

RELATIONSHIPS BETWEEN SELF-ESTEEM, INTEROCEPTIVE AWARENESS, IMPULSE REGULATION, AND BINGE EATING. PATH ANALYSIS IN BARIATRIC SURGERY CANDIDATES

Stefania Cella, Annarosa Cipriano, Cristiano Giardiello, Paolo Cotrufo

Abstract

Objective: The current study investigates the hypothesis that the effect of low self-esteem on binge eating in bariatric candidates was mediated by both difficulties in the perception of bodily signals and impulse regulation after accounting for gender, age, and body mass index.

Method: 59 preoperative patients (both male and female) were screened by means of self-report measures of self-esteem, interoceptive deficits, impulse dysregulation, and severity of binge eating. Results: Results indicated that all direct effects were significant, except for the self-esteem on impulse dysregulation and the interoceptive deficits on binge eating. Self-esteem had a significant indirect effect on impulse dysregulation mediated by interoceptive deficits. Impulse dysregulation, in turn, mediates the effect of interoceptive deficits on binge eating. Moreover, the path starting from self-esteem, going first to interoceptive deficits, then going via impulse regulation difficulties to binge eating was significant.

Results and conclusions: A potential underlying mechanism through which selfesteem is linked to binge eating has been suggested. Obese individuals who perceived themselves as inadequate may carry a stronger burden by the confusion and mistrust related to bodily functioning and, consequently, may act more impulsively, through binge eating.

Key words: binge eating, self-esteem, interoceptive deficits, impulse dysregulation, bariatric surgery candidates

Stefania Cella¹, Annarosa Cipriano¹, Cristiano Giardiello², Paolo Cotrufo¹

¹ Observatory on Eating Disorders, Department of Psychology, University of Campania "Luigi Vanvitelli", Viale Ellittico, 31-81100, Caserta, Italy

² Pineta Grande Hospital, Castel Volturno, Caserta, Italy

1. Introduction

Disordered eating behaviors, such as binge eating, are common in bariatric candidates (Cella et al., 2019; Mitchell et al., 2015; Niego, Kofman, Weiss, & Geliebter, 2007) and may affect surgery outcome (Kalarchian et al., 2007). Given also the high comorbidity of these disorders with various forms of psychopathology (Vinai et al., 2015), it is essential to understand better the potentials factors and underlying mechanisms in the development and maintenance of unhealthy eating behaviors to develop prevention strategies and improve bariatric surgery outcomes.

Notably, the role of emotion dysregulation in binge eating behaviors has received much empirical support among individuals with Binge Eating Disorder (BED; Monell, Clinton, & Birgegard, 2018; Svaldi, Griepenstroh, Tuschen-Caffier, & Ehring, 2012) and in non-clinical samples (Whiteside et al., 2007). Obese adults with BED were found inclined to experience general difficulties with emotion regulation (see Leehr

SUBMITTED NOVEMBER 2019, ACCEPTED DECEMBER 2019 © 2019 Giovanni Fioriti Editore s.r.l. et al., 2015 for a systematic review; Munsch, Meyer, Quartier, & Wilhelm, 2012) and these difficulties accounted for unique variance in prediction of emotional overeating and general eating pathology (Gianini, White, & Masheb, 2013). Eichen and colleagues (2017) showed in-vivo that binge eaters demonstrate more significant emotion dysregulation in a behavioral task. Similarly, studies involving bariatric patients highlighted the critical role that emotion regulation may play in the development of dysfunctional eating behaviors (Baldofski et al., 2016; Taube-Schiff et al. 2015) and suggested that emotion dysregulation should be to address both pre- and postsurgery in order to reduce binge eating episodes and to improve health outcomes (Shakory et al., 2015).

Difficulties identifying and discriminate emotions and physiological sensations (i.e., interoception) and regulating impulse have been found to be the specific types of emotion regulation difficulties most strongly associated with eating disorders (Brockmeyer et al., 2014; Bruch, 1962; Jenkinson, Taylor, & Laws, 2018; Lavender et al., 2015). Specifically, poor interoceptive

OPEN ACCESS

How to cite this article: Cella S, Cipriano A, Giardiello C, Cotrufo P (2019). Relationships between selfesteem, interoceptive awareness, impulse regulation, and binge eating. Path analysis in bariatric surgery candidates. *Clinical Neuropsychiatry*, 16 (5-6), 213-220

https://doi.org/10.36131/ clinicalnpsych2019050604

Copyright: © **Clinical Neuropsychiatry** This is an open access article. Distribution and reproduction are permitted in any medium, provided the original author(s) and source are credited.

Funding: No funding was received.

Competing interests: No author or any immediate family member has current financial relationships with commercial organizations that might present the appearance of a potential conflict of interest with the material presented.

Corresponding author

Stefania Cella Observatory on eating disorders, Department of Psychology, University of Campania "Luigi Vanvitelli", Viale Ellittico, 31 81100, Caserta, Italy. Tel. +39 0823 274773; Fax +39 0823 274773 E-mail: stefania.cella@unicampania.it awareness could be a key feature in binge eating disorder, as difficulties in detecting satiety sensations could lead to overeating and binging behaviors (Fassino, Pierò, Gramaglia, & Abbate-Daga, 2004). Several studies have found that obese with BED showed poor interoceptive awareness compared to obese non-BED (Ramacciotti et al., 2008). Similarly, such difficulties in perception and interpretation of bodily sensations - described as interoceptive deficits - have also been reported among individuals with BED seeking for bariatric surgery (Micanti, Pecoraro, Costabile Loiarro, & Galletta, 2016; Vinai et al., 2015), and it has been hypothesized they could directly contribute to the development and maintenance of binging symptoms in women with bulimia nervosa (Klabunde, Acheson, Boutelle, Matthews, & Kaye, 2013). Theoretical literature suggests that interoception may be the blueprint for providing a coordinated response to sensations arising from the body (Damasio, 1999). Research thus converges on the identification of internal feelings and emotional states as an essential prerequisite for impulse regulation (Feldman Barrett, Gross, Christensen, & Benvenuto, 2001; Füstös, Gramann, Herbert, & Pollatos, 2013; Sim & Zeman, 2004). Concordantly, eating disorder patients with poor interoceptive awareness have also difficulties in modulating the intensity of their negative affect (Lattimore et al., 2017).

While the interoceptive deficit is considered as a critical trans-diagnostic feature across eating disorders (Brockmeyer et al., 2014; Svaldi et al., 2012), only individuals with BED showed more difficulties regarding their impulse control when compared to healthy controls (Monell et al., 2018). In line with these findings, in our previous study, difficulty in impulse regulation – not specifically concerning eating behavior – emerged as the strongest predictor of binge eating severity among individuals being assessed for bariatric surgery (Cella et al., 2019).

Individuals with BED reported more significant impairment in the psychological domain of selfesteem (Rieger, Wilfley, Stein, Marino, & Crow, 2005). Specifically, there is evidence that low levels of selfesteem contribute to binge eating behaviors and may hold implications to weight loss efforts (Herbozo, Schaefer, & Thompson, 2015). Pasold and colleagues (2013), for example, found that binge eating was positively associated with low self-esteem and feelings of ineffectiveness among obese adolescents. Self-esteem was also found negatively correlated to binge eating among undergraduate women (Benjamin & Wulfert, 2005). Similarly, in a study by Brechan and Kvalem (2015), examining the relationship between body dissatisfaction, self-esteem, depression, and disordered eating, self-esteem was found having a significant adverse effect on binge eating.

However, although self-esteem is widely considered a critical vulnerability factor in the development and maintenance of eating disorders (Cella, Cipriano, Iannaccone, & Cotrufo, 2017; Courtney, Gamboz, & Johnson, 2008), its role in determining eating psychopathology among obese adults seeking bariatric surgery has rarely been taken into account. In one of the few research in this field, low self-esteem has been suggested to account for unique variance in binge eating in both Caucasian and African American women (Mazzeo, Saunders & Mitchell, 2005). Moreover, Mitchell and colleagues (2015) have found that low self-esteem was predictive of BED within pre-bariatric surgery patients. However, it remains unclear whether there are underlying mechanisms that may be involved in such an association. In this regard, empirical research suggests that lower levels of self-esteem are correlated to difficulties in emotion regulation (Shekhar & Pangotra, 2017). Sasai and colleagues (2010) have indeed found that individuals with low self-esteem are more prone to show deficits in identifying and describing feelings/ emotions (i.e., alexithymia). Fairburn and colleagues (2003) suggested that low self-esteem might increase the risk for overvaluation of shape and weight, which in turn leads to unhealthy weight-control practices that might subsequently lead to eating behavior psychopathology, such as binge eating. Additionally, a large body of research suggests a link between interoceptive deficits, impulse dysregulation, and binge eating behaviors, providing evidence for the potential mediating role of both psychological dimensions taking part in the emotion regulation process (Burns, Fischer, Jackson, & Harding, 2012; Holmes, Fuller-Tyszkiewiczz, Skoutiers, & Broadbent, 2015). Together, these findings suggest that self-esteem may have an indirect effect, through emotion dysregulation, in contributing to binge eating disorder.

1.1. The current study

Based on the existing literature, it seems that selfesteem, interoceptive deficits, and impulse dysregulation may be a core feature in the development of binge eating disorder. However, most of the previous studies have focused on these risk factors unconnectedly, precluding understanding about interactive effects.

In our opinion, self-esteem may be a key variable to understand the difficulties in identifying and modulating emotional states and may contribute to binge eating severity through problems in emotion regulation (as cited in O'Donohue, Moore, & Scott, 2007).

To best of our knowledge, there is no research to date on this issue in bariatric patients.

Thus, bearing these observations in mind, the purpose of the current study was to provide a preliminary understanding of the relationship between self-esteem and binge eating severity in a sample of bariatric surgery candidates, and individuate if and how interoceptive awareness deficits and impulse regulation difficulties, as assessed by the Eating Disorder Inventory-3 (Garner, 2004), play a role in this relationship after accounting for gender, age, and Body Mass Index.

Consistently with the findings of the research reviewed, we have developed an empirically based model that diagrams the relationship between the variables under study. We hypothesized that poor selfconcept may be positively associated with higher binge eating severity and that this association may be mediated by difficulties in the ability to recognize, understand, and regulate bodily signals and emotional experiences. Specifically, we tested the following set of direct relationships implied by our hypotheses: (1) from selfesteem to interoceptive deficits; (2) from self-esteem to impulse regulation difficulties; (3) from self-esteem to binge eating; (4) from interoceptive deficits to impulse regulation difficulties; (5) from interoceptive deficits to binge eating; (6) from impulse regulation difficulties to binge eating.

The structural model with these direct relationships was expected to have built-in the following hypothesized indirect relationships: (a) the relationship between self-esteem and impulse regulation difficulties was supposed to be mediated by interoceptive deficits; (b) the relationship between interoceptive deficits and binge eating was expected to be mediated by impulse regulation difficulties; (c) the path from self-esteem to binge eating was expected to be mediated by interoceptive deficits and impulse regulation difficulties.

The reason for an understanding of some ways in which the variables reported above may lead to eating pathology is to provide information to improve bariatric surgery outcomes.

2. Method

2.1. Participants and procedures

Participants included obese candidates (BMI \ge 30), both males and females, for gastric bypass surgery at a medical center in southern Italy (Pineta Grande Hospital). All of them agreed to participate, signed an informed consent form, and completed the questionnaire within a week of the surgery date. Individuals were ineligible if they were not at least 18 years of age and had medical, cognitive, or psychiatric impairment.

The study was approved by the Ethic Board of the Department of Psychology and by the Ethic Committee of the University of Campania, and it was performed by the ethical standards of the Helsinki declaration (World Medical Association, 2013).

2.2. Measures

Demographic data. Participants were asked to fill in a form with information about age, gender, race/ ethnicity, and education level.

Self-Esteem. The Rosenberg Self-esteem Scale (RSES; Rosenberg, 1965) is a 10-item self-report measure that assesses global self-esteem. A sample item from the RSES is "*I feel I do not have much to be proud of*". Scores range from 0 to 30, with lower scores indicating lower self-esteem. Rosenberg (1965) reported adequate internal consistency ($\alpha = .85$ to .88). Sample Cronbach's alpha is .76.

Emotion Regulation. In the current study, the Eating Disorder Inventory-3 (EDI-3; Garner, 2004) Interoceptive Deficits and Emotional Dysregulation scales were used.

The Interoceptive Deficits scale measures confusion related to accurately recognizing and responding to bodily and emotional states. It consists of nine items related to two dimensions: "affective confusion" (e.g., "*I get confused about what emotion I am feeling*") and "fear of affect" (e.g., "*I get frightened when my feelings are too strong*"). Sample Cronbach's alpha is .74.

The Emotional *(Impulse)* Dysregulation scale, composed of eight items, assesses tendency toward mood instability, impulsivity, recklessness, anger, and self-destructiveness (e.g., "I feel like I have to hurt myself or others"). Sample Cronbach's alpha is .80.

Participants were asked to rate how much they agreed with statements (e.g., "*I don't know what's going on inside me*") with answers ranging over a scale from 0 ("always") to 4 ("never"), with higher scores indicating a greater symptom severity.

Binge Eating. The Binge Eating Scale (BES; Gormally, 1982) is a 16-item self-report measure to assess the behavioral (e.g., "*I don't lose total control of my eating when dieting even after periods when I overeat*") as well as the cognitive and emotional symptoms (e.g., "*I don't feel any guilt or self-hate after I overeat*") associated with binge eating. The score range is from 0 to 46, with higher scores indicating more severe binge eating problems. Sample Cronbach's alpha is .83.

Body Mass Index (BMI). Each individual was weighed and measured in height.

2.3. Statistical Analysis

Statistical analyses were carried out using SPSS 20 version. First, preliminary univariate distributions of observed scores were examined for normality. Next, Pearson correlation coefficients were investigated to inspect associations among all of the study variables, and the AMOS software was used to analyze the hypothesized mediation model through path analysis. The Maximum Likelihood estimation method was used. We considered following fit indices to assess model fit: Chi-square (χ 2), the Tucker Lewis Index (TLI), the Comparative Fit Index (CFI), the Normed Fit Index (NFI), and the Root-Mean Square Error of Approximation (RMSEA). For a good fit, it is recommended that the RMSEA be less than .08, while the TLI, NFI, and CFI be greater than .90 (Hu & Bentler, 1999). A non-significant χ^2 value indicates that a model is compatible with the data (Schermelleh-Engel, Moosbrugger, & Müller, 2003). The bootstrapping method was used to examine the hypothesized indirect effects, with 1000 bootstrap samples originated from the data to compute 95% bias-corrected confidence intervals (CI). According to literature (Kline, 2005), an indirect effect is considered significant if the CI interval does not include zero.

The value of p less than or equal to .01 was considered statistically significant since the examined sample was of small size.

3. Results

3.1. Preliminary analyses

Values of Skewness and Kurtosis indicated that there was not a violation of the normal distribution (Table 1). All analyses were based upon available data.

3.2. Sample Characteristics

The preliminary sample consisted of 61 bariatric surgery candidates. Of these, two individuals were excluded because returned incomplete questionnaires, so the final sample included 59 Caucasian patients, of whom 71.2% (N = 42) women, with a mean age of 35.34 years (SD = 10.37) and a mean BMI of 41.03 (SD = 5.55). Thirty-three (57%) were morbidly obese (defined as BMI > 40 Kg/m²). Most patients (97%; N=56) held a diploma of higher education or less.

3.3. Correlations

Correlation analysis showed significant relationships between binge eating (BES), self-esteem (RSS; p =.005), EDI-3 Interoceptive Deficit (p = .002), and EDI-3 Impulse Dysregulation (p < .001). Binge eating disorder risk was not significantly associated with demographic variables of sex (r = .064, p = .633), age (r = .101, p =.453) and BMI (r = .019, p = .885) (Table 1).

3.4. Path Analysis

The model with standardized path coefficients and the percentage of variance explained is printed in Figure 1. The model demonstrated a good fit ($\chi^2 = 1.38$, p = .239; RMSEA = .080; CFI = .994; NFI = .985; TLI = .893) and explained 47% of the variance of binge eating. All analyses were controlled for age, sex, and BMI.

Results indicated that all direct effects were

	1	2	3	4	5	6	7
1. Gender ^a	_						
2. Age	.154	_					
3. BMI	.215	065	_				
4. BES Total Score	.003	.097	106	_			
5. RSES Self-esteem	.330**	.289**	098	382**	-		
6. EDI-3 Interoceptive Deficits	190	155	.052	.375**	466***	-	
7. EDI-3 Impulse Dysregula- tion	205	142	.109	.560***	412***	.604***	-
Mean (standard deviation)	-	35.34 (0.28)	41.03 (5.55)	15.37 (8.47)	19.71 (5.143)	10.22 (7.69)	6.58 (6.22)
Skewness	-	.240	2.285	.471	345	.774	.969
Kurtosis	-	393	8.881	043	.096	226	.214

Table 1. Correlations, means (standard deviations), skewness, and kurtosis of the study variables for the complete sample (N=59)

Note: "Female=1, Male=0; *** p=.000; ** p<.01

Abbreviations: BMI=Body Mass Index; BES=Binge Eating Scale; RSES=Rosenberg Self-Esteem Scale; EDI=Eating Disorder Inventory

significant, except for the self-esteem on impulse dysregulation ($\beta = ..13$, p = .28) and the interoceptive deficits on binge eating ($\beta = .01$, p = .92). The analysis of the indirect effects indicated that self-esteem had a significant indirect effect on impulse dysregulation mediated by interoceptive deficits ($\beta = ..28$; 95% CI [-.63 - -.98]; p < .001). Impulse dysregulation, in turns, mediates the effect of interoceptive deficits on binge eating ($\beta = .30$; 95% CI [.12 - .63]; p < .001). Moreover, the path starting from self-esteem, going first to interoceptive deficits, then going via impulse regulation difficulties to binge eating was significant ($\beta = ..20$; 95% CI [-.56 - .06, p < .001).

4. Discussion

To our knowledge, this is the first study that focused on the relationship between self-esteem and emotion dysregulation (expressed by difficulties in interoceptive awareness and impulse regulation) in bariatric surgery candidates and investigated whether these variables affect binge eating severity through path analysis.

Data supported the hypothesized model, and several interesting findings emerged. Difficulties in emotion

regulation may be an essential underlying mechanism linking self-esteem to binge eating, even when statistically accounting for gender, age, and BMI. As hypothesized, low self-esteem had a significant positive direct effect on difficulties in the ability to recognize internal bodily signals and binge eating severity. Results pointed out a non-significant direct association between poor self-esteem and impulse dysregulation, but a significant indirect effect via interoceptive deficits. Our hypothesis that a lack of emotional awareness had a direct effect on impulse regulation, which, in turn, was associated with the severity of binge eating behavior, was confirmed. Moreover, even if indirectly via impulse dysregulation, a link between interoceptive deficits and binge eating emerged.

Consistent with previous evidence (Cella et al., 2019; Racine & Wildes, 2013), results from this study indicate that impulse regulation difficulties could be the only emotion regulation directly associated with binge eating. Taken together, our findings add to the literature suggesting that a deep sense of inconsistency and deficits in interoceptive awareness may be directly relevant to difficulties in impulse modulation. In this manner, low self-esteem could not allow individuals to develop a

Figure 1. Path analysis of the hypothesized model with standardized coefficients and squared multiple correlations controlling for age, sex, and Body Mass Index



Note: *** p<0.001; **p<0.01 $\chi^2_{(1)}$ =1.38, p=.239; RMSEA=0.080; CFI=.994; NFI=0.985; TLI=.893

sense of personal needs, altering their interoceptive awareness and, consequently, their impulse control. As such, being able to identify and responding to emotional and bodily states is essential before being able to impulse regulation (Füstös et al., 2013; Sim & Zeman, 2004). From that perspective, it is possible that obese individuals who perceived themselves as inadequate may carry a stronger burden by the confusion and mistrust related to affective and bodily functioning and, consequently, may act more impulsively, through binge eating episodes or other impulsive behaviors, in response to aversive emotional states. Accordingly, our previous study confirms the association between selfinjury, substance use, and BED (Cella et al., 2019). Furthermore, consistently with the issue, binge eating may be an attempt to regulate uncomfortable emotional experiences (Svaldi et al., 2012), that may arise from low self-esteem (O'Donohue et al., 2007). Further studies on this suggestion would be very needed, but the preliminary results prove promising for application in a clinical setting.

4.1. Clinical Implications

This paper attempts to answer a complex question related to risk for binge eating in bariatric surgery candidates. In this sense, a potential underlying mechanism through which self-esteem is linked to binge eating has been suggested. Pre-bariatric patients with low self-esteem may be at risk for binge eating behaviors, especially if they experience emotion regulation difficulties. Self-esteem and interoceptive deficits account for 40% of the variance in impulse control difficulties, and overall the model accounted for 47% of the variance in binge eating. Since the subjective sense of lack of control over eating is the central feature of a binge episode and also may to be associated with a less successful postoperative outcome (Sarwer et al., 2019), the present study represents a helpful first step suggesting a promising model. Furthermore, to our knowledge, this is the first study that presents a unique contribution to the literature by illustrating the role of self-esteem in emotion regulation difficulties and binge eating. More research is needed to validate these hopeful results.

The results of the present study have implications for eating pathology prevention and treatment. Binge eating represents indeed a limiting factor in patients undergoing bariatric surgery, as it is often associated with an inferior post-operative weight loss (Larsen et al., 2004). Several longitudinal studies have highlighted that patients with pre-surgical binge eating behaviors show lower weight loss and more significant loss of control over eating after gastric restriction surgery (Green, Dymek-Valentine, Pytluk, Le Grange & Alverdy, 2004; Kalarchian et al., 2002; Sallet et al., 2007). On the other hand, Colles and colleagues (2008) have found that BED was reduced after a bariatric procedure. Similarly, binge eating behaviors showed a significant decrease in the follow-up evaluations (Boan, Kolotkin, Westman, McMahon & Grant, 2004; Busetto et al., 2005). These findings seem to suggest that preoperative eating behaviors are not necessarily predictive of outcomes (Sarwer, Wadden, & Fabricatore, 2005). Notwithstanding, the recognition of these relationships may support the choice of specific therapeutic strategies.

Clinicians should consider conducting a routine assessment of these factors. Early detection of the psychological factors that put pre-bariatric surgery

obese at greater risk for dysfunctional eating behaviors could help clinicians in developing target pre-operative and post-operative intervention, and preventing poor outcomes. The bariatric intervention could be most effective if combined by other (pre- and post-surgical) treatments. In this sense, the treatment of low selfesteem and interventions to increase interoceptive awareness and impulse regulation may enhancing the patient's sense of competence and reducing binge eating symptomatology and, in turn, improve bariatric surgery outcome. These issues should be targeted in obesity and binge eating prevention and treatment programs to allow for better weight loss outcomes (Herbozo et al., 2015). In this regard, self-esteem appears to be a salient factor involved in binge eating cessation (Goldschmidt, Wall, Loth, Bucchianeri, & Neumark-Sztainer, 2014). For example, a longitudinal study exploring the quality of life with a two years follow-up after bariatric surgery has found a significant increase in self-esteem and successful post-operative outcome (Burgmer et al., 2007). Similar findings were replicated by other researchers (Green et al., 2004; White, Masheb, Rothschild, Burke-Martindale & Grilo, 2006). Moreover, among BED obese patients, self-esteem emerged as a moderator of the treatment outcome (Wilson, Wilfley, Agras, & Bryson, 2010). Conversely, patients with low self-esteem were found to be more likely to restart overeating (Safer, Lively, Telch, & Agras, 2002). A recent clinical trial involving binge eating patients has demonstrated that impulsivity focused intervention led to a reduction in impulsivity and binge eating frequency (Schag et al., 2015). In addition, a substantial subset of prebariatric obese individuals exhibited a behavioral pattern similar to substance addiction and characterized by the loss of control over the consumption of sugary, salty, and fatty foods (Meule, Heckel, Jurowich, Vögele, & Kübler, 2014). It has suggested that binge eating may itself be an addictive behavior, as it shares some psychological mechanisms with substance-use disorders (i.e., loss of control; Davis & Carter, 2009). Davis (2017) has also suggested the existence of a considerable overlap between binge eating and food addiction. This "food addiction", related to eating pathology (particularly binge eating) and higher general psychopathology (i.e., higher depression and anxiety disorders, higher impulsivity, low self-esteem and higher prevalence of current suicidality) (Benzerouk et al., 2018; Koball et al., 2016; Meule & Gearhardt, 2014; Pursey, Stanwell, Gearhardt, Collins, & Burrows, 2014), may also adverse weight loss after bariatric surgery (Sarwer et al., 2019).

Several researchers have also found that patients experience a "transfer addiction" after bariatric surgery (Bak, Seibold-Simpson, & Darling, 2016). Specifically, empirical research suggests that the bariatric procedure is associated with an increased risk of developing substance use disorders and other addictive behaviors (Bak et al., 2016; King et al., 2017; Östlund et al., 2013).

It could be hypothesized that binge eaters who undergo bariatric surgery might have a pre-existing "addiction" to food, which was "transferred" by replacing the food by another substance (Blum et al., 2011). In this sense, impulsivity, the core feature of the BED and overeating, may lead individuals – unable to binge due to the surgery – to substitute the addictive substance, and contribute to the development of "transfer addiction".

Thus, these findings suggest that an approach that focuses on the individual's self-worth and the impulse regulation ability is likely to be most effective. Additionally, pre-surgical assessment and postsurgical follow-ups are of prime importance to identify and reduce the reemergence and/or development of maladaptive eating patterns after surgery.

5. Limitation

Several limitations necessitate being considered when interpreting the findings of the present study. First of all, these results need to be further tested on a larger sample and must include a control group. Conducting a path analysis with a sample of 59 individuals raises concerns about statistical power; that is, if significant effects are not found, it is not clear whether this was simply a power issue or a null finding.

Emotional dysregulation may also be a consequence of EDs, and the cross-sectional design precludes a conclusion about directionality. Longitudinal studies are necessary to establish the direction of the relationship identified. Additionally, future studies should consider interoceptive awareness as a multidimensional construct and investigate the contribution of different aspects, including lack of clarity regarding internal experiences and non-acceptance of emotional arousal (Merwin, Zucker, Lacy, & Elliott, 2010) separately. Thus, although the assessment of interoceptive awareness and emotion regulation difficulties using the EDI-3 has received empirical support (i.e., Lattimore et al., 2017), future studies would benefit from the inclusion of other specific approaches to the assessment of emotion regulation difficulties (i.e., DERS; Gratz & Roemer, 2004).

Contributors

Cella and Cotrufo designed the study and wrote the protocol. All authors conducted literature searches and provided summaries of previous research studies. Cella, Cipriano, and Giardiello assisted with data collection. Cella conducted the statistical analysis and wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Clinical Implications

- Poor self-esteem affects binge eating severity through emotion dysregulation
- Interoceptive awareness deficits may be directly relevant to difficulties in impulse regulation
- Impulse regulation difficulties are directly associated with binge eating severity
- The evidence is useful to improve bariatric surgery outcome

References

- Bak, M., Seibold-Simpson, S. M., & Darling, R. (2016). The potential for cross-addiction in post-bariatric surgery patients. *Journal of the American Association of Nurse Practitioners*, 28(12), 675–682. doi: 10.1002/2327-6924.12390.
- Baldofski, S., Rudolph, A., Tigges, W., Herbig, B., Jurowich, C., Kaiser, S., ... Hilbert, A. (2016). Weight bias internalization, emotion dysregulation, and non-normative eating behaviors in prebariatric patients. *International Journal of Eating Dis*orders, 49, 180-5. doi: 10.1002/eat.22484.
- Benjamin, L., & Wulfert, E. (2005). Dispositional correlates of addictive behaviors in college women: Binge eating and heavy drinking. *Eating Behaviors*, 6(3), 197–209. doi: 10.1016/j. eatbeh.2003.08.001.
- Benzerouk, F., Gierski, F., Ducluzeau, P.-H., Bourbao-Tournois, C., Gaubil-Kaladjian, I., Bertin, E., ... Brunault, P. (2018). Food addiction, in obese patients seeking bariatric surgery, is associated with higher prevalence of current mood and anxiety disorders and past mood disorders. *Psychiatry Research*, 267, 473–479. doi.org/10.1016/j.psychres.2018.05.087.
- Blum, K., Bailey, J., Gonzales, A. M., Oscar-Berman, M., Liu, Y., Giordano, J., ... Gold, M. (2011). Neuro-Genetics of reward deficiency syndrome (rds) as the root cause of "addiction transfer": A new phenomena common after bariatric surgery. *Journal of Genetic Syndromes & Gene Therapy*, 1,S2–001. doi: 10.4172/2157-7412.s2-001.
- Boan, J., Kolotkin, R. L., Westman, E. C., McMahon, R. L., & Grant, J. P. (2004). Binge eating, quality of life and physical activity improve after Roux-en-Y Gastric Bypass for morbid obesity. *Obesity Surgery*, 14(3), 341–348. doi: 10.1381/096089204322917864.
- Brechan, I., & Kvalem, I. L. (2015). Relationship between body dissatisfaction and disordered eating: Mediating role of selfesteem and depression. *Eating Behaviors*, 17, 49–58. doi: 10.1016/j.eatbeh.2014.12.008.
- Brockmeyer, T., Skunde, M., Wu, M., Bresslein, E., Rudofsky, G., Herzog, W., & Friederich, H.C. (2014). Difficulties in emotion regulation across the spectrum of eating disorders. *Comprehensive Psychiatry*, 55, 565-71. doi: 10.1016/j.comppsych.2013.12.001.
- Bruch, H. (1962). Perceptual and conceptual disturbances in anorexia nervosa. *Psychosom Med*, 24, 187-194, doi: 10.1097/00006254-196210000-00037.
- Burgmer, R., Petersen, I., Burgmer, M., Zwaan, M. D., Wolf, A. M., & Herpertz, S. (2007). Psychological outcome two years after restrictive bariatric surgery. *Obesity Surgery*, 17, 785– 791. doi: 10.1007/s11695-007-9144-9.
- Burns, E. E., Fischer, S., Jackson, J. L., & Harding, H. G. (2012). Deficits in emotion regulation mediate the relationship between childhood abuse and later eating disorder symptoms. *Child Abuse & Neglect*, 36(1), 32–39. doi: 10.1016/j.chiabu.2011.08.005.
- Busetto, L., Segato, G., De Luca, M., De Marchi, F., Foletto, M., Vianello, M., . . . Enzi, G. (2005). Weight loss and postoperative complications in morbidly obese patients with binge eating disorder treated by laparoscopic adjustable gastric banding. *Obesity Surgery*, 15, 195-201. doi: 10.1381/0960892053268327.
- Cella, S., Cipriano, A., Iannaccone, M., & Cotrufo, P. (2017). Identifying predictors associated with the severity of eating concerns in females and eating disorders. *Research in Psychotherapy: Psychopathology, Process and Outcome*, 20(1), 91-99. doi:10.4081/ripppo.2017.199..
- Cella, S., Fei, L., D'Amico, R., Giardiello, C., Allaria, A., & Cotrufo, P. (2019). Binge eating disorder and related features in bariatric surgery candidates. *Open Medicine*, 14: 407-415. doi: org/10.1515/med-2019-0043.
- Colles, S. L., Dixon, J. B., & Obrien, P. E. (2008). Loss of control is central to psychological disturbance associated with binge eating disorder. *Obesity*, 16(3), 608–614. doi: 10.1038/

oby.2007.99.

- Courtney, E. A., Gamboz, J., & Johnson, J. G. (2008). Problematic eating behaviors in adolescents with low self-esteem and elevated depressive symptoms. *Eating Behaviors*, 9, 408-414. doi: 10.1016/j.eatbeh.2008.06.001.
- Damasio A. (1999). The Feeling of What Happens: Body and Emotion in the Making of Consciousness. New York, NY: Harcourt.
- Davis, C., & Carter, J. C. (2009). Compulsive overeating as an addiction disorder. A review of theory and evidence. *Appetite*, 53(1), 1–8. doi: 10.1016/j.appet.2009.05.018.
- Davis, C. (2017). A commentary on the associations among 'food addiction', binge eating disorder, and obesity: Overlapping conditions with idiosyncratic clinical features. *Appetite*, 115, 3–8. doi: 10.1016/j.appet.2016.11.001.
- Eichen, D. M., Chen, E., Boutelle, K. N., & McCloskey, M. S. (2017). Behavioral evidence of emotion dysregulation in binge eaters. *Appetite*, 1, 1-6. doi: 10.1016/j.appet.2016.12.021.
- Fairburn, C. G., Cooper, Z., & Shafran, R. (2003). Cognitive behaviour therapy for eating disorders: A "transdiagnostic" theory and treatment. *Behaviour Research and Therapy*, 41, 509–528. doi.org/10.1016/S0005-7967(02)00088-8.
- Fassino, S., Pierò, A., Gramaglia, C., & Abbate-Daga, G. (2004). Clinical, psychopathological and personality correlates of interoceptive awareness in anorexia nervosa, bulimia nervosa and obesity. *Psychopathology*, 37, 168–174. doi:10.1159/000079420.
- Feldman Barrett, L., Gross, J., Christensen, T. C., & Benvenuto, M. (2001). Knowing what you're feeling and knowing what to do about it: mapping the relation between emotion differentiation and emotion regulation. *Cognition and Emotion*, 15, 713–24. doi: 10.1080/02699930143000239.
- Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2013). On the embodiment of emotion regulation: interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience*, 8, 911-7. doi: 10.1093/scan/nss089.
- Garner, D. M. (2004). Eating Disorder Inventory Third Edition (EDI-3). Lutz, FL, Psychological Assessment Resources.
- Gianini, L. M., White, M. A., & Masheb, R. M. (2013). Eating pathology, emotion regulation, and emotional overeating in obese adults with Binge Eating Disorder. *Eating Behaviors*, 14, 309-13. doi: 10.1016/j.eatbeh.2013.05.008.
- Goldschmidt, A. B., Wall, M. M., Loth, K. A., Bucchianeri, M. M., & Neumark-Sztainer, D. (2014). The course of binge eating from adolescence to young adulthood. *Health Psychol*ogy, 33(5), 457–460. doi.org/10.1037/a0033508.
- Gormally, J. (1982). The Assessment of Binge Eating Severity Among Obese Persons. Addictive Behaviors, 7, 47-55.
- Gratz, K., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, 26, 41–54. doi: 10.1007/s10862-008-9102-4.
- Green, A. E., Dymek-Valentine, M., Pytluk, S., Grange, D. L., & Alverdy, J. (2004). Psychosocial outcome of gastric bypass surgery for patients with and without binge eating. *Obesity Surgery*, 14(7), 975–985. doi: 10.1381/0960892041719590.
- Herbozo, S., Schaefer, L. M., & Thompson, J. K. (2015). A comparison of eating disorder psychopathology, appearance satisfaction, and self-esteem in overweight and obese women with and without binge eating. *Eating Behaviors*, 17, 86–89. doi. org/10.1016/j.eatbeh.2015.01.007.
- Holmes, M., Fuller-Tyszkiewicz, M., Skouteris, H., & Broadbent, J. (2015). Understanding the link between body image and binge eating: a model comparison approach. *Eating and Weight Disord, 20*(1), 81–89. doi: 10.1007/s40519-014-0141-4.
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1-55.
- Jenkinson, P. M., Taylor, L., & Laws, K. R. (2018). Self-reported

interoceptive deficits in eating disorders: A meta-analysis of studies using the eating disorder inventory. *J Psychosom Res*, *110*, 38-45. doi: 10.1016/j.jpsychores.2018.04.005.

- Kalarchian, M. A., Marcus, M. D., Levine, M. D., Courcoulas, A. P., Pilkonis, P. A., Ringham, R. M., ... Rofey, D. L. (2007). Psychiatric disorders among bariatric surgery candidates: relationship to obesity and functional health status. *American Journal of Psychiatry*, 164, 328-34. doi: 10.1176/ ajp.2007.164.2.328.
- Kalarchian, M. A., Marcus, M. D., Wilson, G. T., Labouvie, E. W., Brolin, R. E., & Lamarca, L. B. (2002). Binge eating among gastric bypass patients at long-term follow-up. *Obesity Surgery*, 12(2), 270–275. doi: 10.1381/096089202762552494.
- King, W. C., Chen, J.-Y., Courcoulas, A. P., Dakin, G. F., Engel, S. G., Flum, D. R., ... Yanovski, S. Z. (2017). Alcohol and other substance use after bariatric surgery: prospective evidence from a U.S. multicenter cohort study. *Surgery for Obesity and Related Diseases*, *13*(8), 1392–1402. doi: 10.1016/j. soard.2017.03.021.
- Klabunde, M., Acheson, D. T., Boutelle, K. N., Matthews, S. C., & Kaye, W. H. (2013). Interoceptive sensitivity deficits in women recovered from bulimia nervosa. *Eating Behaviors*, 14, 488-92. doi: 10.1016/j.eatbeh.2013.08.002.
- Kline, R.B. (2005). Principles and Practice of Structural Equation Modeling, 2nd ed. The Guilford Press, New York.
- Koball, A. M., Clark, M. M., Collazo-Clavell, M., Kellogg, T., Ames, G., Ebbert, J., & Grothe, K. B. (2016). The relationship among food addiction, negative mood, and eating-disordered behaviors in patients seeking to have bariatric surgery. *Surgery for Obesity and Related Diseases*, 12(1), 165–170. doi.org/10.1016/j.soard.2015.04.009.
- Larsen, J. K., Ramshorst, B. V., Geenen, R., Brand, N., Stroebe, W., & van Doornen, L. J. (2004). Binge eating and its relationship to outcome after laparoscopic adjustable gastric banding. *Obesity Surgery*, 14(8), 1111–1117. doi: 10.1381/0960892041975587.
- Lattimore, P., Mead, B. R., Irwin, L., Grice, L., Carson, R., & Malinowski P. (2017). "I can't accept that feeling": Relationships between interoceptive awareness, mindfulness and eating disorder symptoms in females with, and at-risk of an eating disorder. *Psychiatry Research*, 247,163-171. doi: 10.1016/j. psychres.2016.11.022.
- Lavender, J., Wonderlich, S., Engel, S., Gordon, K., Kaye, W., & Mitchell, J. (2015). Dimensions of emotion dysregulation in anorexia nervosa and bulimia nervosa: A conceptual review of the empirical literature. *Clin Psychol Rev*, 40, 111–22. doi. org/10.1016/j.cpr.2015.05.010.
- Leehr, E. J., Krohmer, K., Schag, K., Dresler, T., Zipfel, S., & Giel, K. E. (2015). Emotion regulation model in binge eating disorder and obesity--a systematic review. *Neuroscience* & *Biobehavioral Reviews*, 49,125-34. doi: 10.1016/j.neubiorev.2014.12.008.
- Mazzeo, S. E., Saunders, R., & Mitchell, K. S. (2005). Binge eating among African American and Caucasian bariatric surgery candidates. *Eating Behaviors*, 6, 189-196. doi.org/10.1016/j. eatbeh.2004.12.001.
- Merwin, R. M., Zucker, N. L., Lacy, J. L., & Elliott, C. A. (2010). Interoceptive awareness in eating disorders: distinguishing lack of clarity from non-acceptance of internal experiences. *Cognition and Emotion*, 24, 892-902. doi: 10.1080/02699930902985845.
- Meule, A., & Gearhardt, A. N. (2014). Food addiction in the light of DSM-5. *Nutrients*, 6(9), 3653–3671. doi.org/10.3390/ nu6093653.
- Meule, A., Heckel, D., Jurowich, C. F., Vögele, C., Kübler, A. (2014). Correlates of food addiction in obese individuals seeking bariatric surgery. *Clinical Obesity*, 4(4), 228-36. doi: 10.1111/cob.12065.
- Micanti, F., Pecoraro, G., Costabile, R., Loiarro, G., & Galletta, D. (2016). An explorative analysis of binge eating disorder impulsivity among obese candidates to bariatric surge-

ry. Journal of Addiction Research & Therapy, 7, 302-308. doi:10.4172/2155-6105.1000302.

- Mitchell, J. E., King, W. C., Courcoulas, A., Dakin, G., Elder, K., Engel, S., ... Wolfe, B. (2015). Eating behavior and eating disorders in adults before bariatric surgery. *International Journal of Eating Disorders*, 48, 215-22. doi: 10.1002/ eat.22275.
- Monell, E., Clinton, D., & Birgegård, A. (2018). Emotion dysregulation and eating disorders—Associations with diagnostic presentation and key symptoms. *International Journal of Eating Disorders*, 51(8), 921-930. doi:10.1002/eat.22925.
- Munsch, S., Meyer, A. H., Quartier, V., & Wilhelm, F. H. (2012). Binge eating in binge eating disorder: a breakdown of emotion regulatory process? *Psychiatry Research*, 195, 118-24. doi: 10.1016/j.psychres.2011.07.016.
- Niego, S. H., Kofman, M. D., Weiss, J. J., & Geliebter, A. (2007). Binge eating in the bariatric surgery population: A review of the literature. *International Journal of Eating Disorders*, 40, 349–359. doi: 10.1002/eat.20376.
- O'Donohue, W. T, Moore, B. A. & Scott, B. J. (2007). Handbook of Pediatric and Adolescent Obesity Treatment. New York:Routledge.
- Östlund, M. P., Backman, O., Marsk, R., Stockeld, D., Lagergren, J., Rasmussen, F., & Näslund, E. (2013). Increased admission for alcohol dependence after gastric bypass surgery compared with restrictive bariatric surgery. *JAMA Surgery*, *148*(4), 374. doi: 10.1001/jamasurg.2013.700.
- Pasold, T. L., Mccracken, A., & Ward-Begnoche, W. L. (2013). Binge eating in obese adolescents: Emotional and behavioral characteristics and impact on health-related quality of life. *Clinical Child Psychology and Psychiatry*, 19(2), 299–312. doi: 10.1177/1359104513488605.
- Pursey, K. M., Stanwell, P., Gearhardt, A. N., Collins, C. E., & Burrows, T. L. (2014). The prevalence of food addiction as assessed by the yale food addiction scale: A systematic review. *Nutrient*, 6(10). 4552–4590. doi.org/10.3390/nu6104552.
- Racine, S. E., & Wildes, J. E. (2013). Emotion dysregulation and symptoms of anorexia nervosa: the unique roles of lack of emotional awareness and impulse control difficulties when upset. *International Journal of Eating Disorders*, 46, 713-20. doi: 10.1002/eat.22145.
- Ramacciotti, C. E., Coli, E., Bondi, E., Burgalassi, A., Massimetti, G., & Dell'Osso, L. (2008). Shared psychopathology in obese subjects with and without binge-eating disorder. *International Journal of Eating Disorders*, 41, 643-9. doi: 10.1002/ eat.20544.
- Rieger, E., Wilfley, D. E., Stein, R. I., Marino, V., & Crow, S. J. (2005). A comparison of quality of life in obese individuals with and without binge eating disorder. *International Journal* of *Eating Disorders*, 37(3), 234–240. doi: 10.1002/eat.20101.
- Rosenberg, M. (1965). Society and the adolescent self-image. Princeton, Princeton University Press.
- Safer, D. L., Lively, T. J., Telch, C. F., & Agras, W. S. (2002). Predictors of relapse following successful dialectical behavior therapy for binge eating disorder. *International Journal of Eating Disorders*, 32(2), 155–163. doi.org/10.1002/ eat.10080.
- Sallet, P. C., Sallet, J. A., Dixon, J. B., Collis, E., Pisani, C. E., Levy, A., ... Cordás, T. A. (2007). Eating behavior as a prognostic factor for weight loss after gastric bypass. *Obesity Sur*gery, 17(4), 445–451. doi: 10.1007/s11695-007-9077-3.
- Sarwer, D. B., Allison, K. C., Wadden, T. A., Ashare, R., Spitzer, J. C., McCuen-Wurst, C., ... Wu, J. (2019). Psychopathology, disordered eating, and impulsivity as predictors of outcomes

of bariatric surgery. Surgery for Obesity and Related Diseases, 15(4), 650–655. doi.org/10.1016/j.soard.2019.01.029.

- Sarwer, D. B., Wadden, T. A., & Fabricatore, A. N. (2005). Psychosocial and behavioral aspects of bariatric surgery. *Obesity Research*, 13, 639–648.
- Sasai, K., Tanaka, K., & Hishimoto, A. (2010). Alexithymia and its relationships with eating behavior, self esteem, and body esteem in college women. *The Kobe journal of medical sciences*, 56(6), E231-8.
- Schag, K., Leehr, E. J., Martus, P., Bethge, W., Becker, S., Zipfel, S., & Giel, K. E. (2015). Impulsivity-focused group intervention to reduce binge eating episodes in patients with binge eating disorder: Study protocol of the randomised controlled IMPULS trial. *BMJ Open*, *5*: e009445. doi.org/10.1136/bmjopen-2015-009445.
- Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the Fit of Structural Equation Models: Tests of Significance and Descriptive Goodness-of-Fit Measures. *Methods of Psychological Research*, 8, 23-74.
- Shakory, S., Van Exan, J., Mills, J. S., Sockalingam, S., Keating, L., & Taube-Schiff, M. (2015). Binge eating in bariatric surgery candidates: The role of insecure attachment and emotion regulation. *Appetite*, *91*, 69-75. doi: 10.1016/j.appet.2015.03.026.
- Shekhar, C., & Pangotra, A. (2017). Difficulties in emotional regulation, loneliness and self-esteem among adolescence. *Internat. J. Appl. Soc. Sci, 4*, 117-124.
- Sim, L., & Zeman, J. (2004). Emotion awareness and identification skills in adolescent girls with bulimia nervosa. *Journal* of Clinical Child & Adolescent Psychology, 33, 760-71. doi: 10.1207/s15374424jccp3304 11.
- Svaldi, J., Griepenstroh, J., Tuschen-Caffier, B., & Ehring, T. (2012). Emotion regulation deficits in eating disorders: a marker of eating pathology or general psychopathology? *Psychiatry Research*, 197, 103-11. doi: 10.1016/j.psychres.2011.11.009.
- Taube-Schiff, M., Van Exan, J., Tanaka, R., Wnuk, S., Hawa, R., & Sockalingam, S. (2015). Attachment style and emotional eating in bariatric surgery candidates: The mediating role of difficulties in emotion regulation. *Eating Behaviors*, 18, 36-40. doi: 10.1016/j.eatbeh.2015.03.011.
- Vinai, P., Da Ros, A., Speciale, M., Gentile, N., Tagliabue, A., Vinai, P., ... Cardetti, S. (2015). Psychopathological characteristics of patients seeking for bariatric surgery, either affected or not by binge eating disorder following the criteria of the DSM IV TR and of the DSM 5. *Eating Behaviors*, 16,1-4. doi: 10.1016/j.eatbeh.2014.10.004.
- White, M. A., Masheb, R. M., Rothschild, B. S., Burke-Martindale, C. H., & Grilo, C. M. (2006). The prognostic significance of regular binge eating in extremely obese gastric bypass patients: 12-Month postoperative outcomes. *Journal of Clinical Psychiatry*, 67(12), 1928–1935 doi.org/10.4088/JCP. v67n1213.
- Whiteside, U., Chen, E., Neighbors, C., Hunter, D., Lo, T., & Larimer M. (2007). Difficulties regulating emotions: Do binge eaters have fewer strategies to modulate and tolerate negative affect? *Eating Behaviors*, 8, 162-9.
- Wilson, G. T., Wilfley, D. E., Agras, W. S., & Bryson, S. W. (2010). Psychological treatments of binge eating disorder. *Archives of General Psychiatry*, 67(1). 94–101. doi.org/10.1001/arch-genpsychiatry.2009.170.
- World Medical Association. (2013). World Medical Association Declaration of Helsinki. JAMA, 310, 2191–2194. doi. org/10.1001/jama.2013.281053.