



Does an increase in body adiposity negatively impact cognitive function?

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Abstract

Objective: Very few studies have conclusively demonstrated an association between the indices of adiposity and cognitive function. The objective of this study was to determine if there was indeed a correlation between the body mass index (BMI) and cognitive function in young south Indian male subjects.

Methods: The fifty participants who volunteered for this study were divided into five groups based on their BMI. Individuals with a BMI under 18.5 kg/m² were placed in the first group, those with a BMI between 18.5 to 22.9 kg/m² were placed in group two, individuals with a BMI between 23 to 24.9 kg/m² were in group three, subjects with a BMI between 25 to 29.9 kg/m² were included in group four and those with a BMI equal to and above 30 kg/m² were included in group five. The subjects were all required to complete a set of cognitive function tests that included letter cancellation (LC) and Digit symbol substitution test (DSST). Spearman's Correlation Coefficient (ρ) was used to analyse the data.

Results: In Group two, there was a statistically significant negative correlation between the BMI and (ρ -0.474, p-value 0.022). There was a negative correlation between BMI and the DSST in groups 1,2,4 and 5 although it was not statistically significant ($p > 0.05$).

Discussion: The results seem to imply that as the BMI increases there is a corresponding dip in cognitive function.

Keywords: Body mass index, cognitive function, adiposity, Spearman's correlation, South Indian males

Introduction

The correlation between cognitive function and indices of adiposity such as body mass index (BMI) is far from clear. Although several studies have demonstrated that a higher than normal BMI was associated with impaired cognitive function ^[1], others conclude that individuals with a higher BMI actually have better cognitive function ^[2]. Some researchers are of the opinion that underweight individuals have relatively worse cognitive function as compared to those of normal weight ^[3], while others are of the view that there is no correlation whatsoever between BMI and cognitive function ^[4]. In an endeavour to establish a conclusive relationship between BMI and cognitive performance, the present study turned to seldom employed tests of cognitive function such as letter cancellation and Digit Symbol Substitution Test (DSST). Although these are simple and sensitive cognitive function tests, very few studies, if any at all, have investigated the association between these parameters and indices of adiposity such as the BMI. The purpose of this study was to explore a relationship between the BMI and cognitive function in young south Indians, a demographic group not extensively investigated in studies of this nature

Methods

1. Study design

This cross-sectional study was conducted between the years 2009 and 2010 at Pondicherry Institute of Medical Sciences (PIMS), Pondicherry south India.

2. Inclusion and exclusion criteria

Fifty healthy male volunteers between the ages of 18 and 25 were considered for this study.

Those with systemic illnesses such as Diabetes and Hypertension, neuromuscular diseases and sleep disorders were excluded.

3. Ethical approval

Clearance was obtained from the research and ethical committees of the institute and a written consent was obtained from each participant. All procedures were performed in accordance with the principles stated in the Declaration of Helsinki of 1975 that was revised in 2013.

4. Procedure

The recordings were performed at the same time of the morning in the Department of Physiology. The height was determined with the help of a stadiometer and the weight was recorded by a digital scale. The BMI was subsequently calculated. Depending on the BMI, the subjects were slotted into one of five groups. Underweight individuals with a BMI under 18.5 kg/m² were placed in the first group, those with a BMI between 18.5 to 22.9 kg/m² were placed in group two, overweight individuals with a BMI between 23 to 24.9 kg/m² were in group three, obese subjects with a BMI between 25 to 29.9 kg/m² were included in group four and subjects with a BMI equal to and above 30 kg/m² were included in group four. The participant's cognitive function was later determined using the following tests.

Letter Cancellation

The participant was provided with a sheet of paper with jumbled English letters printed on it. The investigator read out random letters and the participant was required to tick the letter called out as quickly as he could. The time taken to do so was noted.

Digit Symbol substitution test (DSST)

The subject was presented a paper with numbers printed on it. The subject was instructed to draw appropriate symbols over even and odd numbers. The time taken to do so was noted using a stopwatch.

5. Statistical analysis

Spearman’s Correlation Coefficient test was used to analyse if the two variables, BMI and cognitive parameters, were correlated with one another or not.

Results

The fifty participants were divided into five groups based on their BMI. Underweight individuals with a BMI under 18.5 kg/m² were placed in the first group, those with a BMI between 18.5 to 22.9 kg/m² were placed in group two, overweight individuals with a BMI between 23 to 24.9 kg/m² were in group three, obese subjects with a BMI between 25 to 29.9 kg/m² were included in group four and subjects with a BMI equal to and above 30 kg/m² were included in group five. Figure:1 depicts the distribution of mean, standard deviation and standard error for the BMI in all 5 groups [Figure:1 Near here]. The correlation between BMI and the cognitive function tests, Letter cancellation (LC) and DSST, is indicated in Table :1. In Group two, there was a statistically significant negative correlation between the BMI and LC, as evidenced by a Spearman’s

correlation coefficient rho value (ρ) of -0.474 and p-value of 0.022 (p ≤ 0.05). In the other groups there was no statistically significant correlation between the BMI and LC. There was a negative correlation between BMI and DSST in groups 1,2,4 and 5, although it was not statistically significant (p>0.05). In group three, there was a positive correlation between the BMI and DSST, which did not reach significance (p value = 0.125) [Table:1 Near here].

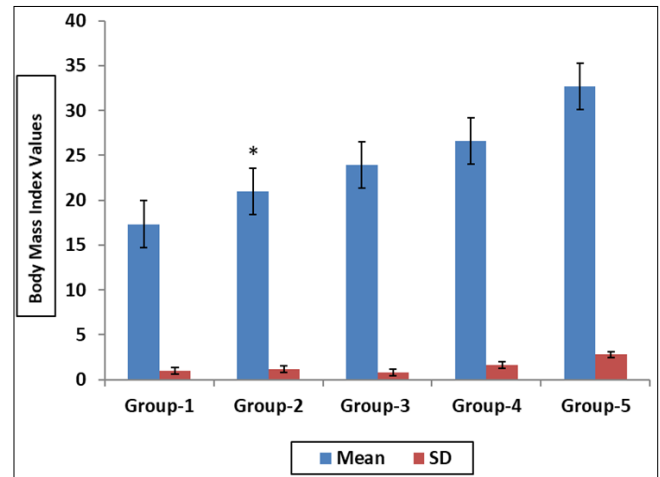


Fig 1: Mean, standard deviation (SD) and standard error of body mass index

Table 1: Anthropometric parameters and correlation between BMI and LC, DSST in Groups 1 to 5

	Age Mean ± SD	Height Mean ± SD	Weight Mean ± SD	BMI Mean ± SD	Correlation between BMI and LC		Correlation between BMI and DSST	
					(ρ)rho value	p - value	(ρ)rho value	p - value
Group – 1 (n = 7)	19.00 ± 1.53	1.67 ± 0.04	48.43 ± 4.47	17.33 ± 0.99	0.037	0.937	-0.500	0.253
Group – 2 (n = 23)	20.70 ± 2.77	1.68 ± 0.05	59.09 ± 4.96	20.98 ± 1.19	-0.474	0.022	-0.371	0.082
Group – 3 (n = 11)	21.82 ± 3.09	1.67 ± 0.04	66.00 ± 3.69	23.94 ± 0.77	0.438	0.178	0.487	0.128
Group – 4 (n = 6)	22.33 ± 2.88	1.65 ± 0.02	72.33 ± 3.88	26.62 ± 1.64	-0.455	0.364	-0.696	0.125
Group – 5 (n = 4)	21.00 ± 3.46	1.67 ± 0.03	91.50 ± 8.35	32.70 ± 2.78	0	1.000	-0.600	0.400

(ρ)rho: Spearman’s Correlation Coefficient. DSST (Digit symbol substitution), LC (Letter cancellation). Bolded p-value was statistically significant (ρ)rho value ‘0’ indicates ‘no’ correlation.

Discussion

1. Summary of main findings

Letter cancellation (LC) and Digit Symbol Substitution Test (DSST) are simple and yet sensitive cognitive function tests. Letter cancellation is a pencil and paper test widely used in clinical settings as a quick measure of concentration and cognitive ability. DSST is a cognitive function test that involves substituting an appropriate symbol for a number. The time taken for DSST is influenced by the age of the subject [5, 6], alcohol intake [7,8], and educational status [9]. In the present study, although most results were not statistically significant, the results seem to indicate, overall, a negative correlation between the BMI and cognitive function parameters. Although several previous studies have been performed to investigate a possible correlation between the BMI and cognitive function, the association remains inconclusive at best.

2. How and why it agrees with existing literature

Most previous studies concur with the findings of the present study. These studies have demonstrated that a higher

than normal BMI was associated with impaired cognitive function [1,10]. Studies employing DSST as a test for cognitive function, reported that a higher BMI was associated with lower scores on the DSST [11]. Other researchers employing other tests of cognitive function including the Wisconsin card sorting test, had similar findings [12]. A study involving 39,153 participants concluded that a higher BMI in midlife was associated with faster cognitive decline later on in life [13]. Other studies have demonstrated that combating mid-life obesity may actually reduce the incidence of cognitive decline in later years [14]. It has been demonstrated that after bariatric surgery performance in cognitive function tests has improved [15].

Several explanations have been suggested to explain the apparent decline in cognitive function with increasing body adiposity which was documented in the present study and other similar studies. Imaging techniques have revealed that the impaired cognitive function encountered in obese individuals is associated with structural alterations in certain portions of the brain [16]. Volumetric analysis has

demonstrated a decrease in the overall grey matter volume in obese subjects [17]. Voxel-based morphometry using high resolution brain magnetic resonance imaging (MRI) in obese subjects demonstrated a decreased grey matter volume in the medial temporal, occipital and frontal lobes [17]. Other similar imaging studies have reported comparable results. High resolution MRI imaging in obese older subjects revealed grey matter atrophy in the left orbitofrontal, right inferior frontal, right para-hippocampal regions [18], thalamus and midbrain [19]. Studies have also shown decreased blood flow to the prefrontal cortex in overweight and obese individuals [20]. Several explanations have been offered to explain the occurrence of these structural and functional changes. One view is that comorbidities related to obesity such as hypertension and metabolic disturbances might alter brain function. Other researchers have demonstrated high levels of C-Reactive protein in obese individuals and are of the opinion that inflammation is probably responsible for the neuronal damage and consequent cognitive impairment in obese individuals [21].

A few other studies seem to indicate that individuals with a higher BMI actually performed better in tests of cognitive function as compared to individuals with a normal body weight [2]. The probable explanation is related to the level of myelination. Since the Myelin sheath is predominantly lipid in composition, a higher level of lipids in the body could possibly result in better myelination. On the other hand, there are researchers who have demonstrated quite the opposite. A study involving 6,372 older adults demonstrated that underweight individuals had relatively worse cognitive function as compared to normal weight controls [3]. Other researchers concur [22, 23]. There are other studies which seem to indicate that both an increase and decrease in body mass index as compared to normal is associated with poor cognitive function [24]. Other studies, however, have concluded that there is no correlation whatsoever between BMI and cognitive function [4].

3. Implications for future research

The implications of this study are quite clear: an increase in body adiposity can adversely affect central neuronal processing and potentially result in structural changes in the brain down the line.

4. Strengths and weaknesses

The authors are of the opinion, in retrospect, that a study involving a larger sample size involving subjects of both genders and employing a larger battery of cognitive function tests would have been more conclusive.

Biography of authors

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Dr Syce is currently employed as Professor in the Department of Physiology at Sri Lakshminarayana Institute of Medical Sciences, Pondicherry, India. He was previously the HOD In-charge department of Physiology at JIPMER Karaikal for a period of seven years. Dr Syce has an MBBS (from JIPMER) and a MD degree in Physiology. He has been teaching Physiology ever since he completed his MD more than 14 years ago

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Authorship confirmation statement

The first author (Dr Syce) was responsible for the conception and design of the study, performed the recording of data and its interpretation and was also responsible for the writing of the manuscript. The statistical analysis was performed by the second author. This manuscript represents original material that has never been published before and is not under editorial consideration elsewhere, in whole or in part. This manuscript will not be submitted elsewhere while under consideration for publication by International Journal of Medical Science and Clinical Research (IJMSCR)

Guarantor and Corresponding author

The first author (Dr Syce) will be the guarantor and corresponding author

Data availability statement

The data that support the findings are available with the corresponding author upon reasonable request.

Disclosure statement

The authors report that there are no conflicting interests to declare

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Conclusion

While it is a well-established fact that obesity may lead to complications such as hypertension, Type II Diabetes and metabolic disturbances, its potential neurological adverse effects are not that well documented. In the present study, although most results were not statistically significant, the results seem to indicate, overall, a negative correlation between the BMI and tests of cognitive function. This seems to imply, on the whole, that as the BMI increases, there is a corresponding dip in cognitive function in young adult males from south India.

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