Original Article

Cognitive Inhibition and Working Memory in Obese and Normal Women

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Article Info

Abstract

Background: The increasing incidence of overweight or obesity is a significant health problem. Hence, this study aims to investigate attention inhibition and memory function in obese and normal women.

Materials and Methods: This descriptive study was conducted from 2017 to 2018 in Ahvaz. A sample of 200 women referred to sports clubs was selected by the convenience sampling method. The tools included the Stroop test and the Working Memory Rating Scale (WMRS). The data were analyzed using SPSS (Version 23), the multivariate analysis of covariance (MANOVA), and the independent t-test.

Results: According to the results, the multivariate analysis of variance at the level of $P<0.001$ showed a significant difference between the mean scores of the obese and normal women. Also, there was a significant difference between the two groups in the portion of correct answers to the Stroop test ($P<0.001$). Findings indicated that obese women had a lower active memory level than normal ones ($P<0.001$).

Conclusion: In this study, the data analysis showed a higher body mass index in women to be associated with attention inhibition and memory function in the obese group. Therefore, the implementation of programs and the promotion of lifestyles that prevent obesity are considered protective factors.

Keywords: Inhibition, Working Memory, Obesity, Women.

Introduction

Obesity is a medical condition that affects millions of people globally; it is a serious health issue in the 21st century [1]. Obesity is the body fat accumulation that adversely affects physical and mental health [2]. Many studies confirm the link between obesity, premature death, metabolic syndrome, cardiovascular disease, and mobility disorders [3-5]. In order to measure obesity, a key indicator termed body mass index (BMI) (height/weight per square kilogram) is used. BMI of 30 is obese; however, the determinants of obesity vary from region to region [6]. Body mass index is associated with decreased cognitive function in communities (e.g., older people, middle-aged people, and young adults), especially in the areas of memory and executive function [7-9].

Evidence suggests that health and obesity issues (e.g., diabetes, high blood pressure, and obesity) have a significant impact on brain structure and function [10-12]. Executive performance plays a key role in regulating behavior, emotion, thought, and, consequently, self-control [13-14]. A significant correlation between high body mass and low cognitive function has been reported, indicating that higher body mass is associated with lower cognitive function [15-17]. Cognitive performance is a subset of executive performance that refers to a set of skills and processes related to self-management and the use of one's own

cognitive resources to achieve a goal (performing actions to achieve a goal) [16].

Recent studies on obese people also show dysfunctional performance characteristics in them [16-18]. Neuroimaging studies have shown functional changes in frontal lobes, anterior scissors, and thalamus/hippocampus of obese older individuals [19]. The prefrontal cortex is the brain's executive processing center, guiding cognitive flexibility, planning, and foresight. It is suggested that the prefrontal cortex, as a processing center, is ultimately the output of targeted behavior [20]. When this processing center, or connection to it, is disrupted, functional defects in cognitive flexibility, information processing speed, reasoning, and attention are observed. The hippocampus is the area of the brain involved in memory formation and spatial guidance, which is closely related to clinical obesity. Decreased hippocampal volume [19-20] and functional impairments in the memory of obese diabetics have been recorded [21].

An increase in the body mass index is associated with low metabolic activity in the forehead and decreased volume of gray matter [22-23]. Decreased gray matter volume is associated with poor executive function in obese women [24]. Working memory refers to the ability to temporarily store and manipulate information about needs. Memory resources seem to be vital to emotional decision-making, playing an ongoing role in assessing all aspects of good decision-making in general [25]. Further, cross-sectional evidence shows that, among midlife adults, higher circulating inflammatory markers are associated with higher BMI, poorer working memory and executive function, and lower hippocampal volume [26-27]. Given that the prevalence of obesity is approaching the epidemic level, its prevention can reduce the burden of significant public health consequences. From the literature reviewed above, it is clear that obesity is generally associated with reduced brain structure and function throughout the adult lifespan, and these associations probably have negative consequences on cognitive inhibition and memory function. Therefore, this study aims at investigating the cognitive inhibition and memory function in obese and normal women.

Materials and Methods

This study was descriptively conducted on all women exercising at sports clubs in Ahvaz city from 2017 to 2018. The convenience sampling method was used to select the subjects; thus, with the consent and collaboration of eight sports clubs,

25 people were selected from each. The sample size was calculated using Kennan's formula. A total sample of 159 was calculated and rounded to 200 to allow for a 10% non-response rate. Considering the number of obese females, a convenience sampling method was used to select eligible participants in the sports clubs. Hence, 200 women were selected as the study population. The inclusion criteria of the research were obese and normal women aged 18 to 48 referred to sports clubs of Ahvaz city. Indeed, the two groups were similar in terms of age. In this study, some characteristics, including marital status, education, and occupation, were recorded. According to the minimum sample size in the descriptive research, 100 individuals were selected for each group to increase the credibility of the investigation and 25 individuals for each variable to improve its normality [28]. Further, the researchers did not consider any criteria for the existing research, except for the satisfaction of the subjects. The authors guaranteed the confidentiality of all information obtained in this research. The researchers presented the necessary explanations to the participants. In addition, they recorded the participants' height and weight to calculate their body mass index. The data were analyzed by software after completing and collecting the questionnaires. The body mass index (BMI) was calculated using the formula of weight (kg)/height2 (m2). A BMI of 25.0 kg/m2 or more is overweight, while the healthy weight is within the range of 18.5 to 24.9 kg/m2. BMI applies to most adults 18 to 65 years old [29]. The tools included the Stroop test and the Working Memory Rating Scale (WMRS). MANCOVA (Multivariate Covariance Analysis) and independent t-test were used to analyze the data by SPSS (Version 23) (P <0.001).

The Stroop Color-Word Test: The Stroop test, developed by Spreen and Strauss10 (named VST), consists of three cards, 21.5 cm x 14 cm. These cards are presented to the subjects in this order: Card D (Dot), Card W (Word), and Card C (Color). Each card has six rows and four columns. Card D includes color dots (red, green, blue, and yellow); the participants are asked to name the colors of dots with a maximum speed possible. Card W includes words "this," "water," "to," and "up" in Farsi printed with red, green, blue, and yellow colors; the participants should rapidly name the color of the words. Card C includes color-words; the color of the words is red, yellow, blue, and green so that the color-words are printed with the incongruent color of the name (e.g., the yellow word is printed with green color), and the participants should rapidly name the color of the words. The naming order in all cards is in the

length of the rows and from left to right. The reaction time and the number of errors in each card are recorded for each participant, and the time difference and error between Cards C and D are calculated. The Stroop test contains three parts: word page (the names of colors printed in black ink), color page (rows of X's printed in colored ink), and word-color page (the words from the first page printed in the colors from the second page; however, the word meanings and ink colors are mismatched), each with 5 columns containing 20 items. The subject's task is to look at each sheet and move down the columns reading words or naming the ink colors as quickly as possible within a given time limit (45 seconds). Three scores, as well as an interference score, are generated using the number of items completed on each page, with higher scores reflecting better performance and less interference on reading ability. The Stroop test can be used on both children and adults (Grade 2 through adult) in approximately 5 minutes.

Interpreting the Stroop scores

- Word, color, and color-word T-Scores of 40 or less are considered "low." 3
- Word, color, and color-word T-Scores above 40 are considered "normal."
- For one score to be considered "higher" or "lower" than another, a 10 point or greater T-score difference is required.

In Iran, correlation coefficients by test-retest in Stroop test for Reaction times of three cards and reaction time interference are 0.86, 0.86, 0.93, and 0.64; and for errors of three cards and that of interference, they are 0.67, 0.37, 0.81, and 0.75, respectively [30].

The Working Memory Rating Scale (WMRS): This is a functional rating scale created by researchers in the United Kingdom to make it easier to recognize students with working memory deficits. WMRS consists of 20 brief examples of characteristic problem-based classroom activities of students with decreased working memory capacity [31]. In this study, the researchers have to rate how typical each behavior is of the participant on a 4-point scale, circling each of the 20 descriptions as 'not typical at all (0)', 'occasionally (1)', 'fairly typical (2)' or 'very typical (3)'. Once WMRS is completed, the total score is calculated by adding all 20 items together. Higher scores indicate greater working memory impairments. The raw scores are then converted to T-scores using the graph provided in the appendix of the WMRS manual. These scores describe the participant's performance with respect to the performance of others within the same age band. [32]. Based on interviews, researchers remove repetitive items and add extra items to explicitly identify various classroom activities that distinguish week and normal working memory children. Originally, a total of 417 children from elementary schools in England were engaged in a study to determine the reliability and validity of WMRS [33]. Schools were chosen from around the United Kingdom to include a representative sample based on regional evaluations. The study found a close relationship between all the WMRS problems, confirming the validity convergent. In addition, the analysis found that WMRS has internal reliability and systemic validity. In Iran, Cronbach's alpha reliability coefficient and split–scale reliability of this scale are 0.77 and 0.88, respectively [34]. The reliability coefficient for the full scale is calculated at 0.76 in the sample of the present study.

Results

According to Table1, the obese and normal individuals were each 97 (50 %) equally from among all study participants.

Table 1. The participants' demographic information in Ahvaz City, 2017

Variable	Group	Normal		Obese	
		%age	Frequency	%age	Frequency
Number	Female	50	97	50	97
Degree	Undergraduate degree	16.49	16	31.9	31
	High school diploma	32.9	32	38.1	37
	Associate degree	16.49	16	11.3	11
	Bachelor's degree	30.9	30	16.49	16
	Master's degree	3.09	3	2.06	2
Job status	Employee	16.49	16	5.1	5
	Self-employment	27.8	27	20.6	20
	Housewife	55.6	54	72.2	72
A History of obesity	Have a history of obesity	44.3	43	82.4	80
	No history of obesity	55.6	54	17.5	17
A history of diabetes	Have a history of diabetes	21.6	21	61.9	61
	No history of diabetes	78.4	76	37.1	36

Moreover, 19.6 % and 77.3 % of subjects were married and single, respectively. Similarly, 0.33 % of normal and 38.1 % of obese females had high school diplomas. In addition, 30.9% of normal and 16.5% of obese women had undergraduate degrees; 3.1% of normal and 1.2% of obese women also had graduate degrees. Most obese and normal women had high school diplomas. The data were analyzed using descriptive statistics after data collection.

Before analyzing the differences, we were assured of the box, Kolmogorov–Smirnov, and Levine tests as the necessary assumptions for MANOVA.

According to the Kolmogorov–Smirnov test, all the examined continuous variables were normally distributed. Also, according to the insignificance of Levin's test for all variables. Moreover, the insignificance of the box test implied the lack of homogeneous variance-covariance matrices.

As presented in Table 2, the difference between the two groups was significant (P <0.001), according to the dependent variables, with the difference (Eta) of 67%, i.e., 67% of the individuals' differences in executive functions were related to differences between the two groups.

Table 2. Results of the multivariate analysis of variance (MANOVA) for research variables

Presumptions	Size	F	Df hypothesis	Df error	Eta	P-Value
Pillai's trace	0.63					
Wilk's Lambda	0.36	13.49	22	171	0.67	< 0.001
Hotelling's trace	1.73					
Roy's greatest root	1.73					

As observed in Table 3, in the second level, as a deterrent measure (P < 0.001), there was a significant difference between the two groups in the portion of correct answers to the Stroop test. In other words, obese women had a lower average number of correct responses, or more accurately, a lower inhibition rate than normal women. In the

second stage of the Stroop test, a significant difference was observed between the two groups in the component of the unanswered number (P <0.001); however, there were significant differences between the two groups in the three components, i.e., the number of response error, time and action, and the interaction score.

Table 3. Multivariate analysis of variance (MANOVA) to compare the results of the components of the Stroop Color-Word Test in two groups of research samples in Ahvaz City, 2017

Variable		Group	Mean ± SD	Mean squares	Effect size	P-value	F
The first stage of the stroop test	Errors	Normal women	0.40±0.68	12.37	0.04	0.005	8.09
		Obese women	0.90±1.60				
	Unanswered	Normal women	0.52±0.90	220.87	0.14	< 0.001	30.55
		Obese women	2.65±3.69				
	Correct	Normal women	47.0±1.08	237.34	0.13	< 0.001	29.16
		Obese women	44.4±4.61				
	Reaction	Normal women	936.01±172.26	1773724.2	0.25	< 0.001	63.24
		Obese women	1127.24±162.53				
The second stage of the stroop test	Error	Normal women	1.03±4.87	254.04	0.04	0.006	7.67
		Obese women	3.31±6.51				
	Unanswered	Normal women	0.46±0.79	370.22	0.23	< 0.001	58.02
		Obese women	3.22±3.48				
	Correct	Normal women	46.45±4.90	`151.24	0.13	< 0.001	29.03
		Obese women	40.86±8.96				
	Reaction	Normal women	964.93±170.49	12564410.5	0.04	0.006	7.75
		Obese women	1473.91±1791.67				
	Interference	Normal women	0.80±5.00	247.22	0.03	0.01	6.55
		Obese women	3.06±7.10				

There was a significant difference between the two groups with respect to the active memory variable, according to the T obtained (P < 0.001), as

presented in Table 4. This indicated that obese females had a lower active memory level than normals.

Table 4. Independent t-test to compare obese and normal women in terms of active memory in Ahvaz City, 2017

Variable	Group	Mean ± SD	T	P-value
Active memory	Normal women	6.80 ± 1.57	7.006	< 0.001
	Obese women	5.17 ± 1.66		

Discussion

This study aims to investigate active memory and attention retention in obese and normal women. This research results indicate a significant difference between the two groups in the number of correct answers to the Stroop test in the second stage "as a deterrent indicator." This means that obese women have a lower average number of correct answers, or precisely, a lower rate of inhibition in responses than normals. Therefore, the results obtained are consistent with the researches of Deckers et al. [35], Demos et al. [36], and Vantieghem et al. [37], in which the performance of obese people in executive functions (inhibition) has been examined. Also, Cserjési [25] shows that the problem of obese people in constant attention and mental flexibility may be due to changes in inhibitory capacity. In explaining this finding, it can be said that since many components of executive functions, such as impulse control, self-observation, and goal-oriented behavior, are directly related to the ability to maintain energy balance and the failure to acquire these skills during growth, directly or indirectly, it is a risk factor for the development of obesity and its persistence [38]. Another explanation is that the problem of inhibition and cognitive bias is obese people's attention to the difference in their neural anatomy with the onset of age 15 [39]. There is a significant relationship between obesity and impairment in executive performance, i.e., planning, problem-solving, and mental flexibility compared to normative data [40]. Favieri & Casagrande [41], in a systematic review, show that cognitive regeneration therapy improves neurological abilities, including attention, memory, and executive function, in obese individuals. Increasing the level of cognitive function may help people make the right decision about lifestyle and stop the vicious cycle. Cognitive reconstruction therapy is effective in treating several diseases, such as anorexia nervosa, and also is helpful for people with overweight [41].

The results of this study indicate a significant difference between the two groups in the active memory variable. This means that obese women have a lower average of active memory than normal ones. This finding is in line with that of the research by Heyward et al. [42] and Farooq et al. [43]. Riggs et al. [44] show that the working memory of obese children is significantly weaker than that of healthy children. Similar to mental attention and flexibility, obese adolescents' working memory performance is significantly worse, even after IQ control, than those with a healthy weight [39]. In contrast, in the research of Reinert et al. [45], no significant difference is observed in EF domains, especially working memory, decision-making, and reasoning. The reason for the difference in findings can be attributed to a variety of experimental methods. According to the results of Cserjési [25], other studies show that obese people suffer from depression and anxiety, impairing their working memory.

In explaining this finding, it can be said that depression and anxiety cause poor performance in working memory. An international team of scientists reports that obesity significantly reduces memory and other features of thinking and reasoning, even among seemingly healthy people. At least some of these disorders appear to be reversible through weight loss [46]. According to previous research, obesity is associated with an increased risk of Alzheimer's disease and stroke. Weight gain is also associated with a long-term decline in cognitive function, even when dementia is not part of the picture. Based on the neuroimaging studies, people with BMI (more than 40) are at risk of cerebral atrophy, although these results are still controversial for younger age groups. In general, the findings of this study are consistent with all the research done in this area, showing that obesity can increase the risk of various cognitive problems.

One of the most important limitations of this study was disturbing variables, including divorces and infertility, which were uncontrollable. Furthermore, the age was considered an interventional variable, and nearly half of the participants did not mention their age; thus, this variable was omitted, creating another restriction for the research.

The risk of more weight gain in overweight people must be reduced, thus preventing severe obesity. In addition, an integrated approach that also takes emotion and mood control into account may be the best way to combat unhealthy eating behaviors and executive functioning. Therefore, an integrated theoretical model should be established that would collectively consider EFs, eating behavior, besides emotion and mood control, in obese people.

Conclusion

In this study, the data analysis shows that a higher body mass index is associated with attention inhibition and memory function in the obese group in women. Since obesity is a phenomenon linked directly to medical, psychological, and social problems, its investigation requires a multidisciplinary approach. Therefore, the implementation of programs and the promotion of lifestyles that prevent obesity are considered protective factors.

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