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The Relationship between Visceral Fat and Cognitive Function in Medical Students

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ABSTRACT

During COVID-19, there was a change in student lifestyle, which triggered visceral fat accumulation. The accumulation of visceral fat is one of the causes of systemic inflammation, which is dangerous for the integrity of the brain and can potentially reduce cognitive function. This study aimed to determine the relationship between visceral fat and cognitive function among medical students. This study used a cross-sectional design towards 73 Faculty of Medicine Universitas Pembangunan Nasional "Veteran" Jakarta students who met the criteria and were selected using a simple random sampling technique. The measurement of visceral fat was done using the Tanita Body Composition Analyzer, while the measurement of cognitive function was done using the Digit Symbol Substitution Test questionnaire. The study showed differences in sex and body mass index between normal and high visceral fat groups. There were no differences in age, consumption of junk food, and physical activity between the visceral fat groups. The Spearman test results showed a relationship between visceral fat and cognitive function ($p = 0.000$; $r = -0.561$). The higher the visceral fat, the lower the cognitive function.

Keywords: Cognitive function; Medical students; Visceral fat

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INTRODUCTION

During the COVID-19 pandemic era, many governments worldwide implemented "stay at home" regulations, which also had adverse effects on the activity patterns of students, including decreased physical activity, increased sleep duration, and increased screen time, leading to weight gain and triggering obesity.[1] Visceral fat is stored in the abdominal cavity, known as organ fat or intra-abdominal fat.[2] Visceral fat is one of the body components that can affect body weight. Body mass index (BMI) is obtained from height and weight calculations. Thus, visceral fat as a body component affects BMI.[3] This indicates that individuals with obesity may have a more significant visceral fat accumulation.[4] Accumulation of visceral fat impacts cognitive function and brain health.[5] Visceral fat accumulation can cause systemic inflammation because fat tissue releases proinflammatory cytokines.[6] The released cytokines can reach the brain at the hypothalamic level and trigger local inflammation, causing synaptic remodeling and hypothalamic neurodegeneration and resulting in cognitive dysfunction.[7] Research results show that elderly subjects (minimum age 64 years) with high visceral fat have lower cognitive function (orientation, concentration, attention, verbal memory, and visuospatial ability). Subjects with a visceral fat mass of 100 cm^2 measured using the EW-FA90 visceral fat meter have low cognitive function. It is also reported that there is a significant association between visceral fat and the occurrence of white matter lesions and dilation of perivascular spaces in the brain.[8] Several other studies also indicate excessive visceral fat is associated with decreased brain volume and increased white matter lesions.[9]

RISKESDAS data shows an increasing prevalence of visceral obesity in individuals over 15 years old, from 18.8% in 2007 to 31% in 2018.[10] The prevalence of visceral obesity in medical students of Udayana University in 2014 was 58 (26.7%) students, consisting of 27 (12.5%) male students and 31 (14.5%) female students.[11]

Medical students greatly require cognitive function, both short-term and long-term memory, to support academic achievement. However, physical activity among medical students tends to be lower than other students due to long reading, sitting, and studying periods.[12] Research findings indicate that regular physical activity can lead to visceral fat accumulation. Therefore, insufficient physical activity can lead to the accumulation of visceral fat.[13] Additionally, the busy schedule of lectures often leads medical students to pay less attention to their dietary intake.[14] Lack of physical activity and minimal attention to dietary intake are factors that can lead to the accumulation of visceral fat. To the best of the researchers' knowledge, there is no relationship between visceral fat and cognitive function in young individuals. Based on this rationale, a study on the relationship between visceral fat and cognitive function was conducted on Faculty of Medicine, Universitas Pembangunan Nasional "Veteran" Jakarta (FM UPNVJ) students.

METHOD

The study used a cross-sectional design and was conducted at the Physiology and Nutrition Laboratory Unit, Medical Education and Research Center. Universitas Pembangunan Nasional

"Veteran" Jakarta. The inclusion criteria for this study were students who completed the questionnaire, underwent visceral data collection procedures, engaged in light or moderate physical activity measured using the Global Physical Activity Questionnaire, had good dietary intake measured using the Adolescent Food Habits Checklist, and were in good health. Students who used narcotics consumed alcohol, smoked, had a history of head trauma, used sedatives, psychotropic drugs, and long-term antiepileptic drugs, and had a history of epilepsy, neurological disorders (stroke, Parkinson's disease), cardiovascular diseases (diabetes, hypertension, hyperlipidemia), thyroid hormone disorders, and pituitary or adrenal gland dysfunction were excluded from the study. A total of 73 samples were taken using a simple random sampling technique with the help of the Microsoft Excel application. This study obtained ethical clearance from the Ethics Commission of Universitas Pembangunan Nasional "Veteran" Jakarta No: 406/X/2022/KEPK.

Visceral fat was measured using the Tanita Medical Body Composition Analyzer (MC-980MA Plus), with a scale of 1-12 indicating normal visceral fat and 13-59 indicating high visceral fat. Tanita has a sensitivity value of 76% and a specificity of 70% when assessing visceral fat.[15] Tanita has been proven to be valid and reliable with a Cronbach's alpha = 0.945.[16] Cognitive function was measured using the Digit Symbol Substitution Test (DSST) questionnaire, which has been proven to be valid and reliable with a Cronbach's alpha of 0.820.[17] The DSST questionnaire was used to measure motor skills, attention, and visual perception. The questionnaire results were displayed in total scores ranging from 0 to 100.

Univariate analysis was conducted to describe the characteristics of subjects, visceral fat variables, and cognitive function. Bivariate analysis using Spearman's test aimed to determine the correlation between DSST scores and visceral fat groups using the Mann-Whitney test.

RESULTS

The study found 131 active medical students at FM UPNVJ who met the study criteria. Subsequently, simple simple random sampling was conducted to obtain 73 research subjects.

Characteristics of Study Subjects

The mean age of the study subjects was 19, and the majority were female. There were gender differences ($p = 0.023$) and BMI ($p = 0.001$) between the high visceral fat and normal visceral fat groups, but there were no differences in age, junk food consumption, and physical activity in both groups ($p > 0.05$) (Table 1).

The Difference in DSST Scores between Visceral Fat Groups

The study found that the DSST score for normal visceral fat was 57 (37–75), and the score for high visceral fat was 50 (45–52). The Mann-Whitney test resulted in a difference in DSST scores between the normal and high visceral fat groups ($p = 0.000$).

Relationship between Visceral Fat and Cognitive Function

Spearman's test results showed a significant relationship between visceral fat and cognitive

function in medical students with moderate strength (p = 0.000; r = -0.562). The higher the visceral fat, the lower the cognitive function.

Table 1. Characteristics of Research Subjects

Characteristic	Normal Visceral Fat (n=66)	High Visceral Fat (n=7)	p-value
Age (mean ± SD)	19.35 ± 1.3	19.57 ± 1.4	0.715[a]
Gender n (%)			
Male	17 (77.3)	5 (22.7)	0.023[*b]
Female	49 (96.1)	2 (3.9)	
BMI n (%)			
Underweight	8 (100)	0 (0)	
Normal	29 (100)	0 (0)	0.001[*b]
Overweight	14 (100)	0 (0)	
Obese	15 (68.2)	7 (31.8)	
Junk Food Consumption (%)			
Almost every day	12 (100)	0 (0)	
Once a week	26 (89.7)	3 (10.3)	
Twice a week	15 (88.2)	2 (11.8)	0.307[b]
Once a month	8 (100)	0 (0)	
More than once a month	5 (71.4)	2 (28.6)	
Physical Activity (%)			
Light	27 (96.4)	1 (3.6)	0.239[b]
Moderate	39 (86.7)	6 (13.3)	

Note: [a]Mann-Whitney test result
[b]Chi-square exact test result
[*]There is a difference in normal visceral fat and high visceral fat groups

DISCUSSION

Characteristics of Research Subjects

This study utilized the population of medical students from Universitas Pembangunan Nasional "Veteran" Jakarta with an average age of 19 years. This age falls within the late adolescent age group, which has an age range of 17-25 years. According to the Indonesian Ministry of Health, this age group often faces health and nutrition problems.[10] The results of this study showed no difference in age between the two visceral fat groups. Therefore, it can be concluded that age does not affect the difference in cognitive function found in this study. Based on theory, age can affect cognitive function. As age increases, there is a decline in executive cognitive function, which involves decision-making, problem-solving, planning and sequencing of responses, and multitasking.[18] Additionally, with age, there is a decrease in the volume of the temporal lobes, especially the medial temporal lobes, including the hippocampus, and a decrease in white matter volume that can affect cognitive function.[18] Cognitive function gradually declines with age due to cellular and metabolic changes, leading to progressive reduction in synaptic plasticity in brain regions crucial for cognitive function.[19]

In this study, most subjects were female, as the population of FM UPNVJ in the Academic Year 2021/2021 is predominantly female. Most students across Indonesia (both freshmen and graduates) in 2020 were female, accounting for 56.10%, while male students accounted for 43.90% of the total

8.483.213 registered students.[20] The results of this study found a difference in gender between the two visceral fat groups (p = 0.023). Body fat distribution differs between males and females, with males tending to accumulate fat in the abdomen. In contrast, females accumulate fat in the hips and thighs, making males more susceptible to visceral fat accumulation.[13] Although there was a difference in gender distribution in the visceral fat group, it did not affect the difference in cognitive function found in this study. Previous research did not find differences in working memory between males and females. Estrogen and testosterone hormones affect cognitive function similarly, as testosterone can be converted into estrogen in many tissues, including the central nervous system. Estrogen has been shown to enhance synaptic plasticity in the hippocampus, which plays a crucial role in memory storage. Additionally, estrogen can enhance synaptic connections, thus improving information processing.[21]

The results of this study found differences in BMI between the two visceral fat groups (p = 0.001). Similar results were found in a 2014 study on medical students at Diponegoro University, which showed a relationship between BMI and visceral fat. Visceral fat is one of the body components that can affect body weight. BMI is an indicator of an individual's nutritional status obtained from height and weight calculation, so visceral fat as a body component can affect BMI.[3] An increase in BMI is associated with a decrease in cortical thickness from the right precentral gyrus to the postcentral gyrus. An increase in BMI is associated with a reduction in gray matter thickness in the lateral occipital cortex, for example, in the fusiform gyrus. The fusiform gyrus is important for distinguishing high-calorie and low-calorie food signals. Obese subjects show decreased fusiform gyrus activation in response to food compared to lean subjects.[22]

This study found that a majority of subjects consumed junk food once a week, consistent with research on health science students showing that 138 students like junk food, and 34% of those subjects consume junk food not because it's not available at home but because of lifestyle.[23] The results of this study showed no difference in junk food consumption between visceral fat groups. Therefore, it can be concluded that junk food consumption does not affect the difference in cognitive function found in this study. Excessive consumption of junk food can indeed affect cognitive function because high-fat and high-sugar junk food consumed in excess can cause changes in brain areas involved in learning, memory, and reward.[24] Additionally, excessive junk food consumption is associated with worse cognitive function and decreased executive performance in adolescents associated with reduced prefrontal cortex volume.[25]

The results of this study showed no difference in physical activity between the two visceral fat groups. This is because this study only included subjects with light and moderate physical activity using the Global Physical Activity Questionnaire (GPAQ).[26] Therefore, it can be concluded that the difference in cognitive function found in this study was not influenced by physical activity. Physical activity can affect cognition because physical activity can stimulate the production of brain-derived neurotrophic factor (BDNF).[27] BDNF plays a crucial role in the cellular mechanisms involved in memory formation and maintenance by triggering synaptic consolidation, thus enhancing memory storage. Additionally,

BDNF can increase neurogenesis.[19] Research on adolescent groups participating in aerobic exercise found an increase in serum BDNF and better working memory in those adolescent groups.[28]

The Difference in DSST Scores between Visceral Fat Groups

The Mann-Whitney test results showed a difference in DSST scores between the two visceral fat groups (p = 0.000). This indicates that visceral fat plays a role in cognitive function. The results of this study found that the DSST score in the normal visceral fat group was 57 (37-75) and in the high visceral fat group was 50 (45-52). A study of 140 students aged 20-30 using the DSST instrument found a mean score of 67.01 with the highest score of 89.34.29. Another study on subjects with an average age of 57.8 years using the DSST instrument found a mean score of 72.6. In that study, subjects with scores < 56.6 were categorized as having low cognitive function.[30]

Relationship between Visceral Fat and Cognitive Function

The Spearman test results on 73 study subjects yielded p = 0.000 and r = -0.561. Thus, it can be concluded that visceral fat is related to cognitive function with moderate strength of association. In other words, the higher the visceral fat, the lower the cognitive function. This study is consistent with the research by Ozato et al. On elderly subjects (minimum age 64 years) showing that subjects with excess visceral fat have lower cognitive function (orientation, concentration, attention, verbal memory, and visuospatial ability). This is because visceral fat is associated with the occurrence of white matter lesions that affect cognitive function.[8] The results of this study are also consistent with the research by Nguyen et al. which showed that adipocyte hypertrophy in obese individuals can increase the release of proinflammatory cytokines TNF-α, leptin, CRP, IL-1β, and IL-6. Cytokines IL-1β and IL-6 were found to disrupt neural circuits involved in memory and cognition. Increased levels of IL-6 and IL-12 cytokines trigger executive function impairment and processing speed. Increased levels of IL-1β, TNF-α, and IL-6 cytokines were also found in hippocampal tissue, leading to increased microglial activation and oxidative stress in the hippocampus.[31] According to Chiba et al., visceral fat accumulation can increase insulin resistance, inflammation, and microvascular diseases that are very dangerous for brain integrity and associated with decreased brain volume and increased white matter lesions, which are crucial for cognitive function.[9] Leoney et al.'s research shows a relationship between visceral obesity and white matter hyperintensity, which is a vascular risk factor for cognitive decline. White matter hyperintensity is associated with brain microvascular disease related to atherosclerosis, vacuolization, axonal degeneration, and tissue volume reduction. Structural damage to white matter due to visceral fat accumulation causes structural changes such as demyelination and increased water content in white matter.[32] This study was conducted according to the research design and procedures, but there were limitations: this study did not specifically determine the cognitive domain affected because the DSST questionnaire assesses cognitive function involving multiple domains.

CONCLUSION AND RECOMMENDATION

Based on the research results, it can be concluded that the higher the visceral fat, the lower the cognitive function of FM UPNVJ students. Further research is recommended to investigate the effects of exercise and diet interventions on visceral fat and cognitive function.

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