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An Examination of the Relationship between Food Addiction and Body Fat Percentage in Adults

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Abstract

Obesity continues to be a problem in the United States, and the quest to combat this epidemic continues. Recently, researchers have begun to examine the concept of food addiction and its potential relationship with increasing levels of obesity among Americans. However, a study has yet to be conducted examining this relationship when classifying obesity using measures of actual body fat percentage. The purpose of this study was to examine the association between level of food addiction and level of body fat percentage among adults. In addition, we examined the food addiction construct in relation to several other factors including self-esteem, emotion regulation, and scores on depression and eating disorder inventories. Upon agreement to take part in this study, participants were asked to complete several surveys including a survey on demographic information, the Difficulties in Emotion Regulation Scale, Beck Depression Inventory II, Eating Disorder Examination Questionnaire, Rosenberg Self-Esteem Scale, and the Yale Food Addictions. Then, body fat was measured using the BodPod. A total of 52 participants completed this study. For the sample as a whole, there was a significant, positive relationship between body fat percentage and food addiction. Food addiction was also positively related to scores on depression, disordered eating, and eating regulation difficulties. However, when examining these relationships in men and women separately, the associations between food addiction and the aforementioned factors remained significant among women only.

1 Introduction

This study explores the relationship between body fat percentage and food addiction. In addition, this study was designed to examine the relationship between food addiction and several other factors including self-esteem, emotional regulation, and score on an eating disorder and depression survey. The United States continues to have a high rate of obesity.[1] Despite many initiatives attempting to reverse this trend, obesity rates remain constant. The cause of this obesity epidemic is often placed on the individual (i.e., overeating and a sedentary lifestyle). However, a body of literature is forming around the idea that many individuals may suffer from food addiction, and this may be a factor impacting obesity rates.

1.1 Reactions to Food within the Brain

To better understand the food addiction construct, it is important to first examine what happens in the brain when food is consumed. Ahmed[2] explored what happens between tasting food and the signals the brain receives. Taste begins on tongue with three different types of taste buds across the pallet. There are taste receptors within a taste bud for sweet, bitter, salty, sour, and savory. Stimulation of the receptors activates other receptors to break down phosphatidylinositol-4,5-bisphosphate which produces diacylglycerol and inositol-1,4,5- trisphosphate (IP3). The IP3 causes calcium to release from the endoplasmic reticulum, which then signals neurotransmitter release and

activation/transmission of the information of the nerve fiber. Taste receptor cells are innervated by cranial afferent nerves that send the information to the taste centers of the cortex via synapses in the brainstem and thalamus. There are several locations in the brain where reward comes in to play. The first structure involved with reward is the medulla oblongata, where the brain discriminates between sweet and bitter. Next, taste rises to the forebrain where it then splits into two paths. The lower path (limbic) goes from the brainstem to subcortical reward structures: the nucleus accumbens (NAc), ventral pallidum, amygdala, and hypothalamus. The upper path (sometimes called the sensory taste path) travels first to the thalamus and then to the taste sensory cortex in the prefrontal cortex (PFC). The signals then go to the orbitofrontal cortex where pleasures are coded. The upper and lower then paths join together. The frontal cortex of the upper path sends reward codes to the NAc of the lower path which projects back to the PFC. This sequence of events creates a food reward signals loop, which travels around the forebrain.

Depending on if one is hungry or full, food reward values can change. The hypothalamic circuits in the brain regulate homeostasis of the body and send 'liking' and 'wanting' neural/chemical messages if one is hungry or full. At the same time, brain reward circuits send signals to the hypothalamus that may trigger cues for palatable food to activate the hunger signals. Recent findings suggest the cause of overeating may be elevated activation of food reward circuits. This can lead to long-term effects on the brain. Dopamine 1 and 3 (DA, D1, D3) receptor binding increases, D2 dopamine receptor binding decreases and the Acetylcholine (ACh)/DA) balance is distorted.[2] These changes that occur over time can make eating less rewarding. Since an individual with less D2 receptors does not get as much of a reward from eating, they may need to overeat to overcompensate for the lack of reward. This could then turn into a cycle of overeating and addiction to food.

1.2 The Food Addiction Construct

The first evidence of food addictions in humans was seen in a study by Wang et al.[3] The purpose was to test the hypothesis that obese persons have a malfunction in dopamine (a neurotransmitter that regulates anticipation and reward) activity by measuring the availability of D2 receptors in the brain. These authors found that the obese individuals in their study had significantly less ($p < .01$) D2 receptor availability in the striatum. The striatum collects inputs from the rest of the brain to send to the basal ganglia. It is associated with movement, initiating behavior, and responding to visual stimuli.[17] Wang et al[3] concluded that since dopamine regulates motivation and reward circuits, deficits in dopamine could potentially motivate overeating as a way to counteract the decreased activation of these circuits.

In their discussion of the neurobiology of overeating, Lee et al[4] provide further information on the role of dopamine in food addiction. According to these authors, the dopamine reward pathway directly affects goal-directed behavior such as eating or taking drugs. Eating, sex or drug use activates dopamine in the nucleus accumbens, an area in the brain that regulates motivation and reward.[5] The release of dopamine lets the brain know that those activities (e.g. eating, sex, taking drugs) are gratifying and worth doing again. The irregular neurotransmitter levels found in obese animals and humans are comparable to those seen in chronic drug abusers.[4] Overeating (and thus over-release of dopamine) can disrupt the system to the extent that continuing these rewarding activities takes over a person's behavior.

1.3 The Relationship between Food Addiction and Obesity

Based on previous research, it appears that there is significant relationship between the brain and food responses indicating that food addiction is a valid concept. In a search to further understand the phenomenon of food addiction, Killgore[6] tested 13 women to see if their body mass index (BMI) correlated with brain response to images of highly palatable foods. Participants were shown pictures of high-calorie foods (e.g., pizza, cookies, ice cream), non-edible, food-related items (e.g., utensils) and non-food objects (e.g., rocks, shrubs). These authors found that BMI was significantly, negatively correlated ($p< 0.001$) with the orbitofrontal cortex during the high-calorie viewing condition. This suggests that, the higher a participants BMI, the less activity occurred in the area of the brain in charge of decision making. Within the normal range of weight, increased body mass was connected with decreased food-responsive activity in brain regions that are crucial for estimating stimulus-reinforcement possibilities, changing recently learned stimulus-reward relations, and correcting feeding-related behavior based on new learning. Overall, obese people have to overcompensate by overeating for the lack of response within the dopamine system.

Previous research has continued in this area.[7] Gearhardt[7] examining the relationship between food addiction and psychological factors in overweight or obese individuals. Results concluded that 56.8% of participants met the requirements for food addiction based on the Yale Food Addiction Scale (YFAS). Food addiction score was not

significantly related to anxiety, alcohol, or drug use disorder. Food addiction score was significantly linked (p=.001) to mood disorder diagnoses, particularly major depressive disorder (p=.006). Food addiction scores were also significantly related with emotion dysregulation and low self-esteem. The strongest correlation was made between food addiction score and impulsivity, suggesting impulse behaviors relate to food addictions. Food addiction score was also significantly correlated with rate of occurrence of binge eating.[7]

Although the Gearhardt study resulted in new information regarding correlations between food addictions and other psychopathologies, further research is needed. These authors used body mass index (BMI) to assess weight status. Although this is a widely used measure, it is merely a ratio between height and weight and thus cannot determine actual body fat percentage (the true indicator of obesity). Given this gap in the literature, it was the purpose of this study to examine the association between level of food addiction and level of body fat percentage among adults. In addition, this study examined the food addiction construct in relation to several other factors including self-esteem, emotion regulation, and scores on depression and eating disorder inventories.

2 Methods

2.1 Participants

Participants were recruited for this study via fliers in the community, on campus and electronically. During recruitment, this study was explained as one examining the factors surrounding food addiction. A total of 52 participants have completed this study, 42 women and 10 men.

2.2 Procedures

Upon providing consent to participate, each participant was asked to complete five surveys: YFAS (Yale Food Addiction Scale), EDE-Q (Eating Disorder Examination Questionnaire), BDI-II (Beck Depression Inventory-II), DERS (Difficulties in Emotion Regulation Scale), and RSE (Rosenberg Self-Esteem Scale). Then, body fat percentage was assessed using the BodPod. They were debriefed after all surveys were taken. Reasons for each survey were explained and the hypothesis (the higher the body fat percentage, the higher YFAS score) was revealed. Subjects were given the option of taking information on free resources for food addiction counseling and eating disorders/disordered eating.

2.3 Measures

The Difficulties in Emotion Regulation Scale (DERS) uses a 5-point scale to assess a variety of emotion dysregulation including non-acceptance, goals, impulse, awareness, strategies and clarity. Early research determined that the DERS has good internal consistency, quality test-retest reliability, and ample construct and predictive validity.[8] The DERS includes 36 statements like "I experience my emotions as overwhelming and out of control" with the scale of *Almost Never*, *Sometimes*, *About Half the Time*, *Most of the Time*, and *Almost Always*.

The Yale Food Addiction Scale (YFAS) inquires about the past year of eating behaviors that represents addiction of high fat and sugar foods based on the medical definition of substance dependence. A combination of dichotomous and Likert scoring options provides two scores (symptoms and diagnostics). The beginning justification of the scale confirmed sufficient internal consistency, convergent legitimacy and incremental authenticity in predicting binge eating.[9] The YFAS consists of 25 statements and questions like "I have consumed certain foods to prevent feelings of anxiety, agitation, or other physical symptoms that were developing" with a scale of *Never*, *Once a Month*, *Two-Four Times a Month*, *Two-Three Times a Week*, and *Four or More Times Daily*.

The Eating Disorder Examination Questionnaire (EDE-Q) assesses eating disorders through an interview method. The survey evaluates severities of over-eating that are compatible with DSM-IV definition of binge eating. The EDE assesses the previous 28 days and is evaluated with a 7-point scale depending on seriousness. Mond et al[10] found the EDE-Q to have coexisting validity and satisfactory criterion validity and is appropriate for use in possible epidemiological studies. An example of the 28 question survey is "have you been deliberately trying to limit the amount of food you eat to influence your shape or weight?" with a scale of *No Days*, *One-Five Days*, *Six-12 Days*, *13-15 Days*, *16-22 Days*, *23-27 Days*, and *Every Day*.

The Rosenberg Self-Esteem Scale (RSE), created by Morris Rosenberg in 1965, uses Likert scoring on a 4-point scale and is a series of agreeable or disagreeable statements that help determine self-esteem. Tinakon et al[11] found that RSE had internal consistency and established the validity of the factor structure. The RSE consists of 10 statements such as, "I take a positive attitude toward myself" with a scale of *Strongly Agree*, *Agree*, *Disagree*, and *Strongly Disagree*.

The Beck Depression Inventory-II (BDI-II), created by Aaron Beck in 1961, has been established as valid and reliable because of its wide use in measuring symptoms of depression using a 21-item evaluation. The participant is asked to choose the most relevant statement. For example: "I do not feel sad, I feel sad, I am sad all the time and I can't snap out of it, and I am so sad and unhappy that I can't stand it." The version used in this study has presented itself with internal consistency.[12]

BodPod measures body fat percentage by a densitometry technique that determines density by air displacement. The participant sits in the BodPod and breathes normally while trying to limit movement. BodPod measures the air that is displaced and finds the participants volume which is then used to determine the participant's body density using measured body mass. Established equations are then used to determine body fat percentage based on this density. According to McArdle at al.,the BodPod is very precise, with mean test-retest variation within 2% body fat. [13]

2.4 Data Analysis

Means and standard deviations were calculated for continuous, descriptive variables. Pearson correlations were conducted to evaluate associations between food addiction, body fat percentage, self-esteem, emotional regulation, and scores on the depression and eating disorder inventories.

3 Results

The average age of the participants was 28.5 ± 12.6 years old. The average height was 66.8 ±3.2 inches, and average weight was 155.9 ± 36.8 pounds. The average waist circumference was 76.07 ±12.3 cm, and average body fat percentage was 23.9 ± 0.09%. The mean body mass index (BMI) was 24.44 ± 4.23 kg/m^2. Out of 52 participants, 19.2% identified as male and 80.7% identified as female. In addition, 96.2% of participants identified as White and 3.9% identified as Hispanic. A total of 59.6% of the participants were students.

Table 1 displays average survey scores for male and female participants. YFAS scores can range from 0-7; the higher the score the more symptoms one has for food addiction. The normal median symptom score for YFAS as determined by Gearhardt[14] was 1. The RSE ranges from 0-30, with the higher the score being a higher self-esteem. Scores below 15 are considered 'low self-esteem' while 15-25 are considered normal.[15] In a study done by Gratz and Roemer,[8] the average score for DERS for females was 77.99 and males was 80.66. Higher scores indicate higher emotional regulation. In a study done in young females by Mond et al[10], the average global score for the EDE-Q was 1.52. Beck[12] found an average score of 21.9, which classifies as moderate depression (0-13: minimal, 14-19: mild; 20-28: moderate; 29-63: severe).

Table 1. Average Survey Scores for Male and Female Participants (N = 52).

Subscale	Males (n = 10)	Females (n = 42)
Yale Food Addiction Scale (YFAS)	1.00 ± 0.67	1.83 ± 1.68
Rosenberg Self-Esteem Scale (RSE)	24.80 ± 4.24	21.66 ± 5.95
Emotion Regulation Scale (DERS)	62.10 ± 16.59	72.86 ± 24.73
Eating Disorder Examination Questionnaire (EDE-Q)	0.95 ± 0.77	1.54 ± 1.28
Beck Depression Inventory II	2.70 ± 2.36	7.60 ± 6.81

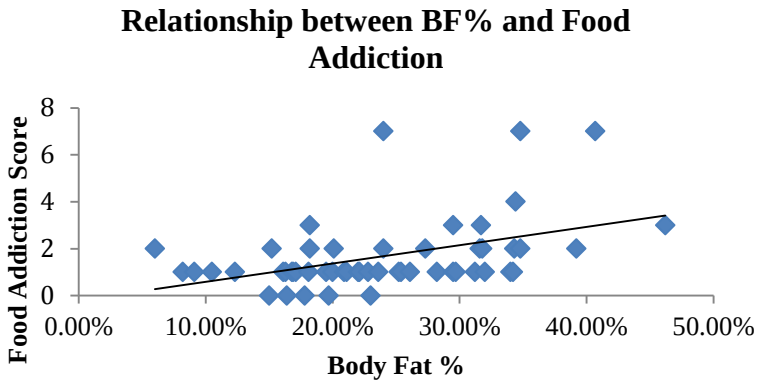

Figure 1: correlations between body fat percentage and food addiction. The higher the body fat percentages, the higher the food addiction scores.

Results demonstrate a significant, positive correlation between BF% and YFAS (Table 2, Figure 1), indicating that higher body fat percentages were related to higher rates of food addiction, and the reverse. There was also a significant, positive correlation between BF% and BDI-II score and the EDE-Q, suggesting a higher body fat percentage relates with a higher depression and eating disorder score. No relationship was found between BF% and measures of self-esteem or emotional regulation. There was a positive correlation between the YFAS and the BDI-II, EDE-Q, and DERS. This suggests the higher the food addiction score, the higher the depression, eating disorder, and emotional regularity score. A positive correlation was found between BDI-II and DERS and EDE-Q. A negative correlation was found between BDI-II and RSE, implying the higher the depression score was, the lower the self-esteem score was and vice versa. A negative correlation was found between RSE and DERS, indicating the higher the self-esteem score, the lower the emotional regularity score and vice versa. The lower the emotional regularity score, the more able one is to regulate their emotions.
When examining these relationships among men and women separately, the associations between food addiction and body fat percentage, depression, and disordered eating remained significant for women only. There were no significant relationships for any variables among men.

Table 2. Relationship among Food Addiction, Body Fat Percentage, Self-Esteem, Emotion Regulation, Eating Disorder Score, and Depression Score (N = 52).

	YFAS	BF%	RSE	DERS	EDE-Q	BDI-II
YFAS	1	0.44*	-0.33	0.40	0.67*	0.42*
BF %	0.44*	1	-0.07	0.17	0.54*	0.35*
RSE	-0.33	-0.07	1	-0.66	-0.29	-0.72*
DERS	0.40*	0.17	-0.66*	1	0.32	0.63*
EDE-Q	0.67*	0.54*	-0.29	0.32	1	0.39*
BDI-II	0.42*	0.35*	-0.72*	0.63*	0.39*	1

Note: YFAS (Yale Food Addiction Scale), BF% (Body Fat Percentage), RSE (Rosenberg Self-Esteem Scale), DERS (Difficulties in Emotion Regulation Scale), EDE (Eating Disorder Examination), and BDI-II (Beck Depression Inventory-II); * indicates a significant relationship ($p<.01$).

4 Discussion

The current study examined the relationship between body fat percentage, food addiction, depression, self-esteem, and eating disorders. The results indicate a significant relationship between the mind and body, especially in response to certain foods that may cause addictive behaviors. These findings add to the current body of literature signifying the importance of food addiction, as it may relate to increasing rates of obesity and have other detrimental consequences.

The positive correlation found between body fat percentage and food addiction indicates significance in the hypothesis that the higher the body fat percentage, the higher the level of food addiction. However, it must be noted that this does not imply causation. That is, higher body fat may result in higher levels of food addiction, or higher levels of food addiction may result in higher levels of body fat. The original study that shaped this research used BMI as their determinant for obesity.[7] Interestingly, within the current study, there was no significant relationship between BMI and food addiction, despite the fact there was a strong relationship between body fat percentage and food addiction. Thus, had BMI been used as a measure of obesity within the current study, correlations would not have been discovered when these relationships were, in fact, present. Thus, caution should be taken when interpreting results from studies using BMI as a measure of obesity, and future studies should rely only on body fat percentage when examining associations between food addiction and obesity.

Interestingly, there was no significant relationship found between body fat and measures of self-esteem. These findings contradict those found by in previous research by Gearhardt et al.[7] However, key differences in study design may partly explain differing results. While Gearhardt et al.[7] examined these factors in obese individuals, the current study used adults of all sizes. Thus, correlations between weight status and self-esteem may only matriculate within a sample of individuals who are obese.

The relationship between food addiction and depression scores suggests that the higher the depression score, the higher the level of food addiction. Research supports the notion that there is a reduced amount of dopaminergic neurotransmission in major depression. This could be a consequence of either decreased dopamine release from presynaptic neurons or damaged signal transduction.[16] It is then relevant to point out that there were similar findings in obese participants, a theory that explains overeating as overcompensating for the lack of D2 receptors.[3] Ahmed[2] discussed the long-term effects overeating has on the reward system, so future research needs to be done to determine if reduced dopamine is a cause or effect of obesity.

Results demonstrated a positive correlation between food addiction and disordered eating as well as body fat percentage and disordered eating. These relationships indicate that high levels of body fat, high levels of food addiction, and disordered eating may all be inter-related. Scores on the depression survey were also significantly, related to food addiction (as aforementioned) as well as body fat percentage and disordered eating. Thus, symptoms of depression may also be involved within this inter-related nature of high body fat, food addiction, and disordered eating. Thus, future research is warranted to examine how these factors interact. For example, one fact (e.g. food addiction) may be related to body fat percentage, not directly, but through symptoms of depression. This research is vital to the prevention and intervention of what can be considered mental and physical illness. A future study may consist of gathering individuals whom relate to high body fat percentage, eating disorder, depression, and food addiction and splitting them into four groups. The participants would have their body composition measured and take the EDE-Q, BDI-II and YFAS. There would be four different interventions for each group, but only addressing one issue. For example, for a group with an intervention on body fat, their goal might be to increase strength training in their exercise routine. The intervention for depression could be counseling, and so on and so forth. There would need to be a post-evaluation done to determine which intervention was most successful on all four variables by seeing which group improved the most on their scores on the EDE-Q, BDI-II and YFAS as well as which group lost the most body fat. Further research should be conducted to test these theories surrounding help for food addiction.

There are some limitations within the current study that warrant further investigation. First, this study was based on a relatively small sample size, especially among men. This sample size may have inhibited the power of statistical analyses to detect significant relationships. Future studies are needed that include a larger and more diverse sample. Additionally, due the cross-sectional nature of this study, relationships between variables were examined, and cause and effect cannot be determined. Future research is needed on whether food addiction causes obesity or obesity causes food addiction. Once completed, a next step in research on the most effective techniques on dealing with food addictions would prove to be helpful in the quest to end the obesity epidemic.

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