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# Using latent class analysis to identify different clinical profiles according to food addiction symptoms in obesity with and without binge eating disorder

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## FULL-LENGTH REPORT



## ABSTRACT

**Background and aims:** Existing research suggests that food addiction (FA) is associated with binge eating disorder (BED) and obesity, but the clinical significance of this relationship remains unclear. This study aims to investigate the different clinical profiles of FA symptoms among patients who have obesity with/without BED using latent class analysis (LCA). **Methods:** 307 patients ( $n = 152$  obesity and BED,  $n = 155$  obesity without BED) completed a battery of self-report measures investigating eating psychopathology, depression, emotional dysregulation, alexithymia, schema domains, and FA. LCA and ANOVAs were conducted to identify profiles according to FA symptoms and examine differences between classes. **Results:** LCA identified five meaningful classes labeled as the "non-addicted" (40.4%), the "attempters" (20.2%), the "interpersonal problems" (7.2%), the "high-functioning addicted" (19.5%) and the "fully addicted" (12.7%) classes. Patients with BED and obesity appeared overrepresented in the "high-functioning addicted" and "fully addicted" classes; conversely, patients with obesity without BED were most frequently included in the "non-addicted" class. The most significant differences between the "high-functioning addicted" and "fully addicted" classes versus the "non-addicted" class regarded heightened severity of eating and general psychopathology. **Discussion and conclusions:** The results bring to light distinct clinical profiles based on FA symptoms. Notably, the "high-functioning addicted" class is particularly intriguing as its members demonstrate physical symptoms of FA (i.e., tolerance and withdrawal) and psychological ones (i.e., craving and consequences) but are not as functionally impaired as the "fully addicted" class. Identifying different profiles according to FA symptoms holds potential value in providing tailored and timely interventions.

## KEYWORDS

food addiction, binge eating disorder, obesity, latent class analysis, eating disorders, psychopathology

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## INTRODUCTION

Food addiction (FA) refers to an eating behavior phenotype characterized by the compulsive consumption of highly processed food (i.e., foods with refined carbohydrates and/or added



fats). It is hypothesized to be a chronic and relapsing condition influenced by a complex interplay of variables that contribute to heightened cravings for highly rewarding foods in order to achieve a desired emotional state (Gearhardt, Corbin, & Brownell, 2009). Neuroimaging research has found parallels in the manner that highly processed foods and addictive drugs trigger the release of mesolimbic dopamine, which plays a significant role in pleasure perception, motivation, learning, and memory (Milano et al., 2023). Although the topic of FA remains controversial, there has been growing clinical and research interest in the topic (Gearhardt, Corbin, & Brownell, 2016; Horsager et al., 2023; Schiestl & Gearhardt, 2018; Schulte & Gearhardt, 2017). The Yale Food Addiction Scale 2.0 (YFAS 2.0) is the main measure to assess FA, which applies the diagnostic criteria for substance use disorders (SUD) to the intake of highly processed foods (Gearhardt et al., 2016). However, FA also shares features with some eating disorders (Munguía et al., 2022), particularly binge eating disorder (BED), and is also associated with obesity (Praxedes et al., 2022).

Due to their frequent overlap, FA is often mistaken as a synonym for both BED and obesity (Riva et al., 2006; Volkow, Wang, Tomasi, & Baler, 2013). BED is characterized by multiple episodes of binge eating without compensatory behaviors (i.e., self-induced vomiting, use of laxatives, diuretics, or other drugs, fasting, and extreme physical exercise) (American Association Psychiatric, 2013). A binge is defined as the consumption of a significant amount of food that exceeds what most people in a similar situation or timeframe (typically around two hours) would typically consume. This excessive eating is accompanied by a distressing feeling of losing control during the binge episode. Based on this definition, it becomes apparent that BED and FA share common characteristics such as diminished control over food consumption, unsuccessful attempts to reduce or control the amount of food, and continued excessive use despite negative consequences (di Giacomo et al., 2022). Mechanisms, like reward dysfunction, impulsivity, emotion dysregulation, and craving have also been hypothesized to play a role in both BED and FA (Schulte, Grilo, & Gearhardt, 2016). However, FA and BED also exhibit important differences. In FA, episodes of altered eating behavior can be continuous, such as grazing or chronic snacking, while in BED they must be episodic. In theories of BED, shape and weight concerns and dietary restraint are often conceptualized as causal mechanisms for triggering binge episodes. In contrast, FA theories propose the potentially addictive nature of highly processed food is a central causal factor. Finally, some criteria - like craving, withdrawal, and tolerance - are key criteria for FA, but not for BED (Bak-Sosnowska, 2017; LaFata & Gearhardt, 2022; Schulte et al., 2016). Around half of individuals with BED meet for FA (Praxedes et al., 2022). Individuals with BED who also meet for FA exhibit more severe clinical presentations, including more frequent binge eating episodes, stronger food cravings, great emotion dysregulation, and more severe psychopathology (Gearhardt et al., 2012; Jiménez-Murcia et al., 2019; LaFata & Gearhardt, 2022).

According to the literature, there is also a significant association between obesity and the occurrence of FA, with approximately 1 out of 3 individuals with obesity meeting the YFAS criteria for FA (Praxedes et al., 2022). Individuals with obesity and FA appear to be less successful in response to traditional behavioral weight-loss treatment (Fielding-Singh et al., 2019). Food addiction in females with obesity is also associated with distinct brain-gut-microbiome profiles associated with reward processing (Dong et al., 2020). However, not all individuals who meet the FA criteria have obesity (Praxedes et al., 2022), suggesting they are distinct constructs.

Given the connections between FA with both BED and obesity (Carbone et al., 2023), a greater understanding of the overlap and heterogeneity in their presentations is warranted as the mechanisms that contribute to the co-occurrence of FA in BED and obesity are not well understood. In this context, latent class analysis (LCA) may represent a suitable approach to better understand the heterogeneity within diagnostic classes (Lazarsfeld & Henry, 1968).

LCA is a statistical method, which uses dichotomous variables to identify underlying groups of individuals based on their pattern of responses across a set of features (i.e., FA symptoms) (Wang & Hanges, 2011). The aim of LCA is to find the smallest number of groups (i.e., latent classes) that best describe the associations among a set of observed indicators, such that individuals in one class are similar to one another but are distinct from individuals in other classes (Nylund, Asparouhov, & Muthén, 2007). LCA is a helpful technique for carrying out person-centered (as opposed to variable-centered) analysis. It can assist in delineating specific subgroups within a patient population by identifying shared characteristics or patterns of symptoms. Moreover, it is valuable for uncovering subtypes or dimensions within a particular disorder and examining patterns of comorbidity among different disorders. These aspects collectively suggest that LCA has the potential to significantly contribute to the advancement of more personalized therapeutic strategies. It has been applied previously in studies with patients with eating disorders, which tend to investigate potential causes of heterogeneity among patients with BED (Carr & Grilo, 2020), in distinguishing BED from other psychiatric disorders (Hilbert et al., 2011) and empirically defining eating disorder phenotypes (Keel et al., 2004). Prior research has already demonstrated that patients who have obesity with and without BED and comorbid FA exhibit more severe psychosocial presentations (Burrows, Skinner, McKenna, & Rollo, 2017; Jiménez-Murcia et al., 2019; Munguía et al., 2022; Romero et al., 2019). Hence, it would be very useful, from a clinical point of view, to share light in the relationship between obesity, BED and FA investigating different subgroups that are characterized by specific FA symptoms to structure more targeted interventions.

Based on the above, the present study aimed to examine the heterogeneity of FA symptoms in a sample of weight-loss treatment-seeking patients who have obesity with and without BED through LCA. We utilized LCA to determine whether there are latent groups that differ in FA



symptoms and examine the differences between the individuals belonging to each latent class according to psychopathological variables. We chose these variables of interest because they are frequently investigated in the field of FA and eating disorders (Aloi et al., 2021; Aloi, Rania, Caroleo, et al., 2020; Araujo, Santos, & Nardi, 2010; Nowakowski, McFarlane, & Cassin, 2013; Pinaquy, Chabrol, Simon, Louvet, & Barbe, 2003; Segura-Garcia et al., 2021). In addition to the tools that evaluate psychopathology (i.e., eating and binge severity, depressive symptoms, emotional dysregulation, and alexithymia), we also used the Young Schema Questionnaire. It is a tool that investigates maladaptive schemas that originate early in life and become stable in adulthood (Young, Klosko, & Weishaar, 2003), for this reason, it provides more information on personality aspects. Therefore, it might be useful to investigate which schema is present in the different subgroups that the LCA will identify. We hypothesized that the class that endorses the highest number of symptoms of FA will also be the most impaired from a psychopathological point of view.

## METHODS

### Participants

For this study, male and female patients with obesity (body mass index, BMI  $\geq 30 \text{ kg m}^{-2}$ ) aged 18–65 years were consecutively recruited during their first visit to the Outpatient Unit for Clinical Research and Treatment of Eating Disorders of the University “Magna Graecia” of Catanzaro between February 2021 and April 2023. The exclusion criteria were BMI  $< 30 \text{ kg m}^{-2}$ , major psychiatric diagnoses (i.e., neurodevelopmental, schizophrenia spectrum, bipolar disorders, and neurocognitive disorders), history of a chronic medical disease or neurological condition that could affect cognitive functioning, active substance dependence or abuse ( $\leq 6$  months), and other serious medical comorbidities or treatments that could condition eating behaviors.

### Procedures

Trained psychiatrists interviewed all participants using the Eating Disorder Examination (EDE 17.0D) (Calugi et al., 2015) and the Structured Clinical Interview for the DSM-5 (SCID-5-CV) (First, 2016) to investigate the presence of an eating disorder or other mental disorders (i.e., mood disorder, anxiety disorder, psychotic disorder). The diagnosis of BED was used to split the sample into two groups for statistical purposes: obesity with BED and obesity without BED.

A total of 307 patients ( $N = 152$  obesity with BED and  $N = 155$  obesity without BED) met the inclusion criteria and therefore were enrolled. This represents a cohort of individuals with obesity actively engaged in a weight loss intervention. The fortuitous alignment in group sizes is in line with the prevalent occurrence of BED among individuals with obesity undergoing weight loss interventions such as

weight loss programs and bariatric surgery (Barbuti et al., 2023; de Zwaan, 2001). Notably, participants in the obesity without BED group did not meet the criteria for any eating disorder.

Participants were informed about the objective of the study and that participation was voluntary and anonymous and gave their consent to participate.

### Measures

**Yale Food Addiction Scale 2.0.** The Italian version of the YFAS 2.0, which assesses addiction-like eating behavior during the past 12 months, was used. The scale consists of 35 items, which are scored on an eight-point scale ranging from 0 (*never*) to 7 (*every*) which accounts for 11 symptoms (Aloi et al., 2017; Gearhardt et al., 2016) (Table 1). The YFAS 2.0 provides two different scoring methods: the first scoring serves to address the total number of criteria that are fulfilled among the possible 11; thus, the total score can range from 0 to 11. The second scoring regards the severity level according to the diagnostic thresholds for SUD in DSM-5: mild FA (when 2–3 symptoms are present), moderate FA (when 4–5 symptoms have been recognized), and severe FA (when  $\geq 6$  symptoms are present). To endorse “FA diagnosis” (present/absent) a minimum of two fulfilled criteria plus the presence of impairment or distress are

Table 1. Diagnostic criteria of Yale food addiction scale 2.0

Amount	Food often consumed in larger amounts or over a longer period than was planned
Attempts	Persistent desire of unsuccessful efforts to cut down or control food intake
Time	Much time is spent on activities required to obtain food or recover from overeating.
Activities	Important social, occupational, or recreational activities are given up or reduced due to overeating on foods
Consequences	Overeating is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by overeating on foods
Tolerance	Need for markedly increased amounts of food to achieve desired effect; markedly diminished effect with continued use of the same amount of food
Withdrawal	Withdrawal syndrome when refraining from eating specific foods; specific foods are eaten to relieve or avoid withdrawal symptoms
Problems	Continued overeating despite having persistent or recurrent social or interpersonal problems causes or exacerbated by the effects of specific foods
Obligations	Recurrent overeating resulting in a failure to fulfill major role obligations at work, school, or home
Situations	Recurrent overeating in situations in which it is physically hazardous
Craving	Craving, or a strong desire or urge to eat specific foods
Impairment/distress	Significant impairment/distress due to food



needed. The Kuder–Richardson coefficient of reliability as internal consistency for the YFAS 2.0 in this study was 0.85.

**Eating Disorder Examination – Questionnaire (EDE-Q).** The EDE-Q is a self-report measure that measures the presence and severity of eating pathology (Calugi et al., 2017). It consists of four subscales: Eating Restraint, Eating Concern, Weight Concern, and Shape Concern, which are used to calculate a global EDE-Q score. In the present sample, we found the following McDonald's  $\omega$  internal consistency reliability indexes: Restraint = 0.77; Eating Concern = 0.76; Weight Concern = 0.77; Shape Concern = 0.82; Global score = 0.85.

**Binge eating scale (BES).** The BES assesses the severity of BED. It consists of 16 items that describe the behaviors, feelings, and cognitions experienced with binge eating (Ricca et al., 2000). Total BES scores <17, 17–27, and >27 respectively indicate improbable, possible, and probable BED. The estimated reliability as internal consistency in this study was McDonald's  $\omega$  = 0.87.

**Beck depressive inventory – II (BDI-II).** Depressive symptoms were investigated with the BDI-II, which consists of 21 items on a Likert scale from 0 to 3. Scores between 0–9, 10–16, 17–29, and  $\geq 30$  indicate minimal, mild, moderate, and severe depression, respectively (Ghisi, Flebus, Montano, Sanavio, & Sica, 2006). In the present research, the McDonald's  $\omega$  internal consistency coefficient was 0.84.

**Difficulties in emotion regulation scale (DERS).** The DERS consists of 36-item to assess emotion dysregulation across six subscales which, if added together, give the total score: (a) nonacceptance of emotions, (b) difficulties in pursuing goals when having strong emotions, (c) difficulties controlling impulsive behaviors when experiencing negative emotions, (d) lack of emotional awareness, (e) limited access to emotion regulation strategies and (f) lack of emotional clarity. Higher scores indicate more problems in emotional regulation (Giromini, Velotti, de Campora, Bonalume, & Cesare Zavattini, 2012). For this study, we only examined the DERS total score, and the internal consistency was 0.89.

**Toronto Alexithymia scale – 20 (TAS-20).** The TAS-20 is the most widely used self-report questionnaire to evaluate alexithymia (Bagby, Parker, & Taylor, 1994). Twenty Likert-type items account for three subscales: difficulty in identifying feelings, difficulty in describing and communicating feelings, and externally oriented thinking. A total score (20–100) above 60 indicates alexithymia. The Italian version (Bressi et al., 1996) of this test was used in this study. The estimated reliability as internal consistency in this study was McDonald's  $\omega$  = 0.86.

**Young Schema Questionnaire short Form-3 (YSQ-S3).** The YSQ-S3 is made up of 90 items on a Likert scale ranging from 1 (completely false for me) to 6 (describes me perfectly) to evaluate the presence of the 18 early maladaptive schemas (EMSs) according to the theory of Young and colleagues

(Young, 2005). Higher scores indicate higher levels of EMSs. According to a new model proposed by Bach and colleagues (Aloi, Rania, Sacco, Basile, & Segura-Garcia, 2020; Bach, Lockwood, & Young, 2018), the 90 items of YSQ-S3 are grouped into 18 EMSs clustered in four domains: (1) Disconnection and Rejection; (2) Impaired Autonomy and Performance (3) Excessive Responsibility and Standards; (4) Impaired Limits. In our study, McDonald's  $\omega$  coefficients ranged from 0.75 (Excessive Responsibility and Standards) to 0.88 (Impaired Autonomy and Performance).

## Statistical analysis

LCA was carried out using the *poLCA* package in R (Linzer & Lewis, 2011). This package estimates the latent class model by maximizing the log-likelihood function. To minimize problems of non-convergence and local solutions, several starting points ( $n = 10$ ) and repeated iteration ( $n = 5,000$ ) were specified to replicate the best model fit. LCA aims to identify distinct groups of individuals with similar patterns within an unobserved categorical variable. LCA was started with a one-class model and systematically increased to more classes. LCA provides both class membership probabilities and item-response probabilities conditions on class membership to help interpret the final identified class. The selection of the best LCA model was informed by using goodness-of-fit indices, supporting statistics, and interpretability of class memberships. The following fit statistics were reported: log-likelihood, Akaike's information criterion (AIC), Bayesian information criterion (BIC), Likelihood ratio/deviance statistic ( $G^2$ ); Chi-square goodness of fit ( $\chi^2$ ) (Nylund-Gibson & Choi, 2018). Lower values of these criteria indicate better prediction accuracy.

Regarding sample size, there is no clear recommendation to derive the minimum sample size in LCA. There is evidence that the number of items, the expected number of classes, and the extension of class membership affect LCA results. Findings from previous research show that  $N \sim 300$ –1,000 is roughly the range in which the most commonly used fit indices for mixture models can be expected to function adequately (Nylund-Gibson & Choi, 2018). For this reason, the sample size in our study ( $N = 307$ ) was sufficient for exploratory latent class analysis purposes.

In the present study, the categorical variables of the eleven FA symptoms and the impairment/distress criteria were included in the model as indicators.

Subsequently, following the identification of a solution, individuals were assigned to a class based on their most likely class membership, and mean differences were compared using analysis of variance (ANOVA) and followed up by a set post hoc test where a Bonferroni correction was applied to control the family-wise error (FWE) rates. We also reported the eta-squared ( $\eta^2$ ), as a measure of the effect size of ANOVA. Statistical significance was set at  $p < 0.05$ .

## Ethics

The research was approved by the Institutional Review Board of Regione Calabria, "sezione Area Centro" (identifier:



67/D.G. 18.02.2021), in accordance with the ethical principles set out in the latest version of Helsinki Declaration (World Medical Association, 2013).

## RESULTS

Table 2 summarizes the one- through six-class solutions, including the descriptive and inferential fit statistics. Since the different fit indices did not converge on a singular solution (specifically, the BIC favored a three-class solution, while the AIC supported a six-class solution), and considering the minimal dissimilarities noted, the selection of a solution was guided by the significance of theoretical interpretability, as emphasized by Weller and colleagues (2020). Consequently, the five-class solution was deemed the most suitable choice.

Specifically, we identified five configurations (Fig. 1) by means of the item-response probability that we labeled as:

- Class 1: “non-addicted”, as members of this class had endorsed no FA symptoms ( $n = 124, 40.4\%$ );
- Class 2: “attempters,” as members of this class were characterized by the full achievement of only the “attempts” indicator ( $n = 62, 20.2\%$ );
- Class 3 “interpersonal problems”, as members of this class were characterized by the full achievement of only “problems” and “obligations” symptoms ( $n = 22, 7.2\%$ );
- Class 4: “high-functioning addicted”, as members of this class were characterized by the full achievement of physical FA symptoms such as “withdrawal”, “tolerance”, and psychological ones like “craving” and “consequences” and, notably, showed less functional impairment ( $n = 60, 19.5\%$ );
- Class 5: “fully addicted”, because, in this group, all the FA symptoms were highly endorsed and impairment was present ( $n = 39, 12.7\%$ ).

Table 3 describes the total sample and each class, including demographic features. In the whole sample, most

Table 2. Absolute fit indices for measurement models

Model	LL	AIC	BIC	G <sup>2</sup>	$\chi^2$
1-class	-2,408.03	4,840.06	4,884.78	2,350.89	379,581.80
2-class	-1,759.54	3,596.07	3,662.24	1,053.90	9,898.01
3-class	-1,643.87	3,363.73	3,505.35	822.56	4,845.26
4-class	-1,607.55	3,317.10	3,507.17	749.93	5,439.76
5-class	-1,585.03	3,298.06	3,536.58	704.89	4,968.13
6-class	-1,566.56	3,287.12	3,574.08	667.95	3,966.03

Note. LL = log likelihood; AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; G<sup>2</sup> = Likelihood ratio/deviance statistic;  $\chi^2$  = Chi-square goodness of fit.

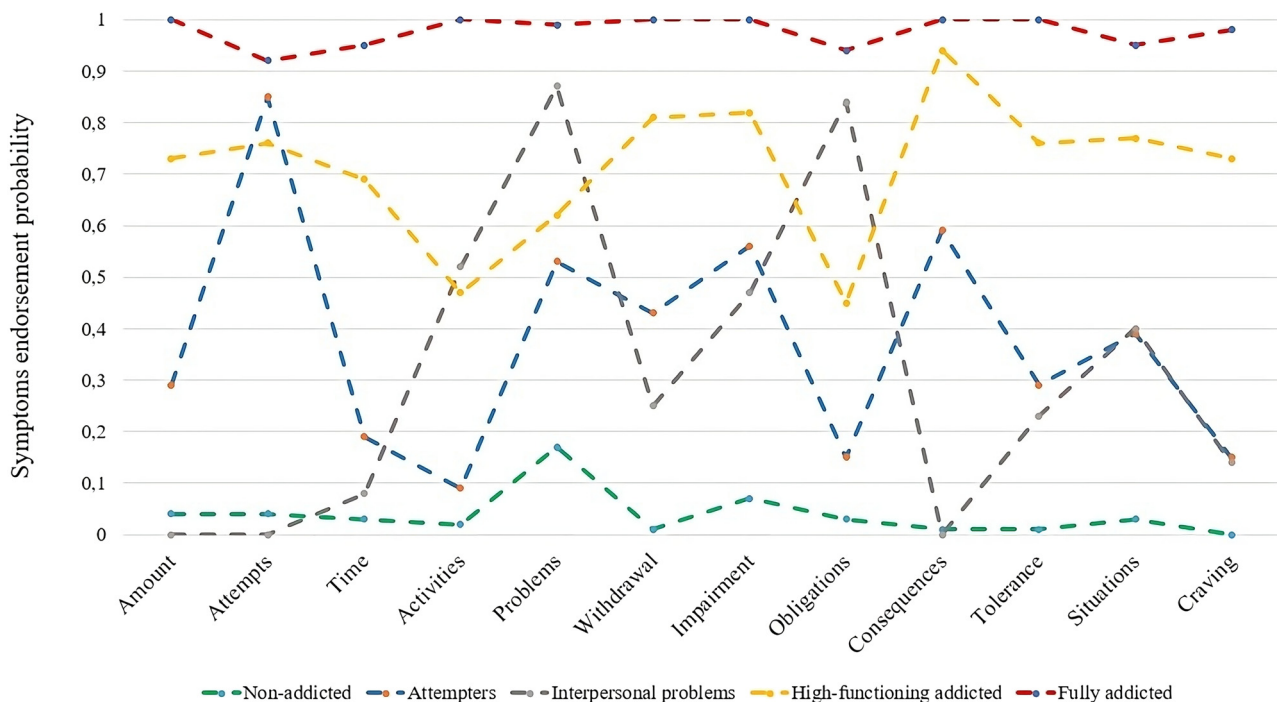


Fig. 1. Profile plot for the latent class analysis of the food addiction symptoms. The Y-axis represents the class-specific mean scores as proportions of the maximum score for the indicator. The X-axis contains the 11 food addiction symptoms and impairment/distress criteria of the Y-FAS 2.0



Table 3. Characteristics of the total sample and by latent classes

		Total Sample		Non-addicted	Attempters	Interpersonal problems	High-functioning addicted	Fully addicted	$\chi^2/F$	<i>p</i>	Post hoc
		<i>N</i> = 307		<i>n</i> = 124	<i>n</i> = 62	<i>n</i> = 22	<i>n</i> = 60	<i>n</i> = 39			
Age <sup>a</sup>		40.6	(13.9)	40.9 (13.1)	39.4 (14.7)	41.7 (14.1)	41.7 (13.9)	38.7 (15.2)	0.417	0.796	
Sex <sup>b</sup>	Female	244	(79.5)	97 (78.2)	45 (72.6)	17 (77.3)	48 (80.0)	37 (94.9)	7.670	0.104	
	Male	63	(20.5)	27 (21.8)	17 (27.4)	5 (22.7)	12 (20.0)	2 (5.1)			
Body mass index <sup>a</sup>		40.6	(7.7)	40.9 (7.4)	42.0 (7.7)	43.3 (6.2)	39.4 (7.6)	38.1 (8.5)	2.363	0.053	
Civil status <sup>b</sup>	Married	177	(57.7)	74 (59.7)	34 (54.8)	9 (40.9)	38 (63.3)	22 (56.4)	10.220	0.597	
	Single	108	(35.2)	40 (32.3)	25 (40.3)	9 (40.9)	19 (31.7)	15 (38.5)			
	Divorced	19	(6.2)	8 (6.5)	3 (4.8)	3 (13.6)	3 (5.0)	2 (5.1)			
	Widow	3	(1.0)	2 (1.6)	0 (0.0)	1 (4.5)	0 (0.0)	0 (0.0)			
Education <sup>b</sup>	Elementary	13	(4.2)	4 (3.2)	5 (8.1)	2 (9.1)	2 (3.3)	0 (0.0)	11.426	0.493	
	Middle school	81	(26.4)	39 (31.5)	11 (17.7)	6 (27.3)	12 (20.0)	13 (33.3)			
	High school	163	(53.1)	63 (50.8)	35 (56.5)	11 (50.0)	35 (58.3)	19 (48.7)			
	Master	50	(16.3)	18 (14.5)	11 (17.7)	3 (13.6)	11 (18.3)	7 (17.9)			
Food addiction "diagnosis"	Negative	170	(55.4)	120 (96.8)	27 (43.5)	12 (54.5)	11 (18.3)	0 (0.0)	171.228	<0.001	5>3,2,1; 3,2>1
	Positive	137	(44.6)	4 (3.2)	35 (56.5)	10 (45.5)	49 (81.7)	39 (100)			
YFAS 2.0 Symptoms count <sup>a</sup>		3.2	(4.1)	0.0 (0.2)	2.2 (2.2)	1.7 (2.2)	6.4 (3.2)	10.7 (0.5)	311.259	<0.001	5>all; 4>3,2,1; 3,2>1

1: Non-addicted; 2: Attempters; 3: Interpersonal problem; 4: High-functioning addicted; 5: Fully addicted.



participants were female, had completed high school, were married and no differences in age and BMI emerged. As expected, individuals classified as “high-functioning addicted” and “fully addicted” showed the highest prevalence of “FA diagnosis”. Regarding FA symptoms, the “fully addicted” class displayed the highest score; the “high-functioning addicted” class showed higher scores than the “interpersonal problems”, “attempters” and “non-addicted” classes; finally, the “interpersonal problems” and “attempters” classes exhibited higher scores than the “non-addicted” class. Regarding the endorsement of “FA diagnosis”, the “fully addicted” class similarly displayed the highest percentage except for the “high-functioning addicted”; and the “interpersonal problems” and “attempters” classes exhibited a higher prevalence of “FA diagnosis” than the “non-addicted” class.

Table 4 displays the distribution of participants with and without “FA diagnosis” within the five classes stratified for obesity with BED/obesity without BED. Overall, 137 (45% of the sample) participants met the “FA diagnosis”, of whom 105 (77%) had obesity with BED. Based on the LCA analyses, individuals with BED and positive results for “FA diagnosis” were most commonly found in the “high-functioning addicted” and “fully addicted” classes. On the other hand, those with obesity without BED and negative results for “FA diagnosis” were predominantly included in the “non-addicted” class. Additionally, patients with both BED/FA and without BED/FA diagnosis are evenly distributed between the “attempters” and “interpersonal problems” classes. For greater clarity, Fig. 2 shows the frequency of FA separately for patients who have obesity only and patients with obesity and BED across each class.

Table 4. Overlap between “Food addiction diagnosis” according to YFAS 2.0 and clinical diagnosis

Classes	Diagnosis	YFAS 2.0 “Diagnosis”			
		Negative		Positive	
		Fr	(%)	Fr	(%)
<b>Non-addicted</b>	Obesity + BED	19	(16)	3	(75)
	Obesity	101	(84)	1	(25)
	<b>Sum</b>	<b>120</b>	<b>(100)</b>	<b>4</b>	<b>(100)</b>
<b>Attempters</b>	Obesity + BED	13	(48)	18	(51)
	Obesity	14	(52)	17	(49)
	<b>Sum</b>	<b>27</b>	<b>(100)</b>	<b>35</b>	<b>(100)</b>
<b>Interpersonal problems</b>	Obesity + BED	6	(50)	5	(50)
	Obesity	6	(50.0)	5	(50)
	<b>Sum</b>	<b>12</b>	<b>(100)</b>	<b>10</b>	<b>(100)</b>
<b>High-functioning addicted</b>	Obesity + BED	9	(82)	44	(90)
	Obesity	2	(18)	5	(10)
	<b>Sum</b>	<b>11</b>	<b>(100)</b>	<b>49</b>	<b>(100)</b>
<b>Fully addicted</b>	Obesity + BED	0	(0)	35	(90)
	Obesity	0	(0)	4	(10)
	<b>Sum</b>	<b>0</b>	<b>(0)</b>	<b>39</b>	<b>(100)</b>
<b>Total sample</b>	Obesity + BED	47	(28)	105	(77)
	Obesity	123	(72)	32	(23)
	<b>Sum</b>	<b>170</b>	<b>(100)</b>	<b>137</b>	<b>(100)</b>

BED: Binge eating disorder; Fr: Frequency.

Regarding psychopathological assessment, Table 5 displays the mean scores and the comparisons between classes of EDE-Q, BES, BDI-II, DERS, TAS-20, and YSQ-S3. The “fully addicted” and “high-functioning addicted” relative to the “non-addicted” class exhibited greater binge severity, depressive symptoms, emotional dysregulation, alexithymia, and maladaptive schema domains. A significant effect of the class emerged for every dimension of EDE-Q. Interestingly, the effect of the class on restraint subscale was small and the post-hoc comparisons between groups were not significant. In general, the “non-addicted” group seemed to have the least eating, shape, and weight concerns whilst the “fully addicted” group was the most severe in these dimensions. A statistically significant difference emerged in depressive symptoms with the “interpersonal problems” class exhibiting higher scores than the “non-addicted” class.

## DISCUSSION

The present study represents the first attempt to share light in the relationship between obesity, BED, and FA symptoms using the LCA approach among treatment-seeking individuals for weight loss. Based on model fit indices and the interpretability of the classes, a 5-class model demonstrated the optimal fit to the data. Specifically, LCA identified five subgroups: “non-addicted”, “attempters,” “interpersonal problems”, “high-functioning addicted”, and “fully addicted”. Importantly, the present study identified two distinct addiction subgroups, namely “high-functioning addicted” and “fully addicted”, which were made up of the majority of patients with BED (90% respectively). These two subgroups, compared to the others, demonstrated significantly greater severity on all psychopathological variables (i.e., eating and binge severity, depressive symptoms, emotional dysregulation, alexithymia, and schema domains). Thus, the study hypothesis that FA may reflect a more severe variant within patients with obesity and BED is supported.

Of particular interest is the “high-functioning addicted” class ( $n = 60$ , 19.5%). This subgroup of patients showed physical symptoms of FA such as “withdrawal”, and “tolerance”, and psychological ones like “craving” and “consequences”. Thus, withdrawal (i.e., adverse physical, cognitive, and affective symptoms due to the reduction or cessation of an addictive substance) and tolerance (i.e., needing more and more of the substance to achieve the same pleasurable effects) may be key addiction indicators for some individuals. However, little research attention has specifically focused on tolerance and withdrawal in the context of highly processed food intake to this point. A withdrawal syndrome in response to highly processed foods has been demonstrated in animal models (Colantuoni et al., 2002; Teegarden & Bale, 2007), and preliminary evidence corroborated subjective withdrawal-like experiences in humans (Parnarouskis, Leventhal, Ferguson, & Gearhardt, 2022). There is also evidence that repeated exposure to highly processed foods may alter reward thresholds in a



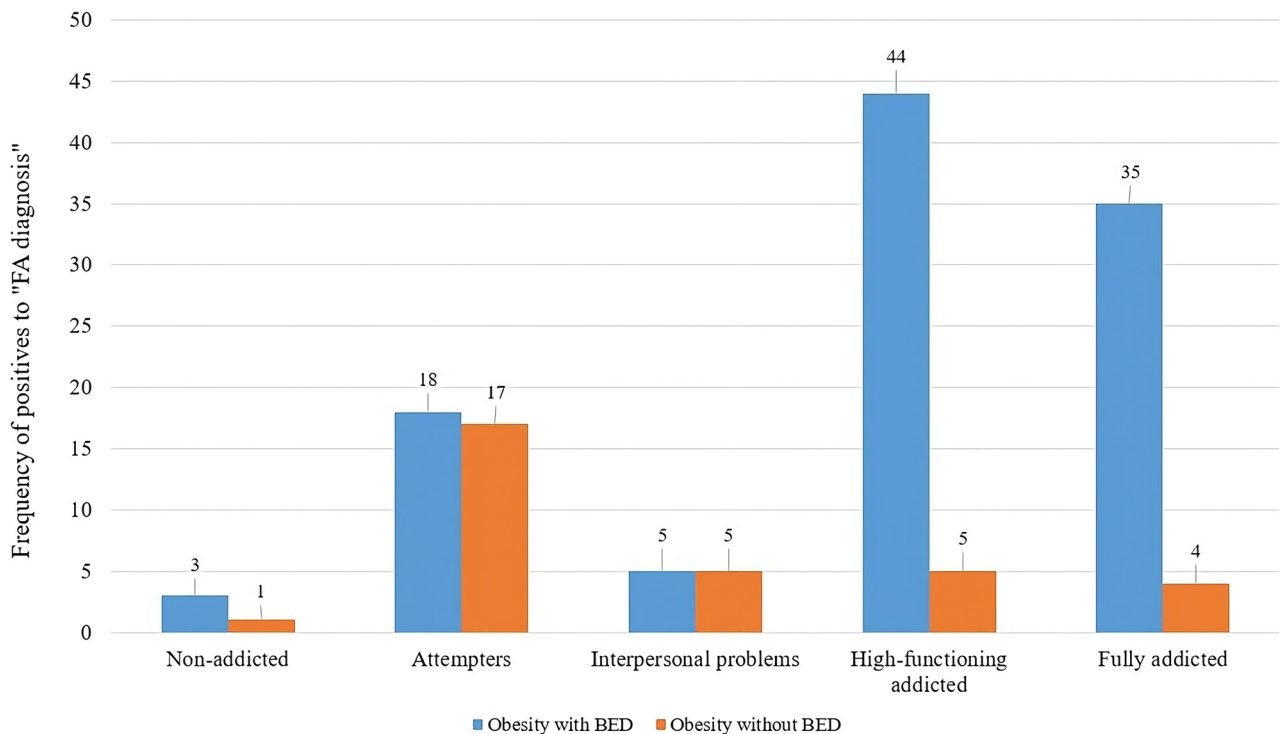


Fig. 2. Frequency of “FA diagnosis” among obesity with BED and obesity without BED across LCA classes

manner that would be consistent with the development of tolerance (Papantoni & Burger, 2021).

Interestingly, 11 individuals in the “high-functioning addicted” class did not meet the “FA diagnosis”. They had more than two FA symptoms ( $7.3 \pm 0.8$ ) but they did not meet the impairment/distress criteria. There is a debate about whether the impairment or distress criteria are always needed (Koehler, Aguirre, Schulte, Bowman, & Struwe, 2021; Ouellette et al., 2018) and one potential interpretation is that this may represent a prodromal category, wherein individuals report the mechanisms of addiction but have yet to experience its consequences. It could be viewed within the context of an early stage of FA. In a similar framework, the National Institute on Drug Abuse (NIDA) has emphasized the significance of recognizing the initial phases of substance use disorders as pre-addiction stages that, if left untreated, could potentially progress into severe health conditions (McLellan, Koob, & Volkow, 2022).

In this vein, the “high-functioning addicted” class might be seen as a group in the pre-addiction phase, still maintaining a relatively high level of functionality. In fact, they appear to experience fewer difficulties in relinquishing activities and meeting their obligations. This group seems to exhibit psychological and physical indicators of addictive processes but may not be as functionally impaired as those who are “fully addicted”. Consequently, they may represent a high-risk group for future adverse functional consequences and could potentially benefit from timely intervention.

Regarding the psychopathological differences between classes, the “high-functioning addicted” and “fully addicted”

classes compared to the “non-addicted” class showed higher scores on eating and binge severity, depressive symptoms, emotional dysregulation, alexithymia, and schema domains. As above mentioned, the “fully addicted” and “high-functioning addicted” classes mainly consist of patients with obesity with BED. Hence, the results pertaining to the variable of interest align with the existing literature. Indeed, several studies have indicated that patients with BED have an impaired ability to distinguish, recognize and describe emotions and thoughts (i.e., alexithymia) (Pinaquy et al., 2003; Westwood, Kerr-Gaffney, Stahl, & Tchanturia, 2017). This impairment associated with emotional dysregulation (measured by DERS) seems to contribute to the escalation of binge eating severity (Aloi et al., 2021; Aloi, Rania, Carbone, et al., 2020). In fact, according to well-established clinical models such as dialectical behavior therapy or interpersonal therapy, binge eating serves as a coping mechanism employed by patients with BED to manage negative emotions or heightened levels of stress (Prefit, Căndea, & Szentagotai-Tătar, 2019; Racine & Horvath, 2018). Food, in this context, assumes a role in modulating intense or unbearable emotional states, or it becomes the sole source of gratification (Linardon, 2018; Safer, Telch, & Chen, 2009), serving as a strategy to cope with negative events or concerns. Further, our results are consistent with previous studies indicating a correlation between numerous Early Maladaptive Schemas (EMS) across various domains and binge eating (Aloi, Rania, Caroleo, et al., 2020; Basile, Tenore, & Mancini, 2019; Imperatori et al., 2017; Maher et al., 2022; Rania et al., 2020; Waller, 2003). These findings

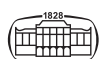




Table 5. Psychopathological differences among latent classes

		Non-addicted		Attempters		Interpersonal problem		High-functioning addicted		Fully addicted		F	Sign.	$\eta^2$	Post hoc
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD				
EDE-Q	Restraint	1.9	1.6	2.2	1.6	2.9	1.8	2.0	1.4	2.5	1.8	2.515	0.042	0.03	
	Eating concern	1.2	1.2	2.2	1.5	2.2	1.4	2.8	1.5	4.1	1.3	39.077	<0.001	0.35	5>All; 2,3,4>1
	Shape concern	3.4	1.7	4.5	1.3	4.7	0.9	4.8	1.2	5.2	1.3	17.140	<0.001	0.19	1<All
	Weight concern	2.9	1.4	3.7	1.2	3.8	1.1	4.1	1.3	4.8	1.4	19.134	<0.001	0.21	5>1,2; 2,3,4>1
	Total	2.5	1.3	3.3	1.1	3.6	0.8	3.5	1.0	4.2	1.2	21.646	<0.001	0.23	5>1,2; 2,3,4>1;
BES		9.6	8.2	17.2	8.8	15.8	9.8	24.2	9.0	32.3	7.3	65.512	<0.001	0.47	5>All; 4>1,2,3; 3,2>1
BDI-II		11.7	11.4	16.1	12.7	22.7	14.8	24.0	10.4	30.4	11.4	24.367	<0.001	0.25	4,5>1,2; 3>1
DERS	Non acceptance	11.6	5.7	13.6	6.1	14.8	5.5	15.6	5.8	19.8	7.1	12.418	<0.001	0.18	5>All; 4>1
	Goals	10.7	4.4	13.7	5.2	13.5	4.3	15.8	5.8	17.7	5.4	15.573	<0.001	0.22	5>All; 4>1
	Impulse	10.5	4.7	13.1	4.6	14.2	5.0	14.4	5.5	18.1	6.9	13.384	<0.001	0.19	5>1,2; 4>1
	Awareness	15.6	5.3	16.4	4.6	16.1	6.3	17.2	4.6	16.1	5.2	0.735	0.569		
	Strategies	14.7	7.4	17.8	8.7	19.2	7.5	22.6	8.2	27.1	8.4	18.181	<0.001	0.24	5>1,2,3; 4>1,2
	Clarity	8.0	3.1	9.1	3.6	10.3	4.4	11.3	4.6	12.8	4.8	11.777	<0.001	0.17	5>1,2; 4>1
	Total	71.4	24.0	82.8	24.6	88.2	27.1	95.9	24.8	111.5	28.7	18.290	<0.001	0.25	5>1,2,3; 4>1
TAS-20	Identifying	13.9	7.2	15.5	6.8	17.7	8.0	19.4	7.6	21.5	8.7	8.295	<0.001	0.13	5>1,2; 4>1
	Describing	11.2	4.7	12.1	5.3	12.7	3.8	13.9	4.3	16.1	5.2	7.314	<0.001	0.11	5>1,2; 4>1
	Externally thinking	18.6	4.8	18.3	5.3	20.2	5.4	19.0	5.3	19.9	4.4	0.861	0.488		
YSQ-S3	Disconnection and rejection	1.8	1.1	1.9	1.2	2.4	1.0	2.6	1.3	3.1	1.1	9.994	<0.001	0.15	5>1,2; 4>1
	Impaired Autonomy and performance	1.6	1.2	1.8	1.2	2.2	0.9	2.5	2.2	2.9	1.0	6.967	<0.001	0.11	5>1,2; 4>1
	Excessive responsibilities and standards	2.6	1.7	2.7	1.4	3.2	1.1	3.4	2.7	3.4	0.8	2.540	0.041	0.04	
	Impaired limits	2.0	1.1	2.2	1.3	2.7	1.1	2.9	1.3	3.3	1.1	10.468	<0.001	0.15	5>1,2; 4>1

1: Non-addicted; 2: Attempters; 3: Interpersonal problem; 4: High-functioning addicted; 5: Fully addicted.

EDE-Q: Eating disorder examination – questionnaire; BES: Binge eating scale; BDI-II: Beck depression inventory – II; DERS: Difficulties in emotion regulation scale; TAS-20: Toronto alexithymia scale – 20; YSQ-S3: Young schema questionnaire – short form 3.



suggest that EMS may be crucial in the development and perpetuation of the disorder. Consequently, assessing EMS as a potential risk factor for eating disorders in primary prevention programs targeting overweight and high-weight children/young adolescents become crucial, considering that schema domains develop during childhood prior to the onset of BED.

The results of EDE-Q deserve a separate explanation. Significant differences emerged in relation to eating, weight, and shape concerns according to the results of LCA where the “fully addicted” and “high-functioning addicted” showed higher scores than the others. This result makes sense as most of them had the diagnosis of BED and higher BMI. Perhaps more interesting is the non-significant difference between groups in the post hoc analyses in the restraint subscale: it has traditionally received significant attention in the theoretical mechanisms of eating disorders. However, it does not seem to exhibit a strong correlation with FA, and in this context, it fails to differentiate between any of the groups. On the other hand, it is crucial to consider that in individuals with obesity, whether they have BED or not, mechanisms other than restraint may be of greater significance as primary factors (Rios, Berg, & Gearhardt, 2023; Rios, Miller, et al., 2023).

Significantly, the “interpersonal problems” class when compared to the “non-addicted” class reported higher scores in terms of depressive symptoms. This class was characterized by exhibiting only symptoms related to “continued use despite problems” and “failure to fulfill obligations”, indicating a risky pattern of addictive behavior with detrimental physical and psychological consequences. Thus, people in this class reported challenges in various domains, such as work/school, family, and in social relationships, due to their FA. It is not surprising, given these circumstances, that this subgroup experiences heightened depressive symptoms. In fact, it is well documented that comorbidity rates of depression in people with SUD can be as high as 60% (Grant et al., 2004, 2016; Han, Olfson, & Mojtabai, 2017). The relationship between depression and SUD is bidirectional, with each condition influencing the etiological risks of the other. Furthermore, when depression and SUD co-occur, they contribute to greater functional impairment, poorer treatment outcomes, and increased treatment costs (Blanco et al., 2012; Mojtabai, Chen, Kaufmann, & Crum, 2014; Munguía et al., 2022).

### Limitations

The following limitations should be considered in this research. The cross-sectional design of the study prevents us from establishing causality and testing the connections between FA and psychopathological measures. The stability of these latent classes over time deserves further study. Nevertheless, the significant statistical differences observed between the scores on the psychopathological constructs in the class with the lowest FA indicators and the class with the highest FA indicators suggest the importance of the association between FA and psychopathology. The present

research involved a sufficiently large sample of patients with obesity, enabling the identification of distinct latent classes in the distribution of FA symptoms based on the best LCA guidelines (Nylund-Gibson & Choi, 2018; Weller, Bowen, & Faubert, 2020). However, we acknowledge that this is an exploratory study (i.e., some classes have few individuals) that therefore needs to be cross-validated by future studies in different and larger populations. Finally, major psychiatric diagnoses (i.e., major depressive disorder, bipolar disorders) and other psychosocial variables (i.e., impulsivity, hedonic hunger, food reinforcement), that could have provided insight into clinically meaningful differences between the classes, were not investigated in this study which may limit the generalizability of the findings. Therefore, future research on this topic in individual with severe mental illness is an important future direction.

### CONCLUSIONS

This is the first study that uses LCA to classify FA symptoms in patients with obesity with and without BED. LCA offers a person-centered approach to identifying distinct patient profiles. Further, class solutions represent typologies that can help clinicians and researchers understand commonalities and differences across individuals that have implications for practice and future research. In the present study, our findings suggest the importance of considering FA symptoms in the diagnosis of BED. Present results have identified a subgroup of patients (i.e., “high-functioning addicted”), that may be getting missed and thus not benefit from an early intervention. This aligns with the contemporary approach in addiction treatment, focusing on intervening before individuals reach a crisis point or “rock bottom”.

Indeed, gaining a deeper insight into potential subgroups within BED could enhance our ability to refine diagnostic, etiological, and maintenance models of BED. As demonstrated, these subtypes exhibit differences in their psychopathological profiles, and it appears that the introduction of FA could introduce complexity into care models for these subpopulations. For this reason, although replication studies and longitudinal data are necessary, the identification of distinct profiles among individuals with BED based on FA symptoms holds promise for clinical practice, facilitating the development of personalized assessments and tailored treatments for this patient population.

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*Authors' contributions:* MA: conceptualization; data curation; methodology; writing – original draft; writing – review and editing. MTL: methodology; resources; software; review and editing. MR: data curation; writing – review and editing. EAC: data curation; writing – review and editing. RdF: data



curation; writing – review and editing. ANG: supervision; writing – review and editing. CSG: supervision; writing – review and editing.

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