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Comparing cognitive and impulsive processes in obese and non-obese people

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Abstract

Introduction: Identifying the cognitive and behavioral factors that cause obesity and overweight, as well as the variables that affect the treatment process can help improve the treatment process of obesity and achieve long-term therapeutic results.

Materials and Methods: In this descriptive study in 2019, 100 female volunteers were selected using the convenient sampling method and divided equally into two groups: overweight and obese individuals and people with normal weight. G*Power software was used to determine the sample size in each group. In each group, positive implicit association, working memory capacity and impulsivity were measured.

Results: Results of the univariate analysis of covariance, by controlling the effect of age, showed the effect of group on positive implicit association figures (P=0.59, F=0.28,) and working memory capacity (P=0.74, F=0.10) was not significant. In other words, obese and non-obese groups were not significantly different in terms of positive implicit association, and working memory capacity. However, results were statistically significant for impulsivity variable (P=0.03, F=7.06).

Conclusion: The results of this study suggested that impulsivity, as a personality trait, plays a crucial role in the success or failure of dieters. Individuals with high body mass index, who are classified as obese, are more likely to experience impulsivity.

Keywords: Impulsivity, Obesity, Working memory

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Introduction

Obesity and overweight, defined as the accumulation of excess body fat, are risk factors for several chronic diseases such as high blood pressure (1), diabetes (2), musculoskeletal problems (3), and respiratory problems (4). Prospective studies have also shown the link between obesity in adulthood and cognitive disorders in old age (5). In addition, obesity appears to be associated with psychological pathology of disorders such as anxiety and depression (6) and social problems like bullying and social isolation (7). The most common risk factors associated with obesity are unhealthy eating habits and lack of physical activities (8), which causes a chronic imbalance between individuals' need for energy and energy acquisition (9). Obesity and its related problems impose significant costs on communities (8). Obesity is predicted to pose a

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significant threat to human health in the 21st century (10). It can be attributed to several factors, including genetics, hormones, metabolism, and behaviors (11). The importance of nutritional behaviors and obesity and their associated issues are among the serious problem of the present century. The prevalence of obesity or overweight has been rising in recent years. In 2014, there were more than 1.9 billion overweight adults, so that 18 goals introduced by the World Health Organization in the program of "Healthy People" are dedicated to obesity (10). From a public health perspective, effective interventions for the treatment of obesity are of paramount importance (12). Obesity management has been the subject of extensive debate. Since obesity is a complex and multifactorial phenomenon, serving as the leading cause or consequence and other biological, psychological, and social factors, its control and treatment are beyond the scope of a single discipline. Identifying empirically proven therapies can help establish the role of psychological interventions as a part of the interdisciplinary approaches to control and treat obesity (11). In clinical guidelines about the prevention and alleviation of obesity in children and adults published by Canadian Clinical Practice in 2006, a qualified team for management and alleviation of obesity includes a doctor of medicine, a diet provider, a sports counselor, and a psychologist (13). Many overweight people receive various treatments such as diet therapy because even conscious willingness to follow a treatment and avoid unhealthy foods is usually insufficient (14). In this regard, some researchers have adopted a dual processing model to justify the contradiction between desire and inability. A dual-processing model is a general approach for explaining human behaviors that underscore the competition and interaction between two different processing systems. This general approach discusses two processing systems, conscious and unconscious. Different authors have proposed a variety of terms for these two systems (15), and this model has been adopted in this study. In Strack and Deutsch's (16) model, at least two systems for information processing compete and interact with each other for behavior control. It is a faster system called "impulse-centered system", which includes automated processes that handle stimuli based on emotional and motivational aspects. This construct is based on associative memory in which learning is slow, and data retrieval is performed with minimal effort and resistance to change. These processes are largely beyond the control of consciousness. "Associative memory" is a pivotal part of this construct. On the other hand, the thought-based system is controlled by the consciousness, for example, when an individual consciously assesses a situation, tries to manage emotions, or evaluates the consequences of an action. The system is based on symbolic processing and has a limited capacity. Hence, "working memory' is seen as part of this construct (17).

Given the potential adverse consequences of unhealthy nutrition, examining the cognitive mechanisms underlining this behavior is important. In particular, current theoretical perspectives and empirical evidence suggest that automated cognitive processing has a vital role in unhealthy behavior. The dual processing models such as the one proposed by Strack and Deutsch (16) suggest that behavior is more thoroughly understood when information is assessed by two different, automatic and controlled processing. Automatic processing incorporates emotions (preferences and attitudes), incentives (e.g., presence and approaching), and responses/reactions to relevant stimuli such as signs and indications of unhealthy food. In contrast, controlled processing is a challenging, slow, and explicit attempt that incorporates conscious decisions based on personal targets and standards (e.g., hygiene and weight loss). These dual processing systems produce contradictory signals, and the outcome is heavily dependent on the power of signals. Hence, according to the dual processing system, behavior is led by the automatic system and regulated by the controlled processing provided by cognitive resources. Automatic and controlled processing systems have been studied in two different avenues of research. First, research on the role of automated processing in eating behavior generally examines the cognitive attention to food symptoms. Cognitive attention points to 'a systematic choice' in processing information that usually favors one type of information over others (18). In other words, this type of research focuses on attention bias, which describes the automatic allocation of attention to food cues and prioritizing other cues (18). Recently, researchers have shifted their focus to cognitive attention, which describes behavioral

tendencies toward stimuli (signs of food) instead of the avoidance of food signs (19). In this regard, it is worth noting that memory, in general, can encode, store and retrieve various forms of stimuli.

Identifying the cognitive and behavioral factors that underlie obesity and overweight and the variables that have a bearing on the treatment process can help improve the treatment process of obesity and achieve long-term treatment outcomes. The results of this research, consistent with the literature, help adopt more appropriate and accurate therapy plans for the treatment of overweight and obesity. In light of the above points regarding the psychological factors associated with obesity, it is possible to study impulsivity and working memory. In this context, the implicit association could effectively predict overweight in obese people. Thus, there should be a measurement for obese individuals to measure the effectiveness of these factors on obesity.

Materials and Methods

This is an applied study that adopts a descriptive (causal-comparative) method. The statistical population consisted of women aged 18 to 45 years dwelling in 12 districts of Mashhad in 2019. Inclusion criteria for both groups were: 18 to 40 years old (due to controlling the effect of general cognitive processing ability), physical and mental health, and a high school diploma or higher degree. Exclusion criteria were intellectual disabilities, a major psychiatric disorder, inability to work with a computer keyboard, color blindness, consumption of psychotropic drugs, alcohol or drug abuse. The study participants were not monitored for weight loss or psychotherapy during the research. Regarding the body mass index (BMI), the inclusion criteria were 18.5<BMI<24.9 kg/m2 for the normal group and BMI<25 kg/m2 for the overweight group. G*Power (20) software was used to determine the sample size in each group. To investigate differences between the two independent groups concerning three variables by considering average effect size, a sample of n=90 people (45 in each group) was calculated by considering a dropout rate of 10%Each group consisted of 50 people (a total of 100 people). The research project was conducted online, and the call of participation was sent in various virtual places. Applicants were selected based on inclusion and exclusion criteria using the available sampling method.

In the particular room considered for the test, the purposes of the research and how to answer computer tests were explained to both groups. Also, a written consent form was obtained from all participants before the study. In this form, participants were ensured about the confidentiality of the information and data publication in groups, and they were urged to fill out the questionnaire and answer tests accurately and honestly. In the next step, they completed the Barat Impulsivity Questionnaire, Positive Implicit Test (IAT), and N-BACK Working Memory Assessment, the reliability, and validity of which have been approved by several experts and reviews. SPSS software16 was utilized for data analysis, including descriptive statistics (comparison of frequency, percentage, mean and standard deviation) and inferential statistics such as the analysis of covariance. Data analysis was based on the univariate analysis of covariance.

Research instrument

A) Barratt impulsive scale-11 (BIS-11): This test is one of the most widely used self-report scales for assessing impulsivity with a validity coefficient of 0.79 to 0.83, which is acceptable (21). The 30-item Barratt Questionnaire is written in descriptive sentences. To answer each item, participants need to choose one of the four alternatives ("rarely / never", "sometimes", "often", and "almost always"). In this questionnaire, eight items measure cognitive impulsivity, 11 measure motor impulsivity, and 11 evaluate non-planned impulsivity. The internal consistency of this questionnaire is reported between 0.79 and0.83 (21). Javid, Mohammadi, and Rahimi reported a test-retest validity of 0.77, a Cronbach's alpha of 0.81, and validity of 0.47 to 0.80 (22).

B) N-Back test: This test, introduced by Krichner (1985), is widely used in neuropsychological studies and interventions. Since this test involves storing and manipulating cognitive information, it provides an ideal tool for working memory assessment. A validity coefficient of between 0.54 and 0.84 has been reported for this test, and its validity, as an indicator of working memory performance, is considered acceptable (23). For this test, items have to be kept active in the working memory for comparison. In this study, the task of one backward was used in which the

subjects were asked to compare each number with a previous number. If the two numbers are identical, they need to press the right key and press the left key. The number of correct answers and the total reaction time of each subject will be recorded by the system. In this type of N-Back test, the stimulus is number repetition. In this test, numbers 1-9 appear repetitively on the computer screen for 9522 milliseconds with a response time of 522 milliseconds between the two stimuli. In this study, the test was conducted at two levels. The overall score of this task is calculated by deducting the score of incorrect answers from the correct ones.

C) Implicit Association Test (IAT): The test adopted in this research was designed by Moghadaszadeh Bazaz using the SuperLab software (SuperLab.4). The test consists of three blocks in which the images (including six images of high-calorie foods) and words (including six pleasant words such as delicious, yummy, good, pleasant, heavenly, and amazing) belonging to the high-calorie category along with six neutral words (moderate, normal, tasteless, permanent, daily, and common)are employed to categorize pleasant and neutral traits (24)

Results

The participants (n=98) were equally divided into two study groups (obese and non-obese). To investigate descriptive indicators of participants such as age, their average age was considered. The average age of the obese and non-obese individuals was 32.27 and 30.57, respectively. In addition, there were 16 single and 33 married participants in the obese group and 20 single and 29 married individuals in the non-obese group. In terms of employment status, there were 19 employed and 30 unemployed participants in the obese group and 25 employed and 24 unemployed individuals in the non-obese group. As for the level of education, most participants had a bachelor's degree (n=22 in the obese group and n=26 in the non-obese groups).

Table 1. Comparison of the mean and standard deviation of positive implicit association scores, working memory capacity, and impulsivity in obese and non-obese persons

Variables	Obese		Non- obese	
	Mean	Standard Deviation	Mean	Standard Deviation
Positive implicit associations	0.08	0.22	0.07	0.16
Working memory capacity	544.06	117.97	547.18	130.25
Impulsivity	62.61	9.28	57.71	10.93

The mean and standard deviation scores related to the measured indicators, including positive implicit associations, working memory capacity, and impulsivity for obese and non-obese groups, are presented in Table 1. In order to compare the mean score of groups in the above variables by controlling the age variable effect, a univariate analysis of covariance test was used. However, before using this test to study the default equality of variances in the ANCOVA test, the results of the Levin test were studied. Based on Levin test values and their significance presented in Table 3, the assumption of the equality of variances for the ANCOVA test has been observed in all three variables (P> 0.05).

Table 2. Levin test results regarding the assumption of the equality of variances of positive implicit associations, working memory capacity, and impulsivity among the obese and non-obese groups

Variable	F	Df1	Df2	P
Positive implicit associations	2.30	1	96	0.13
Working memory capacity	0.66	1	96	0.41
Impulsivity	2.89	1	96	0.09

The results of univariate analysis of covariance in Table 3 demonstrate that by controlling the age factor, the group effect on positive implicit association (F= 0.28, P> 0.001) and working memory capacity (F= 0.10, P>0.001) is not significant. In other words, there is no significant difference between these two variables in both groups. However, the results are quite significant (F= 7.06, P< 0.001), and impulsivity was significantly higher in the obese group than the non-obese.

Table 3. Results of univariate analysis of covariance related to positive implicit association, working memory capacity and impulsivity in obese and non-obese groups

Variable	Source of changes	Total sum of squares	Degree of freedom	Mean square	Value of F	P	Correlation coefficient
Positive implicit association	Age	0.06	1	0.06	1.70	0.19	0.01
	Group	0.01	1	0.01	0.28	0.59	0.03
	Error	3.58	95	0.03			
	Total	3.65	97				
Working memory capacity	Age	45561.63	1	45561.63	3.01	0.08	0.03
	Group	1569.36	1	1569.36	0.10	0.74	0.001
	Error	1436866.52	95	15124.91			
	Total	1482667.03	97				
Impulsivity	Age	446.66	1	446.66	4.49	0.03	0.04
	Group	701.64	1	701.64	7.06	0.009	0.06
	Error	9434.96	95	99.31			
	Total	10469.38	97				

Discussion

Over the past decade, health care professionals have been exposed to the emergence of a new form of addiction - food addiction (25). Eating has always been a basic human behavior dedicated to maintaining homeostasis. However, high-energy foods (with high amounts of fat or sugar), which are increasingly sold in the market (26) due to their energizing results (25), lead to addictive behaviors such as the desire to use, which is similar to drug-induced behaviors (27). A strong desire to consume a product is associated with a high sensitivity of the reward system (28). This oversensitivity of the reward system is well documented in obese individuals (29). The prevalence of obesity or overweight has increased in recent years (10), and now 600 million people are classified as obese. In the case of youth, in 2013, it was estimated that about 42 million children and adolescents between the ages of 5 and 18, and about 12.4% of children under 5 were overweight or obese (9,10). It is predicted that by 2030, about 60% of the world's population will reach the body mass index (30). According to these data, studying the aggravating factors of BMI and body fat related to overeating behavior seems helpful. In recent years, there has been an increase in interest in the cognitive mechanisms involved in obesity (31,32). In addition, recent studies (33) have focused on the relationship between executive functions and obesity to examine the existence and nature of this relationship. Concerning information processing in the brain, it has also been shown in people with obesity that different brain parts have had disorders that can affect how these people respond to food-related variables. Obesity is often associated with eating disorders and defects in appetite, reward, and emotion regulation mechanisms (34). Some selected studies controlled psychological dimensions such as anxiety, depression, or emotional regulation. One study that looked at some emotional components found that emotions can moderate the relationship between executive function and obesity. However, others did not find any effect of psychological variables on this relationship (35). However, examining these psychological variables may better understand the emotionally motivated eating model (36) in people who do not have eating disorders. All of this can be explained by the results that implicit associations do not follow the treatment regimen. This research was done for the first time, so no similar research has been reported in the research literature. We have tried to gather more data from studies that are near to this study present them based on the similarity of the results.

Considering the results, there was no difference in the implicit association between obese or over-weight and non-obese using IAT. These results are consistent with a Roefs et al. review study. They mentioned that even after a successful course of treatment to lose weight, implicit associations with food and physical activity in the subjects had not changed. To re-phrase, success in diet therapy has not been in conjunction with reducing positive association about food. (37). In another research conducted by Trendel and Werle, it is demonstrated that the implicit viewpoint assessed by IAT (positive-negative) is a combination of emotional viewpoint (delicious-disgusting) and cognitive viewpoint (healthy-unhealthy). When cognitive resources are limited, emotional IAT is a better predictor of actual eating behavior,

while more cognitive resources are available, and in non-impulsive individuals, cognitive IAT is a better predictor (38). Furthermore, Roefs, Werrij, Smulders, and Jansen have verified that indirect measurement tools such as IAT, was effective in making differentiation between clinical patients such as those that suffer from lack of appetite and 'normal' people, but fail to provide inferences regarding abstinent and non-abstinent individuals (39). The current study seems to support and corroborate that IAT in distinguishing positive association in over-weight people against non-obese is not sufficiently sensitive to provide reliable inferences. Also, the new assumption can be made that the labels used for the attributes in this test (pleasant versus neutral) imply the specificity and precise nature of the food rather than the individual's preference.

Another significant result of this study was that there was no difference in working memory capacity between obese and non-obese. Some previous studies (40,41) showed that obesity, being overweight, and diet therapy to lose weight are associated with defects in executive functions and working memory capacity. This difference in results can be explained on two levels. First, in the studies above, obese and overweight or that on diet therapies are compared to non-obese. In contrast, in some researches, such as which was done by Moghadaszadeh Bazaz, in both group tests, the subjects were obese and over-weight people that were undergoing treatment to lose weight (24). Therefore, the absence of observing differences may be due to the homogeneity of testable variables. The second aspect that can explain the lack of differences in working memory is the tools used to measure working memory. The present study has utilized the N-BACK test to assess working memory, as Jaeggi, Buschkuehl, Perrig, Meier also stated. It is possible that the N-BACK test is not quite suitable to evaluate the differentiation between individuals at the level of the functioning of working memory but rather beneficial for comparing an individual with her/himself (42). The N-Back test (23) has been used in various articles to examine differences in working memory performance. Of the twenty-four studies that have so far analyzed the relationship between obesity and working memory, six have found no differences between groups (43-48). All the cognitive processes are located in a range encompassing consciousness to unconsciousness. As we move from consciousness to unconsciousness, overcome of excitement on cognition increases. Accordingly, based on results achieved from this study, it can be assumed that the attention process is more unconscious than implicit association (working memory), and therefore the two groups have shown a significant difference. Attributing a stimulus to a characteristic or category (that was the task of the participants at the IAT) requires action compared to diagnosis the place of the dot on the screen (the task of the participants in the point finding test) is more conscious and in terms of cognitive activity at higher levels (24).

Several previous studies (49,50) have concluded that impulsivity is positively correlated with overeating and obesity, which was similar to the present study results. Results demonstrate that concerning the impulsivity variable, there is a meaningful difference between obese and overweight, and non-obese. Also, in a study by Meyer et al., it was shown that the observational and genetic data show a complex pattern of association between impulsive behaviors and BMI of healthy young American-European adults (51). Although some other research such as Moghadaszadeh Bazaz also did not show a significant difference in the impulsivity between successful and unsuccessful recipients and it seems that this lack of difference in the research of Moghadaszadeh Bazaz can be attributed to the homogeneity of the two study groups because both groups consisted of obese or overweight people on a diet (24). It may be concluded that impulsivity as a trait has a significant role in gaining weight in overweight and normal-weight people (not those who have clinical eating disorders) (52). Despite these strengths and practical results, there were some limitations. Due to the time-consuming data collection of each subject through a questionnaire (Impulsivity) and computer tests (two variables of implicit association and working memory) that required focus, speed, and accuracy in the subjects, in some cases, it caused fatigue and tiredness. Another limitation could be that the sample was confined to females, and maybe it is not possible to generalize the results across gender. It is recommended that in future studies, both genders and extending geographical base and groupings are incorporated to achieve broader results applicable to populations at large.

Conclusion

This study showed higher impulsivity in the obese group and no difference in scores of working memory capacity and the implicit association between the two groups. These results can help clarify some aspects of the causes of gaining weight. The process of cognition plays a significant role in considering choices (as when a person on a diet is confronted with a forbidden but delicious and seducing food). Achieving a healthy weight and maintaining it becomes a struggle for some people because the food has a unique appeal for these people, and they are considered as strong rewarders that from the cognitive perspective, this attractiveness of stimuli related to food show itself in the form of bias in the cognitive processes of these stimuli. In other words, high cravings for foods have made their cognitive processing system more sensitive to high-calorie foods. This cognitive bias, in turn, may increase their desire to eat.

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