

Original Research Article

Effect of obesity on cognitive function: a cross-sectional study

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Received: 08 March 2022

Revised: 29 March 2022

Accepted: 30 March 2022

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ABSTRACT

Background: Obesity is the leading cause of many health problems. It mostly affects the brain by cerebrovascular events, but since it is a chronic low-grade inflammatory state, inflammatory cytokines in blood alter neuronal function. The jolly-fat hypothesis says that obese people have better cognition as they have more fat storage which is required to make neurotransmitters. Many studies have been done to support each of the above hypotheses but most are done in the paediatric or geriatric populations which can have other confounding factors. Obesity can be easily treated with proper dietary interventions, exercise, pharmaceutical therapies, or surgical interventions. Thus, it was worth exploring as simple lifestyle changes might lower the incidence of cognitive disabilities.

Methods: This study was done on undergraduate medical students with a sample size of 120 (60 male and 60 female). Their body mass index was calculated after taking body weight and height. The cognition of subjects was studied using the Washington click reaction time test. This was correlated with body mass index using a t test to find a p value with a level of significance of 0.05.

Results: High body mass index is associated with poor cognition as the $p < 0.05$ (0.025006). There was no role of gender on body mass index or cognitive functions.

Conclusions: Obesity does affect the cognitive function in healthy adult populations with no comorbidities irrespective of the gender of the individual. More prospective studies with a more sensitive battery of tests can be done to further understand this.

Keywords: Body mass index, Reaction time, Jolly-fat hypothesis

INTRODUCTION

Obesity is one of the leading causes and a major risk factor for many diseases and health problems in the modern world. Its effects on various systems of our body and how it alters their normal function have been studied in great detail over the years. The effects on the central nervous system like cerebrovascular events have also been studied in detail but its effects on cognitive functions are not that well known and it can be an important etiological factor in many mental disorders which may severely affect brain functions and lead to disabilities. Since body weight and body fat content can

be easily modified with dietary interventions, physical activity, medications, and surgical interventions, it should be studied better as an appropriate intervention might lower the incidence of any probable cognitive disability.

The incidence of anxiety, depression, and mood disorders is more in obese people. The hypothesis placed forward is that there is altered fat metabolism in obese people leading to the release of pro-inflammatory cytokines in blood by adipose cells that may further lead to neuronal dysfunction and death.^{1,2} The vagus nerve can cause satiety or hunger by its action on the melanocortin-arcuate circuit and this circuit is altered by inflammatory

cytokines. The study also confirmed that there was a significant fall in neuroinflammation on giving central acting anticholinergics in dementia patients.³ McIntyre et al concluded in their article that treatment modalities like statins given for lowering serum cholesterol levels also effectively lower neuroinflammation.⁴ Similar to this Chen et al did a case-control study on an elderly population of 9257 and concluded statin use lowers the risk of dementia by 9% per year of drug use.⁵ Obesity is also a misbalance in the ratio of serum values of saturated and unsaturated fatty acids. A study conducted on obese children found more cognitive decline when compared to normal children of the same age group. There was also an increased response to taste cues hinting towards an addictive nature of the food, which might further accelerate weight gain.⁶ Hypertensive patients with metabolic syndrome and low HDL show cognitive decline in a cross-sectional study on the Indian population of age group 45-50 years.⁷ Similar to this another study by Waldstein et al concluded that obesity along with hypertension in otherwise healthy individuals leads to a decline in motor speed, manual dexterity and executive function.⁸

The jolly fat hypothesis says that cognitive function is higher in fat people as they have more storage of fatty acids necessary to synthesize neurotransmitters with sterol nucleus and is confirmed on a cross-sectional study by Zhang et al.⁹ The same hypothesis when applied on an elderly population of 721 individuals in South Korea by Han et al, over two years they found a less cognitive decline in obese men while there was more cognitive decline in obese women and normal weighted subjects. From this, we can conclude that gender affected the cognitive decline of individuals.¹⁰

Beta-amyloid is said to be correlated to Alzheimer's disease and in this study beta-amyloid was not aggravated by the fat metabolism of patients from which we can infer that body fat is not associated with the cognitive decline of Alzheimer's disease.¹¹ Another study stated that high adiponectin level was an independent risk factor for poor cognition in their overall study population but in the case of their obese participants, HbA1c was a better metabolic predictor of cognitive decline.¹²

Most studies were either having paediatric or geriatric populations who were at high chances of having CNS developmental anomalies or senile degeneration respectively. Our study was on the adult population within the age group of 20-25 years which lowered the risk of any co-morbidities and have completed neurological development.

METHODS

Study design

The study design was a cross-sectional study.

Study site

The study was conducted in N. K. P. Salve Institute of Medical Sciences and Research Centre and Lata Mangeshkar Hospital, Nagpur.

Sampling method

The sampling method used was convenient sampling method.

Duration of study

The study was conducted for a period of 2 months (July 2021-September 2021).

Sample size

The sample size was 120 out of which 60 were male and 60 were female.

Sample population

The sample population were undergraduate medical students of age group 20-25 years.

Inclusion criteria

Subjects willing to take part in the study; subjects who were calm, conscious and alert enough to do cognitive tests; subjects without any comorbid conditions like hypothyroidism, epilepsy, anemia were included in the study.

Exclusion criteria

Subjects who have undergone any major weight gain or weight loss in the last 6-8 months; subjects with any visual or neuromuscular limitations that might affect their ability to solve the test; subjects with a history of any major psychiatric disorders; subjects with a history of smoking or alcohol or any other drug addiction; subjects with a history of severe head injury; subjects on medication that can affect CNS function were excluded from the study.

Procedure

After taking informed consent of the study population and approval from the institutional ethics committee, the subjects had their height and weight taken to calculate body mass index. Then they were explained the procedure of the Washington click reaction time test.¹³ The subjects had to tap on the screen of their mobile phones or click the mouse of the computer as per the modality used (computer or smartphone) immediately after a visual cue was provided on the screen. The time interval between the appearance of the cue and response of the subject was recorded by the computer program with the least count of 1 millisecond. After 2 trials when

the subjects became familiar with the test, they were told to perform the test and an average of 5 readings was considered as their visual reaction time. Reaction time is the time elapsed between the presentation of a particular sensory stimulus and the consequent response to it. This measures the attention span, concentration, cortical arousal, and processing speed of the individual and can be a good indicator of the cognitive function of an individual. This is concluded in a study by Prabu et al who correlated fast reaction time with good academic performance in undergraduate medical and dental students in a medical institute in Southern India.¹⁴

Statistical analysis

The reaction time was correlated with their body mass index using a t-test with a level of significance of 0.05 and the p-value was calculated in EPI Info Software version 7.

RESULTS

Respondents' profile (Table 1)

Out of all 120 participants, 10 were underweight (2 male and 8 female), 17 were overweight (9 male and 8 female), and 36 were obese (20 male and 16 female) while the rest 57 (29 male and 28 female) had normal body mass index for Asian population according to the guidelines by the western pacific office of the WHO.¹⁵

Table 1: Respondents' profile.

Demography	Gender	Mean	SD	Mean	SD
Age (years)	Male	22.26666667	0.980929265	22.15833	0.921917
	Female	22.05	0.845083822		
Height	Male	170.8613333	9.400636054	165.4223	15.2326
	Female	159.9833333	7.091054615		
Weight	Male	69.7	14.68820388	64.03333	15.2326
	Female	58.36666667	13.56830457		
BMI	Male	23.73710635	3.853561759	23.224.3	4.251627
	Female	22.71094776	4.558094009		
Reaction time	Male	0.711395	0.203173135	0.735118	0.179825
	Female	0.75884	0.149227847		

DISCUSSION

Obesity is a modern-day pandemic and has many delirious effects on the human body. Obese people have more pro-inflammatory cytokines which affect the normal metabolism of body cells including neurons. This study mainly focused on its effects on the higher cerebral functions like cognition in a young population with no comorbidities or any significant confounding factors. We found that a high body mass index was related to significantly poor reaction time which is a good marker of the attention, concentration, cortical arousal and processing speed of an individual. Ward et al also did a cross-sectional study on a population of 117 individuals and concluded that obese people have a significantly low

Effect of obesity on cognition

The time taken to respond in the Washington click reaction time test was significantly more in people with high body mass index as the $p < 0.05$ ($p = 0.025006$). Thus, we can say that obesity does lead to a prolonged visual reaction time and has a negative effect on the cognitive aspects of our study participants with high body mass index as they have a significantly lower attention span, concentration, cortical arousal, and processing speed in contrast to study participants with normal body mass index.

Comparison between male and female participants

The study found that the average body mass index of male participants was $23.73710635 \pm 3.853561759$ kg/m² and that of female participants was $22.71094776 \pm 4.558094009$ kg/m². There was no significant difference in the body mass index of the male and female population as the $p > 0.05$ ($p = 0.100018$). The reaction time of male and female populations was also not significantly different as the $p > 0.05$ ($p = 0.102707$). The average reaction time of the male population was 0.711 ± 0.203 seconds and that of the female population was 0.7588 ± 0.1492 seconds. From this data, we can conclude that gender has no effect on the cognitive abilities of the subjects and is unrelated to body mass index.

brain volume. High mean arterial pressure and raised serum cholesterol levels directly lower the cognitive functions of the study population.¹⁶ In a longitudinal study on a geriatric population of 417, it was concluded that obesity leads to a fall in both long and short-term memory, processing speed, verbal and spatial abilities of the subjects.¹⁷ On contrary to this, Hou et al concluded that overweight subjects have a low risk of memory impairment at an older age as compared to individuals with normal body mass index.¹⁸ This was supported by Kuo et al who showed obese people had higher processing speed while overweight people had better memory and reasoning as compared to individuals with normal body mass index.¹⁹ A longitudinal study done by Fernando et al found that diabetes had a strong

association with cognitive decline but there was no significant association of obesity and cognition in his study population.²⁰ Similar to this, a continuation of the Framingham heart study was done by Elias et al on a population of 2123 individuals and they concluded that factors such as obesity or diabetes did not contribute to the change in cognition of an individual.²¹ A study done on a healthy adult population was able to associate some cognitive functions with body mass index while others remained unaffected.²² Similar to this, a cross-sectional study was done by Jagust et al showed a fall in brain volume and altered white matter hyper-intensities on t1 weighted image of MRI but could not correlate it with cognition.²³

Due to significant differences in study design, age group, sample size, sampling method, and cognitive tests used in our study when compared to other studies, there are differences seen between the results of our study and the rest of all the studies. Since this was a cross-sectional study for only 2 months, temporal effects of obesity on cognitive functions cannot be determined and a prospective study with a larger population and more sensitive battery of investigations including radiological and pathological correlation can be done. The study population had only 36 participants who were clinically obese, a larger cohort could result in more accurate results. Study participants were not screened for any existing health conditions that could alter the study results.

CONCLUSION

From our study, we can conclude that a high body mass index is directly linked with poor visual reaction time which is an important indicator of higher cerebral functions and it mainly affects attention span, concentration, cortical arousal, and processing speed. This is consistent with the hypothesis that suggested obesity can lead to more pro-inflammatory cytokines in the blood which in turn affect the metabolism of neurons in the brain. The gender of individuals is unrelated to their body mass index and cognitive. Most studies mentioned above show cognitive decline of obesity in older age but from this study we can conclude that cognitive decline due to obesity can begin at an early age.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Gandhi PP, Humaney NR. Effect of obesity on cognitive function: a cross-sectional study. *Int J Res Med Sci* 2022;10:1100-4.