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1. Introduction

Food addiction assumes behavioral and biological parallels between excess food consumption and drug addiction (Davis and Carter, 2009; Fletcher and Kenny, 2018; Randolph, 1956). It refers to the idea that palatable food (e.g. highly processed and caloric) may act on the brain as addictive substances by activating the reward circuit (mesolimbic dopamine system) and promoting an addictive-like response in vulnerable people (Davis et al., 2011). Though controversial, the concept of food addiction is of interest for eating disorders conceptualization and treatment, especially in bulimia nervosa and binge eating disorder (Treasure et al., 2018).

Anorexia nervosa diagnostic criteria are based on food-intake restriction, fear of gaining weight, and a distorted body image (American Psychiatric Association, 2013). Two subtypes of anorexia nervosa are distinguished: a restrictive subtype (marked by food restriction) and a binge-eating/purging subtype (involving large amounts of food consummation in a short period of time _bingeing_ and/or weight gain compensatory behavior like vomiting or laxative use _purging_). The concept of food addiction may at first seem counter-intuitive in Anorexia Nervosa. As suggested in previous studies, restrictive eating behavior in anorexic patients could be implemented to suppress the hunger impulses and the loss of control over food (Granero et al., 2014; Witt and Lowe, 2014). More generally, three core features of addiction may be involved in anorexia nervosa: (1) an impulsive component with individuals experiencing "loss of control" over self-starvation and binge eating; (2) a heightened reward level for palatable food resulting in food restriction or fasting to control this elevated drive (which results in an increased risk of binge eating behavior); and (3) a compulsive component with an awareness that the behavior is inappropriate and unsuccessful attempts to struggle against it despite important distress and detrimental consequences to their social and physical functioning. Furthermore, anorexia nervosa may be closed to the maladaptive cycle of drug-seeking behavior as these behaviors aim to modulate negative emotions and to cope with anxiety towards food (Godier and Park, 2014). Current studies support the hypotheses that among patients with eating disorders, food addiction is associated with higher eating psychopathology and higher general psychopathology (namely higher depressiveness, anxiety, impulsivity, low self-esteem, emotion dysregulation, and low autonomy) in bulimia nervosa (Granero et al., 2018; Vries and Meule, 2016) and binge eating

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disorder (Granero et al., 2018; Romero et al., 2019). Food addiction may also be associated with a poorer prognosis in binge eating disorder treatment outcomes (Romero et al., 2019).

There is a lack of literature analyzing the relationship between food addiction and the severity and prognosis of anorexia nervosa. To our knowledge, only two studies have focused on the diagnosis of food addiction in anorexia nervosa. Using the first version of the Yale Food Addiction Scale in an adult sample of 40 women suffering from anorexia nervosa, Granero et al. found prevalence rates of food addiction up to 50% in patients with restrictive subtype and up to 85.7% in patients with binge eating/purging subtype (Granero et al., 2014). These results are in accordance with the high rates of food addiction found in other eating disorders such as Bulimia Nervosa and Binge Eating Disorder rising respectively up to 96% for bulimia nervosa (Vries and Meule, 2016) and up to 92% for binge eating disorder (Carter et al., 2019; Gearhardt et al., 2013). The second study, by Albayrak et al., showed that 43% of patients with anorexia nervosa met the food addiction threshold but this study was built on a sample of adolescents suffering exclusively from the restrictive anorexia nervosa subtype (Albayrak et al., 2017). None of these studies explored specifically the relationship between food addiction diagnostic and anorexia nervosa severity.

Although the literature often refers to the "severity" of anorexia nervosa, the criteria leading to the classification of severity are not so delimited and may imply somatic and/or psychological parameters. The Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM – 5), categorizes patients with a BMI between 15 and 15.99 kg.m-2 as severe and as extreme if BMI is under 15 kg.m-2 (American Psychiatric Association, 2013). Although such criteria are of interest, they are based on the World Health Organization underweight classification and may not accurately reflect the actual severity of anorexia nervosa (Reas and Rø, 2017). Therefore, several studies indicated that patients with lower BMI at admission or with a low lifetime BMI, especially if the BMI< 13 kg.m-2, had increased mortality and poorer outcome (Huas et al., 2011; Maguire et al., 2008; Zipfel et al., 2000). The duration of the disease is also evoked as a factor of severity but remains controversial (Radunz et al., 2020). In a previous study, Takakura et al., proposed to fix the illness duration severity cut-off at 5 years (Takakura et al., 2019). High symptomatic scores (as assess by different questionnaires), compensatory behaviors, and psychiatric co-morbidities appear to be more consensual factors of severity (Espel-Huynh et al., 2020; Maguire et al., 2008; Zipfel

et al., 2000). From a biological perspective, IGF-1 and leptin are of particular interest in the characterization of anorexia nervosa severity. Both are a reflection of the fat mass and malnutrition severity associated with anorexia nervosa (Misra and Klibanski, 2014). Additionally, IGF-1 also reflects bone loss in anorexia nervosa (Legroux and Cortet, 2019; Misra and Klibanski, 2014). While leptin, aside from reflecting fat mass, could also be linked to food restriction behaviors (Caron et al., 2018; Mars et al., 2005).

Thus, this study aimed to analyze whether the presence of a diagnosis of food addiction is associated or not with markers of severity in anorexia nervosa. We hypothesized that a positive score on the YFAS 2.0 will be associated with greater severity, especially in the symptomatic assessment. We also hypothesized that the relationship between food addiction and anorexia nervosa will be mediated by binge eating/purging behaviors.

## 2. Methods

### 2.1. Participants and procedures

We conducted a retrospective single-center study. Patients aged 18 years or more, with a current diagnosis of anorexia nervosa (restrictive subtype and binge eating/purging subtype), were recruited in a Referral Center for Eating Disorders, between November 2017 and January 2019. This center receives patients with eating disorders to evaluate and refer them to specific care. The standardized evaluation was performed as part of the regular admission procedures. Data were collected from patient's medical records. The initial diagnostic assessment was made according to DSM-5 criteria during a clinical interview conducted by a fully trained psychiatrist. Then, the diagnosis was validated by a second psychiatrist, and any conflict in assessment resolved by discussion. The exclusion criteria were as follow; suffering from another eating disorder than anorexia nervosa (i.e. atypical anorexia nervosa, avoidant and restrictive food intake disorder), patient refusal, inability to understand, and read the surveys, incomplete YFAS 2.0 scoring. As this was an exploratory study, we chose to include only the typical forms of anorexia nervosa in order to limit the potential inclusion bias and to limit power decrease due to heterogeneous clinical forms.

Patients were informed that their data might be used in future studies and consent was obtained. The study was performed under the ethical standards as laid down in the 1964

Declaration of Helsinki and its later amendments. Data were collected and stored following

95    the computer data protection laws (CNIL n°19-041).


2.2. Assessment Measures

2.2.1. Clinical and biological data:

Data extracted were duration of the disease, Body Mass Index (BMI) measurement at

100   admission, minimum and maximum BMI since puberty, weight suppression (i.e. difference between maximum past BMI and current BMI), and variation in BMI (i.e. difference between lifetime maximum and minimum BMI). Biological parameters comprised fasting blood levels of IGF-1 and leptin.

These variables were chosen because they were identified as possible indicators of anorexia

105   nervosa severity. The main continuous variables were dichotomized into two groups according to national or international recommendations to facilitate their use in clinical practice: duration of illness was recorded as <5 or ≥5 years, admission BMI was recoded as <15 or ≥15 $kg.m^{-2}$ (BMI < 15 $kg.m^{-2}$ indicates an extreme form and is based on WHO definition of  severe undernutrition), and minimum BMI was recoded as <13 or ≥13 $kg.m^{-2}$.

110   2.2.2. Psychometric data:

*Yale Food Addiction Scale 2.0 (YFAS 2.0)*

We assessed food addiction using the YFAS 2.0 (Gearhardt et al., 2016). This self-report questionnaire consists of 35 items scored on an eight-level Likert scale (from 0 = never, to 7 = every day). These items allow the assessment of the eleven diagnostic criteria for

115   substance use disorders as specified by the DSM-5 : loss of control eating; inability to cut down; time spent to obtain, consume or recover; use despite physical/psychological consequences; activities given up; tolerance; withdrawal symptoms; craving or strong urge to use; failure in role obligations (school, work, home); use despite interpersonal problems; use in physically hazardous situations. Food addiction can be diagnosed when at least two of

120   the eleven criteria are fulfilled and if the eating behavior additionally causes significant distress or impairment in functioning. Furthermore, the number of positive criteria specifies the severity of food addiction. Food addiction is considered mild if only two or three criteria are met, moderate if four or five criteria are met, and severe if at least six criteria are met. The overall Cronbach's alpha was 0.957 in our sample.

*Eating Disorder Examination Questionnaire (EDE-Q)*

The 28-item EDE-Q (Carrard et al., 2015) was used for the assessment of eating disorder pathology within the past 28 days. Twenty-two of these items measure eating disorder symptomatology on the four subscales restraint (i.e. "*Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight ?*"), eating concern (i.e. "*Over the past 28 days, how concerned have you been about other people seeing you eat ?*"), weight concern (i.e. "*Has your weight influenced how you think about (judge) yourself as a person ?*") and shape concern (i.e. "*Have you had a definite desire to have a totally flat stomach ?*"). The six remaining items assess binge eating and compensatory behaviors. This self-report displays high reliability and internal consistency (Fairburn and Beglin, 1994; Mond et al., 2006). In our ample, overall Cronbach's alpha was 0.956.

*Bulimic Investigatory Test, Edinburgh (BITE)*

The BITE is a 33-item, self-report measure developed by Henderson and Freeman to assess the severity and frequency of binge eating symptoms (Henderson and Freeman, 1987). It includes two scales: the symptoms scale and the severity scale. We only used the symptoms scale in this study. Items are answered in a binary yes-no format and score ranges from 0 to 30. Items in the questionnaire include, for example: « Do you ever eat until you are stopped by physical discomfort?", "Can you always stop eating when you want to?", "Do you ever binge on large amounts of food?". In the overall sample, Cronbach's alpha was 0.853.

*Beck Depression Inventory (BDI-13)*

Current depressive symptoms were screened using the 13-item version of the Beck Depression Inventory (BDI-13). Each item is measured on a four-point Likert scale. Absence (or "as usual") of depressive symptoms in each item is scored as "0" and an increasing presence of symptoms is endorsed between 1 and 3. The total score can range between 0 and 39. The scale content reflects the cognitive, affective, somatic, and vegetative symptoms of depression (Beck et al., 1961) and includes items as: "I am so sad or unhappy that I can't stand it", "*I feel my future is hopeless and will only get worse*", "*I dislike myself*". Because the 13-item version has been shown to perform equally as BDI-21 we selected the shorter version (Aalto et al., 2012; Beck and Beck, 1972). In our sample, Cronbach's alpha was 0.865.

*State-Trait Anxiety Inventory (STAI)*

155    The STAI consists of two questionnaires of 20 items each (Spielberger et al., 1983). Each item is measured on a four-point Likert scale (from 1 to 4). The first questionnaire assesses the state anxiety (how one feels at the moment, i.e. "*I feel calm*", "*I feel jittery*", "*I feel frightened*") and the second questionnaire assesses the trait anxiety (how one generally feels, i.e. "*I am content*", "*I have disturbing thoughts*", "*I feel nervous and restless*"). The

160    score for each questionnaire varies from 20 to 80, higher scores are positively correlated with higher levels of anxiety (<35: very low, 36-45: low, 46-55: moderate, 56-65: high, >65: very high). In the overall sample, Cronbach's alpha was 0.962 for the STAI-State and 0.883 for the STAI-Trait.

*Barratt Impulsiveness Scale 11 (BIS-11)*

165    The BIS-11 is a 30-item self-report questionnaire designed to measure impulsiveness with good psychometric properties (Patton et al., 1995). It includes three subscales measuring three traits of impulsiveness: attentional (i.e. "*I concentrate easily*", "*I often have extraneous thoughts when thinking*"), motor (i.e. "*I do things without thinking*", "*I change jobs*"), and non-planning impulsiveness (i.e. "*I plan tasks carefully*", "*I like to think about complex*

170    *problems*"). All items are measured on a 4-point scale (1-4). All items are summed. The higher the BIS-11 total score, the higher the impulsiveness level. Its French version also has good validity (Gélinas et al., 2015). In our sample, Cronbach's alpha was 0.676.


2.3. Statistical analysis:

175    We calculated the frequency of YFAS 2.0-based food addiction and the YFAS 2.0 symptom count to assess food addiction severity. Patients with (FA+) and without (FA-) food addiction were compared regarding the duration of illness, BMI at admission, minimum BMI, Anorexia Nervosa subtype, leptin, and IGF-1 levels, and self-report scores using a $\chi^2$ test and an independent-sample *t*-test as applicable. Nonparametric tests were used when necessary

180    (Wilcoxon test). In a second step, a partial correlation was carried out between the YFAS 2.0 symptom count and the other parameters, adjusted for age and BMI at admission. Finally, mediation analysis models were used to explore the relationships between food addiction and anorexia nervosa severity (Hayes, 2017). These models reflect a causal sequence in which X affects Y indirectly through mediator variables M. We tested the hypothesis

185    whether the severity of binge eating behavior (as measured by the BITE symptom score _

M_) mediates the relation between the YFAS 2.0 addiction severity (as measured by the number of positive criteria at the YFAS 2.0 scale _X_ ) and symptom severity (as measured by EDE-Q Global score _ Y_).

P-values <0.05 were considered as statistically significant. Analyses were carried out using RStudio® software version 1.2.5001 for windows. The mediation analysis was performed using the PROCESS macro version 3.4.1 by Andrew F. Hayes (39) within SPSS version 26.0.0.1. Homoscedasticity and normality assumption for the residuals were verified. Conservative bootstrap confidence interval (99%) based on 10,000 bootstrap samples was used to estimate significance, accounting for Type I error rate inflation. Mediation analysis was performed separately for severity outcomes.

3. Results

Out of the initial population (N=106), 33 patients were excluded due to incomplete data or misdiagnosis, leading to a final sample of 73 patients (Figure 1).

** Please INSERT FIGURE 1 ABOUT HERE **

3.1. Descriptive data

The characteristics of the whole sample are detailed in the supplemental material (Table 1). There were mainly women (97.2%). At inclusion, the mean age was 28 years (SD=10.5), and the mean BMI was 16.5 kg.m$^{-2}$ (SD=2.3). The prevalence of current food addiction was 47% with 4.4 (SD=3.4) criteria on average.

Of the patients diagnosed with food addiction, 2 (5.9%) patients qualified for mild food addiction, 11 (32.4%) qualified for moderate food addiction, and 21 (61.7%) qualified for severe food addiction. The mean number of food addiction criteria was 6.8 (SD= 2.5) in patients with food addiction vs. 2.3 (SD=2.7) in patients without food addiction.

Among the whole sample, the most frequently endorsed food addiction criteria were "Continuing to use, even when it causes problems in relationships" (68%), "Giving up social, occupational or recreational activities" (63%), "Continued eating despite physical or psychological problems" (50%) and "tolerance" (44%). Clinically significant impairment or

distress was found in 58% of the patients. The percentage of participants who met the threshold for each diagnostic criterion ranged from 23% to 68%.

3.2. Comparison between patients with and without food addiction

BMI (current, minimum, weight suppression, and variation between maximum and minimum BMI), illness duration, impulsivity, and biological parameters did not differ significantly between the two groups (Table 1). Patients reaching the threshold of diagnosis of "food addiction" (FA+) had significantly higher depressions scores ($m_{FA+}$ = 17.63 , SD = 7.68 vs $m_{FA-}$ = 10.11, SD = 7.33; $p < 0.001$) and anxiety scores ( $m_{FA+}$ = 62.78, SD = 11.00 vs $m_{FA-}$ = 51.06, SD = 10.91 ; $p < 0.001$ for STAI-Trait and $m_{FA+}$ = 56.06 vs $m_{FA-}$ = 44.03, SD = 15.49; $p < 0.001$) and reported higher scores on each measure assessing eating disorder psychopathology with the BITE Symptom score ($m_{FA+}$ = 13.24 , SD = 9.42 vs $m_{FA-}$ = 5.92, SD = 7.60; $p$ = .001), the EDE-Q Global score ($m_{FA+}$ = 3.65 vs $m_{FA-}$ = 2.06; $p < 0.001$) as for all EDE-Q sub-scales (cf Table 1). There was more binge-eating/purging subtype in the food addiction group than in the group without food addiction (74% vs 26%; $p$ = 0.015). Compared to the group without food addiction, the group with food addiction had a trend for higher cognitive impulsivity ($m_{FA+}$ = 19.54, SD = 3.96 vs $m_{FA-}$ = 17.52 , SD = 3.44; $p$= .058).

** Please INSERT TABLE 1 ABOUT HERE **

3.3. Correlation between YFAS 2.0 severity and psychopathological symptoms

A significant positive correlation was found between food addiction severity and score of eating disorder symptomatology in BITE Symptom scale and all subscales of EDEQ (Table 2). A positive correlation was found between food addiction severity and BDI score, STAI state, and trait scores. No significant correlation was found between minimal BMI, illness duration, and impulsivity score (BIS-11).

** Please INSERT TABLE 2 ABOUT HERE **

3.4. Mediation analysis

The path (direct effect) from the YFAS 2.0 score to the EDE-Q Global score is positive and significant β'c =0.157, s.e.=.065, p=.018), indicating that persons scoring higher on the YFAS 2.0 are more likely to score higher on EDE-Q than those scoring lower on the measure. The effect of the YFAS 2.0 score on the BITE Symptom Score is positive and significant (βa =.1.772, s.e.=.244, p < .001). The effect of the BITE Symptom Score on EDE-Q Global score is positive and significant (βb =.070, s.e.=.025, p=.006), indicating participants scoring higher on the BITE Symptom Score are more likely to score higher on EDE-Q than those scoring lower on the measure. The indirect effect of the YFAS 2.0 score via the BITE Symptom Score (βindirect=.125) is positive and statistically significant (99%CI = [.007, .165]). The proportion of total effect that is mediated by the BITE Symptom Severity accounts for 44.33%.

** Please INSERT FIGURE 2 ABOUT HERE **

4. Discussion

To our knowledge, this is the first study to examine the relevance of the food addiction diagnosis, as provided by the new version of the YFAS (YFAS 2.0), in terms of severity in a sample of adults with anorexia nervosa. In the present study, we found that about half of patients with anorexia nervosa met the criteria for food addiction using the YFAS 2.0 and that patients with a food addiction diagnosis were more likely to have a binge-eating/purging subtype (74%). We also found that the relationship between food addiction severity and anorexia severity is mediated by the severity of binge-eating/purging behaviors. These results are in accordance with previous studies that found prevalence rates of food addiction between 43% and 50% in the restrictive subtype and up to 85% in the binge-eating and purging subtype (Albayrak et al., 2017; Granero et al., 2014). We can assume that similar to bulimic patients, participants with binge-eating/purging subtype endorsed higher food addiction levels due to the subjective feelings of loss of control and distress that are typically experienced in bingeing episodes (Granero et al., 2018; Wilfley et al., 2016).

In our study, the mean number of criteria of food addiction (4.4 criteria) was higher than symptom count estimations based on the previous version of the YFAS (3.6 criteria) (Granero et al., 2014). This difference is likely to be related to changes between the two versions of

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the YFAS. Indeed, the first version of the scale was updated to fit with the DSM-5 criteria and four new criteria were added (American Psychiatric Association, 2013; Gearhardt et al., 2016, 2009). Besides, the most endorsed criterion was one of the new criteria: "despite
280 interpersonal problems". In line with a study using YFAS in patients with AN, the other three most reported criteria were "activities given up", "despite physical and psychological problems" and "tolerance" (Granero et al., 2014). These criteria may be considered by patients regarding relation to food but also regarding food restriction consequences. Surprisingly, the criterion "unable to cut down" was only endorsed by 28% of our sample,
285 whereas it had been reported in 98% of participants with anorexia nervosa in the study of Granero et al. (Granero et al., 2014). This discrepancy could be related to the lack of clarity when it comes to defining what binge eating is in anorexia nervosa and the considerable variability that patients may have in estimating their food intake (Peat et al., 2009).

Although BMI alone might not be an ideal prognostic marker in anorexia nervosa, low BMI
290 has been associated with poorer outcomes (chronic illness and death) over time especially when the BMI was below the threshold of 13 $kg.m^{-2}$ (Fichter et al., 2017; Hebebrand et al., 1997; Löwe et al., 2001). We decided to complement the BMI by an illness duration > 5 years as it was found to be associated with a worse global outcome (Takakura et al., 2019). Interestingly, we were not able to detect a significant association between food addiction
295 and the selected predictors of poorer prognosis. On the contrary, there was a statistical trend for higher BMI in participants with a food addiction diagnosis. This could be due to the higher prevalence of binge eating/purging subtype in the food addiction group. As it has been suggested before, compensatory weight control behavior may have attenuated the relationship between BMI and food addiction (Meule, 2012).
300 As expected, our study confirmed that higher symptom count on the YFAS 2.0 was associated with more severe anorexia nervosa in terms of eating disorder psychopathology (EDE-Q) and psychological disturbances (anxiety and depression). Moreover, this relationship seemed to be mediated by the severity of binge-eating/purging symptoms. More precisely, the number of food addiction criteria was associated with more shape,
305 weight, and eating concerns. These results are in line with other studies in binge eating disorder and bulimia nervosa (Romero et al., 2019; Vries and Meule, 2016). Interestingly, food addiction was associated with the restraint subscale of the EDE-Q (i.e., the intention to

restrict food consumption). Our findings suggest that eating restriction might be a core feature of food addiction in individuals with anorexia nervosa. This result may seem surprising while considering an addictive phenotype that promotes excess food consumption. This association between the restraint subscale and food addiction may reflect the compulsive and rule-driven nature of addictive eating behavior measured by the YFAS 2.0 (Godier and Park, 2015a). Restrictive behavior may be conceptualized as a compulsive self-starvation behavior (Godier and Park, 2015b). As suggested before, dieting may serve to maintain binge eating among patients suffering from bulimia nervosa or binge eating disorder (Stice et al., 2001), and transgression of strict dietary rules might worsen disinhibited eating with an "*inhibition lift*" (Herman and Mack, 1975). Although patients with a restrictive subtype of anorexia nervosa do not often experience loss of control over food such as overeating nor binge-eating, they strongly fear that it might happen. The more they are restrictive about food, the more they may experience a craving for certain high-calorie food to counteract caloric deprivation (Albayrak et al., 2017; Stice et al., 2001). Therefore, some authors have suggested that restrictive features would be expressed in patients with addictive-like eating to suppress the internal urges of hunger and loss of control over food intake (Albayrak et al., 2017; Granero et al., 2014; Witt and Lowe, 2014). According to this hypothesis, there could be two phenotypes of anorexia nervosa that could be distinguished by the YFAS. One phenotype "food addict" with restrictive features secondary to this subjective food impulsivity or craving and one phenotype "originally restrictive" without any food addictive mechanisms. The extent to which food addiction symptoms might be a premorbid condition of anorexia nervosa or just a consequent factor, should be explored in future studies.

Moreover, it has been found that 40 to 57% of anorexia nervosa restrictive subtype patients evolve in binge-eating/purging subtype or bulimia nervosa form during follow-up (Castellini et al., 2011; Eddy et al., 2008) and that this crossover diagnosis was associated with the presence of unipolar depression and substance abuse (Castellini et al., 2011). Our study showed that food addiction was significantly associated with more depressive symptoms and more binge-eating/purging subtype compared to the non-food addiction. This might emphasize the hypothesis that food addiction in patients with anorexia nervosa could be a marker for this future switch as suggested before (Granero et al., 2014).

Our study could not highlight a significant difference in self-reported impulsivity. However, it has to be noted that participants in the study meeting the criteria for both anorexia nervosa and food addiction diagnosis had a trend to report higher levels of "cognitive impulsivity" (inability to maintain focused attention) compared to those without food addiction. This result may suggest that individuals with food addiction display more impulsivity and/or attentional impairments than those without food addiction. Such an effect could also reflect higher levels of depression or general anxiety that may impact cognitive impulsivity scoring (Swann et al., 2008).

Our study has some limitations. Our sample has a limited size and included mostly women. It could limit projection to all anorexia nervosa patients. Moreover, other severity or prognostic markers could have been discussed such as associated depressive disorder or severity of social issues (Zipfel et al., 2000). However, the prognostic value of psychological comorbidities such as major depressive disorder in anorexia nervosa remains controversial (Franko et al., 2018), as some authors have even noticed that the presence of a characterized depression in anorexia nervosa was associated with a better outcome of the eating disorder (Schlegl et al., 2014). Another limitation of our study is the lack of data on substance use co-morbidities. Indeed, the absence of comorbid substance abuse disorder has been associated with better long-term prognosis (Keshishian et al., 2019). Future studies in the field should take this into consideration. Moreover, the study relied on a self-report scale which may have led to inaccurate responses. Patients might have misinterpreted some items because of some emotional and cognitive related pathology bias (Albayrak et al., 2017). It remains uncertain what patients got in mind when they answered the YFAS item (i.e. food craving, self-starvation behavior, undernutrition consequences). Finally, the cross-sectional design prevents causal statements. We cannot confirm that food addiction came prior to the anorexia and therefore acts as a risk factor or vice versa.

Overall, our findings suggest that the presence of food addiction diagnosis may indicate a greater severity in anorexia nervosa characterized by more food intake restriction and weight preoccupations, as well as poorer mood and anxiety. Longitudinal studies are needed to better understand the etiologic process between food addiction and anorexia nervosa and to explore whether food addiction predicts a more or less favorable evolution of anorexia over time.

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**Figure 1**: Flow chart of the study.
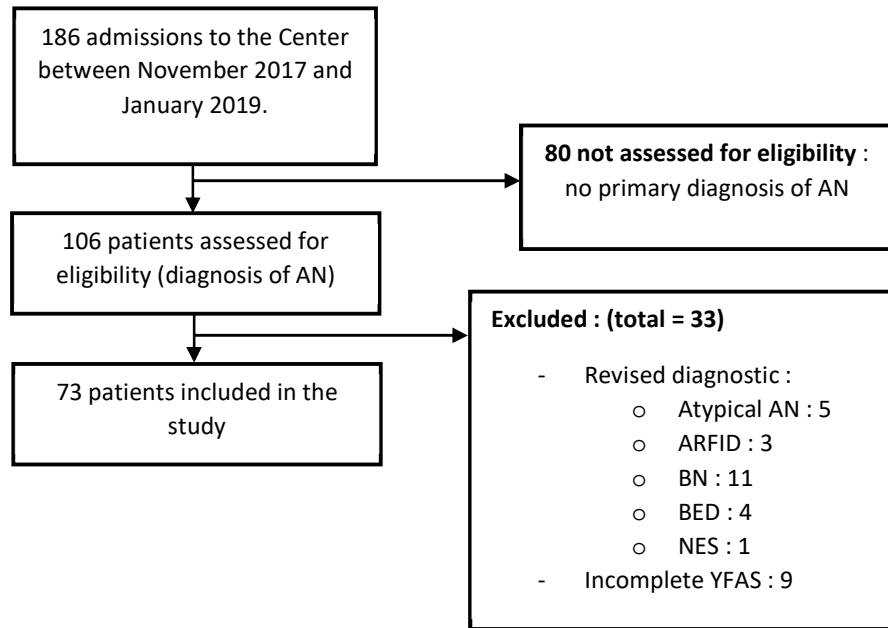


AN : Anorexia nervosa; ARFID : Avoidant and restrictive food intake disorder;   BN :
Bulimia nervosa; BED : Binge eating disorder; NES: Night eating syndrome, YFAS: Yale
Food Addiction Scale

**Figure 2:** Mediation analysis exploring the relations between food addiction and anorexia nervosa severity.
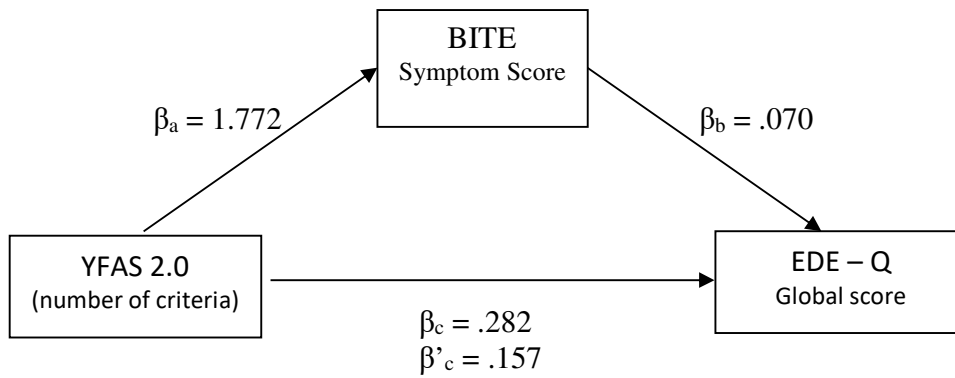


$\beta_c$ : Total effect of YFAS 2.0 on EDE-Q ; $\beta'_c$ : Direct effect of YFAS 2.0 on EDE-Q.

**Table 1:** Group comparison based on YFAS 2.0 diagnosis.

| | | FA = positive | | | | FA = negative | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | n | Mean | ± | SD | n | Mean | ± | SD | *p* |
| **Age** | | 34 | 29.70 | ± | 10.02 | 39 | 27.00 | ± | 10.07 | 0.263 |
| **Current BMl ≤ 15** | | 34 | 21% (7) | | | 39 | 29% (11) | | | 0.586 |
| **Minimum BMI ≤ 13** | | 34 | 21% (7) | | | 39 | 26% (10) | | | 0.769 |
| **Illness duration > 60 months (5 years)** | | 34 | 71% (24) | | | 39 | 53% (20) | | | 0.187 |
| **Anorexia subtype** | | | | | | | | | | **0.015** |
| | *Restrictive* | 34 | 38% (13) | | | 39 | 62% (23) | | | |
| | *Binge eating - Purging* | 34 | 74% (25) | | | 39 | 26% (10) | | | |
| **Weight suppression** | | 34 | 5.02 | ± | 3.66 | 39 | 4.06 | ± | 3.25 | 0.246 |
| **Δ BMI (BMI max - BMI min)** | | 34 | 7.65 | ± | 3.19 | 39 | 6.30 | ± | 3.24 | 0.082 |
| **EDE-Q** | | | | | | | | | | |
| | *Restriction* | 34 | 3.61 | ± | 1.75 | 39 | 1.69 | ± | 1.88 | **<0.001** |
| | *Eating concern* | 34 | 2.98 | ± | 1.51 | 39 | 1.66 | ± | 1.61 | **<0.001** |
| | *Shape concern* | 34 | 4.22 | ± | 1.65 | 39 | 2.51 | ± | 1.65 | **<0.001** |
| | *Weight concern* | 34 | 3.36 | ± | 2.12 | 39 | 2.02 | ± | 1.67 | **0.004** |
| | *Global score* | 34 | 3.65 | ± | 1.49 | 39 | 2.06 | ± | 1.56 | **<0.001** |
| **BITE** | Symptom score | 29 | 13.24 | ± | 9.42 | 36 | 5.92 | ± | 7.60 | **0.001** |
| **BDI** | | 34 | 17.63 | ± | 7.68 | 39 | 10.11 | ± | 7.33 | **<0.001** |
| **STAI** | | | | | | | | | | |
| | *STAI state* | 34 | 56.06 | ± | 13.19 | 39 | 44.03 | ± | 15.49 | **0.001** |
| | *STAI trait* | 34 | 62.78 | ± | 11.00 | 39 | 51.06 | ± | 10.91 | **<0.001** |
| **BIS 11** | | | | | | | | | | |
| | *Motrice imp.* | 31 | 20.87 | ± | 4.43 | 36 | 19.40 | ± | 3.97 | 0.160 |
| | *Cognitive imp.* | 26 | 19.54 | ± | 3.96 | 26 | 17.52 | ± | 3.44 | 0.058 |
| | *Planif. Difficulty* | 31 | 24.77 | ± | 4.91 | 36 | 28.83 | ± | 11.75 | 0.268 |
| | *Total* | 26 | 60.57 | ± | 11.07 | 26 | 59.00 | ± | 9.29 | 0.601 |
| **Biological parameters** | | | | | | | | | | |
| | *IGF 1* | 34 | 138.21 | ± | 62.39 | 39 | 159.79 | ± | 63.43 | 0.151 |
| | *Leptine* | 34 | 2.70 | ± | 3.18 | 38 | 2.23 | ± | 1.46 | 0.612 |
| **YFAS 2.0** | | | | | | | | | | |
| | *Symptoms count* | 34 | 6.76 | ± | 2.54 | 39 | 2.34 | ± | 2.73 | |

SD: Standard Deviation; FA: food addiction; BMI: body mass index (kg.m$^{-2}$); Weight suppression: BMI maximum – current BMI; Δ BMI: BMI maximum – BMI minimum; EDE-Q: Eating Disorder Examination Questionnaire; BITE : Bulimic Investigatory Test, Edinburgh; STAI: State-trait anxiety inventory; BDI: Beck depression inventory; BIS-11: Barratt impulsiveness scale; Motrice imp: motrice impulsivity; Cognitive imp: cognitive impulsivity; Planif difficulty: planification difficulty; YFAS 2.0: Yale Food Addiction Scale 2.0.

**Table 2:** Correlation between the YFAS 2.0 symptom count and clinical, biological and psychological measures.

| | | n | Simple correlation | | Partial correlation (Age and BMI) | |
|---|---|---|---|---|---|---|
| | | | ρ | *p* | ρ | *p* |
| **Minimum BMI** | | 67 | 0.048 | 0.698 | 0.085 | 0.495 |
| **Maximal BMI** | | 67 | 0.084 | 0.494 | 0.082 | 0.511 |
| **Illness duration** | | 67 | 0.091 | 0.456 | 0.024 | 0.847 |
| **Biological parameters** | | 67 | | | | |
| | *IGF 1* | | 0.014 | 0.906 | 0.046 | 0.710 |
| | *Leptine* | | -0.275 | **0.022** | -0.272 | **0.026** |
| **EDE-Q** | | | | | | |
| | *Restriction* | 67 | 0.533 | **<0.001** | 0.571 | **<0.001** |
| | *Eating concern* | | 0.614 | **<0.001** | 0.618 | **<0.001** |
| | *Shape concern* | | 0.520 | **<0.001** | 0.557 | **<0.001** |
| | *Weight concern* | | 0.436 | **<0.001** | 0.464 | **<0.001** |
| | *Global score* | | 0.570 | **<0.001** | 0.605 | **<0.001** |
| **BITE** | *Symptom scale* | 65 | 0.609 | **<0.001** | 0.674 | **<0.001** |
| **BDI** | | 67 | 0.612 | **<0.001** | 0.621 | **<0.001** |
| **STAI** | | 65 | | | | |
| | *STAI state* | | 0.434 | **<0.001** | 0.442 | **<0.001** |
| | *STAI trait* | | 0.515 | **<0.001** | 0.515 | **<0.001** |
| **BIS 11** | | 49 | | | | |
| | *Motrice imp.* | | 0.125 | 0.383 | 0.163 | 0.264 |
| | *Cognitive imp.* | | 0.251 | 0.076 | 0.280 | 0.052 |
| | *Planif. Difficulty* | | -0.050 | 0.727 | -0.046 | 0.752 |
| | *Total* | | 0.120 | 0.402 | 0.145 | 0.319 |

*ρ = Spearman's correlation coefficient; BMI: body mass index (kg.m⁻²); EDE-Q: Eating Disorder Examination Questionnaire ; BITE : Bulimic Investigatory Test, Edinburgh ; STAI: State-trait anxiety inventory ; BDI: Beck depression inventory ; BIS-11: Barratt impulsiveness scale ; Motrice imp: motrice impulsivity ; Cognitive imp: cognitive impulsivity ; Planif difficulty: planification difficulty ; YFAS 2.0: Yale Food Addiction Scale 2.0.*