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Review
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# FOOD-RELATED IMPULSIVITY IN THE TRIANGLE OF OBESITY, EATING BEHAVIORS AND DIET

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**Abstract:** One of the determinants of food intake, impulsivity may contribute to the development and maintenance of obesity by triggering uncontrolled and excessive eating. It is estimated that increased impulsivity makes it harder to resist foods high in sugar, salt and fat. Evidence has been increasing in recent years regarding the roles of different components of impulsivity in obesity and some eating behaviors (especially uncontrolled, emotional and restrictive eating). Unfortunately, animal and human experiments examining the effects of dietary interventions on impulsivity and cross-sectional studies examining the food choices and consumption habits of individuals with high impulsivity are limited. Considering the role of impulsivity in eating disorders is important to elucidate the development and onset of eating disorders, as impulsivity may be associated with some impaired eating behaviors and behaviors such as substance use and non-suicidal self-harm. Current research shows that the use of impulsivity-focused approaches (computer-assisted cognitive training, psychotherapy etc.) to modify impulsivity in people with binge eating episodes is promising. In addition, mindful and intuitive eating trainings that focuses on problematic eating behaviors and difficulties in controlling food intake, can use in the treatment of eating disorders and obesity for reducing the level of impulsivity. In these treatments, complementary therapy to reduce impulsivity in addition to the healthy diet approach should be considered. This article examines the role of impulsivity in obesity and eating behaviors, the results of current intervention studies on this subject, and treatment approaches targeting impulsivity.

**Keywords:** Eating behavior, Eating disorders, Impulsive behavior, Obesity

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## 1. Introduction

Impulsivity, defined as the tendency to react immediately without considering the consequences, the inability to delay gratification, and the tendency to seek new/exciting stimuli, is associated with behavioral addictions such as drug use and gambling, increased suicidal ideation and attempt, attention deficit and hyperactivity disorder, anxiety and major depressive disorders (Heshmat, 2011; Lim et al., 2021). The impulsive system, which involves making decisions quickly, requires minimal cognitive resources and is error-prone. Conversely, the reflective system is driven by thoughts, relatively more controlled. The final decision about eating is determined by the strengths of these two systems. When the future expectation is more attractive than the immediate expectation, the positivity of future possibilities renders the negativity of the imminent expectation tolerable. There are at least two major dysfunctions where this balance shifts in favor of immediate results: hyperactivity in the impulsive system that exaggerates the rewarding effect of incentives such as food, and hypoactivity in the prefrontal cortex or reflective system associated with the long-term consequences of a particular action. In cases such as obesity or food addiction, individuals may be exposed to one or both of these dysfunctions (Heshmat, 2011).

Studies examining the effects of impulsivity (ie, low inhibitory control) on food intake are limited. It is thought that higher levels of impulsivity make it harder to resist palatable, readily available foods that are higher in sodium, sucrose, and lipid compared to healthier foods (Bennett and Blissett, 2020). A study by Guerrieri et al. (2007) examined the relationship between food intake and impulsivity in 38 female participants with normal body weight. Results showed that impulsivity as determined by both the Barrat Impulsivity Scale (BIS-11) and the stop signal task predicts excessive food intake level in the laboratory setting. Researchers have reported that different studies focusing on the stimulation of impulsivity in healthy subjects are needed and that this is the only way to determine whether increased impulsivity really causes excessive food intake. Marques et al. (2020) aimed to evaluate the possible effects of impulsivity on food choices during an impulsivity-inducing intervention (increased food variety). Conclusion of this study showed that in the self-service smart buffet model, impulsivity

did not affect food choices when stimulating impulsivity. Fonseca et al. (2020) examined the relationships between inhibitory control, impulsivity, intake of foods which include high energy and body mass index (BMI) in 51 adult females with anxiety disorder. The impulsivity of the participants was evaluated with the BIS-11, the inhibitory controls were evaluated with the Go/NoGo task, and their food consumption was evaluated with the food frequency questionnaire. The study showed that impulsivity is associated with increasing in intake of sugar and saturated fat, while inhibitory control has no effect on BMI or food intake.

Impulsivity is thought to be related to impaired function of the serotonergic system. In a study conducted in 2021 to evaluate the relationship between impulsivity and intake of tryptophan (n=25), impulsivity was assessed with the Three-Factor Impulsivity Index (TFI) and food intakes were recorded. The results showed that increased tryptophan intake was associated with lower scores on two of the three subscales of TFI (Javelle et al., 2021). Although there are cross-sectional research results reporting that the food consumption of individuals with high impulsivity differs from those with less impulsivity, insufficient evidence exists to determine whether this difference is the cause or consequence of impulsivity.

Studies of the effects of different dietary patterns on the level of impulsivity in rats are limited and generally focus on the effects of high fat and/or sugar consumption on choice and impulse control. Intervention studies in humans have attracted the attention of researchers in the last few years but are very limited in number. Table 1 summarizes some studies focusing on the effects of different dietary interventions on impulsivity in rats and humans (Steele et al., 2017; Steele et al., 2019; Arteaga-Henríquez et al., 2020; Howard et al., 2020; Ross et al., 2020; Beecher et al., 2021; Garman et al., 2021; San Mauro Martina et al., 2022).

**Table 1.** Some researchs examining the effects of dietary interventions on impulsivity

| Reference | Sample | Intervention | Duration | Results |
|---|---|---|---|---|
| Animal Intervention Studies | | | | |
| Garman et al., 2021 | Rats; Long-Evans (n=15) | High fat diet | 14 days | No change was observed in impulsive selection. |
| Beecher et al., 2021 | Rats; C57BL/6J (n=46) | 25% sucrose solution | 12 weeks | Increase in basal locomotor activity and decrease in impulse control, which can be interpreted as hyperactivity |
| Steele et al., 2017 | Rats; Sprague Dawley (n=36) | High-fat diet and high-refined sugar diet | 8 weeks | A high-fat diet: increased latency sensitivity in impulsive choice tasks, decreased incentive motivation<br>A high-sugar diet: increased sensitivity to delay in the impulsive choice task |
| Steele et al., 2019 | Rats; Sprague Dawley (n=24) | High-fat diet and high-refined sugar diet | 8 weeks | High sugar and high fat diet groups: significantly more impulsive choices than the standard diet group |
| Human Intervention Studies | | | | |
| Ross et al., 2020 | 75 overweight/obese adults | Internet based weight loss program | 3 months | Research results have not yet been published |
| Arteaga-Henríquez et al., 2020 | Adults with ADHD and/or borderline personality disorder (n=180) | Synbiotic supplement | 10 weeks | Research results have not yet been published |
| Howard et al., 2020 | 18-50 years old women with BMI> 18.5 kg/m2 (n=33) | Acute fasting | 20 hours | Impaired action inhibition, increase from commission error |
| San Mauro Martina et al., 2022 | Children with ADHD (n=60) | Mediterranean diet, omega-3 supplement and Mediterranean diet + omega-3 supplement | 8 weeks | Fatty acid intake of 550 mg/day EPA and 225 mg/day DHA was associated with less pronounced impulsive behavior compared to the control group and the Mediterranean Diet group |

BMI= body mass index, ADHD= attention deficit and hyperactivity disorder, DHA= docosahexaenoic acid, EPA= eicosapentaenoic acid.

## 2. Obesity

Impulsivity makes it more difficult for some individuals to resist the urge to eat too much than others and can therefore contribute to weight gain. In general, more impulsive individuals are more likely to eat palatable foods or eat in response to emotion, which may contribute to weight gain or complicate weight loss (Heshmat, 2011). Impulsivity is associated with high body mass index and impaired eating behaviors. There are many studies in the literature reporting that overweight individuals have a higher BIS-11 score and a higher BMI is associated with behavioral disinhibition in food stimuli. In addition, obese individuals demonstrate a higher delay discount (where food-related delay discount task predicts body fat percentage) and are more impulsive in the Stop Signal Task; obese women are more impulsive and obese individuals show smaller N2 and P3 amplitudes in the Go/Nogo Task, while obese adolescents demonstrate lower correct response rates during NoGo trials; obese children demonstrate specific electroencephalography (EEG) patterns and have slower reaction times in Stroop Test; attention and motor impulsivity scores in children and adolescents predict perceived self-regulation success in diet; and body fat percentage is associated with impulsive choices in individuals consuming a high-fat diet (Nederkoorn et al., 2006; Meule et al., 2014; Reyes et al., 2015; Meule et al., 2016; Bénard et al., 2017; Cook et al., 2017; Chen et al., 2018; Schmidt et al., 2018; Wen et al., 2020; Rasmussen et al., 2021; Satyal et al., 2021; Steele et al., 2021). In these studies, researchers reported that applying interventions targeting neurobehaviors and helping obese people control their impulses may have a role that complements dietary interventions in the treatment of obesity (Nederkoorn et al., 2006; Satyal et al., 2021).

## 3. Eating Behaviors and Disorders

Although some studies have shown impulsivity to be associated with obesity, binge eating, and restrictive eating, it is unclear which aspects of impulsivity, which is considered to have multiple dimensions, best predict disordered eating. There are some studies aiming to clarify the relationship between different sub-dimensions of impulsivity and eating behaviors. A study conducted by Leitch et al. with 80 female participants shows uncontrolled eating was associated with thinking impulsivity rather than choice/action impulsivity. According to the results of another study conducted by Yeomans et al., the total score and non-planning and motor impulsivity subscale scores obtained from the BIS-11 were higher in women with higher Three Factor Eating Questionnaire (TFEQ) uncontrolled eating scores, and these women made more impulsive choices on the hypothetical monetary reward test. These results show that impulsive behavior is associated with the tendency to overeat and may be a factor that predicts the possibility of not maintaining the diet (Yeomans et al., 2008; Leitch et al., 2013). Similarly, in their study with 240 adult participants, Emiroğlu and Işık reported that although impulsivity was not higher in obese individuals than in healthy individuals, all three sub-dimensions of impulsivity determined by BIS-11 were associated with uncontrolled and emotional eating behaviors (Emiroğlu and Işık, 2022).

Overeating accompanied by recurrent loss of control and/or binge eating is an important public health problem. Research shows that altered reward or control-related processes may contribute to disordered eating in binge-eating populations (Berner et al., 2017). In a study by Lyu et al. (2017), women who engaged in high (n=31) and low (n=31) binge eating completed a Go/NoGo task that included images of high- and low-energy foods. The study showed that the normal-weight, binge-eating women were more sensitive to high-energy food cues (faster to respond to Go trials) than the healthy control group, but reported no evidence of behavioral inhibitory control deficits (false alarm rates). In another study examining the difference in the neural responses of binge eating syndrome and the responses of healthy individuals to visual food stimuli, brain activations of participants were recorded during visual exposure to high-energy foods following a 12-hour night fast. The research results provided the first evidence that increased medial orbitofrontal cortex reactivity to food stimuli can transform the reward drive into compulsive binge eating in patients with binge eating syndrome. Considering this, the researchers drew attention to the necessity of specific therapy approaches for binge eating syndrome (Schienle et al., 2009). A systematic review published by Schag et al. (2013) estimated the results of 51 studies examining food-related impulsivity in individuals with obesity and/or binge eating disorder and found that reward sensitivity is higher in both obese and binge-eating individuals than individuals with only one of these two conditions, and this seems to represent a more pronounced obesity phenotype. Researchers reported that identifying individuals with binge eating disorder as a special obesity subgroup and developing specific treatment programs to reduce impulsivity according to the individual needs of the patient may increase the effectiveness of weight loss programs. The same researchers updated this systematic review in 2017, analyzing the results of 20 articles published since 2012; the most recents studies show that food addiction is highly correlated with binge eating disorder and obesity and is associated with reward sensitivity and inhibitory control. More studies are needed to differentiate the concepts and mechanisms of binge eating disorder, obesity and food addiction, as well as distinguishing between obese patients with / without binge eating (Giel et al., 2017).

Impulsivity is one of the determinants of emotional eating and triggers unhealthy food selection in response to negative mood states (Huang et al., 2017). Negative moods or poor inhibitory control are associated with

binge eating and may contribute to the development of overweight. A study conducted by Byrne et al. in 2021 investigated whether poor inhibitory control mediates the relationship between negative mood and overeating in young people (n=181). The study found that negative emotions may lead to stronger food orientation as well as weaker inhibitory control, and may increase the likelihood of uncontrolled eating. Researchers have recommended studies to determine whether approaches to reducing negative emotions will develop inhibitory control and prevent overeating in young people with depression or anxiety (Byrne et al., 2021). A study conducted by Jasinka et al. in examined the multifactorial relationships between eating behaviors, impulsivity, inhibitory control and BMI in young adults, reporting that increased impulsivity (BIS-11) was associated with increased emotional eating behavior and increased tendency to choose unhealthy foods. The study supported the hypothesis that inadequate inhibitory control (Go/NoGo task) could be associated with unhealthy eating. False alarm rates were found to be significantly correlated with emotional eating scores (Jasinska et al., 2012).

Dietary restriction is the restriction of energy intake to achieve weight loss or maintain weight. Restriction attempts are generally successful in the short term, and restriction has been associated with higher BMI and overconsumption after exposure to food stimuli. Restrictive eaters show altered neural responses in a nutrient-based Go/NoGo task and have been shown to eat more in the laboratory when response inhibition is low (Price et al., 2016). In their study Jansen et al. tested whether the inability to inhibit impulsivity or motor responses differ between successful and unsuccessful restrained eaters. Eating restrictions of 63 female university students were evaluated with the restriction scale; their food intake was evaluated with the taste test; and their impulsivity was evaluated with the stop signal task. The study results showed that overeating is due to the interaction between restraint and impulsivity, and highly restrictive eaters binge only when they are impulsive. It was concluded that being restrictive is not the only determinant of overeating. The researchers declared that dieting will be much easier and possibly more successful when highly restricted eaters are less impulsive, and this data makes such research extremely useful for developmenting interventions that reduce impulsivity in people suffering from impulsive binge eating (Jansen et al., 2009). The study of Koningsbruggen et al. showed that impulsivity is a feature that distinguishes unsuccessful and successful restrictive eaters. Researchers have suggested that less impulsive restrictive eaters may be individuals who exercise self-control in tempting situations and reported that unsuccessful restrictive eaters can be transformed into successful ones with interventions that reduce impulsivity (Koningsbruggen et al., 2013). In recent years, insights into the differences in the processing of food stimuli have begun to be provided by functional magnetic resonance imaging (fMRI). In their 2019 study, Su et al. compared successful restrictive eaters and unsuccessful restrictive eaters in a food-stimulated Go/NoGo paradigm. The study collected fMRI data while participants viewed the food stimuli and found the fMRI results revealed stronger activations for high-energy foods in areas associated with executive function and inhibition in successful restrictive eaters than in unsuccessful restricted eaters. The researchers emphasized that the participants were grouped according to the Dutch Eating Behavior Questionnaire and that their actual eating behaviors would probably be different from the performances shown on the scale such that the actual eating behaviors should be taken into account when grouping the participants in future studies (Su et al., 2019). In their 2020 study, Bennett and Blissett evaluated the effects of impulsivity and dietary restriction on eating behavior in individuals aged 7-11 years. Four tasks were used to identify different aspects of impulsivity and the Dutch Eating Behavior Questionnaire-Child version was used to assess children's restrictive eating behavior. Individuals who completed all procedures consumed a snack in the laboratory for 10 minutes. The results showed that categorizing children as high or low in terms of dietary restriction or impulsivity alone does not predict overeating in children, but the combination of dietary restriction and poor control of motor impulses is associated with the occurrence of overeating (Bennett and Blissett, 2020).

A systematic review of 38 cross-sectional studies between 2005 and 2019 comparing the impulsivity of individuals in the acute phase of Bulumia nervosa and anorexia nervosa to healthy controls found no strong evidence to support the characterization of Blumia nervosa or anorexia nervosa as either high in impulsivity or low in impulsivity (Howard et al., 2020).

The role of impulsivity in eating disorders is important to consider for several reasons:

- Impulsivity may be associated with certain eating disorder behaviors (binge eating and vomiting).
- Impulsivity has the potential to occur with behaviors such as substance use and non-suicidal self-harm.

Understanding the role of impulsivity can be informative in the treatment process, as well as clarifying the development and onset of disordered eating (Lavender et al., 2015).

## 4. Current Complementary Treatment Approaches to Food-Related Impulsivity in Obesity and Eating Disorders

Regardless of the measurement method, evidence supports a positive correlation between increased impulsivity and binge eating behavior in both healthy and clinical cases, and impulsive personality trait is

recognized as a potential etiological and/or sustaining factor for binge eating behavior. A systematic review examining whether binge eating behavior can be modified by impulsivity-focused interventions revealed current impulsivity-focused approaches can be categorized as psychotherapy, direct neuromodulation interventions, pharmacotherapy and computer-assisted cognitive training. All these approaches have been shown to be promising for modifying food-related impulsivity in individuals with episodes of binge eating (Figure 1) (İnce et al., 2021).

Mindful and intuitive eating focuses on problematic eating behaviors and difficulties in controlling food intake. In the treatment of obesity and eating behavior disorders, the level of impulsivity can be reduced with mindful eating and intuitive eating training (Hendrickson and Rasmussen, 2017; Warren et al., 2017).

Non-invasive brain stimulation techniques can be used in conjunction with EEG to reach additional insights. Transcranial direct current stimulation (tDCS) is known to modulate brain activity in a polarity-dependent manner. Previous studies have shown that neuromodulation can affect craving by regulating the release of dopamine and norepinephrine. The study by Lapenta et al. showed that tDCS provides a reduction in energy intake compared to sham stimulation and that noninvasive brain stimulation significantly changes the neural markers of inhibitory control (Lapenta et al., 2014). In their study of published in 2021, Luzi et al. showed that in individuals with obesity (n=45), 5-week deep TMS (dTMS) is associated with a significant decrease in body weight, BMI and impulsivity (Luzi et al., 2021).

Go/NoGo training protocols have been created, where high-energy foods appear on the screen with No-Go cues and foods which include low-energy or non-food images appear with Go cues. This is hypothesized to reduce motor excitability and/or increase inhibitory control for high energy foods. Turton et al. determined that food-specific inhibition training reduced energy-dense food consumption in women with Blumia nervosa (n=30) and binge eating disorder (n=19). Researchers have suggested the use of personalized training protocols in this area (Turton et al., 2018).

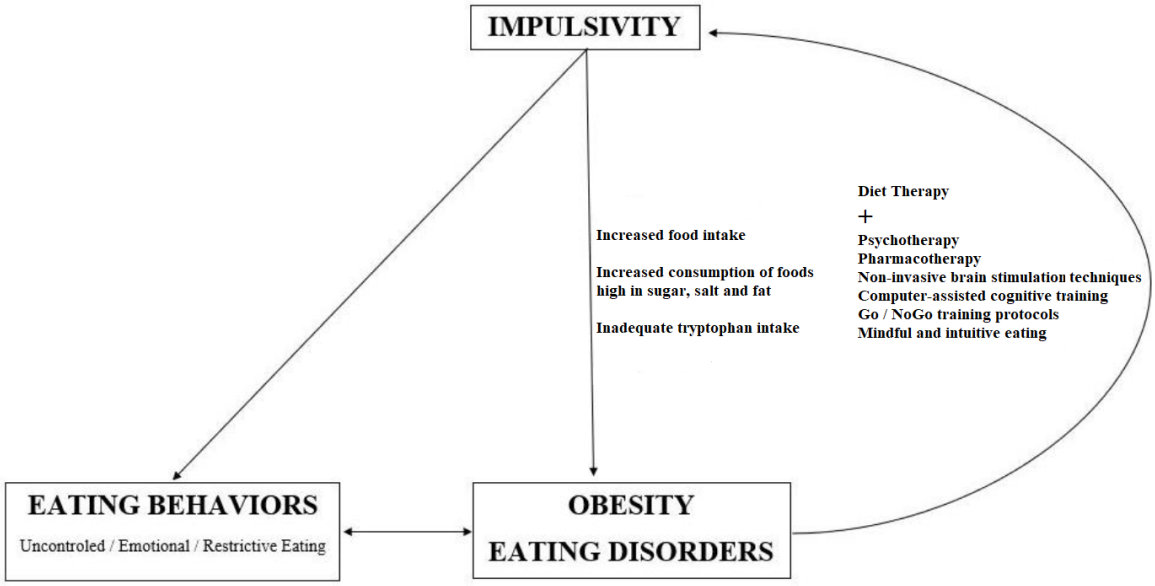


**Figure 1.** Relationships between impulsivity, eating behaviors, obesity and eating disorders.

## 5. Conclusion

An increasing number of studies report that impulsivity can affect impaired eating behavior and play a role in obesity and eating disorders. However, studies examining the eating habits of impulsive individuals and the effects of different eating patterns on impulsivity are insufficient. Future studies should focus on identifying nutritional factors that play a role in the formation and development of impulsivity. Although studies have reported that interventions to reduce impulsivity may increase the effectiveness of treatment in obesity and eating disorders, there are no studies that include the effectiveness of these interventions in addition to diet therapy. In multidisciplinary studies, in which dietitians also take part, the effects of the use of alternative approaches to reduce impulsivity in support of nutritional therapy on the effectiveness and sustainability of the diet should be focused. The results presented in this review, which examines the role of impulsivity in eating behaviors and obesity, give an idea to the experts on the determination of impulsivity in the treatment of obese individuals and the application of impulsivity-reducing approaches if needed, and draw attention to research areas in future studies.

**Author Contributions**

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

| | E.E. | Ş.A. |
|---|---|---|
| C | 50 | 50 |
| D | 50 | 50 |
| S | 50 | 50 |
| L | 50 | 50 |
| W | 50 | 50 |
| CR | 50 | 50 |
| SR | 50 | 50 |

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision.

**Conflict of Interest**

The authors declare that there is no conflict of interest.

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