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Association between Working Memory and Obesity among Secondary School Children

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Authors' contributions

This work was carried out in collaboration among all authors. Author AS designed the study. Author SDC performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors MK and BV managed the analyses of the study. Author CH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Obesity is not just a term but a threat faced by the younger generation. It affects the vital systems of our body and very importantly impairs the cognitive functions of our brain. Lack of exercise, lethargy, increased usage of electronic gadgets is some of the notable reasons for childhood obesity. This study has been designed to find out how obesity is playing a role in a child's short term memory skills.
Materials and Methods: A Cross sectional epidemiological study was conducted among 125 secondary school children from random urban south Indian population. The students were asked to fill in their general details along with height, weight, hip circumference, waist circumference and asked to play a set of matching games and put in their score to measure working memory.
Results: Association between corresponding memory task scores and BMI indicates a strong negative correlation (r = -.008) and (r = -.07).
Conclusion: The present results therefore indicate that there is an association between obesity and poorer working memory performance in secondary school children. Therefore to conclude, the

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extent to which children are physically active is influenced by a multiple and interrelated factors. Addressing physical inactivity and its contribution to childhood overweight obesity requires a broad and holistic approach.

Keywords: Obesity; working memory; waist-hip ratio; BMI.

1. INTRODUCTION

Childhood obesity is a significant problem all around the world, yet current childhood obesity prevention programming approaches have limited efficacy. In this rising era of technological evolution and adverse lifestyle modifications, Incidence of obesity is said to be an increasing trend among school-going children [1]. The increased urge to eat junk foods which are significant less nutritious, spending more time on social media and mobile games, confined posture, have not only decreased the amount of body workout and fitness but have also lead to increased appetite in turn leading to obesity [2]. Studies also suggest that obesity in turn could be influenced by various hormones like ghrelin and GLP-1 [3]. Obesity is chiefly the key factor to early cardiovascular, metabolic problems and other cognitive impairments among young people [4]. Among the various categories of memory, obesity primarily affects working memory [5].

Working memory or short term memory is predominately associated with the temporary storage and retrieval of all kinds of information [6,7]. It mainly involves the areas in the prefrontal cortex of the brain [8]. Working memory is one of the most central executive function skills that develop rapidly during the early childhood years and continues to develop throughout later childhood, and it is most essential for preparing children to be successful in academics [9]. Recent studies have also proved that obesity has a direct effect on the cognitive functions generated by the prefrontal cortex [10,11]. Thus obesity poses to be a threat which should be addressed as earlier. Therefore it is important to evaluate the state of working memory in obese secondary school children. Therefore, the purpose of this study is to investigate and understand the relation between working memory in obese and overweight secondary school children.

2. MATERIALS AND METHODS

2.1 Study Setting and Design

This was a cross-sectional, correlational study. This standard questionnaire was done by 125 overweight and obese children have volunteered to participate in this study. A convenience sample of participants from 13 to 15 years was recruited from Medicine OP, Saveetha Hospitals. The questionnaire was administered through face-to-face contact by the investigator with potential participants. Potential participants who expressed interest in the study were screened for eligibility based on the inclusion/exclusion criteria. Inclusion criteria were as follows: ages from 13 to 15; BMI ranges between 26 to 35; WHR between 1.2 to 2; ability to read, speak, and understand english. Children with Attention deficit disorder, autism, cognitive dysfunction, Down's syndrome were excluded. After the inclusion/exclusion criteria were applied, 125 secondary school children have received paper copies of the study's survey instrument. The study was conducted only with obese children only to focus on cognitive ability in these children. The questionnaire included about age, height and weight, hence BMI and waist hip ratio were calculated.

2.2 Procedure for Measurement of Height, Weight and Waist-hip Ratio

Shoes, bulky clothing, and hair ornaments were removed. The child was standing with feet flat, together, and against the wall. The legs were straight, arms were at sides, and shoulders were level. The child was standing with head, shoulders, buttocks, and heels touching the flat surface (wall). Using a flat headpiece a right angle with the wall and lower the headpiece until it firmly touches the crown of the head. Light mark was done where the bottom of the headpiece meets the wall. Then, using a metal tape, from the base on the floor to the marked measurement on the wall was measured to get the height measurement. The height to the nearest was accurately recorded. To measure weight, the child was asked to remove shoes and heavy clothing, such as sweaters and asked to stand with both feet in the centre of the scale. The weight to the nearest decimal fraction was recorded. Waist Circumference was measured using an inextensible measuring tape at a point midway between the costal margin and the iliac crest (anterosuperior iliac spine) with the subject

standing and breathing out. Hip circumference was measured at the gluteal prominence, and the waist-hip ratio was calculated.

2.3 Procedure

Cognitive function test to measure working memory :

1. (WOM-REST) Picture matching:

In this task, the maximum time limit given was 3.00 minutes and the maximum number of tries was kept within 70. The maximum score was 100. There were 20 cards with 10 pairs of different animal pictures. These cards were hidden before the beginning of the game and as the child starts the game the timer starts and for every wrong match the score keeps on decreasing as the number of tries keeps on increasing. The main objective of the game is to find out how well the child remembers the pictures he sees within a short span of time and matches the cards correctly with the respective pairs [12,13].

2. (WOM-REST) Colour Matching:

In this task, the maximum time limit given was 3.00 minutes and the maximum number of tries was kept within 90. The maximum score was 100. There were 22 cards with 11 pairs of different colours. These cards were hidden before the beginning of the game and as the child starts the game the timer starts and for every wrong match the score keeps on decreasing as the number of tries keeps on increasing. The main objective of the game is to find out how well the child remembers the colours he sees within a short span of time and matches the cards correctly with the respective pairs [12,13]. From the above two games the scores and the number of tries taken are tabulated and analysed for the further discussion.

2.4 Data Analysis

Statistical analysis was done using SPSS Version 25.0. Descriptive variables were reported (Mean with standard deviation, Percentage). Pearson's correlation analysis was used to assess correlations between BMI and the memory task scores. The significance level was set at 0.05.

3. RESULTS

Among 125 participants, the mean and SD for age, height & weight were calculated (Table 1). The questionnaire also consisted of details regarding physical activity academics related questions. Around 59.3% said that the children were not exercising everyday but fortunately around 89% of participants have reported an active participation in physical education training periods. Unfortunately the current research also found that around 79 % of population were not able to concentrate during lecture classes. Students also had studying difficulties (75.8%) and remembering difficulties (67%) (Fig. 1). Mean and SD for BMI, WHR, WOM-REST Picture matching score & WOM-REST Colour matching score are given in Table 2.

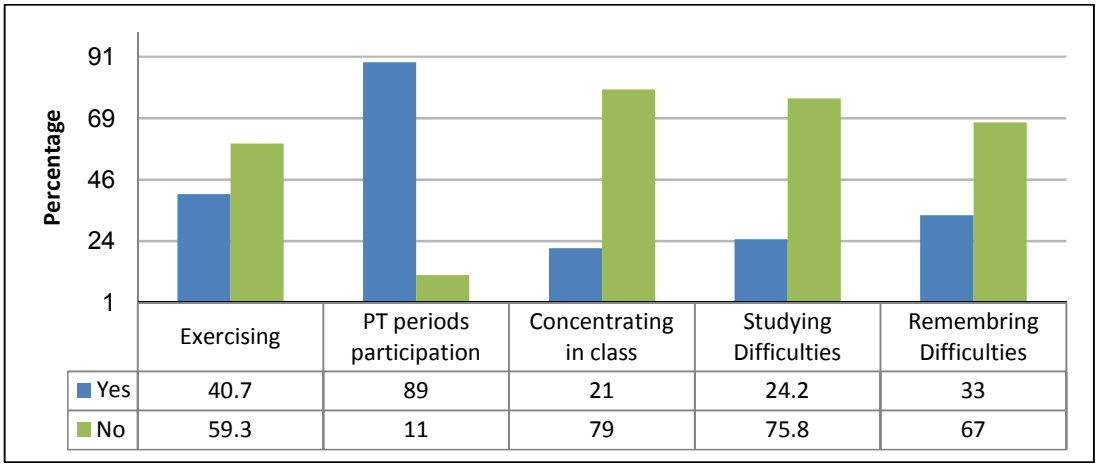

Fig. 1. Number of students exercising, Physical education participation, Concentrating in class, studying difficulties

Table 1. Demographic characteristics of the participants

	Mean	SD	Percentage
Age	12.95	2.48	
Class	8.21	2.73	
Height	135.89	45.1	
Weight	54.72	50.72	
Male			55.4
Female			44.5

Table 2. Summary statistics for BMI, WHR & working memory task scores

Scale	Mean	SD	SEM
BMI	24.16	4.95	0.5
WHR	0.99	0.40	92
WOM-REST Picture matching - Score	81.81	61.93	1.83
WOM-REST Picture matching – Tries taken	17.41	9.98	1.04
WOM-REST Colour Matching - Score	80.9	22.58	2.42
WOM-REST Colour Matching – Tries taken	18.85	8.74	0.91

Table 3. Correlations between BMI, WHR and memory task scores

Scale	WHR		BMI	
WOM-REST Picture matching test	r = - .35	p =0.0004**	r = - .22	p =0.034*
WOM-REST Colour matching test	r = .02	p = 0.783	r = - .12	p = 0.242

BMI and WHR were correlated with WOM-REST Picture matching score & WOM-REST Colour matching score (Table 3). There was a weak negative relationship between BMI and WOM-REST Picture matching test score (r = - .22; p =0.034*). There was also negative relationship between WHR and WOM-REST Picture matching test score (r = - .35; p =0.0004**).

Value shows a negative correlation between WOM REST picture matching test and WHR (p <0.0005) & BMI (p <0.05).

4. DISCUSSION

The present study has shown that obese and overweight children showed a negative correlation between waist-hip ratio and body mass index and WOM-REST picture matching test. A possible association between childhood obesity and poor academic performance was identified in the current study, as our results showed that decreased working memory partially facilitated the link between childhood obesity and poor concentration. Simply, the study has demarcated that children with overweight and obese has reported more worries about their memory, more forgetful-ness, and more use of strategies to ameliorate memory difficulties. Working memory represents the basic cognitive system in that it triggers the capacity to remember moment to moment information on activities and serves to allocate cognitive processing capacity to various other cognitive systems of the brain, according to need of a person [14]. There has been a clear overview concerning the helpful relationship between math, literature learning, and the demand on working memory. The study also added that working memory is increasingly involved in mathematical learning and problem solving [15].

Based on BMI data, children who are overweight or obese, fall in the category of global cognition, verbal fluency, delayed recall, immediate logical memory, and intelligence [16]. Other than BMI, other adiposity measures are also related to cognitive performance and brain changes. It has been shown that visceral fat deposition is inversely correlated with verbal memory and attention. Smaller hippocampus and larger ventricular volume is also associated with high visceral fat deposition [17]. A negative correlation was observed between waist-to-hip ratio and hippocampal volume and a positive correlation between waist-to-hip ratio and white matter hyperintensities [18]. Statistical parametric mapping has revealed a significant negative relationship between BMI and metabolic activity in prefrontal cortex (Brodmann areas 8, 9, 10, 11,

44) and cingulate gyrus (Brodmann area 32) but not in other regions [19-21]. These results further indicate the urgency of creating awareness on obesity in children.

5. CONCLUSION

Obesity has become a worrying health and social issue among children and adolescents. The current study also has shown that obese and overweight children had reduced working memory scores and concentration on studies. Obesity affects cognition mainly through altering the brain structures and functions and motor performance. The study would help the obese individuals to identify any early stage of cognitive impairment and create an awareness to delay or prevent any further metacognitive dysfunction. Regular physical activity and exercise benefits both cognition and motor behaviours among children.

6. LIMITATIONS

The small sample size from a single area of the country also limits generalizability. BMI measurements were independent of the quantity of total body fat and a number of potential confounders, including household income, physical activity, academic marks etc. The study did not differentiate working memory task scores between overweight and obesity. Future research is needed to investigate relationships between these cognition variables, objective neuropsychological tests, and functional MRI imaging. Research can be further extended to comparing below weight, normal, overweight and obese children.

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Self-funded.

CONSENT AND ETHICAL APPROVAL

The study proposal was approved by the board of the Saveetha medical college and hospitals (IRB No. SMC/IEC/2020/03/027). The purpose and objective of the study was clearly explained to the participants through an information sheet. It was emphasized that their participation was optional and the confidentiality of data was assured. The participants and their parents were requested to sign a consent form attached with the questionnaire, to ensure their willingness to participate in the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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