Viewpoint

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The Paradox of Food Addiction and the Obesity Epidemic: A Public Health Perspective

Abstract

Background: The rise in obesity rates presents a grave public health challenge, surpassing even tobacco as the leading cause of preventable death in the United States. Much like other forms of substance use disorder, food addiction is a complex, multi-faceted disease involving a number of neurobiological factors associated with addiction, endocrine response, and social-psychological determinants. These interconnected and often competing systems add to the difficulty of treatment.
Objective: This article explores the complex neuro-endocrine interplay involved in obesity, the parallels to substance addiction, and the societal factors exacerbating the obesity epidemic.
Methods: This study employed a non-systematic literature review across various disciplines, including medicine, public health, addiction, neuroscience, psychology, sociology, criminology, public policy, and social networks. Relevant databases such as PubMed, PsycINFO, and Scopus were searched using keywords related to obesity and its multifaceted implications. Data extraction focused on obesity-related health outcomes, societal impacts, and intervention strategies. The synthesis of findings aimed to aggregate insights from the diverse fields to present a holistic understanding of obesity's complexity.
Results: Research has revealed important findings within many diverse disciplines, but few efforts have taken a multi-disciplinary approach. Given the significant interactions across complex biological and societal systems, obesity requires a holistic treatment approach.
Conclusions: Given the elevated rates of obesity and its severe impact on both the quality and longevity of life, we argue for more targeted funding and a cross-disciplinary approach to achieve multifaceted, affordable, and equitable health solutions.

Keywords: Obesity, Food Addiction, Public Health, Neuro-Endocrine Dysfunction, Social Determinants, Health Equity.

Introduction

In the shifting landscape of public health, obesity is an increasing threat to human health and happiness. The interaction between the neurobiology of addiction and multiple complex neuro-endocrine systems in obesity not only mirrors the addictive responses to substances such as narcotics but also paves a complex path of treatment resistance and social challenges. Mohajan posits that a staggering one-third of the world's population now falls into the category of overweight to obese, a statistic that rings particularly alarming for the United States.[1] Nielsen reports, 4% of the U.S. adult populace transitions into obesity each year[2]—a rate that has catapulted the prevalence of obesity to an unprecedented 42% over the past four decades.[3] With one in every five deaths in the US involving obesity, it may be responsible for over 650 thousand deaths each year[4], exceeding cancer as the leading cause of death in the United States.[5] This surge comes with an onerous economic burden; Kim notes that the United States allocates $149 billion to obesity and related conditions[6], accounting for 7.9% of its annual healthcare expenditures.[7] Compounding this fiscal strain, Dee highlights that the costs tied to lost productivity of individuals with obesity are equivalently detrimental, underscoring the multifaceted impact of this growing public health crisis.[8]

The oncogenic potential of obesity is increasingly recognized, with evidence mounting on its role as a significant risk factor for various cancers. Avgerinos highlights that more than 10 percent of cancers in 13 anatomical sites can be attributed to obesity, which fosters a milieu conducive to malignancy through mechanisms such as insulin resistance, adipokine (cell signaling proteins in fat cells) abnormalities, systemic inflammation, and more.[9] This pro-carcinogenic environment is exacerbated by a plethora of factors including oxidative and endoplasmic reticulum stress, circadian rhythm disruptions, and vascular irregularities.[10] Li's research further delineates the role of adipocyte macrophages in cancer promotion, where a cascade of events including altered macrophage polarization, lipid dysregulation, and secretion of pro-inflammatory cytokines (immune cell signalling proteins) and adipokines, paves the way for oncogenic processes such as angiogenesis, immune evasion, and metastasis.[10] Complementing this, Zhong details how obesity's upregulation of insulin-like growth factor contributes to endocrine cancers, where it interacts with estrogen and adipokines, influencing malignancies in breast, prostate, endometrial, pancreatic, and thyroid tissues.[11] Additionally, Spaander associates obesity with an elevated risk of colorectal cancer, asserting the comprehensive impact of obesity on carcinogenesis.[12] Together, these findings corroborate the thesis that obesity is not

merely a comorbidity but a causative agent in cancer development, thus compounding its importance as a public health crisis.

Obesity is a multifaceted disorder characterized by psychological and normative social forces in addition to intricate neuro-endocrine interactions, which pose significant challenges to effective treatment modalities. The involvement of multiple environmental factors and biological systems in obesity creates a complex network of feedback and regulatory mechanisms. These interactions contribute to the resilience of obesity against simplistic treatment approaches and underscore the need for comprehensive and multidisciplinary strategies. This paper will provide a brief overview of three key mechanisms in obesity; dopaminergic, endocrine, and social-psychological; identify some interaction effects between these systems and offer implications for holistic treatment approaches for this disease.

Neurobiology of Food Addiction

Addiction targets an individual's reward system in the brain primarily through the hormone dopamine which is responsible for a person's sense of motivation and action. This can be seen across individuals' motivation to eat, engage in activities and even involved in social interactions. [18], [19], [20] The dopaminergic system's response to food intake, particularly sugar, is analogous to its reaction to addictive substances[13], [14], [15], with some studies suggesting that sugar can be more addictive than alcohol or cocaine. This comparison is not merely hyperbolic but underscores the potent influence of certain foods on the reward circuitry of the brain, complicating the approach to dietary interventions in obesity management.

Reward circuits are similar across species.[16] In humans, reward circuits of the ventral striatum processes homeostasis signals, sensory perceptions, emotions, learning, and decision-making.[17] Chronic substance abuse initially hijacks the brain's reward system. When individuals experience repeated high spikes in dopamine, their brain compensates by eliminating dopamine receptors.[19], [21] This creates tolerance. Then, without the substance, dopamine levels drop to dangerous levels and the individual no longer feels the effects of the substance in a manner that produces a "high". They need the drug to stabilize their dopamine levels and function.

Over time, mid-brain structures predict the events and cues that lead to dopamine spikes.[22], [23] Much like Pavlov's dogs begin to salivate at the smell of meat, people with addiction become conditioned to experience initial dopamine spikes in response to cues from their environment, actions, and social interactions. This creates feelings of craving and hunger which reinforces drug (or food) seeking behavior.

Initially the brain experiences neuroplasticity, which allows the brain to rewire itself and function differently than before. In the case of the addicted patient, this rewiring predominantly occurs in the frontal cortex which affects decision-making.[21], [24]. It also converts anxiety, realized in the midbrain, into long-term memories.[25], [26] The combined effect is that drug (or food) seeking behavior becomes hardwired into neural pathways, triggered by dopamine spikes in conditioned response to drug cues

and impaired by damaged self-control that favors drugs (or food) over the negative emotional and physical consequences.

In other forms of substance abuse, abstinence and avoidance of substance use is a common first step in recovery. In the case of food addiction, however, people cannot abstain from eating. Moreover, neuro-endocrine complexities can mean that significant dietary changes and reductions in caloric intake or addictive foods may lead to increased weight gain and metabolic changes in a sort of boomerang effect. Subsequent dysregulation in the neuroendocrine system then leads to increased obesity and a number of other health concerns.

Endocrine Complexity in Obesity

Obesity is not merely a matter of caloric imbalance but is increasingly recognized as a complex disorder that involves and disrupts multiple neuro-endocrine and immune systems, leading to widespread systemic effects. The pathological basis of obesity-related inflammation and immunity impairment is multifaceted, entailing changes in cellular and hormonal milieu that contribute to the development of various metabolic diseases.

Insulin resistance in obesity is a key player, generating reactive oxygen species and a pro-inflammatory state. This is characterized by a shift in immune cell profile, with macrophages transitioning from an anti-inflammatory M2 phenotype to a pro-inflammatory M1 state, which is implicated in the pathogenesis of atherosclerosis.[27] Furthermore, obesity-related hypoxia within the expanded adipose (fatty) tissue leads to necrosis and further recruitment of macrophages, enhancing the inflammatory response.[28] This is coupled with altered levels of inflammatory markers such as IL-6 and C-reactive protein, commonly used in clinical practice to assess inflammation.

The adipose tissue acts as an endocrine organ by secreting a plethora of hormones and adipokines, which have profound effects on metabolism. Excess visceral fat results in elevated levels of various adipokines, including those that promote insulin resistance and inflammatory responses. Adipokines like leptin, resistin, and tumor necrosis factor not only contribute to the development of insulin resistance but also alter hunger regulation and energy expenditure.[29] The imbalance of these adipokines, including a decrease in beneficial molecules like adiponectin and an increase in pro-thrombotic factors such as PAI-1, drives the progression towards a chronic inflammatory state, impacting multiple organ systems.[29], [28]

The immune system, while essential for homeostasis, can become destructive in the context of obesity. Adipocytes in an obese state can induce insulin resistance both locally and systemically. The extracellular matrix becomes congested with increased adipocyte mass and fatty acids, leading to inadequate vasculature and persistent inflammation.[30] Trayhurn elucidates that white adipose tissue in obesity produces an abnormal array of inflammatory adipokines, including leptin and adiponectin, which signal through hypoxia-inducible factor-1, triggering a cellular immune response.[31]

Moreover, the dopaminergic reward system is intertwined with these endocrine and immune alterations, where the conditioned response to food intake, particularly high-calorie, high-fat diets, mirrors the addictive pathways seen in substance abuse. The resultant insulin resistance further exacerbates the reward system dysfunction, creating a feedback loop that complicates the treatment of obesity.

In simpler terms, our body has a sophisticated system that helps balance how much we eat and how much energy we use. This system involves hormones, such as leptin, insulin, orexin, ghrelin, and PYY. These hormones do more than just help manage our energy; they also influence our cravings and how much we enjoy food. Leptin is an adipokine hormone made by fat cells that decreases our appetite. When we don't eat enough, our fat cells make less leptin, and this signals our brain to make us feel hungrier. People who don't have enough leptin feel hungry all the time and can become extremely overweight. Luckily, for those with this rare condition, there's a treatment that can help. Insulin is another hormone that's important for controlling our blood sugar levels and how much we feel like eating. People with type 2 diabetes, who have trouble responding to insulin, may find that they feel hungrier and crave more food than others. The gut also produces hormones after we eat that affect how hungry we feel. One of these, Peptide YY, helps make us feel full after eating, which helps us stop eating. Another, ghrelin, does the opposite—it's released when we're hungry and signals the brain to make us want to eat.

All these hormones work together in a complex system that affects our hunger levels, how much we eat, and how much we enjoy eating. However, when we eat a lot of high-calorie, tasty foods and don't move much, this system can get out of balance. We might continue to eat more than we need, which can lead to storing the extra energy as fat and becoming obese. The endocrine imbalance in obese patients has many other detrimental health impacts such as diabetes, cancer, psychological depression and more. A comprehensive list is well beyond the scope of this paper.

Overall, the neuro-endocrine and immune involvement in obesity illustrates a complex pathophysiological web, where inflammation, immune response, and metabolic dysregulation are deeply interlinked, contributing to the chronic nature of obesity and the array of associated comorbidities.

Social Determinants and Psychological Factors

The social brain is intricately involved in the cycle of obesity. Emotional states such as anxiety, isolation, and depression are pivotal in precipitating relapse and impeding impulse control. Additionally, obesity can propagate through social networks. In this context, a social network is a set of people and the set of friendships and acquaintances between them.[35] These networks of social interaction challenge the homeostasis of a healthy body image. The marginalization and discrimination faced by individuals with obesity can undermine treatment efforts and exacerbate health outcomes.

Christakis and Fowler's research has elucidated the profound influence of social networks on obesity, suggesting that this condition can manifest within social circles akin to patterns of contagion.[32] Their landmark study posits that if an individual

becomes obese, the likelihood that a friend of theirs will also become obese increases significantly. This pattern extends to various degrees of separation within the network, indicating that friends, and even friends of friends, can influence an individual's risk of obesity, regardless of geographic separation.

The study's findings highlight that social ties have a substantial impact on obesity rates, suggesting that behaviors leading to obesity can spread through social networks as shared norms and mimicry of health-related behaviors. This network phenomenon was observed to be stronger among mutual friends than among individuals with unidirectional friendships, implying that the mutual reinforcement of lifestyle choices and perceptions of social norms regarding body weight are significant.

Christakis's work underscores the need to consider the social context when addressing the obesity epidemic. Interventions that leverage the influential power of social networks could, therefore, be a potent strategy in combating obesity on a larger scale. The research implies that promoting positive health behaviors within social networks has the potential to produce a ripple effect, reducing the prevalence of obesity in a wider community.

De la Haye's similarly finds that obesity can spread through adolescent peer networks, highlighting the social dimensions of health behaviors such as diet and physical activity.[33] Her research underscores the value of considering the broader socio-ecological systems when designing public health interventions. She finds that normative influence is an important factor in obesity and designing health interventions. A person's view of a healthy body image and level of activity is often normatively defined by peers within their social network and perhaps others in the media. This body of work demonstrates that the fight against obesity can benefit from strategies that acknowledge and utilize the influential power of social networks.

Social stigma, marginalization, and discrimination significantly impact obese patients' ability to sustain weight loss as well. The prejudice they face can lead to increased psychological stress, which is associated with higher calorie consumption and reduced physical activity, thus creating barriers to effective weight management. Anxiety and stress is a key factor in a broad range of addiction relapse [25],[26], and food addiction should be no different. This stress may also trigger binge eating disorders, exacerbating the challenge of weight loss.

Eisenberg discovered that when people are socially rejected, the pain of social exclusion occurs in the exact same region of the brain as physical pain.[34] She conducted a study where an experimental group was prescribed Tylenol, which showed statistically significant improvement in the subjects' pain reduction resulting from social rejection. This the impact of stigma, marginalization, social rejection, and isolation has a clear biological mechanism contributing to relapse or binge eating in the case of addiction. Addressing these social barriers is crucial for the successful treatment of obesity, as they not only hinder individual progress but also influence the quality of healthcare provided to obese patients.

Discussion

Obesity adversely affects health involving multiple systems at multiple levels: endocrine, environmental, gastrointestinal, genomic, immunologic, neurologic, psychiatric, and social. Every cell of the body is affected involving intra- and intercellular signals directing metabolism. Reward and motivation neuroendocrine circuits regulate this process deep in the brain, a large portion of which is below the level of consciousness. Learned behavior by conditioning is a significant component of the pathophysiology.

Obesity is not a disease of moral failing. Social stigma associated with obesity is an impediment to understanding and treating obesity. There are some common principles which apply to most cases of obesity. Obesity is a variegated collection of diseases which are extraordinarily diverse. Obesity will be cured one person at a time with highly individualized, personalized, multi-omic, multidisciplinary prevention, intervention, care, treatment, and lifelong maintenance. The resources, intensity, and sophistication of care required to treat obesity have been under-estimated.

Individuals' self-perception of their body often mirrors what society views as the normative body image. This perspective is influenced by cultural and media representations, including the role of plus-size models, which may contribute to normalizing larger body sizes. While this inclusivity fosters acceptance, it may inadvertently set a new standard that overlooks the health risks associated with obesity. Public health initiatives face the delicate task of promoting a balanced body image that recognizes diversity without undermining health, avoiding weight-related stigma that can exacerbate social and psychological distress and potentially trigger relapse in those with food addiction. This issue presents a nuanced challenge for public health communication and policy-making that requires more targeted research on the social components driving food addiction.

Another approach for treating obesity involves Glucagon-like peptide-1 (GLP-1) receptor agonists. Semaglutide (also known as Ozempic or Wegovy) is a GLP1 receptor agonist medication. These medications have multiple physiologic effects and benefits. They allow patients to sustain levels of satiety through a mechanism other than leptin in addition to metabolic benefits. However, the lack of affordability and insurance coverage underscores the prevailing health inequity. Cultural disparities in diet further complicate the landscape, necessitating a nuanced approach to support and acceptance in recovery.

With obesity as a significant co-morbidity in deaths from COVID-19 and cancer, we must question whether our research and health budgets align with our public health challenges. The investment in obesity-related health issues is a reflection of our commitment to addressing this epidemic.

Conclusion

Addressing obesity requires an approach that balances the recognition of its complexity with actionable, compassionate treatment strategies. The need for

affordable, innovative health solutions that support individuals in a holistic manner is imperative. As we navigate the complexities of this disease, the calibration of our health communication and policies may well define the success of our public health strategies in the coming era.

Conflicts of Interest

"none declared".

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