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Correlates of food addiction in obese individuals seeking bariatric surgery

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What is already known about this subject

- Obesity and over-eating show similarities to addictive behaviours.
- Obesity, over-eating and substance use are associated with impulsivity.
- Research on the relationship between alcohol use and obesity is inconsistent.

What this study adds

- A substantial subset of obese individuals seeking bariatric surgery can be classified as food-addicted.
- Food addiction may be related to lower alcohol use in pre-bariatric patients and food addiction and alcohol use are differentially related to specific facets of impulsivity.
- Food addiction and impulsivity interactively predicted alcohol use, which demonstrates that there is a complex interplay between eating style, psychological factors and alcohol use, independent of body mass.

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Summary

Recent evidence suggests that palatable, high-calorie foods may have an addictive potential. Accordingly, obesity and overconsumption of such foods have been associated with addiction-like eating behaviour. The present study investigated whether individuals with obesity can be classified as food-addicted and which factors would differentiate between food-addicted and non-addicted individuals. We administered the German version of the Yale Food Addiction Scale and other questionnaires to obese individuals seeking bariatric surgery ($N = 96$). Results showed that 40% of the sample could be diagnosed as food-addicted. Food-addicted individuals reported more frequent food cravings, higher eating disorder psychopathology and more depressive symptoms than the non-addicted group. Age, body mass and gender distribution did not differ between groups. The food addiction group had higher attentional but similar motor and non-planning impulsivity, and had lower scores on the Alcohol Use Disorders Identification Test (AUDIT) compared with the non-addicted group. Scores on the AUDIT were associated with impulsivity in the non-addicted group only. We conclude that the prevalence of food addiction is higher in candidates for bariatric surgery compared with the general population and obese individuals not seeking bariatric surgery. A diagnosis of food addiction is associated with higher eating pathology and depression. Moreover, only attentional impulsivity, but not other dimensions of impulsivity, is associated with addictive eating. Finally, food addiction and impulsivity interactively predicted alcohol use, suggesting a crucial role of psychological variables and eating style in determining alcohol consumption in pre-bariatric patients, independent of body mass.

Keywords: Bariatric surgery, binge eating, food addiction, obesity.

Introduction

The most effective weight loss treatment for severe obesity is bariatric surgery (1). Studies investigating psychological characteristics of obese individuals presenting for bariatric surgery have found lower psychosocial functioning and quality of life and higher levels of aberrant eating behaviours compared with normal-weight controls (2). Approximately 25–50% of pre-bariatric patients engage in regular binge eating or receive a diagnosis of binge eating disorder (BED) (3,4). Notably, levels of psychopathology and disordered eating behaviour, particularly binge eating, are also higher in those patients as compared with obese individuals seeking non-surgical weight loss treatment (5).

In recent years, a food addiction model of over-eating and obesity has gained more and more popularity (6). Specifically, there is a plethora of theoretical articles discussing the parallels between substance use disorders (SUDs) and obesity or other types of over-eating, e.g. binge eating in patients with bulimia nervosa and BED [e.g. (7,8)]. Part of this debate concerns the question of whether high-calorie foods or specific ingredients (e.g. sugar) have an addictive potential comparable to drugs of abuse (6,9). Nevertheless, food addiction remains a highly controversial and heavily debated issue (10–13). For example, a major point of discussion is that researchers do not have a unique definition of food addiction or disagree about the exact food addiction equivalents of SUD symptoms (11,13).

In an attempt to overcome these issues, the Yale Food Addiction Scale (YFAS) was developed (14). This 25-item instrument measures the presence of food addiction symptoms based on the substance dependence criteria in the DSM-IV, i.e. seven symptoms. In addition, two items assess clinically significant impairment or distress as a result of over-eating. When both clinically significant impairment or distress is present *and* at least three of the seven symptoms are met, then food addiction can be 'diagnosed'. Prevalence rates for food addiction according to the YFAS range between 5 and 10% in community or student samples (14–17), 15 and 25% in obese samples (18–22) and 40 and 60% in obese individuals with BED (23,24).

Although the prevalence of food addiction is markedly increased in obese samples, there is no evidence for differences in body mass index (BMI) between food-addicted and non-food-addicted obese individuals (25). Also, food addiction appears to be independent of age and gender within obese samples (18,19,21,23,24). Nevertheless, there are marked psychological differences between obese individuals with or without a food addiction diagnosis. For example, food-addicted obese individuals have higher levels of self-reported and behavioural impulsivity, emotion regulation difficulties, depression, eating disorder psychopathology (e.g. more frequent binge episodes), emotional eating and food cravings (18,19,21,23,24,26). A recent study showed that those groups can also be differentiated by a dopaminergic multilocus genetic profile such that a composite genetic index of elevated dopamine signalling was higher in obese individuals receiving a food addiction diagnosis as compared with non-addicted obese individuals (20).

The relationship between obesity and substance use appears to be complex, with studies showing inconclusive results. Specifically, there are studies reporting positive, negative or no associations between BMI or obesity and substance use (27). Accumulating evidence suggests that often new-onset SUDs emerge after bariatric surgery, particularly in gastric bypass patients, possibly reflecting an 'addiction transfer' (28). Indeed, post-bariatric patients who retrospectively reported their food addiction symptomatology were more likely to exhibit post-surgical SUD with higher pre-surgical YFAS scores (29). Similarly, former smokers were more likely to meet current food addiction criteria and current smoking was inversely associated with food addiction in a recent study in middle-aged and older women (17). Other studies, however, did not find a relationship between YFAS scores and substance use in non-obese (14,15) or obese samples (23,24,26).

The current study is the first that investigated correlates of the YFAS in pre-bariatric patients. Specifically, individuals with a food addiction diagnosis were compared with those not receiving a food addiction diagnosis with regard to sociodemographic and anthropometric information and variables related to eating behaviour, psychopathology and alcohol use. Moreover, the YFAS symptom count was correlated with the very same variables. Thus, all of the following hypotheses refer to both the group comparisons using the dichotomous YFAS score and to the correlational analyses using the continuous YFAS score.

Based on previous findings in other samples (15,19,20,23,24,30,31), it was expected that food addiction would be associated with more frequent experiences of food craving, higher eating disorder psychopathology, higher depression and higher self-reported impulsivity. Current food craving was expected to be unrelated to food addiction as there was no experimentally manipulated food exposure involved. Also, age, gender and BMI were expected to be unrelated to food addiction (18,19,21, 23,24). Furthermore, we explored if the number of hypertension and diabetes diagnoses would differ between food-addicted and non-addicted individuals as this has been found in a recent study (17). Moreover, we expected that individuals with a food addiction diagnosis would score lower on a measure of alcohol use and associated problems, as there might be an inverse relationship between food addiction symptomatology and substance use (17). Finally, as both food addiction and alcohol abuse are associated with higher impulsivity (19,32), we explored if there are also interactions between food addiction and

impulsivity when predicting alcohol use and associated problems.

Materials and methods

Participants

Participants were $N = 96$ obese candidates for bariatric surgery. Parts of the present data have been published previously (33). Mean age was M = 39.92 years (standard deviation [SD] = 11.51) and mean BMI was M = 50.64 kg m^{-2} (SD = 8.99). The sample comprised 63 women (65.60%) and 33 men (34.40%). The most common physical comorbidities were primary hypertension ($n = 32$), diabetes mellitus ($n = 19$), joint or lumbar spine troubles ($n = 13$), dyspnoea ($n = 13$) and sleep apnoea ($n = 9$). All study variables were screened for extreme outliers using box plot analyses. As a result, data of two participants with extreme scores on the Alcohol Use Disorders Identification Test (>98th percentile) were excluded.[1] Thus, the final sample comprised $n = 94$ participants. Sample size differs by analyses due to missing data.

Measures

Yale Food Addiction Scale (YFAS)

The YFAS (14,15) measures symptoms of food addiction. This 25-item instrument contains different scoring options (dichotomous and frequency scoring) to indicate experience of addictive eating behaviour within the past 12 months. A symptom count can be calculated, which can range between zero and seven food addiction symptoms. Moreover, a diagnosis of food addiction can be made if at least three symptoms and a clinically significant impairment or distress are present. Internal consistency was Kuder–Richardson's $\alpha = 0.83$ in the present study.

Food Cravings Questionnaires (FCQs)

The FCQs (34,35) measure experiences of food craving on a trait and state level. The 39-item trait version (FCQ-T) assesses the frequency of food craving experiences on a 6-point scale from *never* to *always*. It comprises nine subscales measuring food cravings in relation to (i) intentions to consume food; (ii) anticipation of positive reinforcement; (iii) relief from negative states; (iv) lack of control over eating; (v) preoccupation with food; (vi) hunger; (vii) emotions; (viii) cues that trigger cravings and (ix) guilt. Only the total score was used in the current study and internal consistency was Cronbach's $\alpha = 0.97$.

[1]Note that both individuals received a food addiction diagnosis. Instead of deleting the AUDIT scores only, we decided to fully exclude the data of those individuals as alcohol dependency probably adversely affected other measures [e.g. see (56) for relationships between alcohol dependency, BMI and eating behaviour].

The 15-item state version (FCQ-S) measures the intensity of current food craving on a 5-point scale ranging from *strongly disagree* to *strongly agree*. It comprises five subscales referring to current food craving in relation to (i) an intense desire to eat; (ii) anticipation of positive reinforcement; (iii) relief from negative states; (iv) lack of control over eating and (v) hunger. Only the total score was used in the current study and internal consistency was Cronbach's $\alpha = 0.94$.

Eating Disorder Examination – Questionnaire (EDE-Q)

The EDE-Q (36,37) measures eating disorder psychopathology over the last 28 days. It consists of 22 items and items are scored on a 7-point scale ranging from *no days/not at all* to *every day/markedly*. It comprises four subscales assessing (i) restraint; (ii) eating concern; (iii) weight concern and (iv) shape concern. Internal consistencies were Cronbach's $\alpha = 0.72$ (restraint), $\alpha = 0.74$ (eating concern), $\alpha = 0.58$ (weight concern), $\alpha = 0.73$ (shape concern) and $\alpha = 0.86$ (total scale) in the current study. Six additional items assess the frequency of other relevant behaviours, such as binge eating and self-induced vomiting, of which we only used the self-reported number of days with objective binge episodes (i.e. eating large amounts of food with a feeling of loss of control) over the last 28 days in the current analyses.

Barratt Impulsiveness Scale – short form (BIS-15)

The BIS-15 (38,39) is a 15-item short form of the 11th version of the Barratt Impulsiveness Scale (40). It measures trait impulsivity on a 4-point scale ranging from *rarely/never* to *almost always/always*. It comprises three subscales assessing (i) attentional; (ii) motor and (iii) non-planning impulsivity. Internal consistencies were Cronbach's $\alpha = 0.62$ (attentional), $\alpha = 0.81$ (motor), $\alpha = 0.87$ (non-planning) and $\alpha = 0.81$ (total scale) in the current study.

Alcohol Use Disorders Identification Test (AUDIT)

The AUDIT (41,42) measures the amount and frequency of alcohol consumption and associated addiction symptoms and problems. It consists of 10 items with different scoring options. Internal consistency was Cronbach's $\alpha = 0.74$ in the current study.

Center for Epidemiologic Studies Depression Scale (CES-D)

The CES-D (43,44) measures depressive symptoms within the past week. It consists of 20 items which are scored on a 4-point scale ranging from *rarely or none of the time* to *most or all of the time*. Internal consistency was Cronbach's $\alpha = 0.91$ in the present study.

Procedure

Individuals were approached during consultation hours for bariatric surgery at the Center for Surgical Medicine of the

Table 1 Group differences on continuous study variables

	Food addiction group ($n = 38$)		No food addiction group ($n = 56$)		Test statistics		
	M	SD	M	SD	*t*	df	*P*
Age (years)	39.29	9.77	40.38	12.74	0.44	92	ns
Body mass index (kg/m^2)	50.89	8.08	50.62	9.68	0.14	92	ns
Food Cravings Questionnaires							
State	31.94	12.21	30.10	12.35	0.67	81	ns
Trait	135.73	31.90	93.85	33.63	5.80	83	<0.001
Eating Disorder Examination – Questionnaire							
Restraint	2.70	1.46	2.10	1.41	1.87	79	0.07
Eating concern	2.71	1.38	1.48	1.19	4.30	79	<0.001
Weight concern	4.17	0.87	3.50	1.18	2.81	79	<0.01
Shape concern	4.76	0.95	3.99	1.18	3.13	79	<0.01
Total	3.58	0.86	2.77	0.95	3.97	79	<0.001
Binge days	9.09	9.28	2.48	3.55	4.43	79	<0.001
Barratt Impulsiveness Scale – short form							
Attentional	10.94	2.96	9.36	2.44	2.60	77	<0.05
Motor	11.50	2.78	11.24	3.59	0.35	77	ns
Non-planning	10.64	2.78	10.78	3.82	0.19	77	ns
Total	33.08	6.21	31.38	7.32	1.08	77	ns
Alcohol Use Disorders Identification Test	1.77	2.16	3.13	3.86	1.78	76	0.08
Center for Epidemiologic Studies Depression Scale	28.55	11.34	17.82	10.00	4.45	77	<0.001

P values greater than 0.10 are displayed as ns.
SD, standard deviation.

University Hospital in Würzburg, Germany. They were asked to participate in a questionnaire study, which would be unrelated to their eligibility for a later surgery. Participation in the study was voluntary and the study was approved by the ethical review board of the medical faculty at the University of Würzburg, Germany. Written informed consent was obtained from participants prior to study participation. After signing the informed consent, participants completed the questionnaires. Data on height, weight and medical conditions were obtained from the medical examination in the hospital.

Data analyses

Group differences in sample characteristics and questionnaire measures between individuals receiving a food addiction diagnosis (FA group, $n = 38$) and those not receiving a diagnosis (no-FA group, $n = 56$) were tested with *t*-tests and, where appropriate, with χ^2-tests. Associations between the number of food addiction symptoms with BMI and questionnaire measures were tested with Pearson's correlations. Interactions between food addiction and impulsivity when predicting scores on the AUDIT were tested with linear regression analyses using *Interaction!* Version 1.7.2211 (Freeware available at http://www.danielsoper.com/interaction). Continuous variables were *z*-standardized and regression analyses were performed using AUDIT scores as dependent variable and food addiction diagnosis or food addiction symptoms, scores on the BIS-15 and the interaction food addiction × BIS-15 as predictor variables. This was done for the BIS-15 total score and each subscale separately. To examine the nature of interaction effects when using food addiction symptoms, simple slopes were computed for the regressions of BIS-15 scores on AUDIT scores for individuals with few or many food addiction symptoms (one SD below and above the mean, respectively) (45). Inclusion of gender and BMI as covariates in the regression analyses did not significantly affect results and are thus not reported. As we did not have directional hypotheses for a possible interaction effect of food addiction and impulsivity, all *P* values are reported two-tailed. Results were considered as significant at $P < 0.05$. Exact *P* values are reported for marginal significance ($P = 0.05$–0.10). *P* values greater than 0.10 are displayed as ns.

Results

Group differences

Groups did not differ in gender distribution ($\chi^2_{(1)} = 0.47$, ns), number of hypertension or diabetes diagnoses (both $\chi^2_{(1)}$s < 0.14, ns), age or BMI (Table 1). The FA group had higher FCQ-T scores than the no-FA group, but groups did not differ in FCQ-S scores. The FA group had higher scores on the EDE-Q subscales eating concern, weight concern

Table 2 Descriptive statistics of continuous study variables and correlations with the Yale Food Addiction Scale symptom count

	M (SD)	*r*
Yale Food Addiction Scale (symptom count)	3.39 (1.75)	–
Age (years)	39.94 (11.59)	–0.26*
Body mass index (kg/m^2)	50.73 (9.02)	–0.11
Food Cravings Questionnaires		
State	30.88 (12.25)	0.33**
Trait	111.58 (38.78)	0.68***
Eating Disorder Examination – Questionnaire		
Restraint	2.36 (1.45)	0.15
Eating concern	2.01 (1.41)	0.52***
Weight concern	3.79 (1.10)	0.35**
Shape concern	4.32 (1.15)	0.37**
Total	3.12 (1.00)	0.44***
Binge days	5.33 (7.39)	0.45***
Barratt Impulsiveness Scale – short form		
Attentional	10.02 (2.76)	0.39***
Motor	11.35 (3.26)	0.11
Non-planning	10.72 (3.40)	0.10
Total	32.09 (6.89)	0.26*
Alcohol Use Disorders Identification Test	2.59 (3.34)	0.01
Center for Epidemiologic Studies Depression Scale	22.30 (11.78)	0.45***

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

and shape concern as compared with the no-FA group. The FA group also had higher total EDE-Q scores, reported more binge days and had marginally significant higher scores on the restraint subscale as compared with the no-FA group (Table 1).

The FA group had higher scores on the BIS-15 attentional impulsivity subscale as compared with the no-FA group. Groups did not differ on motor impulsivity, non-planning impulsivity and the BIS-15 total score. The FA group had marginally significant lower AUDIT scores than the no-FA group. Finally, the FA group had higher CES-D scores than the no-FA group (Table 1).

Correlations with food addiction symptoms

The YFAS symptom count was negatively correlated with age. It was positively correlated with scores on the FCQs, the EDE-Q subscales eating concern, weight concern and shape concern, and with EDE-Q total scores and binge days. It was also positively correlated with the attentional impulsivity subscale and total scores of the BIS-15 and with CES-D scores. BMI, EDE-Q restraint, motor and non-planning impulsivity and AUDIT scores were not correlated with the YFAS symptom count (Table 2).

Relationship between food addiction, impulsivity and alcohol use

Food addiction diagnosis

In all models, YFAS diagnosis significantly or marginally predicted AUDIT scores such that a food addiction diagnosis was associated with lower AUDIT scores, replicating results from the group comparisons. Scores on the BIS-15, particularly on the subscales motor and non-planning impulsivity, positively predicted AUDIT scores. Importantly, there were also significant interactions between food addiction diagnosis and impulsivity when predicting scores on the AUDIT (Table 3). Total scores on the BIS-15 were positively associated with alcohol use in the no-FA group ($\beta = 0.51$, $t_{(73)} = 3.99$, $P < 0.001$), but not in the FA group ($\beta = -0.03$, $t_{(73)} = -0.13$, ns). Similarly, scores on the BIS-15 motor impulsivity subscale were positively associated with alcohol use in the no-FA group ($\beta = 0.43$, $t_{(73)} = 3.42$, $P = 0.001$), but not in the FA group ($\beta = -0.18$, $t_{(73)} = -0.92$, ns).

Table 3 Linear regression analyses for predicting AUDIT scores as a function of food addiction diagnoses and impulsivity

	AUDIT		
	β	*t*	*P*
YFAS diagnosis	–0.22	–2.09	0.04
BIS-15 – total score	0.29	2.68	0.009
YFAS diagnosis × BIS-15 – total score	–0.25	–2.30	0.03
YFAS diagnosis	–0.23	–1.92	0.06
BIS-15 – attentional	0.15	1.23	ns
YFAS diagnosis × BIS-15 – attentional	–0.07	–0.64	ns
YFAS diagnosis	–0.20	–1.87	0.07
BIS-15 – motor	0.18	1.68	0.10
YFAS diagnosis × BIS-15 – motor	–0.29	–2.63	0.01
YFAS diagnosis	–0.19	–1.73	0.09
BIS-15 – non-planning	0.28	2.40	0.02
YFAS diagnosis × BIS-15 – non-planning	–0.16	–1.35	ns

P values greater than 0.10 are displayed as ns.
AUDIT, Alcohol Use Disorders Identification Test; BIS-15, Barratt Impulsiveness Scale – short form; YFAS, Yale Food Addiction Scale.

Food addiction symptoms

The YFAS symptom count did not predict AUDIT scores. Again, scores on the BIS-15, particularly on the subscales motor and non-planning impulsivity, positively predicted AUDIT scores. Food addiction symptoms and scores on the BIS-15 motor impulsivity subscale interactively predicted AUDIT scores (Table 4). Motor impulsivity was positively associated with alcohol use in individuals with few food addiction symptoms (one SD below the mean; $\beta = 0.47$, $t_{(73)} = 3.01$, $P = 0.004$), but not in individuals with many food addiction symptoms (one SD above the mean; $\beta = 0.02$, $t_{(73)} = 0.14$, ns).

Discussion

In the current study, 40% of pre-bariatric patients were classified as food-addicted. This prevalence is higher than

Table 4 Linear regression analyses for predicting AUDIT scores as a function of food addiction symptoms and impulsivity

	AUDIT		
	β	*t*	*P*
YFAS symptoms	–0.04	–0.32	ns
BIS-15 – total score	0.33	2.90	0.005
YFAS symptoms × BIS-15 – total score	–0.10	–0.87	ns
YFAS symptoms	–0.01	–0.07	ns
BIS-15 – attentional	0.08	0.62	ns
YFAS symptoms × BIS-15 – attentional	0.05	0.43	ns
YFAS symptoms	0.02	0.18	ns
BIS-15 – motor	0.23	2.10	0.04
YFAS symptoms × BIS-15 – motor	–0.23	–2.04	0.05
YFAS symptoms	–0.01	–0.07	ns
BIS-15 – non-planning	0.38	3.29	0.002
YFAS symptoms × BIS-15 – non-planning	0.11	0.93	ns

P values greater than 0.10 are displayed as ns.
AUDIT, Alcohol Use Disorders Identification Test; BIS-15, Barratt Impulsiveness Scale – short form; YFAS, Yale Food Addiction Scale.

that found in other obese samples, e.g. obese individuals seeking non-surgical weight loss treatment (18,21,25,46). It corresponds with the food addiction prevalence (approximately 50%) reported in a recent study with post-bariatric patients, who were instructed to retrospectively report their YFAS symptoms before surgery (26). Thus, it can be concluded that a substantial proportion of extremely obese individuals exhibit addiction-like eating behaviour, comparable to prevalence rates found in obese individuals with BED (23,24). Unlike findings from non-obese samples, in which women usually display higher food addiction symptomatology according to the YFAS (14,15), no differences in gender distribution between groups was found in the current study, which is in line with other studies investigating obese samples (19–21,23,24). Furthermore, the FA and no-FA group did not differ in BMI, confirming other studies which also found that the positive association between BMI and food addiction symptomatology vanishes in extremely obese samples (25). In a recent study, both hypertension and diabetes were positively associated with food addiction, but these relations were not significant after adjusting for BMI (17). Accordingly, in the absence of differences in BMI between groups, no associations were found with hypertension or diabetes in the present study.

As expected, and in line with previous studies (19,20), food addiction was associated with trait food craving. Notably, this effect was large ($r > 0.5$, Table 2), indicating that individuals with food addiction frequently experience intense food cravings. In the newly revised fifth version of the DSM, craving is now included as a diagnostic criterion for SUD (47). Accordingly, craving appears to be a core feature of both SUDs and food addiction, and preliminary evidence suggests that obese individuals with BED easily meet the full criteria for SUD according to DSM-5, including its craving criterion (48). Thus, it may be that including the craving criterion in future studies on food addiction may lead to higher prevalence rates than those found based on the DSM-IV criteria (49). Future studies are warranted that investigate food addiction using those revised criteria and scrutinize if and how this will impact the concept of food addiction.

Furthermore, food addiction was related to higher eating disorder psychopathology such as eating-, weight- and shape-concern and more frequent binge episodes. Restrained eating behaviour only marginally differed between groups and was uncorrelated with food addiction symptoms which, again, is in line with previous reports (23). This lack of an association between food addiction and restraint is probably reflected in the YFAS symptom assessing *a persistent desire or unsuccessful efforts to cut down or control eating*, which is usually endorsed by most (more than 90%) of obese individuals, independent of food addiction symptomatology (23,24,33).

As hypothesized, according to previous studies (23,24), food addiction was associated with higher depression scores. The FA group had marginally lower AUDIT scores than the no-FA group, but AUDIT scores were uncorrelated with food addiction symptoms. That is, the expected association between food addiction and reduced alcohol use was only partially shown. Although there appears to be a tendency that food-addicted individuals drink less alcohol, this effect appears to be rather small, which corresponds with findings from other studies that did not find an association between the YFAS and alcohol use (14,15,23,24,26).

Food addiction symptomatology was associated with attentional impulsivity only, but not with motor or non-planning impulsivity. This result is in line with other studies, which used versions of the Barratt Impulsiveness Scale and showed that various measures associated with over-eating are particularly related to higher attentional, but rarely to motor or non-planning, impulsivity (50). Results are further corroborated by a recent study in a non-obese sample: Using the UPPS-P Impulsive Behavior Scale, only impulsivity related to *negative urgency* and *lack of perseverance* was associated with YFAS scores (51). Those subscales are highly correlated with attentional impulsivity as measured with the BIS-15 (38) and, thus, support the notion that attentional impulsivity in particular is related to over-eating.

Interestingly, the reverse pattern was found in relation to alcohol. Scores on the AUDIT only were correlated with motor and non-planning impulsivity, but not with attentional impulsivity. This parallels findings from a recent study by Papachristou and colleagues (52): Heavy drinkers

differed from light drinkers only in motor and non-planning impulsivity, but not in attentional impulsivity. Thus, it appears that both food addiction and excessive alcohol consumption are related to heightened levels of impulsivity, but that different aspects of impulsivity are related to each behaviour. Future studies are necessary to reveal the exact mechanisms why specific impulsivity facets may increase risk for different types of addictive behaviour. These may involve behavioural measures of impulsivity in addition to self-report instruments. For example, one study did include such measures (delay discounting and delay of gratification) and found that participants with a food addiction diagnosis took more impulsive decisions than those without a food addiction diagnosis (19). In another study with students, food addiction symptoms were correlated with faster reactions to high-calorie food cues, but not to motor response inhibition, which further supports that food addiction symptomatology may be related to attentional rather than motor aspects of impulsivity (31). However, those interpretations are preliminary and future research is needed to elucidate if these are stable findings.

In addition to those dissociations, there also were interactive effects between self-reported impulsivity, alcohol use and food addiction. Higher impulsivity was related to higher alcohol use in non-food-addicted individuals only, but not in those with a food addiction diagnosis. This might be explained by the fact that impulsivity constitutes a common risk factor for over-eating, addictions and other disorders, but may result in unique manifestations (53). Specifically, when impulsive individuals increasingly consume alcohol, they do not exhibit addiction-like over-eating and, vice versa, when impulsive individuals present with addiction-like over-eating, they do not drink much alcohol. This finding highlights the importance of considering moderators such as impulsivity and food addiction when investigating the relationship between obesity and alcohol use. Specifically, studies that investigated the co-occurrence of alcohol or other substance use and obesity are inconsistent (27). Thus, it appears to be necessary to move beyond co-prevalence research on body mass and substance use and, instead, take into account the crucial role of psychological aspects such as impulsivity and eating styles in determining substance use (54).

Interpretation of the current results is limited by the use of self-report measures and the correlational study design. Specifically, self-reports can potentially be biased, which may be particularly critical when reporting habitual alcohol use and food addiction symptoms such as withdrawal or tolerance (13). Moreover, we did not follow up development of BMI and self-report measures after surgery. Recently, food addiction symptoms have been found to be associated with reduced weight loss after a 7-week weight loss treatment in obese adults (18). This finding, however, could not be confirmed in another recent study (22). With regard to bariatric surgery, psychological pre-surgical conditions rarely predict treatment outcome after surgery (55). Yet, regardless if pre-surgical food addiction may be a predictor of reduced post-surgical weight loss, an even more relevant issue is how it is related to post-surgical substance use. Emerging evidence suggests that there is an elevated prevalence of SUDs in post-bariatric patients by about 2 years after surgery and that many of those are of new onset (28). While this may be caused by changes in the absorption of alcohol and other substances, it has also been noted that 'the [weight-loss surgery] patient is abruptly confronted with an inability to over-eat without experiencing discomfort, and if combined with limited coping skills for managing palatable food urges through other means, this may create conditions that fosters onset of SUDs' [(28), p. 474]. Thus, future prospective studies are needed, which may identify pre-surgical food addiction as an important predictor of post-surgical SUDs, and in particular alcohol abuse.

In summary, the present study showed that a substantial subset of pre-bariatric obese individuals exhibit an addiction-like eating behaviour and differ from their non-addicted counterparts in several psychological characteristics related to eating and general psychopathology. Moreover, distinct relationships and interactions of aspects of impulsivity, food addiction symptomatology and problematic alcohol use were found, highlighting the role of common risk factors for and correlates of compulsive over-eating and other addictive behaviours.

Conflicts of Interest Statement

No conflict of interest was declared.

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AM, CV and AK conceived the study. AM and DH collected and analysed the data. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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