of life corresponds with early adulthood, a time during which we expect to have our highest cognitive functioning [10,11]. On the reverse, when unhealthy lifestyle behaviours such as obesity, physical inactivity or poor diet could also negatively impact body composition and cognitive health. Despite the increasing trend of overweight and obesity among young adults, there are few studies examining anthropometric parameters related to cognitive functions in various populations, including the Indian population [12, 13]. Most studies conducted so far used BMI as a major measurement, limiting our ability to determine the independent associations of fat mass, skeletal muscle mass and visceral fat (apart from BMI) with cognitive function [14].

While it is novel to investigate how different detailed anthropometrical parameters of body composition correlate with cognitive function using an extensive battery of continuous tests in healthy young adults, Unlike prior studies which were predominantly cross-sectional, potentially including only obese older adults with existing comorbidities and examining pro-disease pathological variables, our study includes healthy young individuals that would be at risk of developing clinically overt metabolic or neurologic disorder later in life. If the early associations between body composition and cognitive performance can be recognized, then there may be opportunities for targeted lifestyle interventions to decrease the risk of late-life cognitive impairment [8-12].

As obesity is very common and the verdict on its brain-related consequences is still out, it stands to reason that research leading to advancements in how body fat distribution predicts cognition would be paramount for public health [15]. Purpose To assess the association of body composition with cognition in healthy young adults. Test was conducted regarding the body composition which includes Tanita BC-601 Body Composition Analyzer, BMI and WHR. Cognitive function was assessed by using standard neuropsychological examinations like TMT, the Six-Letter Cancellation test (SLCT) and DSST. The study also aimed to assess the relationship between anthropometric indices and body composition parameters with cognitive performance in healthy young adults.

Materials & Methods

Study Design and Setting

This cross-sectional observational study was conducted on undergraduate medical students of Sri Devaraj urs Medical College, Kolar, to compare between body composition and cognitive function among healthy young adults. This study was conducted after getting an approval from the Institutional Ethics Committee, and written informed consent was taken before enrollment from all participants.

Study Population

The study population included undergraduate medical students between ages of 18–25 yrs who were enrolled at Sri Devaraj Urs Medical College during the time period of this study. We included 85 participants in the study.

Sample Size

The sample size was calculated from the correlation study by Linda Fabea et al. on the relation between body composition and cognition in young adulthood. According to the correlation sample size formula $n = [(Z\alpha + Z\beta)/C]^2 + 3$, our minimum requirement for sample size was approximately estimated by using $Z\alpha = 1.96$ (95% confidence) and $Z\beta = 0.84$ (80% power) to be 85 subjects.

Inclusion Criteria

Inclusion Criteria All apparently healthy male and female undergraduate medical students 18–25 years of age were included in the study who agreed to participate.Consent was obtained from each participant (after being explained given about the purpose of the study) before collecting any data.

Exclusion Criteria

Those with clinical histories of neurological or psychiatric disease, systemic illnesses such as diabetes mellitus or hypertension, established sleep apnoea syndrome and those with a history of alcohol and substance abuse to facilitate exclusion of other confounding factors that might negatively affect cognitive function were excluded from the study population.

Data Collection Procedure

After recruiting eligible participants, a complete assessment was performed using a structured study proforma. Demographics such as age and gender were also documented. Anthropometric measurements including standing height, weight, waist circumference and hip circumference were measured following standardized procedures. Then, Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR) were derived.

Body composition analysis, including body fat percentage, visceral fat, skeletal muscle mass, total body water, bone mass, and metabolic age using the Tanita BC-601 Body Composition Analyzer according to the manufactures protocol.

Three validated neuropsychological tests were performed to assess cognitive function. For EF, visual attention and cognitive flexibility: Trail Making Test (TMT) Parts A and B; sustained attention, concentration and psychomotor speed: Six-Letter Cancellation Test (SLCT); processing speed working memory/attention/visuomotor coordination: Digit Symbol Substitution Test (DSST). All of the assessments was conducted under standardized conditions by trained investigators.

Statistical Analysis

Data entry was carried out on Microsoft Excel and analysed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were reported as mean ± SD values, and categorical variables as frequencies and percentages. Before the analysis, we checked the normality of our data. Normally distributed variables were evaluated using Pearson's correlation coefficient to evaluate the relationship between anthropometric indices, body composition parameters, and corresponding cognitive test results. The Chi-square test was used to examine associations between categorical variables as indicated. Statistical analyses: For all statistical analyses, a p-value <0.05 was deemed significant.

Result

Table 1. Baseline Characteristics of the Study Participants (n = 85)

Variable	Frequency (%) / Mean ± SD
Age (years)	21.3 ± 1.6
Male	38 (44.7)
Female	47 (55.3)

Height (cm)	165.2 ± 8.7
Weight (kg)	63.8 ± 11.9
BMI (kg/m²)	23.4 ± 3.8
Waist Circumference (cm)	81.7 ± 9.4
Hip Circumference (cm)	94.2 ± 8.5
Waist-Hip Ratio	0.87 ± 0.06

The study included 85 healthy young adults with a mean age of 21.3 ± 1.6 years. Females constituted 55.3% of the study population. The mean BMI was 23.4 ± 3.8 kg/m², indicating that most participants were in the normal-to-overweight range.

Table 2. Body Composition Parameters Assessed Using Tanita BC-601

Parameter	Mean ± SD
Body Fat (%)	24.8 ± 7.4
Visceral Fat Score	5.4 ± 2.1
Muscle Mass (kg)	46.2 ± 7.6
Total Body Water (%)	55.2 ± 5.8
Bone Mass (kg)	2.74 ± 0.42
Metabolic Age (years)	23.6 ± 3.4

The mean body fat percentage was 24.8 ± 7.4%, while the average visceral fat score was 5.4 ± 2.1, suggesting relatively healthy body composition in most participants with moderate inter-individual variation.

Table 3. Nutritional Status Based on BMI

BMI Category	Frequency (%)
Underweight (<18.5)	8 (9.4)
Normal (18.5–24.9)	52 (61.2)
Overweight (25–29.9)	20 (23.5)
Obese (≥30)	5 (5.9)

Most participants (61.2%) had a normal BMI, whereas 29.4% were either overweight or obese, indicating a considerable proportion at risk for obesity-related health consequences.

Table 4. Cognitive Function Assessment

Variable	Mean ± SD
TMT-A Completion Time (sec)	35.6 ± 8.2
TMT-A Errors	0.8 ± 0.9
TMT-B Completion Time (sec)	84.5 ± 18.6
TMT-B Errors	1.3 ± 1.2
Difference Score (B−A)	48.9 ± 13.5
SLCT Net Score	42.4 ± 6.8
DSST Score	7.3 ± 1.3

Participants demonstrated satisfactory cognitive performance with a mean TMT-B completion time of 84.5 ± 18.6 seconds, mean SLCT net score of 42.4 ± 6.8, and mean DSST score of 7.3 ± 1.3, indicating generally preserved executive function, attention, and processing speed.

Table 5. Distribution of Cognitive Performance Categories

Test	Good n (%)	Moderate n (%)	Poor n (%)
TMT	49 (57.6)	29 (34.1)	7 (8.2)
DSST	40 (47.1)	34 (40.0)	11 (12.9)
SLCT	45 (52.9)	31 (36.5)	9 (10.6)

More than half of the participants demonstrated good cognitive performance on all three neuropsychological tests, while less than 13% showed poor cognitive performance.

Table 6. Correlation Between Anthropometric Indices and Cognitive Function

Variable	TMT-B (r)	SLCT (r)	DSST (r)	p-value
BMI	0.384	-0.329	-0.347	0.002
Waist Circumference	0.401	-0.352	-0.368	<0.001
WHR	0.298	-0.271	-0.286	0.011

BMI, waist circumference, and WHR showed significant correlations with cognitive performance. Higher anthropometric indices were associated with longer TMT completion times and lower SLCT and DSST scores ($p < 0.05$), indicating poorer executive function and attention.

Table 7. Correlation Between Body Composition Parameters and Cognitive Function

Variable	TMT-B (r)	SLCT (r)	DSST (r)	p-value
Body Fat (%)	0.442	-0.394	-0.381	<0.001
Visceral Fat	0.461	-0.413	-0.401	<0.001
Muscle Mass	-0.318	0.296	0.324	0.005
Total Body Water	-0.287	0.251	0.276	0.014

Body fat percentage and visceral fat demonstrated moderate positive correlations with TMT completion time and negative correlations with SLCT and DSST scores ($p < 0.001$). Conversely, muscle mass and total body water were significantly associated with better cognitive performance ($p < 0.05$).

Table 8. Multiple Linear Regression Analysis for Predictors of Cognitive Function (DSST Score)

Predictor	β Coefficient	Standard Error	t-value	p-value
Body Fat (%)	-0.341	0.102	-3.34	0.001
Visceral Fat	-0.294	0.094	-3.12	0.003
Muscle Mass	0.247	0.087	2.84	0.006
BMI	-0.181	0.081	-2.24	0.028
Age	-0.061	0.056	-1.09	0.279

Multiple linear regression analysis revealed that body fat percentage ($\beta = -0.341$, $p = 0.001$) and visceral fat ($\beta = -0.294$, $p = 0.003$) were independent negative predictors of cognitive performance, whereas muscle mass ($\beta = 0.247$, $p = 0.006$) was a significant positive predictor. Age was not significantly associated with cognitive function ($p = 0.279$).

Discussion

The current study consisted of 85 healthy young adults with age and gender distribution mixed (mean21.3 ± 1.6 years, Female: Male = 55.3%:54.). The mean BMI was 23.4 ± 3.8 kg/m² and most subjects were in the normal range for people with a BMI of 18.5, 24.9 Gupta et al. also reported similar findings. They noted that although the majority of Indian students were in the normal BMI range, researchers were witnessing overweight and obesity with increasing frequency due to changing social habits.[1]

There was a significant variation in mean body fat percentage (24.8 ± 7.4%), visceral fat score (5.4 ± 2.1), muscle mass (46.2 ± 7.6 kg) and total body water (55.2 ± 5.8%) of the participants across study groups, respectively. These results echo those of Smith et al. Maalouf [3], reported that body composition parameters yield a better evaluation of metabolic health than BMI alone and correlate closely with cognitive outcomes. Of the participants, 61.2% had normal BMI status, while 23.5% and 5.9% were overweight and obese, respectively in this study. This is similar to the systematic review by Ahirwar and Mondal [2], in which they stated that there is increasing prevalence of overweight and obesity among Indian young adults.

Excess body weight was observed in almost a third of participants, reflecting the increasing incidence of obesity in this age group.

The mean TMT-A completion time was 35.6 ± 8.2 seconds, TMT-B was 84.5 ± 18.6 seconds, SLCT net score was 42.4 ± 6.8, and DSST score was 7.3 ± 1.3. These findings indicate generally preserved executive function, attention, and processing speed among healthy young adults. Pradhan and Nagendra [8] similarly reported that higher SLCT scores reflect better sustained attention and psychomotor performance, while Belghali et al. [9] demonstrated that executive function tests are sensitive indicators of cognitive performance in young adults.

More than half of the participants demonstrated good cognitive performance across all three tests, whereas only a small proportion exhibited poor performance. This observation agrees with the findings of Cheke et al. [4], who reported that healthy young adults generally perform well on executive function tests, although individuals with higher BMI tend to show subtle cognitive deficits. A significant positive correlation was observed between BMI ($r = 0.384$, $p = 0.002$), waist circumference ($r = 0.401$, $p < 0.001$), waist-to-hip ratio ($r = 0.298$, $p = 0.011$), and TMT completion time, while negative correlations were observed with SLCT and DSST scores. These findings are comparable to those of Cheke et al. [4], who demonstrated that higher BMI was associated with poorer episodic memory and executive function, and Dye et al. [5], who reported reduced cognitive performance among individuals with excess adiposity.

Body fat percentage ($r = 0.442$, $p < 0.001$) and visceral fat ($r = 0.461$, $p < 0.001$) showed significant negative associations with cognitive performance, whereas muscle mass ($r = 0.324$, $p = 0.005$) and total body water ($r = 0.276$, $p = 0.014$) demonstrated positive correlations. Similar findings were reported by Fitzpatrick et al. [6], who concluded that increased adiposity is associated with impaired executive functioning, whereas better physical fitness is associated with improved cognitive performance.

Strengths & Limitations

The current study utilized detailed body composition measurements and validated cognitive measures to provide insight into obesity-cognition which exists at an early stage in healthy young adults.

The findings are limited in generalizability due to the cross-sectional design, sample size and population representing a single institution. Other confounding factors like physical activity, dietary habits and sleep quality were not evaluated.

Conclusion

The relationship between body composition and cognitive function in healthy young adults was a major finding of the current study. Higher BMI, body fat percentage and visceral fat were associated with lower cognitive performance, while more muscle mass was related to better cognitive function. These results necessitate that lifestyle modifications to better maintain a healthier body composition to be implemented and the resulting outcome used as a proactive step to retain optimum cognitive health in younger adults.

Conflict of Interest: The authors declare that they have no competing interests or conflicts of interest related to this work.

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