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Food and Addiction among the Ageing Population

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Abstract

Obesity among the elderly is a growing public health concern. Among the various factors that may contribute to the current rates of obesity is the rewarding aspect of highly palatable foods and beverages, which may lead to overconsumption and excess caloric intake. The present review describes recent research supporting the hypothesis that, for some individuals, the consumption these highly palatable foods and beverages may lead to the development of addictive-like behaviors. In particular, the authors consider the relevance of this hypothesis to the ageing population.

1. Introduction

Obesity in the elderly population is a developing public health concern (Arterburn et al., 2004; Zamboni and Mazzali, 2012), with data showing that approximately 35% of adults in the United States aged 65 and over were obese in 2007–2010 (Fakhouri TH, 2012). This includes more than eight million adults between the ages of 65–74 and nearly 5 million adults aged 75 and above. With the percentage of the adult population aged 65 and over in the United States expected to increase from 13% to 20.2% between 2010 and 2050 (Vincent and Velkoff, 2010) and the numerous medical comorbidities associated with obesity, including type II diabetes, cardiovascular disease, many forms of cancer, gallbladder disease, asthma, chronic back pain and osteoarthritis (Guh et al., 2009), it is important to consider the factors that may contribute to excess weight within this population. While the addictive potential of palatable foods has been studied in animal models and the food addiction hypothesis has been investigated in human research in recent years, this concept has received little attention with regard to the elderly population. The current article will summarize key points from the literature on overweight and obesity in the elderly, describe research findings that offer support for the concept of food addiction, and conclude with recommendations for future research to investigate food addiction in the elderly.

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2. Physiologic Changes, Obesity and Associated Health Effects among the Elderly

Among other physiological changes, the aging process involves shifts in body composition. As age increases, skeletal muscle mass declines (Janssen et al., 2000) and fat mass increases (Schutz et al., 2002). Additionally, body fat is redistributed, with, for example, increased intramuscular (Cree et al., 2004) and abdominal fat (Koh-Banerjee et al., 2004; Teh et al., 1996) and decreased subcutaneous fat (Hughes et al., 2004). Despite these changes, body weight can remain stable, which may mask alterations in body composition (Kuk et al., 2009). Other relevant physiological changes associated with aging include decreased height (Wahlqvist and Flint, 1988) and decreased basal metabolic rate (Chau et al., 2008).

The most common measure used to assess adiposity in humans, the body mass index (BMI), is based on measurements of both height and weight. However, these guidelines do not take into account the physiological changes associated with aging, such as decreases in height, which could inflate BMI measurements (Sorkin et al., 1999). Additionally, BMI could underestimate adiposity because this measurement does not account for age-related increases in adipose tissue, despite body weight remaining the same (Zamboni et al., 2005). Consequently, researchers have investigated other approaches to measuring overweight and obesity in this population, including waist circumference (WC), which can be used to measure adiposity (Janssen et al., 2002; Pouliot et al., 1994). However, the parameters of abdominal obesity (≥102 cm in men and ≥88 cm in women) need to be further investigated (Zamboni et al., 2005). Other forms of assessment include waste-to-hip ratio (Dobbelsteyn et al., 2001; Taylor et al., 1998) and sagittal abdominal diameter (Mukuddem-Petersen et al., 2006; Turcato et al., 2000).

Sarcopenic obesity (SO) adds to the complexity of studying overweight and obesity in the elderly. Various definitions of sarcopenia have been proposed, but for the purpose of this article, we will use the operational definition proposed by the European Working Group on Sarcopenia in Older People (EWGOP): a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a risk of adverse outcomes (Cruz-Jentoft et al., 2010). According to the EWGOP, a diagnosis of sarcopenia is considered appropriate if an individual has low muscle mass and either low muscle strength or low physical performance (Cruz-Jentoft et al., 2010). Additionally, sarcopenia is associated with other states involving muscle wasting; one of which is sarcopenic obesity. Like sarcopenia, the definition of SO varies, however, here again the authors will employ the definition established by the EWGOP: the loss of lean body mass while fat mass is preserved or increased (Cruz-Jentoft et al., 2010). In addition to the various definitions in the literature, there does not appear to be a clear consensus regarding the cut-off points or techniques to measure sarcopenia or SO. Thus, it is unknown whether the presence of SO is under- or overestimated in the literature. In fact, one study found rates of SO to be 16.7% and 5.7% among a sample of men and women, respectively, when SO was defined as appendicular skeletal muscle mass divided by height2. However, when defined as appendicular skeletal muscle mass divided by weight, these rates increased to 35.1% and 48.1% in men and women, respectively (Lim et al., 2010).

Sarcopenic obesity has been associated with insulin resistance, physical disturbances, inflammation, increased risk of falls, decreased physical activity, and increased risk of metabolic syndrome (Stenholm et al., 2008; Zamboni et al., 2008, Lim et al., 2010). Like SO, some of the proposed health consequences of overweight and obesity in the elderly relate to function and mobility. These include disability (Launer et al., 1994), osteoarthritis (Hochberg et al., 1995), and insulin resistance (Willey and Singh, 2003). It is noteworthy that there is evidence showing that obese individuals with cardiovascular disease have a survival advantage relative to their leaner peers (Horwich et al., 2001; Lavie et al., 2003), a phenomenon labeled “the obesity paradox.” One theory that has been proposed to explain this points to the errors associated with using BMI discussed earlier (Romero-Corral et al., 2007), however, a definitive consensus regarding the mechanisms underlying this paradox has yet to be reached.

3. The Food Addiction Hypothesis

Obesity is an endpoint with multiple contributing factors. While the role of each of these variables is important to consider, the purpose of the present article is to discuss the evidence suggesting that palatable food consumption and its effect on neural reward systems might contribute to the current rates of overweight and obesity seen in the U.S. and worldwide, a topic that has been discussed extensively in recent years (Corsica and Pelchat, 2010; Corwin and Grigson, 2009; DiLeone et al., 2012; Epstein and Shaham, 2010; Gearhardt et al., 2014; Rogers and Smit, 2000; Smith and Robbins, 2013; Volkow et al., 2012; Ziauddeen et al., 2012), with a specific focus on how this might be germane to the ageing population. The United States Department of Agriculture (USDA) reports that between 1950–1959 and 2000, the consumption of caloric sweeteners increased by 39%, with the greatest increases in the form of corn sweeteners such as high fructose corn syrup (HFCS) (United States Department of Agriculture, n.d.). In fact, over this time, HFCS consumption rose by approximately 64%. Accordingly, the number of calories consumed daily from caloric sweeteners increased by 83 kcal in the U.S. between 1977 and 1996, an effect that was largely driven by soft drink and sugary fruit drink consumption (Popkin & Nielsen, 2003). This data is relevant, as studies have frequently shown associations between increased intake of sugar-sweetened beverages and increased body weight (Melanson et al., 2008). Additionally, a systematic review and meta-analyses found significant positive associations between intake of dietary sugars and body weight (Te Morenga et al., 2013). Among U.S. adults ages 60 and above in particular, the percentage of total calories from salty snacks, desserts, candy, soft drinks, fruit drinks, alcohol, French fries, hamburgers, cheeseburgers, pizza, and Mexican food increased significantly between 1977–1978 and 1994–1996. Further, during this time, the percentage of total calories consumed at restaurants and fast food establishments increased from 5.3% to 13.9% among members of this age group (Nielsen, Siega-Riz, & Popkin, 2002), which is pertinent as increased fast food consumption predicts greater mean population BMI (De Vogli et al., 2014).

Many are aware of the detrimental health effects associated with the excessive consumption of foods that are highly palatable but offer little nutritional value, which extend beyond the consequence of weight gain. However, rates of overweight and obesity remain high, suggesting that such eating patterns are impervious to change. This has led some to question whether certain foods, namely foods that are highly palatable, might affect the brain's reward system in ways that may engender dependence.

4. Defining Substance Use Disorder

The Diagnostic and Statistical Manual of Mental Disorders V (DSM V) lists 11 criteria for the classification of substance use disorder (SUD) (American Psychiatric Association, 2013). These include, but are not limited to, spending a considerable amount of time obtaining a substance, using a substance, or recovering from substance use, cravings, and withdrawal. These criteria are further grouped into 4 overarching categories: impaired control, social impairment, risky use, and pharmacological criteria. The severity of one's disorder may range from mild to severe depending on the number of criteria met, with 2 to 3 symptoms indicating mild severity, 4–5 suggesting moderate severity, and 6 or greater indicating a severe SUD. It is important to point out, especially when considering the construct of food addiction, that, according to the DSM V, certain SUD symptoms may be less appropriate or even inapplicable depending on the drug.

5. Parallels between Substance Dependence and Food Addiction

5.1 Underlying Physiological Mechanisms

To understand the reinforcing properties that certain foods can have it is important to discuss the neural and hormonal factors involved in the regulation of food intake. Two systems are thought to influence food intake: the homeostatic and hedonic systems. The first consists of neural systems and hormones that maintain energy balance by regulating hunger and satiety (Kenny, 2011). The hedonic system, in contrast, refers mainly to neural mechanisms implicated in the reward associated with consumption of palatable foods and can override the homeostatic system (Kenny, 2011; Zheng et al., 2009). An extensive body of research implicates dopaminergic and opioidergic systems in the hedonic system. Consumption of both drugs of abuse and palatable foods increase extracellular dopamine in the nucleus accumbens (Hajnal et al., 2004; Hernandez and Hoebel, 1988), suggesting a common neural basis for drug addiction and overeating. GABAnergic neurons normally inhibit dopamine systems (Volkow and Wise, 2005), however, when μ-opioids bind to the μ-opioid receptors on these neurons, they block this inhibition and dopamine is released in the NAc (Volkow, 2005). Opioids are also strongly implicated in the hedonic or pleasurable aspects of food intake, as opioid agonism stimulates and antagonism reduces palatable food intake (Gosnell and Levine, 2009).

While traditionally viewed as distinct, increasing evidence suggests that the homeostatic and hedonic systems interact (Murray et al., 2014). For instance, ghrelin, a hormone secreted from the stomach, is known to promote food intake. In normal individuals, plasma ghrelin levels are greatest when fasting and decline following meals (Sam et al., 2012). Recent preclinical research has also found ghrelin administration to promote rewarding behaviors, such as palatable food and alcohol consumption, and ghrelin receptor knockout and antagonism to attenuate these behaviors and the accumbal dopamine release that accompany them (Egecioglu et al., 2010; Jerlhag et al., 2009; Revitsky and Klein, 2013). Among patients with alcohol dependence, higher ghrelin levels prior to substance abuse treatment has been linked to greater alcohol consumption and craving during treatment (Leggio et al., 2012), further suggesting a potential role for ghrelin in rewarding and even addictive processes. Thus, phsyiological mechanisms implicated in energy regulation and the rewarding aspect of food consumption appear more closely related than perhaps initially thought.

5.2 Research in Animal Models

Laboratory animals are often used to model human behavior. However, when studying certain disorders it is sometimes only possible to isolate and replicate specific aspects of a disorder. In the case of anorexia nervosa, for example, animals can model caloric restriction and patterns of excessive exercise, however, the psychological components of this disorder are impossible to capture in the laboratory setting. Thus, addiction research with laboratory animals is characterized by modeling specific symptoms, such as withdrawal and use of the substance despite consequences. In this section, we will discuss how animal models of SUD symptoms have been applied within the context of food addiction research. These will be described according to each of the four categories of criteria list in the DSM V, except for the category of social impairment, as the authors are unaware of any studies to date exploring this topic with respect to food addiction.

5.2.1 Impaired Control—Our laboratory has used a limited access feeding paradigm in which rats are food restricted for 12 h/day and given access to both chow and sugar solutions for the remaining 12 h to study several indicators of addiction. After approximately 3 weeks on this access schedule, rats begin to demonstrate excessive consumption of the sugar solution within the first hour of access, constituting a “binge” episode (Avena et al., 2008). The emergence of this binge behavior might thus be considered to fulfill the first SUD criteria, which reads, “the individual may take the substance in larger amounts or over a longer period than was originally intended.” Further, if sugar is removed, rats with a history of intermittent sugar access and a tendency to drink high amounts of sugar exhibit greater levels of responding (lever pressing) for sugar access than prior to abstinence (Avena et al., 2005), which may indicate both craving (SUD criterion 4) as well as a greater propensity for “relapse.” While craving has been described as “a strong desire to use” a substance (Wilson and Sayette, 2014), and thus is considered psychological in nature, it is often measured in animals via operant responding, which provides an indication of the amount of effort an animal is willing to exert in order to obtain a reward. For instance, rats that are trained to lever press for a sucrose solution for 2 h/day are thought to demonstrate craving by responding more on day 30 than day 1 of forced abstinence when presented with sugar-associated cues. This phenomenon, termed “incubation of craving,” has also been observed in studies of drug withdrawal (Grimm et al., 2001). Interestingly, this behavior is attenuated by the administration of the opioid antagonist naloxone, indicating perturbation of the opioidergic system (Grimm et al., 2007). Recent evidence also suggests impaired control over use following exposure to palatable food; rats given intermittent (2 h/day) access to sweetened condensed milk (67% sugar) do not alter responding following food devaluation, perhaps reflecting a shift from goal-directed behavior to habitual behavior, which has been hypothesized to underlie the development of an addiction (Furlong et al., 2014).

5.2.2 Risky Use—In addition to showing signs of craving, studies with laboratory animals have begun to suggest that palatable food consumption may also lead to the fulfillment of criteria 8: "recurrent substance use in situations in which it is physically hazardous." For instance, Oswald et al. (2011) have observed that rats identified as "binge-eating prone" will endure electric foot shocks at greater intensities than those considered "binge-eating resistant" in order to obtain palatable food. Additionally, rats with extended access (18–23 h/day) to a cafeteria diet of meats and dessert items are less likely to decrease their intake of palatable food when shown a stimulus associated with a foot shock compared to those with 1 h/day access or no access to the cafeteria diet at all (Johnson and Kenny, 2010). Likewise, rats identified as having high trait impulsivity are significantly more likely to eat palatable food under aversive conditions (in the light phase of a light/dark test) than rats with low impulsivity and rats only given access to standard rodent chow, regardless of their level of impulsivity (Velazquez-Sanchez et al., 2014a). Finally, a recent study found that rats are more likely to continue to lever press for palatable food when this behavior was accompanied punishment (in the form of a mild foot shock) than rats lever pressing for methamphetamine (Krasnova et al., 2014).

5.2.3 Pharmacological Criteria—Rats maintained on the limited sugar access schedule described above also show somatic signs of withdrawal, such as teeth chattering and anxiety, following the administration of the opioid antagonist, naloxone (Colantuoni et al., 2002). Using a similar experimental paradigm, Wideman et al. (2005) observed the emergence of withdrawal symptoms, including decreased body temperature, biting, shaking, and teeth chattering when rats were simply denied access to sugar. Additionally, rats given limited access (2 days/week) to a highly palatable sucrose diet demonstrate greater immobility in a forced swim test, considered an indication of depression, when palatable food is taken away, which has also been shown in many studies of drug withdrawal (Iemolo et al., 2012). Notably, this effect was abolished when palatable food was returned. The evidence is currently mixed regarding whether fat may also lead to symptoms of withdrawal when removed (Bocarsly et al., 2011; Sharma et al., 2013), though discrepancies in the literature may be due to differences in study design (diet composition, limited vs. *ad libitum* diet access, etc.). Finally, while some data challenge close comparisons between palatable food and drugs of abuse (Harb and Almeida, 2014; Voon et al., 2014), the clinical value of these distinctions warrants further investigation.

5.2.4 Neural Correlates of Addictive-like Eating—Concomitant with these behavioral signs of addiction are neural alterations that resemble those found in the addiction literature. As mentioned earlier, both palatable foods and drugs of abuse elicit a release in extracellular dopamine in the nucleus accumbens. Notably, although dopamine release wanes with repeated exposure to standard rodent chow, sugar-bingeing produces a similar dopaminergic response each time in intermittent access models (Rada et al., 2005). Further, following a history of intermittent sugar access, food deprivation results in a pattern of decreased dopamine and increased acetylcholine in the nucleus accumbens of rats, akin to what is seen during drug withdrawal (Avena et al., 2008; Pothos et al., 1991; Rada et al., 1991). Extended access to palatable food also leads to a downregulation of striatal D2 receptors and elevated brain reward thresholds, similar to what has been shown following exposure to drugs of abuse (Johnson and Kenny, 2010; Kenny et al., 2006; Volkow et al., 2004). Additionally, like drugs of abuse, natural rewards such as sucrose and sexual behavior have been shown to increase transcription factor ΔFosB expression in the nucleus accumbens (Wallace et al., 2008). Moreover, recent research shows a positive correlation between ΔFosB expression in the nucleus accumbens shell and "addiction scores" (dependent upon 3 indices of addictive-like food-related behaviors) in animals (Velazquez-Sanchez et al., 2014b).

5.3 Research Among Human Participants

In light of such findings, researchers have begun to explore whether some individuals may experience an "addiction" to food. Cassin and von Ranson (2007) assessed addiction-like behaviors regarding food in a sample of women with BED using an adapted version of the DSM-IV criteria for substance dependence disorder, which substituted the term "substance" with "binge eating." The authors of this study found that a remarkably high number (92.4%) of participants met the DSM-IV substance dependence criteria when asked about their relationship with food. A recent qualitative study also found that 100% of obese women with BED, and almost half of the obese women without BED, in this smaller sample met modified DSM-V criteria for SUD (Curtis and Davis, 2014). Similar to the measure employed by Cassin & von Ranson (2007), Gearhardt et al. (2009) developed the Yale Food Addiction Scale (YFAS) based on the substance dependence disorder criteria listed in the DSM-IV-TR and measures designed to study behavioral addictions. This assessment tool has now been used in numerous studies among various samples, revealing several noteworthy correlates of food addiction.

Studies that include large sample sizes with a wide range of BMIs show a positive relationship between food addiction and BMI (Flint et al., 2014; Gearhardt et al., 2014; Mason et al., 2013; Murphy et al., 2014; Pedram et al., 2013). Findings such as these lend further support to the hypothesis that pharmacological agents used in the context of addiction treatment might also be applicable in certain cases of obesity (Avena et al., 2013). Not surprisingly, those with greater food addiction symptomology also tend to report greater eating-related difficulties, including binge eating (Bégin et al., 2012; Burmeister et al., 2013; Clark and Saules, 2013; Davis et al., 2013; Gearhardt et al., 2013), emotionally driven eating (Burmeister et al., 2013; Clark and Saules, 2013; Davis et al., 2013), and food cravings (Davis et al., 2011; Davis et al., 2013; Meule et al., 2014; Meule and Kubler, 2012). Many, but not all (Gearhardt et al., 2013), studies have also revealed increased depression (Burmeister et al., 2013; Davis et al., 2011; Eichen et al., 2013; Gearhardt et al., 2012; Meule et al., 2014) and impulsivity (Bégin et al., 2012; Davis et al., 2011; Meule et al., 2014; Meule et al., 2012; Murphy et al., 2014) among those with higher YFAS scores. Finally, a recent study among women found that a history of severe physical and sexual abuse in childhood and adolescence increased the risk for food addiction by approximately 90% (Mason et al., 2013).

Neuroimaging research has also found that those with higher YFAS scores show heightened activation in brain areas associated with motivation to eat and craving when participants anticipating palatable food. However, these participants exhibit less activation of the left lateral orbitofrontal cortex, a brain region associated with inhibition, during food consumption (Gearhardt et al., 2011). Additionally, some, though not all (Dunn et al., 2012; Eisenstein et al., 2013), studies demonstrate a negative correlation between striatal DA D2 receptor availability and BMI (Haltia et al., 2007; Volkow et al., 2008; Wang et al., 2001). With respect to eating patterns, a negative correlation has been noted between D2 receptor availability in the dorsal striatum and emotional eating in a healthy sample (Volkow et al., 2003). These findings are noteworthy as reduced D2 receptor availability has also been associated with greater positive reinforcement derived from drug use in nondrug-abusing individuals (Volkow et al., 2002). In light of the conflicting reports, most likely due to methodological differences, further research is needed to clarify the precise relationship between D2 receptor availability and BMI.

7. Food Addiction and The Elderly

The first large-scale study assessing food addiction among an older cohort of women nurses (ages 62–88) in the U.S. found that 2.7% of participants met the criteria for food addiction when using an abbreviated version of the YFAS (Flint et al., 2014). While food addiction may not be common among members of this cohort, it is possible that given the rates of food addiction observed in samples of younger individuals (in this study, 8.4% of women between the ages of 45–64 met the criteria for food addiction), the prevalence of food addiction in the elderly may rise as members of younger generations age, just as the need for substance abuse treatment among older adults is predicted to increase (Gfroerer et al., 2003). Therefore, it may be beneficial to explore this topic proactively.

Alternatively, it is possible that individuals may simply “age out” of food addiction, a phenomenon that has been noted among those with substance dependence disorder (Vogt Yuan, 2010). This is supported in part by research showing decreased cravings for sweets with age among women, as well as fewer cravings overall and a greater ability to resist cravings among older individuals (Pelchat & LaChaussee, 1994; Pelchat, 1997). Declines in both substance dependence and cravings for sweets among older cohorts further suggest similar neurocircuitry underlying the motivation for drugs of abuse and palatable food. A greater understanding of the relevant adaptations in these neural systems during the aging process may illuminate possible targets for the treatment of addictive-like patterns of overeating. Additionally, it is worth noting that although individuals may “age out” of addictive-like eating, the consequences of such habits (e.g., excess weight, type II diabetes, etc.) may continue to affect the health and necessary care of these individuals in old age.

8. Conclusions

Past research has investigated a variety of food-related behaviors in the elderly, such as food habits (Gustafsson and Sidenvall, 2002), fruit and vegetable intake (Baker and Wardle, 2003), and food shopping experiences (Hare, 1999; Meneely, 2009). In light of the current obesity epidemic and predicted increases in the size of the elderly population, research efforts aimed at investigating the potential relevance of the food addiction construct in this age group may be worthwhile. Potential areas for future research include using existing feeding paradigms to study features of food addiction in older animals as well as investigating age-related neural adaptations that may be associated with reduced addictive behavior. Additionally, it could be useful to explore the construct of food addiction in an elderly sample with the use of existing measures, such as the YFAS. Such research would expand the current knowledge regarding food addiction and potentially lead to improved clinical care.

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Highlights

- Obesity among the elderly is a growing public health concern.
- There is evidence to suggest that, in some, consumption of highly palatable foods may lead to addiction-like behaviors.
- It would be beneficial to explore the food addiction hypothesis among older samples to better understand and potentially treat this issue, especially as it may contribute to rates of overweight and obesity in this age cohort.