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ORIGINAL RESEARCH

Impact of GLP-1 Receptor Agonists on Perceived Eating Behaviors in Response to Stimuli

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Background: Several Glucagon-like peptide-1 (GLP-1) receptor agonists are FDA-approved for weight loss in patients with obesity primarily through targeting gastrointestinal pathways to reduce caloric intake; however, less is known about the GLP-1 receptor agonist impact on the behavioral aspects of eating. Our study investigated how patients' perceived eating behaviors evolve in response to different stimuli after initiating a GLP-1 receptor agonist. We hypothesized that participants reported eating behaviors are more in tune with their physiological cues (hunger and satiety) and less influenced by emotional, situational, and external sensory cues after starting their GLP-1 receptor agonists.

Materials and Methods: This was a survey-based cross-sectional study that included 101 participants with BMI >27 who were prescribed a GLP-1 receptor agonist medication. The survey inquired about participants' perspectives on their eating behaviors before and after starting GLP-1 receptor agonists. The survey was created through Google Forms and consisted of 31 questions in a multiple-choice format. A paired *T*-test was used to compare the participants' numerical scores for a given question before and after starting the GLP1 receptor agonist.

Results: Participants reported feeling significantly more cognizant of their hunger cues and a significant reduction in the frequency with which they ate past the point of feeling full. Participants also reported a significant reduction in the frequency with which they desired to eat food in response to external sensory cues and situational cues. In addition, participants reported a significant reduction in the frequency of consuming food in excess in response to emotional cues.

Conclusion: Together, these results suggest that GLP-1 receptor agonists may promote substantial weight loss through improved perceived regulation of eating behavior, supporting a state in which physiological cues have a greater influence on food intake than emotional, external, sensory, and situational cues.

Keywords: glucagon-like peptide-1, GLP-1, obesity, glucagon-like peptide-1 receptor agonist, cues, eating behaviors

Introduction

Understanding the physiology of obesity is pivotal in its treatment. Acosta et al describe the "Four Types of Obesity" biological and behavioral phenotypes that categorize human eating behaviors - (1) the Hungry Brain, (2) the Hungry Gut, (3) the Emotional Hunger, and (4) Slow Burn. Certain behaviors, such as emotional eating (eating in response to emotional cues) and external eating (eating in response to external food-related stimuli), have been previously associated with weight gain and difficulty with weight-loss maintenance.[1]

Glucagon-like peptide-1 (GLP-1) receptor agonists were initially researched and developed to improve insulin release in patients with Type 2 Diabetes; however, these medications are now approved to treat patients affected by obesity due to the medications' ability to promote substantial and sustained weight loss.[2] Currently, the GLP-1 receptor agonists, Liraglutide (Saxenda®), Semaglutide (WeGovy®), and Tirzepatide (Zepbound®), are FDA-approved for weight loss in patients with obesity primarily through targeting gastrointestinal pathways to increase satiety, reduce appetite, and consequently reduce caloric intake;[2,3] less is known about the GLP-1 receptor agonist impact on eating behaviors. Prior studies have demonstrated that treatment with Liraglutide, compared to insulin, results in a decreased fMRI response in brain regions related to reward, devaluation of stimuli, and cravings in response to viewing high-calorie

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foods.[4] In addition, a randomized control trial conducted by Blundell et al found that weekly twelve weeks of weekly Semaglutide was associated with a decreased preference for high-fat foods, reduced cravings, and improved overall control of eating, as assessed at the end of the treatment period.[5] Together, these results suggest that the neuromodulatory properties of GLP-1 receptor agonists contribute to their ability to promote significant weight loss.

This study assesses how patients' perceived eating behaviors evolve in response to different stimuli after initiating a GLP-1 receptor agonist. We hypothesized that participant-reported eating behaviors are more in-tune with their physiological cues (hunger and satiety) and less influenced by emotional, situational, and external sensory cues after starting their GIP/GLP-1 receptor agonists (Semaglutide, Liraglutide, Tirzepatide, Dulaglutide).

Materials and Methods

Study Design

This was a survey-based cross-sectional study that inquired about patients' perspectives on their eating behaviors before and after starting GLP-1 agonists. The survey was created through Google Forms and consisted of 31 questions in multiple-choice format. To distribute the survey, we made a flyer containing a QR code that automatically brings the user to the Google form survey when scanned using a smartphone camera. The flyers were distributed through Email and in person to several Cooper University Health Care physicians across 33 Cooper internal medicine, family medicine, and endocrinology offices within South Jersey. Physicians then posted these fliers in their waiting rooms and patient encounter rooms so that patients could complete the tasks while waiting for the provider.

Survey Design

The survey contained an introductory paragraph describing the purpose of the study, the inclusion and exclusion criteria, and a statement explaining that participation in the survey is not required, and that the information collected would be kept anonymous and used solely for medical research purposes.

The questions were divided into four categories: how the participants' desire to eat or consume food in excess before and after using GLP 1 agonists changed in response to physiological cues (hunger and satiety), external sensory cues (being physically near food, seeing food advertisements, and smelling food), situational cues (eating with others, alone, while distracted, while bored), and emotional cues (stress, positive emotions, negative emotions). The participants were asked to rate their behavioral change on a 5-point linear scale, with one indicating "never" and five indicating "always" (Appendix 1).

In addition to the above questions, the survey also inquired about the participants' specific GLP-1 agonist, present treatment duration, achievement of weight loss, past medical history of type 2 diabetes or bariatric surgery, and whether they were happy with their medication (Appendix 1).

Participants

The study had 101 participants. Inclusion criteria included any patient on a GLP-1 receptor agonist under the supervision of a Cooper University Health Care physician with a BMI >27 m^2/kg.

Outcomes

The primary outcome of this study is to assess the degree to which participants perceive a change in food behavior in response to different stimuli after starting a GLP-1 receptor agonist.

Statistical Analysis

We used a paired *T*-test to compare the participants' numerical scores for a given question inquiring about their behavior before and after starting the GLP1 receptor agonist. We generated a mean, standard deviation, and p-value for each before and after question comparison. Participants who failed to respond to the pre- and post-question survey components were excluded from the statistical analysis. When participants selected two numbers instead of one in response to

a multiple-choice question requiring an answer on a scale from 1 to 5, the average of the two numbers was used in the analyses.

Ethical Considerations

This study was reviewed by the HRPP director of Cooper University Health Care and deemed exempt from IRB approval according to the criteria at 45 CFR 46.104. All participants provided informed consent, in accordance with the Declaration of Helsinki.

Results

Study Participants

As shown in Figure 1, out of the 101 study participants, 6 were using Dulaglutide (Trulicity), 13 were using Tirzepatide (Mounjaro), 14 were using Semaglutide (WeGovy), 17 were using Liraglutide (Saxenda), 48 were using Semaglutide (Ozempic), and 3 did not report which medication they were using.

As shown in Figure 2, out of the 101 study participants, 9 participants had been on their respective medication for <1 month, 51 had been on their respective treatment for 2–6 months, 38 had been on their respective medication for >6 months, and 3 did not report the duration of their medication usage.

As shown in Figure 3A and B, out of the 101 study participants, 86 denied ever undergoing weight loss surgery, 9 reported undergoing a prior weight loss surgery, and 6 did not respond. In addition, 52 denied ever being diagnosed with Type 2 Diabetes, 43 endorsed being diagnosed in the past, and 6 did not respond.

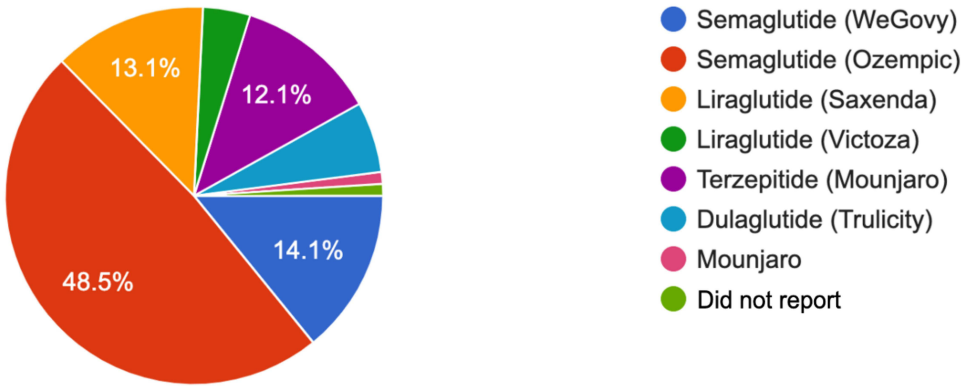

Figure 1 Distribution of GLP-1 Receptor Agonists Among Study Participants.

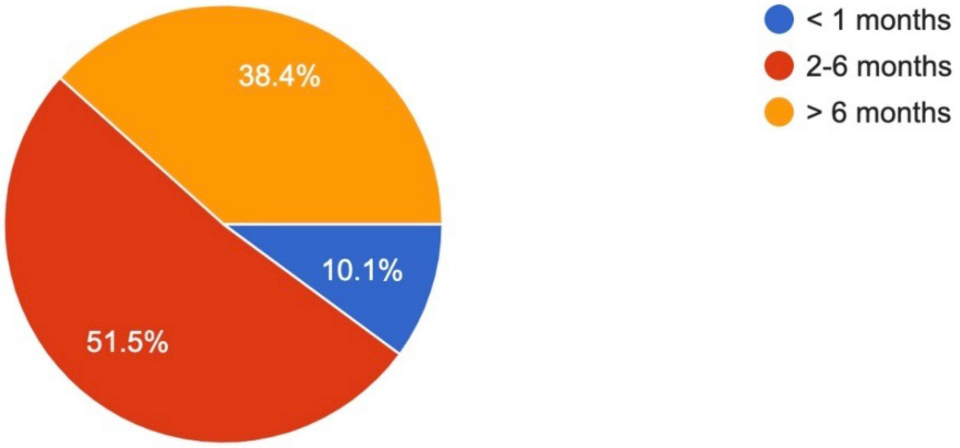

Figure 2 Duration of GLP-1 Agonist Use Among Study Participants.

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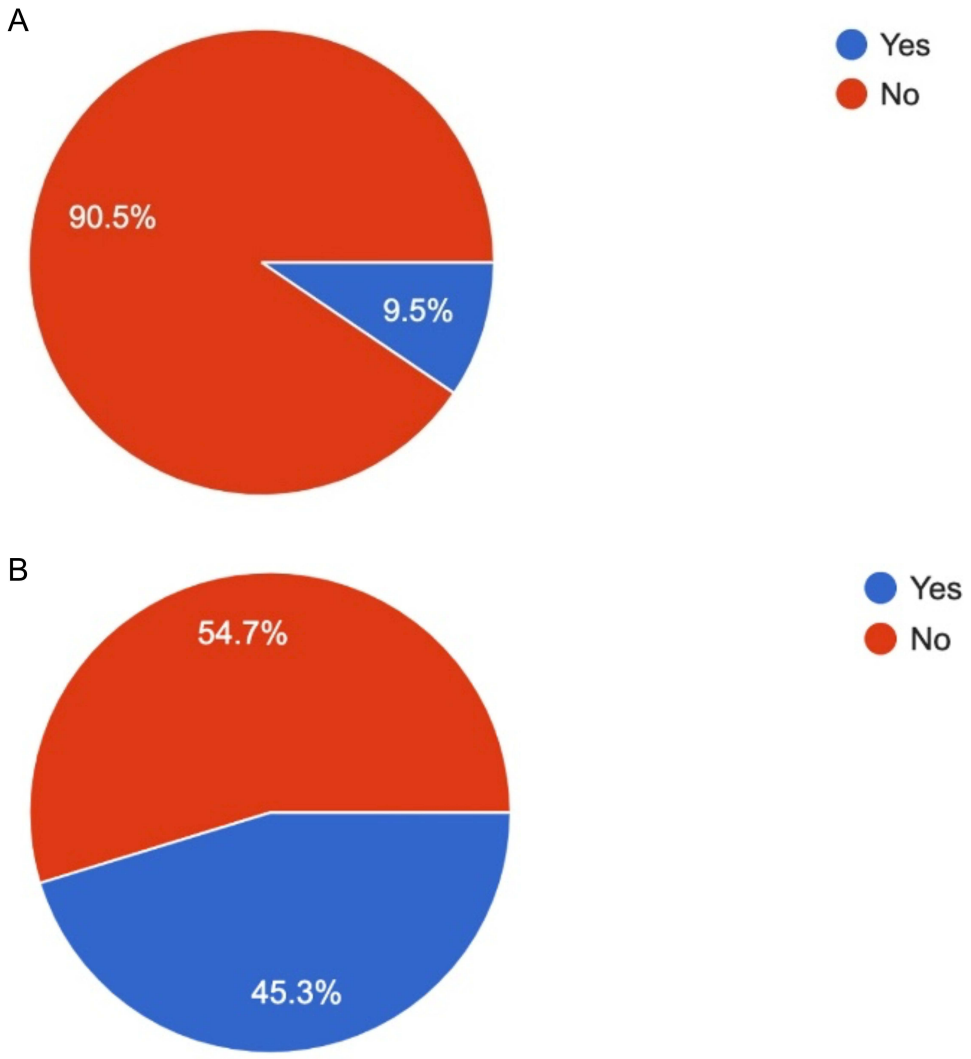

Figure 3 (**A** and **B**) Percentage of Study Participants Who Have Undergone Bariatric Surgery. Percentage of Study Participants Have Type 2 Diabetes.

As shown in Figure 4, out of the 101 study participants, 94 reported being happy with their respective medication, while 7 reported not being happy.

As shown in Figure 5, out of the 101 study participants, 86 reported feeling as if they have lost weight since being on their medication, while 15 denied any perceived weight loss.

Primary Outcome

As shown in Table 1, 98 of the 101 study participants responded to the pre-and-post components of the questions regarding physiological cues. Participants reported feeling significantly more in tune with their hunger cues and a significant reduction in the frequency they ate past the point of feeling full. The average score change in each of the 3 questions has a $p < 0.001$.

As shown in Table 2, 98 of the 101 study participants responded to both the pre-and-post components of the questions regarding external cues. Participants reported a significant reduction in the frequency in which they desired to eat when physically near food, seeing food advertisements, and smelling food. The average score change in each of the 3 questions has a $p < 0.001$.

As shown in Table 3, 95 of the 101 study participants responded to both the pre-and-post components of the questions regarding situational cues. Participants reported a significant reduction in the frequency in which they desired to eat during periods of boredom in addition to the frequency at which they consumed food in excess when eating with others, eating alone, and when distracted. The average score change in each of the 4 questions has a $p < 0.001$.

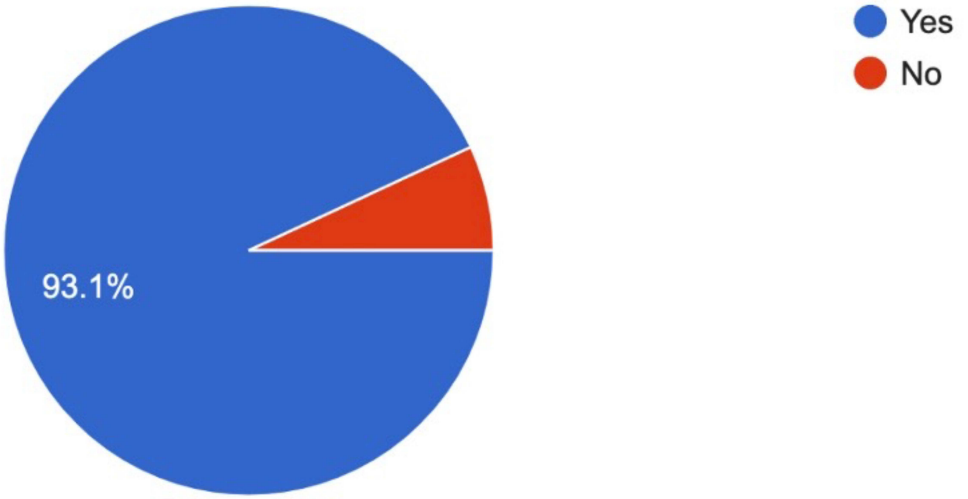

Figure 4 Percentage of Study Participants Who Are Happy with their Medication.

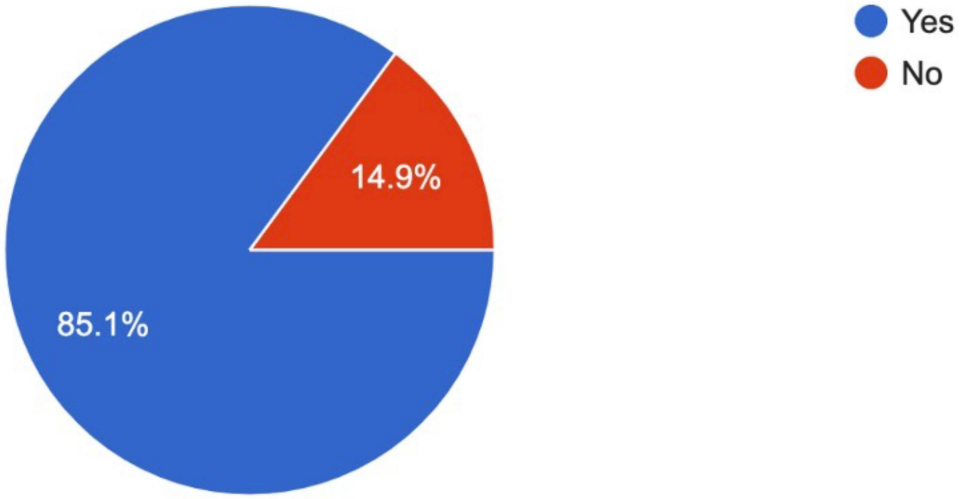

Figure 5 Percentage of Study Participants Who Feel that they have Lost Weight on their Medication.

As shown in Table 4, 97 of the 101 study participants responded to both the pre-and-post components of the questions regarding emotional cues. Participants reported a significant reduction in the frequency of consuming food in excess when experiencing stress, positive emotions, and negative emotions. The average score change in each of the 3 questions has a $p < 0.001$.

Table 1 Participant-Reported Eating Behaviors in Response to Physiological Cues Before and After Initiating a GIP/GLP-1 Receptor Agonist Medication

Question (Physiological Cues)		Mean	N	Std. Deviation	P-value
How in-tune do you feel with your hunger cues (ie eating only when hungry or physically necessary)?	**Pre**	2.34	98	1.08	<0.001
	Post	3.31	98	1.13	
How often did you continue to eat after you felt full?	**Pre**	3.1	98	1.06	<0.001
	Post	1.66	98	0.85	

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Table 2 Participant-Reported Eating Behaviors in Response to External Cues Before and After Initiating a GIP/GLP-1 Receptor Agonist Medication

Question (External Cues)		Mean	N	Std. Deviation	P-value
How often did you have the desire to eat when physically near food?	**Pre**	3.37	95	1.03	<0.001
	Post	2.02	95	0.89	
How often did you have a desire to eat upon seeing advertisements for food?	**Pre**	2.74	97	1.16	<0.001
	Post	1.57	97	0.84	
How often did you have a desire to eat upon smelling food?	**Pre**	3.13	98	1.06	<0.001
	Post	2.03	98	0.97	

Table 3 Participant-Reported Eating Behaviors in Response to Situational Cues Before and After Initiating a GIP/GLP-1 Receptor Agonist Medication

Question (Situational Cues)		Mean	N	Std. Deviation	P-value
How often did you consume food in excess when eating with others?	**Pre**	3.07	97	1.05	<0.001
	Post	1.72	97	0.8	
How often did you consume food in excess when eating alone?	**Pre**	3.11	97	0.98	<0.001
	Post	1.63	97	0.86	
How often did you consume food in excess when distracted? (Television, Reading, Working, Conversation)	**Pre**	3.08	98	1.14	<0.001
	Post	1.7	98	0.91	
How often did you have a desire to eat when you had nothing to do (Boredom)?	**Pre**	3.33	95	1.04	<0.001
	Post	1.79	95	0.92	

Table 4 Participant-Reported Eating Behaviors in Response to Emotional Cues Before and After Initiating a GIP/GLP-1 Receptor Agonist Medication

Question (Emotional Cues)		Mean	N	Std. Deviation	P-value
How often did you consume food in excess when experiencing stress?	Pre	3.34	97	1.2	<0.001
	Post	1.9	97	0.94	
How often did you consume food in excess when experiencing positive emotions (Happiness, Excitement)	Pre	2.74	97	1.01	<0.001
	Post	1.57	97	0.73	
How often did you consume food in excess when experiencing negative emotions (Sadness, Anger)?	Pre	3.12	97	1.17	<0.001
	Post	1.86	97	1.01	

Discussion

This study demonstrated a reduction in self-reported emotional, external, and situational eating behaviors in conjunction with a self-reported increase in physiological eating behaviors after beginning a GLP-1 Receptor agonist. In addition, the majority of participants reported being happy with their medication and feeling as though they had lost weight on it.

The underlying mechanisms that motivate and regulate food intake include a variety of genetic, physiological, cognitive, psychological, social, cultural, and environmental factors.[6] The participants' self-reported change in food behaviors in response to physiological cues is likely attributable to GLP-1 receptor agonist GI motility inhibitory effects and neuromodulatory properties. Most notably, GLP-1 agonists have been shown to significantly delay gastric emptying following food consumption, which can symptomatically manifest as an increased sensation of satiety.[7–9]

GLP-1 receptor agonists are located throughout the brainstem and hypothalamus. Current evidence suggests that ingesting food induces the release of GLP-1 locally from the neuroendocrine L-cells of the small intestine and centrally from the nucleus of the solitary tract (NTS) via stimulation by the vagal afferents. The GLP-1-producing neurons of the NTS project to the paraventricular nucleus of the hypothalamus, which regulates food intake and promotes satiety.[10,11]

Our study demonstrated a reduction in self-reported emotional and external eating behaviors after beginning a GLP-1 receptor agonist. The results would be consistent in part with Nicolau et al, who showed that participants with obesity experienced a significant decrease in emotional eating, external eating, binge eating episodes, and sweet and savory cravings after three months of Semaglutide therapy.[12] Masaki et al also demonstrated that participants with obesity and type 2 diabetes experienced a significant decrease in emotional eating at 3 months and 6 months on Semaglutide therapy. Although Masaki et al did observe a downward trend in eating behavior in response to external stimuli, the results were not statistically significant.[13]

Past studies have shown that GLP-1 receptor activation reduces fMRI brain response to visual food cues in the insula, amygdala, orbitofrontal cortex, and putamen. According to Ten Kulve et al, 12 weeks of treatment with liraglutide, compared to insulin glargine, resulted in a decreased fMRI response in the insula and putamen in response to viewing high-calorie foods in both a fasted and post-prandial state.[4] Both these regions are involved in reward processing; several studies have suggested that the insula has a more specific role in the activation in response to food and drug-related cravings and involvement in assigning value to food.[14,15]

Together, these results suggest that GLP-1 receptor agonists may promote substantial weight loss through improved perceived regulation of eating behavior, supporting a state in which physiological cues have a greater influence on food intake than emotional, external sensory, and situational cues.

Strengths & Limitations

There are several limitations to the study. This study is a cross-sectional study, so it cannot establish causal relationships since the questions are asked at a single point in time. In addition, the behaviors recorded in this study are both self-reported and retrospective in nature, and are thus internal factors such as recall bias, social desirability bias, and degree of self-awareness. Our study also employed convenience sampling, which may result in a less representative sample. Individuals who are more motivated and have access to smartphone technology may be overrepresented, while those who are less motivated or have limited access may be underrepresented. In addition, our study did not collect demographic data on our participants, limiting our ability to evaluate the study population for generalizability.

Our study's strengths include its sample size of 101, with a minimum of 95 individuals responding to each question. In addition, the number of participants who were and were not affected by type 2 diabetes was similar (43 vs 52), enabling these results to potentially apply to both patient populations. Although our results are self-reported, the primary outcome of this study is based on perceived changes in behavior, so the limitations described above are less applicable to our analyses.

Future Goals

A prospective cohort study with a control group is needed to further validate these findings and minimize the impact of recall bias. Future studies should provide a detailed summary of the participants' baseline characteristics to enable

potential stratification of results by factors such as gender, age, comorbidities, medication subtype, and treatment duration, allowing for the assessment of differential effects. In addition, the complex nature in which GLP-1 agonists regulate eating behavior sheds light on the vast array of conditions these medications have a role in treating, including disorders of emotional eating and addiction.

Disclosure

The authors report no conflicts of interest in this work.

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