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Food addiction and body-mass-index: A non-linear relationship

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ABSTRACT

Excessive food consumption has been recognized to show similarities with substance dependence. Subsequently, it has been proposed that food addiction might contribute to the obesity epidemic. Recent studies using questionnaires for the assessment of food addiction have found statistically significant, but negligible positive correlations with body-mass-index (BMI). Moreover, group comparisons between food-addicted and non-addicted individuals in normal-weight or obese samples did not show differences in BMI. However, the prevalence of food addiction diagnoses is remarkably increased in obese individuals. In the current article, it is suggested that there might be a cubic relationship between food addiction and BMI. Food addiction symptomatology may remain stable in the under- and normal-weight range, increase in the overweight- and obese range, and level off at severe obesity. Empirical data in support of this view are presented.

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Introduction

Obesity is a condition of excessive fat accumulation in adipose tissue to the extent that health may be impaired [1]. Body-mass-index (BMI), which is defined as weight in kilograms divided by the square of height in meters (kg/m²), is commonly used to classify underweight, normal-weight, overweight, and obesity in adults, although it does not distinguish between weight associated with muscles and weight associated with fat. According to the World Health Organization (WHO), obesity is classified as a BMI > 29.99 kg/m² and individuals with a BMI > 34.99 kg/m² are described as severely obese [1]. Obesity is a worldwide health and economic burden [2]. In the US population, for example, some 30% of adults are currently obese [3,4]. While the prevalence of obesity seems to stabilize, the prevalence of severe obesity continues to rise [3–6].

In the light of this obesity epidemic, a food addiction model of obesity and overeating is gaining more and more popularity in recent years [7–11]. This food addiction model proposes that there are striking similarities – both neurobiological and behavioral – between obesity (or overeating) and substance dependence and suggests that hyperpalatable foods could have an addiction potential [9]. One of the most highlighted arguments is that DSM-IV substance dependence criteria also apply to overeating, e.g. when they are modified with references to binge eating [12]. Another line of argument refers to a possible reward deficiency syndrome reflected by a downregulation of striatal D2-receptor availability and concurrent hypersensitivity to palatable food-cues in obese individuals [13].

There have also been critical evaluations of the food addiction model [14,15]. For instance, definitions and interpretations of food addiction symptoms, i.e. the eating-related equivalents to substance dependence criteria, are unclear and inconsistent [15,16]. Moreover, the concept of food addiction lacks a clear addictive agent. Animal studies suggest that high-sugar foods in particular have an addictive potential [22]. While most of the food addiction literature has focused on obesity or binge eating disorder (BED, see below), it has also been recognized that only a subset of obese individuals could be described as food addicted and that symptoms of food addiction are also present in under- or normal-weight individuals [15,23–25], those with bulimia nervosa (BN) in particular [26–28].

Few questionnaires have been provided that assess addicted eating behavior. Merlo et al. [29] used the Eating Behaviors Questionnaire (EBQ) which was specifically created for their study in a sample of overweight children. Questions include the “3 Cs” of addiction (compulsive use, attempts to cut down, continued use despite consequences) and one question directly asks “Do you think you are addicted to food?” [29]. A recent study used Eysenck’s Addiction Scale (AS) [30] for the assessment of general addictive personality and some custom-made questions for the
assessing food addiction symptomatology and BMI in samples with a wide body mass range. For instance, a small positive correlation ($r = .17$) between YFAS symptoms and BMI was found in a predominantly normal-weight sample in Germany [34]. Prevalence of food addiction diagnoses differed between weight classes such that obese participants had higher prevalence (37.5%) than overweight (14.0%) or normal-weight (6.3%) participants [34]. Contrarily, food addicted participants did not differ in BMI from non-addicted participants in a comparable sample [35]. Moreover, no correlation between the YFAS and BMI was reported in a similar sample in the US that had a smaller sample size [32]. In a sample of 39 young healthy women ranging from lean to obese, there was no association between the YFAS and BMI [36]. The authors speculated that some individuals may experience compulsive eating behavior but engage in compensatory behaviors to maintain a lower weight or that lean participants who endorse FA are at risk for future weight gain [36].

There are also some studies in which food addiction was assessed in samples restricted to overweight or obese individuals. There was a small positive correlation ($r = .31$) between scores on the EBQ and BMI in a study with overweight children [29]. Contrarily, the AS did not correlate with BMI in obese adults seeking bariatric surgery [31]. Likewise, food addicted individuals (as measured with the YFAS) did not differ in BMI from non-addicted individuals in two obese samples [37,38].

To sum up, studies that calculated correlations between BMI and food addiction symptoms or compared groups of food addicted vs. non-addicted individuals for BMI did not yield a clear positive relationship between BMI and food addiction.

**Binge eating and BMI**

Research on food addiction is in its infancy and, therefore, only few data are available on food addiction symptomatology and BMI. A field of research where there are plenty of studies and which is closely related to food addiction, is binge eating and BED. Research criteria for BED include recurrent episodes of binge eating, i.e. eating large amounts of food in a discrete period of time with a sense of lack of control over eating, which occur at least 2 days a week for 6 months and are associated with marked distress [33]. Diagnostic criteria for BED will be included in the fifth revision of the DSM [39]. Although food addiction and BED have multiple similarities, the two constructs do not entirely overlap [40]. For example, only 56.8% of obese patients with BED could be classified as food addicted using the YFAS [41]. Vice versa, 72.2% of obese individuals who received an YFAS diagnosis were also diagnosed with BED [37].

Without any doubt, BED is associated with overweight and obesity [42–44]. Positive, but rather small relationships have been found between BMI and binge eating severity in samples with diverse body weight [45–47]. Higher binge eating frequency could be found in obese as compared to non-obese women [48]. This positive association between BMI and binge eating seems to be vanished within obese samples. No differences in BMI can be found when obese binge eaters are compared with obese non-binge eaters [49–53]. In one study, even lower BMI was found in obese binge eaters compared to obese non-binge eaters which, however, could be due to the recruitment procedure [54,55]. In samples with severely obese individuals seeking bariatric surgery, no differences were found in BMI between patients with full BED and less regular binge eating [56] or between groups which were classified as non-binge eaters, once weekly binge eaters, and twice weekly binge eaters [57].

To conclude, there seems to be only a small positive relationship between binge eating severity and BMI in samples with a wide body mass range and there is no such relationship within obese samples.

**A proposed non-linear relationship**

At first glance, results about the relationship between BMI and food addiction (or binge eating, respectively) seem inconsistent. While many studies show a positive association between variables, comparing groups with and without food addiction or BED usually do not find differences in BMI. Interestingly, researchers usually assume linear relationships between variables and only few studies have examined non-linear relationships between BMI and eating-related constructs (e.g. reward sensitivity) [58–60].

The lack of differences in BMI between food-addicted and non-addicted individuals could be explained by the fact that groups were either compared within samples of primarily normal-weight participants [35] or within samples of morbidly obese patients [37,38]. However, positive correlations between food addiction and BMI could be primarily due to increases in food addiction symptomatology in overweight and moderate obese individuals. This view would therefore assume a cubic relationship between food addiction symptomatology and BMI. Specifically, there may be a stable degree of food addiction symptomatology in the under- and normal-weight range and within morbidly obese samples. Increases in food addiction symptomatology might be particularly pronounced in overweight and moderate obesity.

Fig. 1 displays aggregated data from three studies in which the YFAS was used and BMI was assessed ($N = 1499$) [34,35,38]. Participants were classified in weight categories according to standard guidelines [1]. The relationship between weight categories and both food addiction symptoms and food addiction diagnoses could be mapped with a third order polynomial function (Fig. 1). This function explained 95% (symptoms) and 89% (diagnoses) of the variance, respectively (which was higher than plotting a quadratic function: $R^2 = .87$; diagnoses: $R^2 = .83$) or linear (symptoms: $R^2 = .85$; diagnoses: $R^2 = .73$) function). As can been seen in Table 1, food addiction symptomatology did not differ between underweight and normal-weight individuals, but increased from normal-weight to overweight individuals. Furthermore, food addiction symptomatology did not differ between overweight individuals and those with moderate obesity, but between individuals with moderate obesity and severe obesity (Table 1). Finally, no differences were found between obesity classes II and III (Table 1).

**Conclusions and caveats**

Several limitations have to be considered when assuming this non-linear relationship between BMI and food addiction. First, although classification in weight categories using BMI are usually based on standard guidelines provided by the WHO [1], those categories are not based on scientific evidence but are rather arbitrary ranges. Second, BMI is not an optimal measure of adiposity as it is based solely on weight and height and does not exactly represent
Finally, a further factor moderating the relationship between BMI and food addiction could be the intake of alcoholic beverages. Studies investigating the relationship between alcohol use and BMI yielded inconsistent findings [62]. Yet, some studies point out an inverse association between alcohol use and BMI which could be explained by food and alcohol competing for the same brain reward sites [63–65]. In line with this idea, participants who were diagnosed with food addiction reported less alcohol use than their non-addicted counterparts in a sample of severely obese individuals seeking bariatric surgery [66]. Hence, although food addicted individuals might eat more than non-addicted obese individuals, the latter ones might get additional calories from alcoholic beverages which contribute to equal BMI in both groups.

In conclusion, a cubic relationship between BMI and food addiction symptomatology was proposed in the current article indicating an increase in food addiction symptomatology in overweight and obese individuals but stable levels in under-/normal-weight and severely obese individuals. This relationship provides an explanation for the fact that there is a small positive relationship between food addiction (or binge eating) and BMI, but no differences can be found when only normal-weight or severely obese samples are investigated.

**Conflict of interest statement**

None declared.

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