Review of the Effect of Sedentary Behaviour and BMI on Cognitive Decline in Young Adults

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ABSTRACT

Cognition is the process of identifying, selecting, interpreting, filtering, and using information that makes sense. It encompasses a complex function concerning the domains of memory, executive, attention, perception, language, and psychomotor. Consequently, impaired cognitive function in adulthood might potentially lead to a decrease in the function of daily activities, increase the injury risk, require the attention of caregivers, and increase death risk. In adulthood, this function is affected by education level, physical activity, sedentary behaviour, stress, disease history, history of head injury, and Body Mass Index (BMI). Physical activity plays an important role in brain health across all age groups, specifically among young adults, which is the peak of changes in certain cognitive abilities. Furthermore, it consists of sedentary behaviour, as well as very mild, mild, moderate, heavy, and very heavy physical activity. Watching television, sitting in front of a computer, driving a vehicle, sitting at work, playing, sitting while listening to songs are physical activities that include sedentary behaviour. Prolonged sedentary time potentially affects areas of cognitive function causing weaker executive function and slower processing speed. Currently in Indonesia, the adult age group above 18 years is still dominated by obesity and malnutrition problems. Meanwhile, both high BMI and obesity are associated with low-grade chronic inflammation and elevated pro-inflammatory cytokines, which explains the detrimental effects of cognitive function. This indicates a high BMI causes lower cognitive performance in the areas of attention and impulsivity compared to individuals with a normal value. The purpose is to review the effect of sedentary behaviour and BMI on-cognitive decline in-young adults. Journal searches are conducted by researchers by looking from various sources such as PubMed / NCBI, google scholar, science direct by entering the initial keyword sedentary behaviour, which is then followed by other keywords namely cognitive, body mass index, and young, adults. The result of this review is the effect of sedentary behaviour on the cognitive decline is due to different physiological responses at the molecular level in obese individuals or others with excess BMI which decreases cognitive function through several mechanisms such as low-grade chronic inflammation, brain structural changes, and changes in leptin levels. Conclusion based on a literature review is sedentary behaviour and higher BMI can decline the cognitive function.

Keywords: *Sedentary Behaviour; Cognitive; Body Mass Index; Young Adults*

1. INTRODUCTION

Cognition is the process of identifying, selecting, interpreting, filtering, and using information that makes sense [1]. Meanwhile, impaired cognitive function in adulthood is associated with decreased functioning of daily activities. It is, increased risk of injury, need for caregivers, and increased risk of death [2]. According to 2011 study by the Centers for Disease Control and Prevention, the prevalence of mild cognitive impairment in young adults was 4% in Iowa, 8% in Michigan and California, as well as [3] 40% in Vancouver, Canada [4].

Several factors affect cognitive function, namely age, education level, physical activity, stress, medical history such as head injury, and Body Mass Index (BMI) [5]. Physical activities is a pivotable role in brain health across all age groups ranging from energy expenditure, sedentary behaviour, mild intensity, to heavy intensity activity [6]. Furthermore, sedentary behaviour is an activity in a sitting or lying position with a value of < 1.5 METs (metabolic equivalent of tasks) [7]. The United States Department of Health recommends groups of individuals in early adulthood to engage in moderate to heavy intensity physical activity three days a week [6].

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Early adulthood or young adulthood is categorized as the age range between 18 to 25 years [9] and the peak age for changes in certain cognitive abilities [10]. Moreover, nutritional status is also important in early adulthood and usually monitored using BMI [11]. Presently, BMI is one of the anthropometric indices that are still used to determine a person's nutritional status [11]. According to the Basic Health Research in 2013, the prevalence of underweight adults was 8.7 %, overweight by 13.5%, and obesity by 15.4% [8], while the Ministry of Health in 2013 also stated that the adult age group above 18 years was dominated by obesity and malnutrition problems which were still high [1].

Based on the explanation above, this study aims to review the literature on sedentary behaviour and BMI by increasing the risk of cognitive decline in young adults. The results are expected to increase knowledge on how sedentary behaviour and BMI increase the risk of cognitive decline in young adults, as well as the prevention efforts to obtain maximum cognitive function.

2. METHOD

Journal searches are conducted by researchers by looking from various sources such as PubMed / NCBI, google scholar, science direct by entering the initial keyword sedentary, which is then followed by other keywords namely Sedentary behaviour, Cognitive, Body Mass Index, Young adults. Displayed about 42.600 results (0.12 seconds) and taken as many as 40 international journals for review.

2.1. Sedentary Behaviour

Sedentary behaviour is any character outside of bedtime that is indicated by the energy expenditure of ≤ 1.5 METs, including sitting, half lying down, or lying down [11]. METs is a unit that expresses the amount of energy released from a specific activity [1]. The 2013 Basic Health Research obtained the results of the proportion for the population with sedentary behaviour. The proportion for duration < 3 hours/day was 33.9%, for duration 3 – 6 hours/day was 42.0%, and for duration > 6 hours/day was 24.1%. The highest proportion of sedentary activity namely > 6 hours in the population aged more than 10 years was found in Riau Province, while East Nusa Tenggara Province has the lowest, which is 3.5% [8].

Physical activities categorized as sedentary behaviour include watching television, sitting in front of a computer, driving a vehicle, sitting at work, reading a book, playing a computer or video game, sitting while listening to a song, sitting on the phone, and playing a musical instrument [13]. The several factors that increase the incidence of sedentary behaviour are employment, demographic factors, age, and education level [14,15]. Sedentary behaviour tends to cause several metabolic diseases related with a lack of physical activity. Many studies explained the association between sedentary behaviour and the risk of other diseases, namely obesity, cardiovascular disease, and metabolic syndrome [16,17,18]. Sedentary behaviour patterns are measured objectively using accelerometers, inclinometers, as well as questionnaires [19,20].

2.2. Body Mass Index

Body Mass Index (BMI) is a measurement scale used in the health sector considering that various kinds of diseases and psychiatric conditions in humans are still widely associated with BMI values [21]. The World Health Organization (WHO) divides BMI into 5 categories [22].

Table 1 BMI Categories

BMI	Categories
<18.5	Underweight
18.5-22.9	Normal
23-24.9	Overweight
25-29.9	Obesity type I
>30	Obesity type II

BMI is often affected by several factors, likes physical activity, socioeconomic status, television ownership and viewing duration, as well as diet [22].

2.3. Cognitive Function

Cognitive function is a complex term involving aspects of memory, executive, attention, perception, language, and psychomotor functions. It is also defined as the procedure of processing sensory input in the form of tactile, visual, and auditory to be changed, processed, stored, and then used for perfect interneuron connection as well as sensory output [20]. Cognitive function has aspects commonly known as the cognitive domain, namely attention, memory, language, visuospatial ability, and executive function [20,23]. Various factors affect the cognitive function of an individual, namely age, education, systemic disease, physical activity, stress, head injury, and brain tumour [24,25,26,27,28,29,30]. The cognitive function might decline due to various reasons, thereby causing impairment. Cognitive impairment causes a decrease in brain function related to attention, concentration, calculation, decision making, reasoning, and abstract thinking. Impaired cognitive function ranges from Mild Cognitive Impairment (MCI) to dementia or Alzheimer's disease [31].

Cognitive function is assessed with a variety of instruments, the most often sed are The Mini-Mental State Examination (MMSE) and The Montreal Cognitive Assessment (MoCA), which are already available in the Indonesian version (MoCA-Ina). MMSE is the most often used to evaluate cognitive function because of its

convenience. The MoCA-INA score is more sensitive to detect MCI and also has a good correlation with the MMSE score. Both tests had comparable results but MoCA-INA showed lower average with wider range of scores [32].

2.4. Relationship between Sedentary Behaviour and Cognitive Function

At the cellular and molecular levels, physical activities consistent with the recommendations increase the release of neurotrophins and growth factors such as Brain-Derived-Neurotrophic Factor (BDNF), nerve growth factor, insulin-like growth factor 1, and vascular endothelial growth factor. Furthermore, neurotransmitters such as dopamine and serotonin as well as endocrine changes (glucocorticoids) are thought to affect the relationship between physical activity and cognitive function. Therefore, considering that sedentary behaviour is in contrast to physical activity, behaviour tends to modulate hemodynamic responses by adversely affecting blood vessel structure and function such as arterial stiffness, which in turn affect vascular health. Damage to blood vessels is also a factor in the incidence of Alzheimer's disease and dementia [33].

Study conducted by Nóbrega showed that physical activity and sedentary behaviour contributed to cognitive function. Moreover, moderate physical activity benefits working memory in young adults. This is in accordance in some areas, sedentary behaviour affects cognitive function and academic performance, specifically working memory [33]. In contrast, Boucard did not find correlation in cognitive outcomes between individuals classified as active and sedentary individuals in the young adult and young elderly age group [34].

2.5. Relationship between BMI and Cognitive Function

Higher score BMIs persons typically experience low-grade chronic inflammation and increased production of pro-inflammatory cytokines, which presumably explain the deleterious effects on cognitive function controlled by dopamine in overweight and obese BMI individuals. Other investigated mechanisms include structural changes in the brain, metabolic disorders in the brain, increased levels of leptin, and inflammation. Leptin levels are often elevated in overweight and obese individuals, as well as cause cognitive impairment. Furthermore, high levels of inflammatory proteins such as C-Reactive Protein (CRP) are also found in overweight and obese individuals [35].

Chauhan *et al.* showed differences in cognitive function between individuals with normal and high BMI [35], while Cook *et al* reported that individuals with higher BMI had lower cognitive performances in the realm of attention and impulsivity compared to others with normal BMI, although the overall results of cognitive function tests were still within normal limits [36].

3. DISCUSSION

Journal searches are conducted by researchers by looking from various sources such as PubMed / NCBI, google scholar, science direct by entering the initial keyword sedentary, which is then followed by other keywords namely cognitive, body mass index, young, adults, sedentary behaviour, cognitive, body mass index, and young adults. The selection of journals spanned the last 10 years by paying attention to and considering relevant topics, variable, methods, and approaches in research journal.

3.1. Sedentary Behaviour and Cognitive Function

Nòbrega demonstrated a mechanism which showed that physical activity and sedentary behaviour affect cognitive function. It was found that physical activity in line with the recommendations given increases several factors such as the release of neurotrophins and growth factors such as BDNF, nerve growth factors, insulin-like growth factors 1 (IGF-1), and vascular endothelial growth factors. Furthermore, Nóbrega stated that 5 weeks of physical exercise improved hippocampal-dependent task, executive function, and visuospatial memory, but not verbal memory and concentration [33].

Another study by Lee *et al.,* was conducted to recognize changes in serum BDNF results and cognitive function after running on a treadmill for 12 minutes. Cognitive function was measured using digit span, symbol-digit, choice reaction time, and vigilance task. The subjects' blood samples were taken up to 5 ml after resting for 10 minutes, while the Serum BDNF was determined using the ELISA method. The results showed that there were changes in the outcomes of cognitive function tests, working memory, and reaction time in both conditions, namely changes in visual search with the neck cooling method, as well as changes in memory in others that did not use neck cooling [37].

Furthermore, Hoang *et al.* demonstrated that young adults with prolonged sedentary time might be at risk of having a weak executive function and slower processing speed [38]. Meanwhile, Loprinzi stated that even one physical exercise produces better cognitive function test scores and also shows that different physiological responses occur molecularly in the body in response to sedentary behaviour as opposed to physical activity [39].

Edwards *et al.* showed that no statistically significant evidence was found on the effect of group interaction with time, namely decreased physical activity or increased sedentary behaviour within 1 week did not

affect cognitive function [40]. This was also supported by Boucard *et al.,* which reported that there was no significant difference in cognitive function between the group of young adults classified as active and the group that performed sedentary behaviour [34].

Several studies conducted on the results of declining physical activity on cognitive function show physiological mechanisms that explain the reduction in cognitive function. BDNF is also a major molecule involved in learning and memory [41]. The study conducted by Huang shows that physical activity increases the production of BDNF. Subsequently, BDNF infusion in humans improves the learning process, while the deficiency causes disturbances in the learning process. In other words, the increase in BDNF caused by physical activity is an important factor in the learning process mechanism [42]. The study conducted by Adriani shows that physical activity such as Brain Gym exercises sessions can increase plasma BDNF level in the elderly women[43]. Another study conducted by Imran shows the significant association between brain gym performed twice weekly for 60 minutes, during a time period of three months, and increased cognitive functioning [44]

3.2. BMI and Cognitive Function

In addition to sedentary behaviour, BMI has an important role in cognitive function. This study found that there is a relationship between obesity and the state of brain anatomy, as well as cognitive function [42]. Obesity in young adulthood increases the risk of cognitive dysfunction [45]. According to Chauhan *et al.,* another mechanism that best explains the effect of BMI on cognitive function is structural changes in the brain which potentially worsens brain atrophy, and leads to decreased Gray matter volume, as well as white matter hyperintensity [35].

Leptin also plays a role as a hormone found in body fat, that is supported by Chauhan *et al.* and Mathieu which reported that leptin levels tend to increase in overweight and obese individuals, thereby leading to cognitive dysfunction [35,46]. High levels of proteins inflammation for example CRP are also found in overweight and obese individuals, that is supported by Hillman which obtained lower cognitive function test results [47].

Study conducted in India [6] stated that the direct effect of adiposity in neural tissue is through inflammatory mediators produced by adipocytes and endocrine messengers that respond to food intake. Adipose tissue is a source of pro-inflammatory cytokines in people with obesity and also in because of the insensitivity of the receptor to the hormone leptin. People with obesity experience functional changes in adipose tissue caused by the interaction of genetic and environmental factors, leading to hypertrophy, hypoxia, and other processes of inflammation. [48].

Furthermore, Cook *et al.* in study on the association between BMI and cognitive function showed that person with normal and high BMI had cognitive function test results that were still within normal limits. However, there were differences in the results of cognitive function tests, where individuals with higher BMIs have lower cognitive performance in the realm of attention and impulsivity compared to others with normal BMIs [36]. This is supported by Bove *et al.* which reported that adiposity is not related to the executive domain of the cognitive function [49].

3.3. Sedentary Behaviour, BMI and Cognitive Function

Increased sedentary behaviour is associated with a variety of conditions such as high BMI or obesity, cardiovascular disease, and metabolic syndrome. The increase might be related to decreased energy expenditure, increased risk for insulin resistance, impaired insulin sensitivity, and abdominal fat accumulation. Apart from genetic conditions, several mechanisms also explain the effect of sedentary behaviour on abdominal fat accumulation, including low muscle activities such as sitting and watching television which potentially causes a positive energy balance because it is not balanced with a decrease in energy intake. Sedentary behaviour is also associated with high energy intake, which might alter adiposity. Furthermore, when physical activity is replaced with sedentary behaviour, it culminates in decreased energy expenditure and increasing body weight, thereby leading to obesity [17,22,50].

Obesity and high BMI are also factors that potentially decrease cognitive function. Although the potential biological pathways underlying the association between BMI and cognitive function are not clearly understood, there is some evidence from several studies conducted using experimental animals that explain related mechanisms such as disorder of insulin and glucose regulation, increased systemic and central inflammation, as well as increased brain atrophy [43,51,52]. Moreover, high BMI is associated with chronic low-grade inflammation and elevated pro-inflammatory cytokines, which explains the detrimental effects of dopamine-supported cognitive function [35]. Other possible mechanisms which explain the effect of BMI on cognitive function include structural changes in the brain such as worsening brain atrophy, decreased gray matter volume, and white matter hyperintensity [35].

Leptin is a hormone found in body fat and also plays a role as it influences obesity of the adipose tissue as an indication of the fat deposits in the body. Defects in the hormone cause excessive eating patterns which lead to

obesity. This means leptin levels are usually found to be elevated in obese individuals. Furthermore, obesity is often associated with leptin resistance due to an elevation in the hormone levels caused by an increase in fat mass which is not matched by a corresponding energy release and a decrease in appetite [35,46].

In addition to the hormone leptin, CRP levels are often found to be elevated in obese individuals. The highest CRP levels were found in individuals with increased total and visceral adipose tissues. Moreover, CRP levels in the blood circulation are also associated with the characteristics of the metabolic syndrome, meaning the more severe the metabolic syndrome, the higher the levels. Metabolic syndrome is also a risk factor for cognitive decline [44]. The involvement of interleukin 1β levels with adiposity and impaired cognitive function shows that inflammation, specifically low-grade, affects several brain functions, from early to the development of neurodegenerative, as well as psychiatric diseases related with cognitive function deficits and dementia [48].

4. CONCLUSION

The effect of sedentary behaviour on the cognitive decline is due to different physiological responses at the molecular level in obese individuals or others with excess BMI which decreases cognitive function through several mechanisms such as low-grade chronic inflammation, brain structural changes, and changes in leptin levels.

Further studies are needed on sedentary behaviour with cognitive function in young adult subjects because this age group is an important period for performing physical activities to achieve optimal cognitive function. Also, further studies are recommended to focus on physical activity criteria that targeting on cognitive and brain health such as frequency, duration, intensity, and type of physical activity. Another recommendation is for more clinicians, professionals, and students to examine the association between sedentary behaviour and BMI with cognitive function at the age of 18-25 years. This is expected to educate young adult individuals to carry out more physical activities and maintain BMI within normal limits to achieve optimal cognitive function.

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