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# Examining the Relationship between Obesity and Memory Function in Female School Children of Riyadh, Saudi Arabia

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ABSTRACT

*Objectives:* The surge in the prevalence of childhood obesity has drawn attention to its impact on executive and cognitive functions. The adverse correlation between an increase in body weight and a fall in brain health is well reported in the literature. The study was done to examine the relationship between obesity and memory function in female school children in Riyadh, Saudi Arabia.
*Methods:* The participants of this study (8 to 12 years) were recruited from schools in Riyadh. The memory function test was done using a digit span memory model and a recall test was conducted using the lecture-recall technique. The data obtained was subjected to descriptive analysis and the impact of obesity on memory was interpreted using multiple and stepwise linear regression analysis (SPSS-IBM 23).
*Results:* A total of 611 female school children (average age, 10.3 ± 1.1 years) were included in this study. Around 57% of them were in the healthy weight category. The percentage of failures for students in the memory function test and the recall test were 15% and 11%, respectively. It is noted that with every increase in the BMI category (from underweight, healthy weight, overweight and obese), there was a decrease in working memory scores. The least decreased prediction of the score was found in the working memory food category. Tahfeez had a positive impact on working memory. In four of the five tests, an increase in age by one year had a positive impact, except for the recall test. Similarly, a change in school had a negative impact on recall tests.
*Conclusion:* Overall, a greater level of memory function deficit was noted in obese children. Also, obese children tend to remember food items more accurately, and there is a positive role for memorizing practice in functional memory.


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## 1. Introduction

The data from epidemiological and nutritional studies suggests there is a high prevalence of nutritional abnormalities in both developed and developing countries. Among many other nutritional diseases, obesity has reached epidemic levels in developed countries (Popkin and Doak, 1998). Globally, the level of obesity has increased by three times since 1975. During the year 2016, 650 million people were found to be obese and around 1.9 billion

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were overweight (World Health Organization, 2018). Obesity is the leading cause of death among all deaths due to malnutrition.

In addition to genetic influence, environmental factors play an important role in the spread of obesity. The prevalence is amplified by poor eating habits and a sedentary lifestyle (Ohta et al., 2001). Furthermore, it has been proposed that behavioral criteria (such as diet and physical activity), which are key causative factors in the development of obesity and an increased risk of chronic diseases, have their roots in childhood (McGill et al., 2000). Obesity is common among children in many parts of the world (Leon Guerrero et al., 2020; Buru et al., 2020). Similar to other developed nations, Saudi Arabia is also witnessing a high prevalence of childhood obesity with a slightly increased prevalence rate in girls than boys (21% compared to 17.4%) (Salman, 2018).

Obesity is a problem for people of all ages, but it is especially dangerous for children. It has a negative impact on growth and development. It is one of the most important public health issues of the twenty-first century. Obesity/overweight affects more than 340 million children between the ages of 5 and 19 years (World Health Organization, 2018). Specifically, developed countries have witnessed a phenomenal rise in the occurrence of childhood obesity during the last four to five decades (Sahoo et al., 2015). A large number of Saudi Arabian children are reported to be obese (World Health Organization, 2013). The proportion of obesity among adolescents and children, between 5 and 12 years, has reached up to 11.3% in Saudi Arabia (Musaiger, 2011). Childhood obesity continues to exist during adult life (Singh et al., 2008) and is associated with several metabolic and cardiovascular diseases (Mead et al., 2017). Apart from the health implications, obesity often has social and economic consequences (Gortmaker et al., 1993). Childhood obesity is harder to treat due to the scarcity of treatment choices (Al-Khudairy et al., 2017). Obesity is more common in girls than in boys, most likely due to hormonal deficiencies (Gupta, 2009) or a lack of physical fitness activities among girls compared to boys in the conservative Saudi Arabian population (Mora-Gonzalez et al., 2020).

Obesity has a negative relationship with psychological growth and health-related quality of life (Schwimmer et al., 2003) as well as neurocognitive (Prickett et al., 2015) and executive functions (EF) (Hayes et al., 2018). Inverse correlations exist between body mass index (BMI) and executive functions (Hayes et al., 2018). The skills of EF are a group of cognitive processes that give a definite shape to the cognitive and behavioral outcomes of a growing child (Wu et al., 2017). Working memory growth begins in early childhood and continues into adulthood, and it is regarded as a critical factor in a child's academic performance (Liew. 2012). Reading comprehension differences indicate differences in working memory ability, which eventually leads to differences in academic performance (Best et al., 2011). Working memory is an act of intellectual awareness that controls the ability to remember events of the past and process them based on future needs. Recent evidence suggests that WM training can enhance neurocognitive functioning and cognitive control (Brooks, 2016). Working memory thus serves as an indicator of academic performance. An earlier study found a link between students' poor mathematical ability and difficulties with working memory, which interferes with problem-solving ability and recalling relevant mathematical information (Raghubar et al., 2010). Given the importance of working memory in executive function and neuro-cognition, it is important to determine its possible role in children with obesity. Since working memory is an indicator of academic performance and obese children have a poor track record of academic achievement compared to non-obeses (Sabia, 2007), it is expected that there is a link between obesity and working memory. The primary focus of this research was to determine whether there is an association between body mass index (BMI) and the working memory of female school children. Expanding the focus of working memory causes a change in obese children, whether that change is task or domain-specific.

## 2. Methods

### 2.1. Sampling

Ethical approval for this research was obtained from the Research Committee of the College of Pharmacy, AlMaarefa University, Riyadh, Saudi Arabia (MCST (AU)-COP 1905/RC). To keep our study free from anxiety and examination stress for participating students, the study duration was kept between January and March 2019. According to Saudi Arabia's academic calendar, this period is relatively free of school examinations.

The sample size (3 8 4) required for our study was calculated (www.surveysystem.com/sscalc.htm) based on the population size (www.stats.gov.sa/ar/indicators/1) given on the Riyadh administration website for the number of female residents in the age group of 8–12. However, due to the good support and coordination of school management as well as the enthusiasm of school children, a total of 611 female study participants were recruited from several schools in Riyadh, Saudi Arabia.

### 2.2. Study procedure

After recording the age and educational level (class in which participants were studying), participating students were asked about their practice of tahfeez-al-Quran. Tahfeez-al-Quran refers to the memorization of the Holy Quran, the sacred book of Islam. It is a custom in the Islamic world to motivate growing children to memorize the Holy Quran, either completely or partially. After the necessary permission from school management, consent from parents, and assent from the participants, members of the research team recorded their weight and height. Participants were weighed in their light uniform clothes, without any badges or fittings, using an electronic scale (with a degree of accuracy of up to 0.1 kg) on an even, hard surface. The height of the participants was measured without shoes using a stadiometer placed on a hard, even surface. The BMI was calculated using the formula (weight)/(height in meters)$^2$. The cutoff of obesity was considered based on the International Obesity Task Force guidelines (Cole et al., 2000), a leading manual on education and advocacy related to obesity. It considers "overweight" for children aged 8 to 12 years to be a BMI of 21–23 kg/m$^2$, while "obesity" is defined as a BMI greater than 23.

### 2.3. Measuring tools

#### 2.3.1. The digit span memory test

The digit span memory test is a subtest taken from WAIS-IV (Zhang. 2009). It is a standard tool to measure immediate memory and working memory maintenance (Wu et al., 2017). The working memory developed in this study is adapted from a study done by Wu et al. (2017) with modifications. The image-generated working memory material was presented at the center of the computer screen with a series of recall sets. All participants in the study were given three types of sets, and each set had eight items to recall. The first set was made up of a series of numbers (sequences of numbers were shuffled) and participants were asked to write down the sequence of numbers which were presented to them in reverse order within a recall period of 5 sec/image. The second set had digits along with food or drink items. Participants were given 5 sec/image to recall the sequence of images in reverse order. The third working memory set had cartoons along with digits and students were made to recall them as described above. The scores obtained by students in each task were converted into percentages and further categorized into grades A through F, wherein grade A refers to a score of ≥90%, grade B, grade C, grade D, and grade F represent ≥ 80%, ≥70%, ≥60% and <60% scores respectively.

*2.3.2. Recalling ability on lectured items*

One of the research team members gave a brief lecture to the study participants for a total of 10 min on "Strategies to avoid the negative influence of social media" in a simple English language appropriate for the intended age group. The content of the lecture was checked for content and construct validation. The same speaker delivered the lecture for a similar duration with the same content throughout the study period in all sessions. Students' ability to recall was tested using 10 multiple choice questions developed based on the lecture delivered. The outcome of the students' performance was measured in the form of grades ranging from 'A' to D, as described in the digit span memory test above.

## 2.4. Statistical analysis

Descriptive analysis was done to ascertain the profile of the participants. Bivariate correlation analysis was done to check the correlation between demographic variables (age, study level, tahfeez, and type of school) and dependent variables (WMF < WMC, WMD, OWM, and RT scores). The impact of obesity on working memory and recalling ability was measured and interpreted using multiple linear regression analysis. All the statistical analysis was done using the SPSS IBM 23 statistical application. A P value of less than 0.05 was considered significant.

# 3. Results

## 3.1. BMI-based demographic characteristics of participants

Table 1 presents the comparison of the body mass index of the study participants with their demographic characteristics. Overall, out of the 611 participants, 122 children were found "obese (BMI, >23 kg/m$^2$)", and 108 children were categorized as "overweight (BMI, 21- <23 kg/m$^2$)". Three hundred fifty-one children were "normal weight (BMI, 18–21 kg/m$^2$)," while the remaining 30 were "underweight (BMI, less than 18 kg/m$^2$)" (Table 1). The average age of the participants in our study was 10.3 ± 1.15 (mean ± SD) years, with around 34% of them in an age group of 10–11 years (Table 1). Around 40% were level 5 students, and 57% were from a private school. Further, only 9.8% of the students were doing memorization of the Holy Quran in addition to their regular school curriculum. A significant relationship (P < 0.05) was noticed between BMI and tahfeez of the participants, as well as BMI and the type of the school (private vs. public) in which they were studying.

## 3.2. Frequency distribution for performance in working memory and recall tests

The percentage of failures (grade F) was 29.3%, 28.8%, and 31.3% in working memory digits (WMD), working memory food (WMF), and working memory cartoon (WMC), respectively. However, the failure percentage dropped down to 15.4% in the overall working memory score (OWM), indicating a variation in performance of students on each of the working memory tests. Further, only 10.6% of the students failed the recall test (RT), whereas 39.3% of the students' scored a grade A (Table 2).

## 3.3. Regression analysis with multiple variables

The P-P plots generated using SPSS IBM-25 showed linearity between the dependent variables, which are working memory food (WMF), working memory food (WMC), working memory digits (WMD), overall working memory (OWM), and recall test (RT) scores compared to BMI, study level, tahfeez, age and type of school. The deviation from linearity in the ANOVA output table for comparison of multiple independent variables with scores (dependent variable) was found to be greater than 0.05. Multiple regression was run to predict the scores of working memory food (WMF), working memory food (WMC), working memory digits (WMD), overall working memory (OWM), and recall test (RT) from

**Table 1**
Demographic variables and BMI of the participants.

| Demographics | Body mass index category, n (%) | | | | | P value* |
|---|---|---|---|---|---|---|
| | Underweight | Healthy-weight | overweight | Obese | Total | |
| **Study level** | | | | | | 0.626 |
| Level 3 | 9 (30) | 70 (19.9) | 16 (14.8) | 28 (23) | 123 (20.1) | |
| Level 4 | 2(6.7) | 49(14) | 12(11.1) | 19(15.6) | 82(13.4) | |
| Level 5 | 11(36.7) | 139(39.6) | 50(46.3) | 46(37.7) | 246 (40.3) | |
| Level 6 | 8 (26.7) | 93(26.5) | 30(27.8) | 29(23.8) | 160 (26.2) | |
| | 30 (4.9) | 351 (57.4) | 108 (17.7) | 122 (20) | 611 | |
| **Tahfeez** | | | | | | 0.006 |
| Yes | 8 (26.7) | 27 (7.7) | 10 (9.3) | 15 (12.3) | 60 (9.8) | |
| No | 22 (73.3) | 324 (92.3) | 98 (90.7) | 107 (87.7) | 551 (90.2) | |
| | 30 (4.9) | 351 (57.4) | 108 (17.7) | 122 (20) | 611 | |
| **Type of school** | | | | | | 0.045 |
| Private | 22 (73.3) | 186 (53) | 63 (58.3) | 78 (63.9) | 349 (57.1) | |
| Public | 8 (26.7) | 165 (47) | 45 (41.7) | 44 (36.1) | 262 (42.9) | |
| | 30 (4.9) | 351 (57.4) | 108 (17.7) | 122 (20) | 611 | |
| **Age (Years)** | | | | | | 0.529 |
| Upto 9 | 8 (26.7) | 84 (23.9) | 19 (17.6) | 35 (28.7) | 146 (23.9) | |
| Upto 10 | 7 (23.3) | 90 (25.6) | 27 (25) | 36 (29.5) | 160 (26.2) | |
| Upto 11 | 9 (30) | 123 (35) | 40 (37) | 37 (30.3) | 209 (34.2) | |
| Upto 12 | 6 (20) | 54 (15.4) | 22 (20.4) | 14 (11.5) | 96 (15.7) | |
| | 30 (4.9) | 351 (57.4) | 108 (17.7) | 122 (20) | 611 | |

*Pearson Chi-square test (2-sided); BMI formula = (weight)/ (height in meters) ^2; WMD: working memory digits; WMF: working memory food; WMC: working memory cartoon; OWM: overall working memory; RT: recall test.

**Table 2**
Frequency distribution for working memory and recalling tests.

| Tests | Grades achieved in test | Frequency | Percentage |
|---|---|---|---|
| Working memory digits | Grade A | 171 | 28 |
| | Grade B | 78 | 12.8 |
| | Grade C | 92 | 15.1 |
| | Grade D | 91 | 14.9 |
| | Grade F | 179 | 29.34 |
| Working memory food | Grade A | 166 | 27.2 |
| | Grade B | 21 | 3.4 |
| | Grade C | 119 | 19.5 |
| | Grade D | 129 | 21.1 |
| | Grade F | 176 | 28.8 |
| Working memory cartoon | Grade A | 195 | 31.9 |
| | Grade B | 23 | 3.8 |
| | Grade C | 106 | 17.3 |
| | Grade D | 96 | 15.7 |
| | Grade F | 191 | 31.3 |
| Overall working memory | Grade A | 112 | 18.3 |
| | Grade B | 112 | 18.3 |
| | Grade C | 138 | 22.6 |
| | Grade D | 155 | 25.4 |
| | Grade F | 94 | 15.4 |
| Recall test | Grade A | 240 | 39.3 |
| | Grade B | 147 | 24.1 |
| | Grade C | 96 | 15.7 |
| | Grade D | 63 | 10.3 |
| | Grade F | 65 | 10.6 |

BMI, age, study level, type of school and tahfeez (Table 3). The independent variables, including BMI, age, study level, tahfeez, type of school, produced a significant change in WMF, WMC, WMD OWM, and recall test scores.

The unsaturated coefficient (Table 4) of BMI shows a negative association of BMI with working memory scores. This means with every increase in BMI category (underweight, healthy weight, overweight and obese), there will be a decrease in working memory scores of 0.003, 0.021, 0.089, 0.045, and 0.084 in WMF, WMC, WMD, OWM, and RT respectively. The least decreased prediction of the score was found in the working memory food category. Tahfeez has a positive effect on working memory scores, with increases of 0.138, 0.159, 0.159, 0.031, and 0.070 in WMF, WMC, WMD, OWM, and RT scores, respectively. In four of the five scores, an increase in age by one year had a positive impact, except for the recall test. Similarly, a change in school has a negative impact on test recall.

### 3.4. Bivariate correlation analysis

The bivariate correlation analysis was carried out between demographic variables and dependent variables. The Pearson's correlation coefficient between age, grade, tahfeez, and type of school with WMF, WMC, WMD, OWM, and RT was less than 1 and was positively correlated (Table 5).

### 3.5. Analysis of stepwise linear regression

In addition to the multiple regression analysis, stepwise linear regression analysis was done to determine the role of individual independent variables on working memory scores. All demographic variables produced significant variations in their working memory scores. More than 11% of the variance in working memory food scores (WMF) was noticed due to the overall impact of the independent factors. A one-level increase in study level may result in an increase in the 0.419 WMF score; similarly, a change in school type, with or without tuition, and an increase in age by one year may result in increase in the 0.302, 0.138, and 0.030 WMF scores. On the other hand, a fall in WMF score is expected with an increase in one BMI category (underweight, healthy weight, overweight and obese). Table 6 also describes the predictors for WMC, WMD, OWM, and RT scores. An increase in the BMI category was negatively related to all the working memory scores. A negative association was also found between school type and recall memory test score (RT), similar to multiple regression analysis. Furthermore, there was a negative correlation between the working memory digit score (WMD) and the RT score.

## 4. Discussion

This study aimed to look into the impact of childhood obesity on female schoolchildren in Riyadh, Saudi Arabia's cognitive and executive functions. This research revealed three main findings: First, childhood obesity was found to be inversely related to the participants' working memory and recall abilities (Table 4). In addition, we discovered that, while overweight and obese children performed poorly in working memory tests, obesity has little effect on remembering food/eatables. Another interesting finding was that children who participated in tahfeez (memorization of the Holy Quran) have better working memory (Table 4).

Even though there is evidence of a negative association between childhood obesity and low academic performance (Datar et al., 2004), there is a lack of clarity on the precise reason for this relationship. One of the factors contributing to the lower academic achievement of students in school is a drop in self-esteem caused by excess body weight (Schwartz and Puhl, 2003). In addition to the hormonal and biochemical factors linked to childhood obesity, obesity-related stereotypes, discrimination, and prejudice are responsible for the majority of negative health and psychological outcomes (Guardabassi et al., 2018). In obese or over-weight infants, vulnerability to weight-related stereotypic danger begins early in life and can disable working memory (Guardabassi and Tomasetto, 2020). High body weight is linked to a reduction in brain volume, which results in smaller grey matter in the temporal, frontal, and occipital cortices, as well as the thalamus and midbrain (Shefer et al., 2013). The working memory feature is harmed by atrophied grey matter (Román et al., 2016). Working memory loss in children with a high body mass index is therefore regarded as a warning sign of gray matter loss. As a result, we discovered that obese children have trouble processing information, which is consistent with previous research.

**Table 3**
Multiple linear regressions analysis of variables.

| Dependent variables | F | R | R square | Adjusted R square | Standard error of the estimate | *P* value |
|---|---|---|---|---|---|---|
| WMF | 15.48 | 0.337 | 0.113 | 0.106 | 1.478 | 0.000 |
| WMC | 12.876 | 0.310 | 0.096 | 0.089 | 1.573 | 0.000 |
| WMD | 13.593 | 0.318 | 0.101 | 0.094 | 1.526 | 0.000 |
| OWM | 23.841 | 0.406 | 0.165 | 0.158 | 1.227 | 0.000 |
| RT | 30.156 | 0.447 | 0.200 | 0.193 | 1.218 | 0.000 |

WMD: working memory digits; WMF: working memory food; WMC: working memory cartoon; OWM: overall working memory; RT: recall test.

**Table 4**
Predictors of working memory scores.

| | WMF | | WMC | | WMD | | OWM | | RT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | B[1] | P value | B[1] | P value | B[1] | P value | B[1] | P value | B[1] | P value |
| Constant | 0.893 | 0.049 | 1.683 | 0.001 | 1.814 | 0.000 | 1.485 | 0.000 | 3.856 | 0.000 |
| Tahfeez | 0.138 | 0.512 | 0.159 | 0.477 | 0.159 | 0.465 | 0.031 | 0.859 | 0.070 | 0.685 |
| BMI | -0.003- | 0.960 | -0.021- | 0.776 | -0.089- | 0.215 | -0.045- | 0.433 | 0.084 | 0.141 |
| Study level | 0.419 | 0.000 | 0.417 | 0.000 | 0.464 | 0.000 | 0.494 | 0.000 | 0.429 | 0.000 |
| Type of school | 0.302 | 0.020 | 0.234 | 0.090 | 0.403 | 0.003 | 0.285 | 0.008 | −1.059- | 0.000 |
| age | 0.030 | 0.790 | 0.040 | 0.739 | -0.072- | 0.533 | -0.032- | 0.729 | -0.061- | 0.510 |

[1]Unsaturated Beta coefficient; WMD: working memory digits; WMF: working memory food; WMC: working memory cartoon; OWM: overall working memory; RT: recall test.

**Table 5**
Bivariate correlation analysis.

| Dependent variables | Age | | Study level | | Tahfeez | | Type of school | |
|---|---|---|---|---|---|---|---|---|
| | r[1] | *P* value | r[1] | *P* value | r[1] | *P* value | r[1] | *P* value |
| WMF | 0.282 | 0.001 | 0.320 | 0.001 | 0.253 | 0.001 | 0.161 | 0.001 |
| WMC | 0.268 | 0.001 | 0.302 | 0.001 | 0.221 | 0.001 | 0.159 | 0.001 |
| WMD | 0.243 | 0.001 | 0.291 | 0.001 | 0.161 | 0.001 | 0.166 | 0.001 |
| OWM | 0.332 | 0.001 | 0.391 | 0.001 | 0.152 | 0.001 | 0.173 | 0.001 |
| RT | 0.153 | 0.001 | 0.225 | 0.001 | 0.083 | 0.041 | 0.332 | 0.001 |

Pearson' r – i.e., the correlation coefficient; WMD: working memory digits; WMF: working memory food; WMC: working memory cartoon; OWM: overall working memory; RT: recall test.

**Table 6**
Step-wise regression analysis.

| Dependent variables | R square | Adjusted R square | Unsaturated B coefficient | Confidence interval | | P value |
|---|---|---|---|---|---|---|
| | | | | Lower | Higher | |
| WMF score | 0.113 | 0.106 | 0.893 | 0.004 | 1.781 | 0.049 |
| Study level | | | 0.419 | 0.209 | 0.628 | |
| School type | | | 0.302 | 0.048 | 0.556 | |
| tahfeez | | | 0.138 | −0.275 | 0.551 | |
| Age in years | | | 0.030 | −0.190 | 0.250 | |
| BMI | | | −0.003 | −0.140 | 0.133 | |
| WMC score | 0.096 | 0.089 | 1.683 | 0.737 | 2.628 | 0.001 |
| Study level | | | 0.417 | 0.195 | 0.640 | |
| School type | | | 0.159 | −0.599 | 0.280 | |
| tahfeez | | | 0.234 | 0.121 | 0.504 | |
| Age in years | | | 0.040 | −0.194 | 0.274 | |
| BMI | | | −0.021 | −0.166 | 0.124 | |
| WMD score | 0.101 | 0.094 | 1.814 | 0.897 | 2.732 | 0.001 |
| Study level | | | 0.464 | 0.248 | 0.680 | |
| School type | | | 0.403 | 0.141 | 0.666 | |
| tahfeez | | | 0.154 | 0.132 | 0.268 | |
| Age in years | | | −0.072 | −0.299 | 0.155 | |
| BMI | | | −0.089 | −0.230 | 0.052 | |
| OWM score | 0.165 | 0.158 | 1.485 | 0.748 | 2.223 | 0.001 |
| Study level | | | 0.494 | 0.321 | 0.668 | |
| School type | | | 0.285 | 0.074 | 0.496 | |
| tahfeez | | | 0.031 | 0.021 | 0.312 | |
| Age in years | | | −0.032 | −0.215 | 0.150 | |
| BMI | | | −0.045 | −0.158 | 0.068 | |
| RT score | 0.200 | 0.193 | 3.856 | 3.123 | 4.588 | 0.001 |
| Study level | | | 0.429 | 0.256 | 0.601 | |
| School type | | | −1.059 | −1.269 | −0.850 | |
| tahfeez | | | 0.070 | −0.270 | 0.411 | |
| Age in years | | | −0.061 | −0.242 | 0.120 | |
| BMI | | | −0.084 | −0.028 | 0.197 | |

WMD: working memory digits; WMF: working memory food; WMC: working memory cartoon; OWM: overall working memory; RT: recall test.

Another measure of cognitive function is recall ability. With a rise in body weight, cerebral white atrophy has been identified (Verstynen et al., 2012). Adipokines (Kershaw and Flier, 2004) are secreted as a result of increased activation of pro-inflammatory cytokines, which contribute to white matter anomalies. Overweight and obese children's recall abilities are hampered in part by white matter damage. Since childhood obesity is on the rise in Saudi Arabia (Musaiger, 2011), it's critical to focus on preventing it from spreading further.

As previously stated, obese children's poor cognitive performance was due in part to their impaired working memory and recalling ability. However, the level of working memory deficit in obese children for recalling food items was low in this study. When compared to other objects, obese and overweight children were able to remember items with food markings correctly. Obesity has been linked to higher responsiveness to food items in explicit memory tasks in the past (Hankin et al., 1998). Food cues such as thinking, smell, or sight of food products have been shown to improve obese people's mental efficiency by creating imagery, which allows them to quickly organize external information on specific food items into internal representative representations stored in an image or spatial schema (Geliebter and Aversa, 2003). As a result, obese people have an easier time recalling food-related things.

Memorization of the Quran has been related to better learning abilities in the formal educational system (Nawaz and Jahangir, 2015). We discovered that students who practice tahfeez perform better, which is consistent with previous research. However, since there were fewer students with tahfeez in this study (Table 1), additional research is needed to validate our findings.

Although the main goal of this study was to look into the effect of increased body weight on working memory, there are still several variables that need to be looked into to compare the impact of obesity on causing working memory changes. This research was conducted during an examination-free period during the academic year. The lower working memory was likely due to the laziness that students typically acquire during this time. As a result, a longitudinal study may have provided a solution to this issue. Furthermore, since this study only included female students, the conclusions drawn do not apply to everyone. Future research with greater sample sizes, both male and female participants, and consideration of additional factors will help to explain the connection between childhood obesity and working memory. Despite these limitations, this is one of the few studies conducted in Saudi Arabia to correlate the role of body weight in altering executive function in terms of working memory in female schoolchildren.

## 5. Conclusions

There is a negative association between body weight and working memory among Riyadh's female schoolchildren. The cognitive disorders of school children are domain-specific, and memorization practice improves executive performance.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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