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WHEN FOOD KILLS - ADDICTION TO EATING AND NOT EATING

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ABSTRACT

The aim of this paper is to discuss, based on the literature on the subject, the problem of food addiction, binge eating, anorexia nervosa, and to compare these disorders in terms of their biology and neurobiology. The literature review includes the definition of the concepts of food addiction, binge eating, and anorexia nervosa, the epidemiology of these phenomena based on population studies, the diagnostic criteria for these disorders, and the likely neurobiological factors responsible for their development, as well as a list of types of anorexia nervosa and their differentiation in terms of coexistence with food addiction. The paper also includes a brief discussion of the somatic symptoms observed in the course of obesity and anorexia nervosa.

Introduction: Anorexia nervosa is an eating disorder characterized by extreme food restriction and actions aimed at reducing body weight, leading to serious somatic and hormonal changes and high mortality. Its development is facilitated by cultural pressure as well as a genetic predisposition to anxiety and perfectionism.

The concept of food addiction describes reactions to highly processed, caloric foods similar to classic addictions, as they strongly activate the reward system. Although the topic is controversial, more and more studies confirm biological and behavioral mechanisms

resembling addiction. Women seem to be more susceptible to food addiction, probably due to hormonal differences and food preferences.

Aim of the study: The aim of this paper is to present and compare, based on available scientific literature, the phenomena of food addiction, binge eating, and anorexia nervosa, with particular emphasis on their biological and neurobiological basis, as well as to discuss their diagnostic criteria, epidemiology, possible risk factors, and somatic symptoms. The paper also aims to highlight the similarities and differences between these disorders and to identify elements common to the mechanisms of classic addictions.

Conclusions: Both eating avoidance disorders and those based on excessive consumption show biological, neurobiological, and psychological similarities, and their diagnosis is based on criteria that include elements typical of addictions. In both cases, the same neurotransmitter pathways are involved, which also play a role in classic addictions, and extreme eating patterns—both starvation and overeating—lead to destructive effects on the body. A deeper understanding of these mechanisms may enable the development of more effective treatment methods, which is particularly important in view of the increasing prevalence of anorexia and food addiction.

Keywords: anorexia nervosa, anorexia, food addiction, obesity, eating disorders

1. Introduction

Anorexia nervosa is a specific eating disorder that manifests itself as a set of abnormal mental attitudes, visible in the restriction of the amount and type of food consumed, resulting in somatic, metabolic, and endocrine changes (Ziółkowska 2017). Restricting the amount of food consumed is supported by a series of activities leading to weight loss, such as excessive physical activity, inducing vomiting, using laxatives, diuretics, cooling the body, restricting fluid intake, and others (Weterle-Smolińska et al. 2015). Patients do not stop reducing their body weight, even when they reach their previously set goal or when their body is physically destroyed (Kręgielska-Narożna et al. 2015). For this reason, anorexia nervosa is a mental illness with the highest mortality rate. Cultural ideals of beauty and the cult of slimness can trigger the

development of eating disorders in sensitive individuals who have a genetic predisposition to anxiety and perfectionism. Both starvation and purging can initially calm these feelings (Westmoreland et al. 2016).

The concept of food addiction is currently a widely debated topic in both society and scientific circles. The term food addiction suggests that individuals may experience food-related reactions similar to those observed with classic addictive substances (Hauck et al. 2020). Individuals exhibiting characteristics suggestive of food addiction show a particular preference for high-calorie, highly processed foods that are high in fat or refined sugar, which are characterized by an evolutionarily conditioned potential to activate the reward system and improve mood (Poprawa et al. 2020). Furthermore, studies show that mixed foods rich in fats and carbohydrates are more valued than tasty foods high in fat or carbohydrates alone, and that mixed foods have a greater effect on the activity of brain areas involved in reward than single-ingredient foods (Fletcher and Kenny 2018). The concept of food addiction is controversial among researchers. While some question the validity of this construct, a growing body of research provides evidence of biological and behavioral changes in response to highly palatable foods that meet the criteria for addiction (Gordon et al. 2018), women were more likely than men to develop food addiction, but some studies show that there is no statistically significant relationship between food addiction and gender. Overall, women are more prone to food addiction than men. This may be because men and women have different hormone levels and food preferences (Aytaş and Alataş 2023).

1. Diagnostic criteria for anorexia nervosa

Anorexia nervosa is characterized by intentional weight loss or failure to gain weight as expected. However, it should be remembered that both weight loss and refusal to eat can be symptoms of other somatic or mental disorders. Only after ruling out other causes of weight loss, such as gastrointestinal diseases, endocrine problems, or cancer, is it possible to diagnose or rule out an eating disorder. The World Health Organization (WHO) has proposed five criteria for the diagnosis of anorexia nervosa – all criteria must be met in order to diagnose anorexia nervosa.

1. Intentional weight loss or failure to gain weight during childhood development, resulting in underweight equal to or greater than 15% of expected body weight. In adults and older adolescents, a criterion referring to the so-called body mass index, or BMI, is used. The first criterion for diagnosing anorexia nervosa is met if this index is 17.5 or less (in practice, however,

this method is imprecise and can cause many errors, especially when assessing younger adolescents, and it is better to use a percentage assessment).

2. Weight loss through restricting food intake (especially so-called fattening foods) and at least one of the following behaviors: inducing vomiting, laxative use, excessive exercise, use of appetite suppressants and/or diuretics.

3. Presence of so-called body image disorders, i.e., an inadequate perception of one's own appearance (e.g., an emaciated person perceives themselves as obese or certain parts of their body as excessively "fatty" or "thick"). In practice , the presence of this symptom is associated with experiencing severe stress, anxiety, and taking actions aimed at losing weight. Body image disorders affect both perception – "I perceive myself as obese," thinking – "I think I am 'fat,'" and affect – "I hate myself because of my appearance."

4. The presence of characteristic hormonal disorders, which in girls is manifested by the loss of menstruation or the absence of the first menstruation if anorexia nervosa began before puberty.

5. Stunted physical development (Żechowski 2013).

Taking into account the latest DSM-V criteria, the following should be considered when diagnosing a person for eating disorders:

- restriction of energy intake leading to significant weight loss in the context of age, gender, developmental norms, and physical health,
- intense fear of gaining weight, obesity, or persistent behaviors that interfere with weight gain, even in the case of significantly reduced body weight,
- disturbances in body image: excessive influence of weight and shape on self-esteem, as well as persistent unawareness of being underweight (Bąba-Kubiś et al. 2018).

2. Epidemiology of anorexia nervosa

Eating disorders occur regardless of gender, age, race, ethnicity, or socioeconomic status. However, they are significantly more common in rich and highly developed countries, and are also more frequently reported in young women (Kucharska 2017). It is estimated that children as young as 13–14 years old already suffer from eating disorders. It is known that the vast majority of cases occur before the age of 18–20, usually at the transition from puberty to early adulthood, between the ages of 14 and 20, when important changes related to sexual maturation and identity formation take place in the body and psyche. Anorexia is much less common after the age of 25. People aged 15–19 account for 40% of newly diagnosed cases. The peak incidence occurs between the ages of 14 and 18, and about 85% of cases begin before the age of 20. Anorexia nervosa is relatively rare in the population under the age of 13. Some studies

indicate an increasing incidence of anorexia, especially in women aged 15–24 (Jagielska and Kacperska 2017).

According to the National Association of Anorexia Nervosa and Associated Disorders, approximately 0.9% of women may suffer from anorexia. In Poland, no large-scale epidemiological studies on this topic have been conducted to date, but it is estimated that anorexia may affect 0.8–1.8% of girls under the age of 18. Boys and young men also suffer from this disorder, but much less frequently than women (Pawełczyk-Jabłońska 2019).

According to other large population studies, the prevalence of anorexia nervosa in women ranges from 1.2 to 2.2%, and the estimated prevalence in men is several times lower. Bulik et al. reported the prevalence of anorexia nervosa (according to DSM-IV criteria) in women at 1.2% and in men at 0.29%, and according to DSM-V criteria, the prevalence of anorexia in the population of 14-year-olds was estimated at 3.2% in women and 1.6% in men. Studies conducted in the general population indicate that only 17-31% of people with a probable diagnosis of eating disorders seek adequate treatment (Świątkowska 2022).

3. Types of bulimia nervosa

The basic feature of anorexia is organizing one's entire life around a single goal, which in this case is weight loss and preventing weight gain at all costs – refusing to eat then leads to extreme emaciation and destruction of the body. At the same time, a person suffering from anorexia has a constant belief that their body does not look right and that they are still too heavy. There are two types of anorexia:

- Restrictive anorexia – the patient strives to lose weight by limiting the amount of food consumed or by irregularly using laxatives. Intense and exhausting physical exercise ("fat burning") is also characteristic of this type of disorder.
- Bulimic anorexia - the patient usually restricts their food intake, but has periods of excessive overeating, which they try to "regulate" through numerous regular activities aimed at limiting the absorption, assimilation, or utilization of food by the body, including vomiting, systematic use of laxatives or diuretics, sometimes exceeding the recommended dose many times over (Borowiecka-Karpiuk 2023).

Many people experience both forms of the disorder during the course of their illness. Despite differences in the behavior of people with both types, their main goal is to lose weight and change their body shape. In addition, in both types of the disorder, sufferers do everything they can to burn as many calories as possible, e.g., they bathe in cold water, dress too lightly,

stay in cold rooms, try to constantly tense their muscles, or perform certain activities while standing or squatting (Kucharska 2017).

4. Causes of anorexia nervosa

There are many theories attempting to explain the etiopathogenesis of anorexia. Today, it is emphasized that the sources of the disease should be sought deeper than just in weight loss treatments, which become an obsession that is difficult to control. Anorexia affects the whole personality and not just eating problems. Risk factors include genetic, environmental, and cultural factors. Researchers are currently trying to determine the percentage contribution of these three factors to the etiology of eating disorders. Research to date shows that genetic and environmental factors predominate in anorexia, i.e., certain stresses associated with development must overlap with a fairly strong genetic susceptibility to the disease (Żechowski 2013).

In terms of genetic factors, a concordance rate of 44% was observed in identical twins and 12% in fraternal twins. The total heritability is high, ranging from 33% to 84%. Despite genetic research, it has not yet been clearly established which genes are responsible for the predisposition to developing anorexia (Baker et al. 2017).

Personality traits described as predisposing to the development of anorexia include perfectionism, discipline, diligence, conscientiousness, and a focus on achieving success—both in school and other areas of life—regardless of actual abilities. Other character traits include rigidity, lack of acceptance of femininity, difficulty in naming and expressing emotions, avoidance of confrontational situations and situations requiring decision-making, emotional immaturity, and emotional coldness. In people who play sports or engage in activities that require a slim figure (models, dancers, ballerinas, gymnasts, athletes), the risk of developing anorexia increases several times over (Delsedime et al. 2013).

One of the reasons for anorexia is the desire to gain control over a certain aspect of one's life. Not eating can then become a way of achieving independence, for example from parents who try to interfere excessively in their child's life. Patients who are driven by such motives are usually raised in an environment where there is a lot of pressure to meet family and social norms, with little reinforcement based on their own actions. This gives rise to both a sense of loss of control over their life, understood as the externalization of feelings, and susceptibility to cultural influences (Jaros and Oszwa 2014). The body then becomes an area where the patient can decide for themselves, and diet is an independent decision that no one can change, which gives the patient a sense of autonomy (Szpytman et al. 2016). For people who feel that their lives are

constantly controlled from the outside, their need for independence is completely transferred to food (Kobierzycka 2024). Anorexia is treated as an attempt to regain lost control or disturbed self-control – narrowed down to the area of weight loss, maladjusted to requirements and focused on an inappropriate, short-term goal. The external locus of control is also associated with a greater severity of anorexia symptoms and is a risk factor for the development of comorbid disorders, such as depressive, anxiety, or obsessive-compulsive disorders, which worsen the course of the disease and complicate the treatment process. It also plays an important role in the treatment of anorexia, as a sense of lack of control over one's life makes it difficult to decide to start therapy (Jaros and Oszwa 2014).

Another important cause of developing eating disorders, including anorexia nervosa, is socio-cultural influence. The fashion, sports, and culture industries' promotion of a slim figure contributes to a significant decline in self-esteem in people whose appearance differs from that promoted by the media (Szpytman et al. 2016). Many social researchers believe that the body is one of the most important cultural symbols. It is a model that shapes our view of the world – it is omnipresent in the media, which significantly influences how we perceive and interpret the world (Jarząbek 2007). Women, especially teenagers, are most sensitive to these influences. It is the pressure exerted by the environment on people who do not fit the canon created by the media that becomes a mechanism leading to anorexia (Szpytman et al. 2016).

5. The neurobiology of anorexia nervosa

The serotonin (5-HT) system is of particular importance in the neurobiology of anorexia nervosa. People suffering from anorexia nervosa have significantly lower baseline concentrations of 5-hydroxyindoleacetic acid, the primary metabolite of the serotonin system, in their cerebrospinal fluid, while patients who have overcome the disorder show significantly elevated levels of 5-hydroxyindoleacetic acid compared to people who have never suffered from eating disorders. Particularly high levels of this metabolite are observed in people who have suffered from bulimic anorexia in the past, a type of anorexia nervosa involving binge eating followed by purging (Bailer and Kaye 2011).

The dopaminergic system is a neurotransmitter system largely associated with the serotonergic system, which is also considered in the etiology of anorexia nervosa. It has been found that homovanillic acid, the main metabolite of dopamine in humans, is reduced in the cerebrospinal fluid of people with anorexia nervosa in a pathological state. Positron emission tomography (PET) imaging with the radiotracer [11C]raclopride was used to assess dopamine D2/D3 receptor function in individuals with anorexia nervosa. The researchers reported

significantly higher [11C] raclopride binding potential in the anterior striatum than in control participants, suggesting that anorexia nervosa is associated with reduced intra-synaptic dopamine concentration or increased D2/D3 receptor density; the authors suggest that this may contribute to the impaired reward processing seen in anorexia nervosa. Another study using amphetamine and PET showed that individuals recovered from anorexia nervosa showed a positive association between endogenous dopamine release and anxiety due to caudate nucleus stimulation, possibly explaining why food-related dopamine release causes anxiety in individuals with anorexia nervosa but is pleasurable in healthy individuals (Bailer et al. 2013).

Neuropeptides are also of interest in research on anorexia nervosa because they are involved in the regulation of eating behavior. Abnormalities have been found in individuals with this disorder for various neuropeptides, including opioid peptides, oxytocin, neuropeptide Y, and leptin, although the differences observed appear to normalize after restoration of normal body weight, suggesting a state effect rather than a trait (Bailer and Kaye 2003).

6. Symptoms and course of anorexia nervosa

The disease usually begins with a desire to lose a few extra pounds, which over time turns into an obsession with one's appearance and weight loss. This means that the onset of anorexia is usually hidden, almost imperceptible to those around the person, and the person affected by the disorder does not perceive themselves as ill. During this period, the person's weight loss is seen by those around them as a sign of an effective weight loss diet. As the weight loss increases, the anxiety of loved ones grows. Interestingly, anorexia is similar to alcohol addiction in this respect and, like alcoholism, develops in four phases:

Phase I – Euphoria – after the first few days of fasting, the metabolism subsides, as does the previously nagging hunger, and is replaced by a feeling of excitement, vitality, and euphoria, otherwise known as "starvation ecstasy" (Kowalczuk 2008). At this stage, gradually reducing food intake, similar to an alcoholic occasionally reaching for alcohol, does not differ much from the socially accepted norm, and the sufferer is convinced that their actions are under control and will lead them to the desired success. In this phase, the patient also exercises more intensively and undertakes various types of daily physical activity (e.g., walking or cycling everywhere). Similar to an alcoholic who shows increased confidence as symptoms of alcohol fascination appear, a person suffering from anorexia nervosa is also inclined to undertake numerous activities and is bursting with good mood and optimism.

Phase II – Increased self-control – the patient begins to impose self-destructive rules on themselves, and perfectionism in following them makes them feel superior to others. A sense

of superiority develops in them, motivated by the fact that they are in control of their appetite. For this reason, this phase is also called the "moral superiority phase" (Kowalczuk 2008). This stage can often be very misleading, as the person gives the impression of being very careful about their diet. They often demonstrate above-average knowledge of nutrition, calorie tables, and meal preparation skills. Just as an alcoholic in the second phase of addiction actively seeks opportunities to drink and eagerly initiates social gatherings for this purpose, a person suffering from anorexia nervosa enjoys preparing meals for the whole family. However, it is worth noting that, unlike alcoholics, people with anorexia often do not eat meals with family members, using numerous arguments to explain this behavior (Cierpiałkowska 2007). This is due to the fact that while in the case of an alcoholic, the presence of alcohol is the addictive factor, in people suffering from anorexia, it is the lack of food.

III. Phase – Anxiety – at this stage, the patient experiences anxiety at every meal, fearing that even the slightest deviation from their diet will cause them to lose control. They also disregard worrying symptoms and the fact that they suffer from an eating disorder. The clinical picture of this phase is dominated by the fear of gaining weight and refusing to eat regular meals (Szpytman et al. 2016). The patients' perception of their own body is so distorted that, regardless of their actual weight, they are convinced that it is too high. This causes significant suffering for the patients (Cierpiałkowska 2007). There is a noticeable similarity to the third stage of alcohol addiction, when the drinker loses control over their consumption, just as anorexia sufferers completely lose control over the behaviors that lead to weight loss. Passions and interests fade into the background. In this phase, both alcoholism and eating disorders begin to be noticed by those around them.

Phase IV - symptoms of obsessions and depression. The psychological consequences of eating disorders intensify, which is associated with the onset of obsessions - for example, about cleanliness, mortification of the body - for example, through ice-cold baths, and even depression reflected in suicidal thoughts (Szpytman et al. 2016). Here, too, similarities can be seen with alcohol addiction, in which the fourth stage of addiction is characterized by episodes of depression, anxiety, and problems with memory and concentration (Skoczek et al. 2020).

7. Diagnostic criteria for food addiction – the Yale scale

The increased scientific interest in food as an addictive substance and overeaters as addicts is partly due to the discovery, with the advancement of neuroimaging methods, that obesity and overeating are associated with changes in dopaminergic signaling and hyperactivation of

reward centers in the brain. This phenomenon is comparable to the processes observed in people who use drugs.

The Yale Food Addiction Scale (YFAS) was developed to provide a standardized measure for assessing food addiction. It is a 25-point tool that measures the presence of food addiction symptoms based on the DSM-IV criteria for substance addiction, which include:

1. Tolerance, defined as consuming increasing amounts of the substance to achieve the same effects or experiencing reduced effects with continued use of the same amounts of the substance.
2. Withdrawal symptoms when the substance is not used, or use of the substance to avoid withdrawal symptoms.
3. Using the substance in larger amounts or for a longer period than intended.
4. Persistent desire or unsuccessful efforts to reduce substance use.
5. Increased time spent obtaining or using the substance or recovering from its effects.
6. Reduction in social, occupational, or recreational activities due to substance use.
7. Use of the substance despite a persistent physical or psychological problem caused or exacerbated by the substance.

According to the DSM-IV scale, substance dependence can be diagnosed when at least three of the listed symptoms have been present in the past year. In addition, two items on the Yale scale assess clinically significant impairment or distress as a result of overeating. The prevalence rates for these diagnoses range from 5% to 10% in non-clinical samples, 15% to 25% in samples of obese individuals, and 30% to as high as 50% among morbidly obese bariatric patients. Among obese individuals, almost all participants meet the criterion of persistent cravings or unsuccessful attempts to restrict or control eating (Meule and Gearhardt 2014).

8. Diagnostic criteria for food addiction – DSM-V scale

The newly revised version of the DSM suggests replacing the previous category of "Substance-Related Disorders" with "Addictions and Related Disorders," thus enabling behavioral addictions to be diagnosed on this basis for the first time. This tool measures 11 symptoms of food addiction:

1. Eating larger amounts of certain foods and for longer than planned
2. Constant craving for specific foods or unsuccessful attempts to limit or control consumption,
3. Spending a lot of time on activities aimed at finding specific foods, eating them, and reducing the negative consequences of doing so,
4. Neglecting or abandoning important life activities because of food,

5. Repeatedly consuming excessive amounts of specific foods despite awareness of the negative consequences,
6. Tolerance expressed by a marked increase in the amount of specific food and a progressive decrease in the desired effect,
7. The appearance of characteristic negative withdrawal symptoms (after restricting or stopping eating certain foods) and returning to excessive eating in order to reduce these symptoms,
8. Continuing to overeat despite recurring social problems, including interpersonal problems,
9. Overeating that contributes to failure to fulfill social roles (at work, home, or school),
10. Eating certain foods even when it poses a threat to health and life,
11. Craving or strong urge to eat certain foods that is difficult to resist.

The following clinical diagnostic criteria have been added to the above symptoms:

12. The occurrence of distress and life problems caused by eating habits.

Food addiction can be inferred if this problematic eating pattern leads to significant clinical problems and excessive stress, with symptoms must have occurred within the last 12 months (Poprawa et al. 2020). Based on this scale, three levels of symptom severity can be determined, ranging from mild with two to three symptoms, to moderate with four to five symptoms, to severe with at least six symptoms. Analyzing the above criteria with the awareness that addiction is a severe, chronic, and recurrent disease of the nervous system characterized by an uncontrollable urge to obtain, seek, and use a substance, despite full awareness of the serious threat to health and life associated with it, and behavioral addictions reflect an addiction to a behavior or feeling caused by that behavior, rather than to the substances themselves, it seems most accurate to say that food addiction is classified as both an addiction to the act of eating (behavioral addiction) and an addiction to food itself (substance addiction) (Nowak-Perlak et al. 2023).

9. The neurobiology of food addiction

The growing interest in the concept of food addiction is linked to the pandemic spread of obesity and, at the same time, to the discovery, using neuroimaging techniques, of similarities in the brain functioning of obese overeaters, people with selected eating disorders, and people suffering from disorders related to psychoactive substance use and behavioral addictions (Poprawa et al. 2020). Currently, these studies suggest that tasty food and abused drugs may affect the functioning of similar areas of the brain (Fletcher and Kenny 2018).

More and more studies are drawing attention to the importance of neuroplastic processes in the pathogenesis of obesity and eating disorders. Research indicates a strong link between the consumption of high-calorie foods and the induction of plastic processes in neural areas associated with the sensory evaluation of food and their neural regulation of the hypothalamus and other structures of the mesocorticolimbic system. Furthermore, dopaminergic transmission within these structures plays a key role in appetite control, motivation to eat, and food valuation (Nowak-Perlak et al. 2023).

A diet high in saturated fats and carbohydrates can contribute to changes in neural circuits in the mesolimbic system and to behavioral changes resembling food addiction. Studies show that the foods most commonly associated with addiction symptoms are those high in added fats and/or refined carbohydrates, such as sugar (Gordon et al. 2018).

As part of the hypothalamic-pituitary-adrenal axis, neurons in the paraventricular nucleus are responsible for the secretion of corticoliberin and vasopressin, among other substances, in response to stress stimuli, and food consumption leads to a decrease in its activity, which is why it is attributed with anxiolytic and antidepressant effects (Zhan et al. 2021). Therefore, the phenomenon of "eating away" negative emotions is gaining importance, which in turn leads to compulsive and repetitive episodes, and often also to the development of obesity (Seabrook and Borgland 2020).

Some researchers question whether food can be addictive if it is necessary for our survival, while others point to common biological (e.g., brain reward pathway), behavioral (e.g., relapse, using more than intended), and psychological (e.g., preoccupation, impaired control) similarities between compulsive consumption of highly palatable foods and the use of addictive drugs (Gordon et al. 2018). Research indicates that drugs can affect our brain's reward system, particularly the dopaminergic mesolimbic system. Excessive readiness to consume food and problems with self-control over food intake are also associated with impaired functioning of the reward system—the mesolimbic pathway, running from the ventral tegmental area (VTA) to the nucleus accumbens (NAC). In some cases, engaging in certain activities or using substances causes excessive dopamine release and feelings of disproportionately strong pleasure, which in turn leads to a constant search for reinforcing stimuli (Bąk-Sosnowska 2017). These findings suggest that there are common neural substrates for both food and drug addiction, and that both depend on dopaminergic circuits. Furthermore, human brain imaging studies strongly support the role of dopaminergic circuits in the control of food intake. Drugs cause large increases in synaptic DA concentrations in the mesolimbic system. Similarly, rewarding food has been reported to stimulate dopaminergic transmission in the nucleus accumbens,

which receives axons from the dopaminergic nuclei of the mesolimbic pathway. When DA was measured by microdialysis in the nucleus accumbens of freely moving rats in the presence of food reward, it was observed that the injection of amphetamine and cocaine increased DA levels in the nucleus accumbens, which is normally activated by food, suggesting that the release of DA by food may be a factor in the development of food addiction.

Many human studies have pointed to the importance of the dopamine D2 receptor in regulating food reward in the context of obesity, specifically demonstrating altered function and expression of the D2 receptor in the striatum. Both obese and drug-addicted individuals tend to have reduced expression of dopamine D2 receptors in striatal areas, and imaging studies have shown that similar brain areas are activated by food- and drug-related cues. PET studies suggest that DA D2 receptor availability is reduced in obese individuals in proportion to their body mass index, thus suggesting that DA deficiency in obese individuals may perpetuate pathological eating as a way to compensate for reduced activation of dopaminergic reward circuits. An alternative explanation is that individuals with low D2 receptor numbers may be more susceptible to addictive behaviors, including compulsive food intake, thus providing direct evidence for a deficit in DA D2 receptors in obese individuals. Davis and colleagues found in their studies that individuals who met the YFAS criteria and suggested clinically significant symptoms of food addiction had higher multi-locus genetic profile (MLGP) scores associated with increased dopamine signaling. They also showed that an appetite-suppressing drug that blocked dopamine function was not effective in adults who scored positive on the YFAS test for food addiction compared to the control group, suggesting altered dopamine signaling strength in adults with more symptoms of food addiction, similar to that seen in adults with substance use disorders (Gordon et al. 2018). It is worth noting that knowledge about the overlapping brain systems involved in regulating the motivational properties of palatable foods and drugs may prove important in the development of therapeutic agents to combat both addictions. The available evidence is promising in this regard. For example, the cannabinoid 1 receptor antagonist rimonabant, developed as an anti-obesity drug, facilitates smoking cessation in humans (Cahill and Ussher 2007). Similarly, the anti-obesity drug lorcaserin, a serotonin 2C receptor antagonist, also facilitates smoking cessation (Shanahan et al. 2017). Beyond the clinical aspect, these findings also provide evidence that overeating and drug use are likely to be driven by common brain processes (Fletcher and Kenny 2018).

Studies have shown a significant association between D2 receptor levels in the striatum and activity in the dorsolateral prefrontal cortex, medial orbitofrontal cortex, and cingulate gyrus in obese individuals. Because these areas are involved in inhibitory control, salience attribution,

and emotional reactivity, this finding suggests that disruption of these areas may cause impulsive and compulsive behaviors, and that this may be one of the mechanisms by which low D2 receptor levels in obesity contribute to overeating and obesity.

In addition, inefficient emotional regulation mechanisms play an important role in overeating. They are associated with the predominance of arousal processes over inhibition processes and result in, among other things, an avoidant style of coping with emotional tension, reduced ability to delay gratification, and impulsivity (Ogińska-Bulik 2014).

10. Obesity

Obesity and overweight have been recognized as epidemics of our time in a report by the World Health Organization (WHO) (Tąpolska et al. 2019). It is estimated that worldwide, about 40% of adults are overweight and 10-15% are obese (McLachlan 2016). Obesity and excessive body weight are a serious health problem for the entire population and are usually the result of excessive accumulation of fat tissue in the body (Barczyk et al. 2017). Its etiology is complex and includes biological, psychological, and environmental factors (Krzyżanowska-Świniarska et al. 2012).

This disorder is highly likely to require an environment that promotes high energy intake and/or low levels of physical activity. The main problem is eating habits, which have changed significantly in recent decades: irregular meals, incorrect distribution of meals throughout the day, and a lack of variety in the diet, incorrect proportions between specific food groups, or excessive consumption of certain food groups, especially fats and monosaccharides (Olszewska et al. 2018).

Overeating means consuming more energy than you expend. People with low resting energy expenditure and/or low levels of physical activity may overeat and thus gain weight despite eating normal-sized portions. Most types of obesity are based on a small degree of overeating and therefore evolve slowly over time, so only a combination of clinically significant and regular overeating, showing characteristics of abnormal eating behavior, justifies consideration of food addiction. Although food addiction, currently diagnosed using the YFAS and related scales, is considered separate from obesity (Fletcher and Kenny 2018), research shows that in humans, symptoms of food addiction are more common in overweight and obese adults (24.9%) compared to adults with a normal BMI (11.1%). Nevertheless, given the insight we have gained into the regulation of food intake and body weight, it is difficult to draw a line between food addiction and biologically driven increased appetite or hunger. For example, patients with leptin deficiency exhibit food cravings, withdrawal, and overeating from infancy. Their behavior

throughout the day is focused on seeking and consuming food. Of course, they would meet the criteria for substance use disorders, except that their addiction is to food in general, rather than to a specific ingredient, substance, or "chemical." Importantly, a study comparing overweight/obese adults found hormonal differences (e.g., amylin, prolactin, thyroid-stimulating hormone) between those who met the criteria for food addiction and those who did not (Gordon et al. 2018).

Presumably, genetic predispositions to weight gain also play an important role in the pathogenesis of obesity itself – it is assumed that 50% or more of the variance in BMI in the general population can be explained by genetic factors (Brondel et al. 2022). In families where both parents are obese, the risk of obesity in children is 10 times higher than in the general population (Reilly et al. 2005). The use of classic methods of studying monozygotic and dizygotic twins raised together and separately has proven that genetic factors play a significant role in the etiopathogenesis of obesity, as evidenced by the heritability of BMI at a level of 40-70% (Barczyk et al. 2017).

Another factor that may be associated with the development of obesity is the modification of the composition of the gut microbiota. Initial analysis showed that the dominant microbiota in both obese and lean individuals were Bacteroides and Firmicutes species, with obese individuals having less Bacterioides and more Firicutes compared to the control group of lean individuals. A gradual, year-long reduction in body weight resulted in an increase in Bacteroides and a simultaneous decrease in Firmicutes. Based on the results obtained, it was concluded that obesity is linked to the composition of the gut microbiota, which may have potential therapeutic implications (Babicz and Kropiwiec-Domańska 2021).

It is important to remember the health consequences of excessive body fat. The accumulation of visceral fat in the walls of the renal arteries can lead to increased blood pressure and, consequently, hypertension, which is often observed in obese individuals (Jiang et al. 2016). Obesity is also accompanied by an increase in the number of macrophages and other immune cells in adipose tissue, and thus an increase in the secretion of pro-inflammatory cytokines, which leads to insulin resistance and, consequently, the development of type 2 diabetes (Tąpolska et al. 2019). In addition, scientific evidence emphasizes the increased risk of low self-esteem, mood disorders, motivation disorders, eating problems, impaired body image, and interpersonal communication problems in obese individuals, which directly or indirectly impairs their quality of life (Rajan and Menon 2017). Obese individuals report higher levels of social isolation compared to individuals of normal weight. Although this is likely a result of weight gain, interpersonal problems such as interpersonal distrust, social insecurity, or

hostility have also been found to be associated with binge eating, regardless of body weight (Meule and Gearhardt 2014).

11. BED

Binge eating disorder (BED) is characterized by regular episodes of binge eating, during which people consume relatively large amounts of food and experience a loss of control over their eating behavior. The global prevalence of BED in 2018–2020 is estimated to be 0.6–1.8% in adult women and 0.3–0.7% in adult men (Giel et al. 2022). The DSM-5 diagnosis of BED requires that objective binge eating occur at least once a week for 3 months. Unlike binge eating in bulimic-type anorexia nervosa, binge eating in BED occurs without regular, inappropriate compensatory behaviors to prevent weight gain, such as self-induced vomiting, fasting, or laxative abuse (Hilbert 2019).

Binge eating appears to be associated with many mechanisms characteristic of addiction, including increased motivation to seek palatable foods, greater neural activity in reward circuitry in response to high-calorie food cues, and impaired cognitive control (Meule and Gearhardt 2014). However, it is important to remember that people diagnosed with BED are not homogeneous. We distinguish between a subtype that exhibits high levels of dietary restraint and a subtype that exhibits greater impulsivity and pathological behaviors in the context of eating.

These two subtypes of BED may be driven by different mechanisms, with the addiction process contributing to the second subtype (but not the first). Therefore, some individuals diagnosed with BED may experience an addictive response to certain foods (Meule and Gearhardt 2014), However, despite the fact that there are many similarities between binge eating and addiction, including behavioral impulsivity and compulsivity, as well as increased reward sensitivity, increased neuroticism, and decreased conscientiousness, (Lee and Dixon 2017) not all individuals who meet the criteria for food addiction suffer from binge eating. While some studies have suggested that food addiction may be a more severe form of binge eating, this has been questioned because impaired control over eating behaviors may not necessarily be limited to a specific type of eating episode (Leigh and Morris 2018).

12. Comparison of anorexia nervosa and food addiction

Inappropriate regulation of neurotransmitter levels, like the psychological mechanisms described above, is not only observed in people suffering from obesity. They occur in eating disorders associated with overeating and most often lead to excessive body weight in this group

of patients as well (Bąk-Sosnowska 2017). The presence of food addiction in patients with eating disorders is associated with more severe symptoms related to eating disorders (e.g., more frequent episodes of binge eating, emotional eating, and compulsive eating), as well as more dysfunctional personality traits (i.e., high impulsivity) and greater overall psychopathology (mainly a greater number of depressive symptoms) (Miranda-Olivos et al. 2023). Undoubtedly, a common feature of the disorders discussed above is also repeated unsuccessful attempts to control, limit, or stop the behavior (Meule and Gearhardt 2014).

Studies have been conducted to assess the prevalence of behaviors indicative of food addiction in different subtypes of anorexia nervosa, as well as to examine clinical and personality variables between two different profiles of restrictive anorexia, classified according to the presence of food addiction, and bulimic anorexia. There are systematic reviews showing that up to 56.8% of people with binge eating disorder and 83.6-100% of people with bulimic type anorexia nervosa meet the criteria for food addiction (Lee and Dixon 2017). It is important to note that the prevalence of food addiction in patients with anorexia nervosa is higher than the prevalence of food addiction found in studies of the healthy population (Meule and Gearhardt 2014). This is consistent with the idea that food addiction is not exclusive to overweight populations, but rather a transdiagnostic problem that affects individuals with high concerns about food who may have episodes of binge eating or even restrict their food intake (Gearhardt et al. 2014). Notably, patients with bulimic anorexia showed a higher prevalence of food addiction than the restrictive subtype (75% and 54.2%, respectively). All criteria used in the diagnosis of food addiction were more frequently observed in the sample representing the bulimic type of anorexia than in the restrictive type. As expected, the presence of compulsive eating behaviors was more common in those AN patients who exhibited bulimic symptomatology (Fauconnier et al. 2020). With this in mind, assessing food addiction in patients with anorexia nervosa could help prevent the onset of these behaviors. Currently, there are no studies analyzing the impact of food addiction on the prognosis of anorexia nervosa. However, recent studies based on the clinical similarities between restrictive-type anorexia nervosa with food addiction traits and bulimic-type anorexia nervosa suggest that food addiction in restrictive anorexia may increase the likelihood of a diagnosis of bulimic anorexia.

For example, a group of individuals with restrictive-type anorexia nervosa who exhibited features of food addiction showed very similar results to a group of individuals with bulimic-type anorexia nervosa in terms of erectile dysfunction symptoms, as well as general psychopathology and personality traits. These similarities were not found between the group with restrictive type anorexia nervosa but without food addiction traits and patients with bulimic

type anorexia. In addition, groups with restrictive anorexia and food addiction traits and groups with bulimic anorexia showed similar personality profiles, with differences from restrictive anorexia without food addiction in terms of self-direction and avoidance of harm. Both personality traits were associated with a higher risk of developing addictive disorders (Steward et al. 2017). The only personality trait that showed significant differences between the group with restrictive anorexia and food addiction and patients with bulimic anorexia is novelty seeking. Addictive behaviors are often associated with high scores on novelty seeking, but patients with restrictive anorexia typically score significantly low on this dimension, regardless of the presence of food addiction (Atiye et al. 2015).

It is worth mentioning that both people suffering from bulimic type anorexia nervosa and binge eating disorder experience a significant sense of shame and therefore hide their binge eating, which often involves deceiving others about the extent of their overeating. Another feature common to many types of addiction, including bulimic type anorexia nervosa and binge eating disorder, is the criterion of financial situation. It has been shown that money spent on overeating significantly affects the quality of life of people with these eating disorders, with those suffering from binge eating disorder being particularly affected by financial problems (Meule and Gearhardt 2014).

However, there are also fundamental differences between eating disorders and food addiction, such as the presence of compensatory behaviors in bulimic-type anorexia nervosa, but not in BED or food addiction. Thus, eating disorders and food addiction may have similar characteristics, but they are not consistent (Hauck et al. 2020) (Hauck et al. 2020).

13. Summary

Both eating disorders involving food avoidance and those involving excessive food consumption show certain similarities at the biological and neurobiological level, as well as in terms of the psychological profile of patients who are susceptible to them. The criteria used to diagnose them are based on the same assumptions, taking into account the characteristics of addiction that are clearly evident not only in relation to food addiction, but also in the case of anorexia nervosa, which is not directly referred to as an addiction in the literature.

The same neurotransmitter pathways are involved in the development of both types of disorders, which also participate in the development of addictions to classic substances commonly considered addictive, such as alcohol or drugs. Similarly, eating too little or too much has a destructive effect on the body, affecting almost every system.

A better understanding of the underlying causes of these disorders may provide a basis for developing more effective forms of therapy and tools to combat them, which seems particularly important in view of the upward trend observed in the incidence of both anorexia and food addiction.

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Author's contribution

Conceptualization: Katarzyna Kowalska
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Check: Katarzyna Rendaszka, Paulina Kwaśniewska
Formal analysis: Marta Pyziołek
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