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Research Article

Effect of Obesity on Cognitive Function among School Adolescents: A Cross-Sectional Study

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Keywords

Cognitive function · Obesity · School children

Abstract

Objectives: Childhood obesity contributes to the risk of numerous health problems and has become a major global health concern. This study aimed to establish the association between obesity and cognitive function among healthy school adolescents. ***Methods:*** This study was carried out by taking school adolescents (*n* = 400) from June 2016 to December 2017. The mean age of the participants was 13.93 ± 0.81 years. The students were divided into group A (obese, *n* = 223) and B (non-obese, *n* = 177). Cognitive functions were recorded as per study tool of the Cambridge Neuropsychological Test Automated Battery (CANTAB). ***Results:*** Severely obese students showed a significant delay in cognitive functions as compared to students with normal BMI. Attention Switching Task (AST)-Latency among students with normal BMI was 647.88 ± 137.59 compared to the students with high BMI (685.08 ± 115.92, $p = 0.05$), AST-Incongruent was 680.78 ± 142.07 versus 726.76 ± 122.31 ($p = 0.02$), AST-Percent correct trials was 84.31 ± 10.45 versus 78.09 ± 14.87 ($p = 0.001$), and Intra-Extra Dimensional Set Shift (IED) Total errors among students with normal BMI was 33.93 ± 21.53 compared to the students with high BMI (42.86 ± 37.27, $p = 0.03$). ***Conclusion:*** Cognitive functions including AST-Latency, AST-Incongruent, AST-Percent correct trials, and IED Total errors were significantly weakened in markedly obese students. Significant impairments in their cognitive functions, especially attention, retention, intelligence, and cognitive flexibility, were observed. The findings of this study emphasize the need to involve school adolescents in physical activities to reduce body weight in order to have cognitive functions within normal range and also to minimize obesity-associated complications.

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Introduction

Obesity in childhood and adolescents is a serious community concern [1] of the 21st century. The magnitude of the problem is progressively affecting low-, middle-, and high-income states, mainly the urban population. The obese children are likely to stay obese into their adolescence and later part of their life. It initiates an ever-growing global epidemic, which affects children's current health and threatens their future health [2]. Worldwide, more than 1.9 billion adults 18 years and older are overweight and 650 million are obese. Over 41 million children under the age of 5 and 340 million children and adolescents aged 5–19 are overweight or obese globally [3].

School age, a period of strenuous growth because of a greater amount of activity and the development of physical and cognitive functions, requires a balanced nutrition. From the approach of neuropsychology, ample nourishment with physical activity is compelling for healthy brain growth, optimal learning, and scholastic performance [4]. A major change in lifestyle of families with eating habits and increasing hours of inactivity because of video games, social media, and computer has played a noteworthy role in enhancing obesity in school-going children who are overweight (body mass index [BMI] ≥25) or obese (BMI ≥30) [2]. The consequences of childhood obesity are its perseverance into adulthood with health-associated risks such as diabetes mellitus and cardiovascular and hormonal disorders [5]. The literature highlights the relationship of obesity with cognitive health impairment, but the findings are still unrevealed. Hence, the current study investigated healthy school-going adolescents and hypothesized that young children with obesity would have significantly lower cognitive functions.

Subjects and Methods

This descriptive study was carried out at the Physiology Department of the College of Medicine, King Saud University, Riyadh. The ethical review committee of the college approved the study protocol (IRB # CMED-305). All participants were well informed about the research purpose and written consent was obtained.

Four hundred and eighty healthy male school students, as convenient sample, were recruited with an age range of 12–15 years from four high schools located in Riyadh province. Students with known cases of chronic diseases such as diabetes mellitus, asthma, epilepsy, cognitive disorders, sleep disorders, vision problems, anxiety, attention deficit, skeletal muscle disorders, and those who had a history of sleep disturbance or were using sedatives were excluded from the study [6, 7]. Other exclusion criteria were students below 12 or above 15 years of age, who smoked or resided near the motorway or in highly polluted areas [8]. Based on the above criteria, 80 participants were excluded from the study, and finally, 400 students were recruited.

Each participant's height and weight were measured using portable digital weight floor scale and a wall meter, and BMI was calculated by the BMI equation, which is body weight in kg divided by the height in meters squared. They were grouped as obese (group A, n = 223) and non-obese (group B, n = 177) based on BMI.

Cognitive Function Tests

Cognitive function tests assess the three domains of cognitive health-processing speed, sustained attention, and executive functions [9]. We used a custom battery with tests available within the Cambridge Neuropsychological Test Automated Battery (CANTAB). Spatial Recognition Memory (SRM), Attention Switching Task (AST), and Intra-Extra Dimensional Set Shift

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Table 1. Demographic data of school adolescents (*n* = 400)

Parameters	Group A (*n* = 223)	Group B (*n* = 177)
Mean age, years	13.85±0.77	14.00±0.80
BMI	Obese, BMI 30.00–34.99 (*n* = 118) Severely obese, BMI ≥35.00 (*n* = 105)	Underweight, BMI <18.50 (*n* = 85) Normal, BMI 18.50–24.99 (*n* = 92)

BMI, Body mass index.

(IED) were used to associate the role of obesity with cognitive functions among the experimental and control groups.

The AST measures the attention and cognitive flexibility; intelligent behavior involves selecting task-relevant familiarity and decreasing interference from inappropriate information. The AST is fundamental to various cognitive tasks to adjust their behavior in harmony with changing task goals [10]. The IED is essential to cognitive flexibility and relies on frontal lobe function. It assesses the processes involved in categorizing the various stimuli into sets such as visual discrimination and responding flexibly shifting attention. The SRM task is a test of memory retention and visuospatial information; it is vital to measure the working memory for spatial stimuli [11].

CANTAB Test

CANTAB test version 6.0.37 is the standard computer software applied to recognize the cognitive functions across the life age. It distinguishes the performance of executive functions as positive and negative in both healthy and obese subjects. Both experimental and control subjects were briefed by a senior lab technologist on how the entire cycle of test would take place. The chosen subjects were asked to sit turn by turn and each individual performed the test in 30–35 min. Responses were recorded and observed by an academician as blind observer to reduce the biasness. The cognitive tests AST, SRM, and IED were recorded.

Analysis of Data

The data were analyzed by SPSS Statistical Package for the Social Sciences version 22. Independent *t* test was used to compare the mean values between the obese and non-obese groups and to associate the role of obesity with cognitive functions. p value <0.05 was taken as significant. The effect size was calculated using Cohen's *d* test; the effect size is small when $d = 0.2$, medium when $d = 0.5$, and large when $d = 0.8$ [12].

Results

Table 1 shows the distribution of group A (obese, $n = 223$) and group B (non-obese, $n = 177$) according to age and BMI values. The mean age of group A was 13.85 ± 0.77 and that of group B was 14.00 ± 0.80 years. The cognitive functions were significantly delayed in group A compared to the students of group B. AST-Latency among students with normal BMI was 647.88 ± 137.59 compared to the students with high BMI (685.08 ± 115.92, $p = 0.05$), AST-Incongruent was 680.78 ± 142.07 versus 726.76 ± 122.31 ($p = 0.02$), AST-Percent correct trials was 84.31 ± 10.45 versus 78.09 ± 14.87 ($p = 0.001$) and IED Total errors among students with normal BMI was 33.93 ± 21.53 compared to the students with high BMI (42.86 ± 37.27, $p = 0.03$) (Table 2–4).

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Table 2. Comparison of cognitive performance between normal and severely obese students

Cognitive test performance	Normal (*n* = 92) BMI 18.50–24.99	Severely obese (*n* = 105) BMI ≥35.00	Cohen's *d* value	*p* value
AST-Latency	647.88±137.59	685.08±115.92	0.29	0.05
AST-Congruent	622.04±137.65	655.88±119.16	0.26	0.07
AST-Incongruent	680.78±142.07	726.76±122.31	0.34	0.02
AST-Percent correct trials	84.31±10.45	78.09±14.87	0.48	0.01
IED Total errors	33.93±21.53	42.86±37.27	0.29	0.03
SRM Percent correct	72.46±12.04	71.51±14.38	0.07	0.62

Values are presented in mean ± SD. AST, Attention Switching Task; IED, Intra-Extra Dimensional Set Shift; SRM, Spatial Recognition Memory.

Table 3. Comparison of cognitive performance between normal and obese students

Cognitive test performance	Normal (*n* = 92) BMI 18.50–24.99	Obese (*n* = 118) BMI 30.00–34.99	Cohen's *d* value	*p* value
AST-Latency	647.88±137.59	690.93±168.12	0.28	0.06
AST-Congruent	622.04±137.65	664.67±172.15	0.27	0.06
AST-Incongruent	680.78±142.07	726.23±181.62	0.27	0.06
AST-Percent correct trials	84.31±10.45	80.33±14.27	0.31	0.03
IED Total errors	33.93±21.53	34.16±20.31	0.01	0.94
SRM Percent correct	72.46±12.04	69.22±16.38	0.22	0.12

Values are presented in mean ± SD. AST, Attention Switching Task; IED, Intra-Extra Dimensional Set Shift; SRM, Spatial Recognition Memory.

Table 4. Comparison of cognitive performance between normal and underweight students

Cognitive test performance	Normal (*n* = 92) BMI 18.50–24.99	Underweight (*n* = 85) BMI <18.50	Cohen's *d* value	*p* value
AST-Latency	647.88±137.59	645.93±133.78	0.01	0.92
AST-Congruent	622.04±137.65	617.84±131.64	0.03	0.84
AST-Incongruent	680.78±142.07	652.85±141.60	0.19	0.92
AST-Percent correct trials	84.31±10.45	85.25±12.26	0.08	0.59
IED Total errors	33.93±21.53	32.46±20.85	0.06	0.66
SRM Percent correct	72.46±12.04	69.56±14.56	0.21	0.16

Values are presented in mean ± SD. AST, Attention Switching Task; IED, Intra-Extra Dimensional Set Shift; SRM, Spatial Recognition Memory.

Cohen's *d* for AST-Correct latency was 0.29, for AST-Congruent 0.26, for AST-Incongruent 0.34, for AST-Percent correct trials 0.48, for IED Total errors 0.29, and for SRM Percent correct 0.07 between the groups; it shows the magnitude of effect size of obesity on cognitive function impairment (Table 2–4).

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Discussion

Cognitive functions, customarily divided into the various domains of perception, attention, recognition, memory, and executive functions [8], were the focus of this study. It was identified that the students with high BMI showed a significant delay in cognitive functions as compared to the students with normal BMI. The findings of this study support the concept that a high BMI affects attention, memory, and recognition, as found in other studies [13–15].

Obesity-associated negative effects on cognitive functions of the victims have been highlighted. Reduced memory, executive function, and increased impulsivity are some of the cognitive functions which appear as health consequence of obesity [16–18].

This study observed a potential link in cognitive function and obesity in children. The results of this study are in alignment with the findings identified by Raine et al. [19] and Cook et al. [20], who showed that children and young women with obesity had lower cognitive functions, across the memory and executive functions and impulsivity domains. The findings of this study are consistent with those published that administered the same tool on preschool or young female. In this study, the cognitive functions of male children were assessed and similar results were found. This is evidence that the obesity has played the same role in brain growth in both genders. However, the mechanism is unknown.

Although some studies found that obesity affects cognitive function, other studies suggested that cognitive function in healthy children and adolescents is not associated with high BMI [21–24]. However, in other previous studies, the obese group, relative to the non-obese group, showed a weaker inhibitory control of attention in the visuospatial attention task. In addition to that, the obese group in another study showed impaired performance on a decision-making task [25].

Attentiveness was significantly lower in obese adolescents. Studies reported a lower attention in young obese women compared to non-obese controls [9, 26]. This is evidence that cognitive function is altered by obesity, no matter if male or female. However, how much the magnitude differs in both genders is the issue further to be investigated. Literature connecting impulsivity and obesity is harmonious with studies detailing that obese individuals may have difficulty inhibiting a commanding attitude and delaying indulgence. Higher sensitivity is observed in obese individuals as compared to a normal-weight control group. High impulsivity associated to reduced weight control during treatment is also reported in some studies [27–29]. Therefore, weight management intervention may address deficiency in attention and impulsivity. In addition, overeating in obesity may be the cause of minimized inhibition and might explain the lower scores observed in obese teenagers in this study.

Strengths and Limitations

We made extensive efforts to adjust the confounding factors; still, there might be some residual confounding elements. This study has a relatively reasonable sample size, well-established research methodology, exclusion criteria, and reliable tools used to measure the cognitive function. The enrollment of male gender only is the limitation of this study due to the rules and regulations in Saudi Arabia, which does not allow co-education systems in schools and universities.

Conclusions

This study was designed to examine and compare cognition in obese and healthy school children. Overall, cognitive functions in markedly obese participants were in the lower range compared to healthy adolescents. They showed significant impairment in their cognitive functions. The results convinced us that school children with higher BMI should reduce their weight in order to have cognitive functions within the normal range. Some efforts from the schools aiming at increasing students' physical activity to help them control their body weight are recommended. This was the first study in school children in an Arab region investigating the association between uncomplicated obesity and cognitive functions of teenagers. The findings of noteworthy differences in cognitive functions reinforce the need for additional research across the BMI spectrum and how different cognitive limitations confront successful weight management.

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Statement of Ethics

The ethical committee, Department of Family Medicine, College of Medicine, King Saud University approved the study (CMED-305/2016).

Disclosure Statement

The authors declare no conflict of interest.

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