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RESEARCH ARTICLE

Bodily sensations and bariatric surgery: Links between interoceptive sensibility, intuitive and disordered eating behaviour in obesity and obesity surgery

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[Correction added on 04 February 2024, after first online publication: The copyright line was changed.]

Abstract

Objective: This study evaluated interoceptive sensibility, intuitive and disordered eating among bariatric candidates, operated individuals and individuals with obesity seeking non-surgical treatment.

Method: We recruited 57 individuals with obesity seeking nonsurgical weight-loss (IOB), 84 bariatric candidates (Pre) and 22 individuals post-bariatric surgery (Post) who responded to questionnaires: Multidimensional Assessment of Interoceptive Awareness, Intuitive Eating Scale-2 (IES-2), Dutch Eating Behaviour Questionnaire, Binge Eating Scale, State-Trait Anxiety Inventory, Beck's Depression Inventory.

Results: Overall, the Post group manifested higher scores on 'Body-Listening' ($F = 4.95, p = 0.01$), 'Emotional Awareness' ($F = 8.83, p < 0.001$) and 'Trusting' ($F = 6.71, p = 0.002$) interoceptive dimensions, on the IES-2 total score ($F = 5.48, p = 0.007$) and 'Reliance on hunger and satiety cues' ($F = 31.3, p < 0.001$) when age was controlled. The IOB group presented higher scores on emotional ($F = 3.23, p = 0.047$) and binge eating ($F = 5.99, p = 0.004$). Among operated individuals, intuitive eating mediated the relationship between interoceptive sensibility dimensions and binge eating: 'Attention regulation' (54%) 'Self-regulation' (75.1%), 'Body listening' (94.09%) and 'Trusting' (84.9%).

Conclusions: Our results suggest the therapeutic potential of interoceptive sensibility and intuitive eating in obesity management in/beyond the bariatric context.

KEYWORDS

bariatric surgery, disordered eating, interoceptive sensibility, intuitive eating, obesity

Highlights

- Few studies address interoceptive sensibility, disordered and intuitive eating in relation to obesity management in and beyond the bariatric context.

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- The present study assessed and demonstrated group differences and interrelations between interoceptive sensibility dimensions, disordered and intuitive eating among bariatric candidates, operated individuals and individuals with obesity seeking nonsurgical weight loss.
- Interoceptive sensibility and intuitive eating appear to be promising psychotherapeutic targets in disordered eating and weight management in obesity and obesity surgery.

1 | INTRODUCTION

Obesity is often comorbid with Binge Eating Disorder (BED), Bulimia Nervosa and subclinical disordered eating behaviours (da Luz et al., 2018) that may nonetheless compromise healthy eating behaviour and weight (Tanofsky-Kraff & Yanovski, 2004). Restrained eating (food-centred cognitions and behaviours intended to reduce food intake and weight), emotional eating (food intake induced as a response to emotional states rather than physiological cues) and external eating (in response to external cues rather than internal physiological cues) are disordered eating behaviours highly associated to obesity and eating disorders (van Strien et al., 1986). In addition, as per the psychosomatic theories of obesity, individuals with obesity may lack the capacity to distinguish between anxiety and hunger (Kaplan & Kaplan, 1957) and rely more on external stimuli to eat rather than internal cues (van Strien et al., 1986).

Regarding internal cues, sensing, interpretation, and integration of bodily signals, that is, interoception (Khalsa et al., 2018) was found to be associated to obesity. Obesity may be characterised by hypersensitivity to hunger signals contributing to positive alliesthesia and undermined attempts to maintain healthy eating behaviour, and an incapacity to detect satiety causing positive energy balance (Simmons & DeVille, 2017). Interoceptive deficits were positively associated with BMI (Robinson, Marty, et al., 2021). Interoception is a multidimensional construct, wherein interoceptive accuracy refers to behavioural performance on objective measures of body signal detection, whereas interoceptive sensibility is the subjective capacity, that is, the degree to which one engages in bodily signals. Lastly, interoceptive awareness is the metacognitive correspondence between interoceptive precision and sensibility (Garfinkel et al., 2015). Interoceptive deficits across dimensions and modalities are observed in eating disorders and related to emotional, external, restrained, and subclinical binge eating. Nevertheless, evidence regarding the role of interoception in disordered eating is limited (Martin et al., 2019).

Disordered eating behaviours progressively reappear post bariatric surgery and their underlying mechanisms are unclear (Ivezaj et al., 2021). Preoperative disordered eating has been linked to long-term post-operative

disordered eating behaviours (Martin-Fernandez et al., 2021), although pre-operative binge eating had no effect on post-surgical weight-loss up to 60 months after surgery (Kops et al., 2021). Among bariatric surgery candidates, higher interoceptive dysregulation was associated to binge eating symptoms and emotional eating (Cella, Cipriano, et al., 2019; Willem et al., 2021). However, few studies assess subjective interoception post bariatric surgery. 2 years post gastric bypass, poor subjective interoception was reported with binge eating symptoms among 27% of the sample (Beck et al., 2012).

One-form of adaptive eating gaining research and clinical interest is intuitive eating, that is, eating in response to physiological cues of hunger and satiety (Tylka, 2006), which is also considered as a measure of subjective interoception specific to food sensations (Martin et al., 2019). Lower self-reported interoceptive accuracy was found to be associated with lower intuitive eating and higher emotional eating. The authors believed this behavioural tendency to explain the link between poorer self-reported interoceptive accuracy and higher BMI in a sample composed of 53% individuals with overweight and obesity (Robinson, Marty, et al., 2021). Among individuals with obesity, intuitive eating was found to be negatively correlated to body weight, BMI, emotional eating, waist-height and waist-hip ratios (Ayyıldız et al., 2023). Post-bariatric surgery, intuitive eating was associated to weight loss (Nogué et al., 2019) and a healthier relationship with food (Virani et al., 2019). However, studies assessing intuitive eating in relation to interoception and disordered eating behaviour in the bariatric field are rare.

To address the gaps in the literature pertaining to the links between subjective interoception, adaptive intuitive and disordered eating behaviour in the obesity and bariatric context, we aimed to assess the differences between individuals with obesity seeking nonsurgical weight loss, bariatric surgery candidates and operated individuals. Anxiety and depression symptoms were evaluated to statistically control potential group differences. We hypothesised that operated individuals would manifest better interoceptive capacities and higher adaptive intuitive eating, and that intuitive eating would mediate the relationship between interoceptive sensibility dimensions and binge eating among the study groups.

2 | METHOD

2.1 | Study design and participants

In this study, 163 adults were recruited on a voluntary basis between January to December 2022. French-speaking adults with obesity having undergone or preparing to undergo bariatric surgery and opting for non-surgical weight-loss were eligible to participate. Participants were separately recruited into three groups: individuals with obesity opting for nonsurgical weight-loss (IOB), bariatric surgery candidates in preparation for a bariatric surgery (Pre) and operated individuals (Post). The IOB group, recruited upon their arrival at the Nutrition unit of a Physical rehabilitation centre, included 57 participants (Mean age = 50.3 ± 12.7 , Mean BMI = 37.9 ± 5.34 , 82.5% female, 10.5% on current dietary regime). The Pre group, recruited upon their arrival to a Therapeutic-Education Programme as a part of their preparation for bariatric surgery at the Nutrition Unit, included 84 participants (Mean age = 40.5 ± 10.3 , Mean BMI = 42 ± 5.63 , 88.1% female, 8.3% on current dietary regime, average preoperative preparation duration in months = 7.95 ± 4.67). The Post group, recruited at bariatric surgery units included 22 participants (Mean age = 38.3 ± 8.41 , Mean BMI = 28.8 ± 5.20 , 95.5% female, 4.5% on current dietary regime, average postoperative preparation duration in months = 28.6 ± 27.1). Exclusion criteria were neurological, psychotic, and cognitive impairment disorders, multiple/corrective bariatric surgeries. The postoperative participants underwent the following operation types: sleeve gastrectomy (54.5%), gastric bypass (36.4%), mini gastric bypass (4.5%) and gastric banding (4.5%). Informed consent was obtained after the participants being informed regarding the study's procedure, affiliations, their right to refuse/withdraw without retaliatory action conforming to the Declaration of Helsinki. The duration of the protocol was approximately 30 min.

2.2 | Measures

2.2.1 | Interoceptive sensibility

The French validation of the *Multidimensional Assessment of Interoceptive Awareness* (Mehling et al., 2012; Willem et al., 2022), a 32-item self-report measure of interoceptive sensibility, was employed. Scores across 8 dimensions on a 6-point scale range from 0 (never) to 5 (always): (a) Noticing (noticing neutral, comfortable, uncomfortable bodily sensations), (b) Not Distracting and (c) Not Worrying (not ignoring or worrying about painful/uncomfortable sensations), (d) Attention Regulation

(focussing and sustaining attention on bodily sensations), (e) Emotional Awareness (attributing body sensations to emotional states), (f) Self-regulation (managing psychological distress by attending to bodily signals), (g) Body listening (actively listening to bodily sensations for insight), (viii) Trusting (considering bodily sensations as safe and trustworthy). Appropriate-to-good internal consistency for 6/8 subscales was observed in the French validation study ($\alpha = 0.42\text{--}0.87$). 'Not-Distracting' and 'Not-Worrying' had the lowest internal consistency, like previous validations.

2.2.2 | Intuitive eating

The 18-item *Intuitive Eating Scale-2* (Camilleri et al., 2015; Tyłka, 2006), with responses ranging from 'strongly disagree' to 'strongly agree', was employed. It contains the following dimensions: (a) Eating for physical reasons, that is, eating in response to physical cues of hunger rather than emotional ones; (b) Reliance on hunger and satiety cues, that is, trusting and using physical cues of hunger and satiety and finally, (c) Unconditional permission to eat, that is, the willingness to eat in the face of hunger without labelling foods as being unacceptable or acceptable. The internal consistency of the French version is adequate ($\alpha = 0.79$).

2.2.3 | Eating behaviour

The 33-item *Dutch Eating Behaviour Questionnaire* (Brunault et al., 2015; van Strien et al., 1986) evaluates emotional eating, externality and restricted eating. Higher scores endorse higher eating behaviour for each dimension. Cronbach alpha coefficients range from good to excellent (0.81–0.90) for the French validation employed in the current study. The 16-item *Binge Eating Scale* (Brunault et al., 2016; Gormally et al., 1982) can be interpreted dimensionally or categorically with a cut-off score of 18 with a higher score indicating clinically significant binge eating. Internal consistency was found to be excellent for the French version ($\alpha = 0.88$).

2.2.4 | Depression and anxiety symptoms

The 21-item *Beck's Depression Inventory* (Beck et al., 1961) was employed, with higher scores indicating greater depressive symptoms with items ranging from 0 to 3. The French validation (Bourque & Beaudette, 1982) showed excellent internal consistency ($\alpha = 0.92$). The trait anxiety form of the *State-Trait Anxiety Inventory*

(Spielberger, 1983) was employed (range: 20–80). The French validation of the trait form showed excellent internal consistency ($\alpha = 0.91$) (Gauthier & Bouchard, 1993).

2.3 | Statistical analyses

The 'Jamovi' software was used to conduct statistical analyses. Missing data for even one outcome variable resulted in the participant's exclusion as the data sets were eliminated. The descriptive statistics were computed. Correlational analyses were conducted for the outcome variables for the three study groups respectively. An analysis-of-variance (ANOVA) was employed to test the group differences, followed by Tukey's Post-hoc test, after which an analysis-of-covariance (ANCOVA) was conducted with age as a covariate, to control its confounding effect, for the significantly different variables across the groups as per the univariate analysis. Simple mediational models were conducted to assess the mediating role of intuitive eating in the relationship between interoceptive sensibility dimensions and binge eating.

3 | RESULTS

Group differences were evaluated for age, anxiety, and depression scores to avoid confounding bias. The effect of age was found to be significant, and we found no significant differences for anxiety and depression scores. Table 1 presents the significant group differences; we presented the significant data to be concise. The Post group reported higher scores than IOB for MAIA 'Noticing', 'Emotional Awareness', 'Body Listening' and 'Trusting'. With regards to the MAIA, the Post group showed higher scores than the Pre group on 'Emotional Awareness' and 'Trusting'. In terms of the IES total score, the Post group had higher scores than IOB and the Pre group. The IOB group manifested higher scores than the Pre group on binge eating and emotional eating. The Post group presented higher scores for 'Reliance on hunger and satiety cues' in comparison with IOB and Pre groups; the Pre group scored higher than the IOB group. Group differences remained significant for all variables except MAIA 'Noticing' when age was controlled for. Significant results of correlational analyses significant for further analyses for the IOB, Pre and Post groups, respectively are presented in Tables 2–4. Mediational analyses were performed using a simple mediational model to assess the mediating role of intuitive eating in the relationship between interoceptive sensibility dimensions and binge eating. No mediations were found for the IOB and Pre groups. In the Post group, intuitive

eating was found to significantly mediate the respective relationships between MAIA 'Attention regulation', Self-regulation', 'Body Listening' and 'Trusting' with binge eating (Table 5).

4 | DISCUSSION

The objective of the current study was to assess the links between interoceptive sensibility, intuitive and disordered eating among individuals with obesity opting for nonsurgical weight-loss (IOB), bariatric surgery candidates (Pre) and individuals having undergone bariatric surgery (Post), respectively.

Overall, the Post group manifested higher capacities to listen to, trust and attribute bodily sensations to emotions and higher adaptive intuitive eating, compared to the IOB group. When age was controlled for, the differences remained significant, except for 'Noticing'. Previously, detection of cardiac interoceptive signals has been negatively correlated to age (Khalsa et al., 2009). These results could be, in part, attributed to the weight loss after bariatric surgery. Indeed, the mean BMI of the postoperative group was significantly lower than the IOB and Pre groups ($M = 28.8$), also indicating overweight but not obesity as per the diagnostic criteria (WHO, 2021). Our results are partly in line with previous studies, but do not confirm the role of BMI in subjective interoceptive abilities and eating behaviour across the study groups, given the absence of significant correlations. Previously, higher BMI was found to be associated to interoceptive deficits (Robinson, Marty, et al., 2021). However, most of the studies included in this meta-analysis measured objective cardiac interoceptive accuracy, whereas the few studies measuring subjective interoception employed *Porges' Body Perception Questionnaire* (BPQ, Porges, 1993). Indeed, self-report questionnaires of interoceptive sensibility (including the BPQ and the MAIA) showed inexistent to moderate correlations, suggesting that they measure different aspects of subjective interoception (Desmedt et al., 2022). On the other hand, poor self-reported interoceptive accuracy predicted higher BMI and was associated to lower intuitive eating (Robinson, Marty, et al., 2021). Assessing the direction of the relationship of BMI, subjective interoception and eating behaviour in future studies seems promising, considering that obesity is associated to hypersensitivity and hyposensitivity to interoceptive signals of hunger and satiety, respectively (Simmons & DeVile, 2017). The further evaluation of these associations post-surgery is warranted, given that according to previous studies, bariatric surgery is associated to structural and functional postsurgical neural modifications suggesting an improved

TABLE 1 Significant group differences.

	Bariatric surgery candidates (pre)	Postoperative patients (post)	Individuals with obesity (IOB)	Group comparison	Post-hoc (Tukey)
	Mean ± SD				
Age	40.5 ± 10.3	38.3 ± 8.41	50.3 ± 12.68	F (2, 63.3) = 14.6, p < 0.001	
BMI	42 ± 5.63	28.8 ± 5.20	37.9 ± 5.34	F (2, 59) = 53.8, p < 0.001	IOB-post, M = 9.14, p < 0.001 IOB-pre, M = -4.07, p < 0.001 Post-pre, M = -13.21, p < 0.001
MAIA					
Noticing	3.15 ± 0.98	3.56 ± 0.66	2.94 ± 1.09	F (2, 69.3) = 4.95, p = 0.01	IOB-post, M = -0.618, p = 0.04
Emotional awareness	3.07 ± 1.20	3.87 ± 0.70	3.20 ± 1.09	F (2, 73) = 8.83, p < 0.001	IOB-post, M = -0.673, p = 0.04 Post-pre, M = 0.801, p = 0.008
Body-listening	1.99 ± 1.12	2.59 ± 1.29	1.71 ± 1.04	F (2, 55.6) = 4.27, p = 0.02	IOB-post, M = -0.883, p = 0.006
Trusting	1.63 ± 1.24	2.65 ± 1.13	1.94 ± 1.11	F (2, 59.4) = 6.71, p = 0.002	IOB-post, M = -0.716, p < 0.05 Post-pre, M = 1.017, p = 0.001
IES-2					
Reliance on hunger and satiety cues	3.14 ± 0.98	3.94 ± 0.48	2.71 ± 0.93	F (2, 80.9) = 31.3, p < 0.001	IOB-Post, M = -1.23, p < 0.001 IOB-Pre, M = -0.425, p = 0.03 Post-pre, M = 0.801, p < 0.001
IES total score	3.06 ± 0.65	3.33 ± 0.70	2.78 ± 0.71	F (2, 56.7) = 5.48, p = 0.007	IOB-post, M = -0.548, p = 0.004 IOB-pre, M = -0.282, p = 0.04
DEBQ					
Emotional eating	2.45 ± 1.07	2.47 ± 1.14	2.92 ± 1.11	F (2, 56.7) = 3.23, p = 0.047	IOB-Pre, M = 0.464, p = 0.04
BES	25.1 ± 11.90	27.2 ± 8.31	31 ± 8.58	F (2, 64.1) = 5.99, p = 0.004	IOB-pre, M = 5.91, p = 0.003

Note: The bold values in the table are statistically significant results.

Abbreviations: BES, Binge Eating Scale; BMI, Body Mass Index; DEBQ, Dutch Eating Behavior Scale; IES-2, Intuitive Eating Scale 2; MAIA, Multidimensional Assessment of Interoceptive Awareness.

TABLE 2 Correlation analyses for bariatric surgery candidates (Pre).

	Not-worrying	Attention regulation	Emotional awareness	Self-regulation	Body listening	Trusting	EPR	RHS	UPE	IES
EPR	0.21	0.12	-0.19	-0.003	0.06	0.27*	-	-	-	-
RHS	0.21	0.04	0.12	0.26*	0.24*	0.29*	0.39***	-	-	-
UPE	0.17	0.18	0.08	-0.004	-0.05	0.15	0.01	-0.21	-	-
IES	0.30**	0.15	-0.04	0.13	0.15	0.37**	0.87***	0.71***	0.19	-
BES	0.03	0.22*	0.23*	0.19	0.19	-0.10	-0.79***	-0.37***	-0.07	-0.74***

Note: The bold values in the table are statistically significant results.

Abbreviations: BDI, Beck's Depression Inventory; BES, Binge Eating Scale; EPR, Eating for Physical Rather than Emotional reasons; IES, Intuitive Eating Scale Total score; RHS, Reliance on Hunger and Satiety cues; STAI, State-Trait Anxiety Inventory-Y form; UPE, Unconditional Permission to Eat.

TABLE 3 Correlation analyses for post-operative patients (Post).

	Not worrying	Attention regulation	Self-regulation	Body listening	Trusting	EPR	RHS	UPE	IES
EPR	0.57**	0.51*	0.63**	0.50*	0.61**	-	-	-	-
RHS	0.26	0.31	0.14	0.27	0.46*	0.43*	-	-	-
UPE	0.41	0.35	0.16	0.54**	0.56**	0.59*	0.60**	-	-
IES	0.55**	0.50*	0.48*	0.55**	0.67***	0.92***	0.69***	0.82***	-
BES	-0.36	-0.58**	-0.45*	-0.43*	-0.56**	-0.79***	-0.46*	-0.48*	-0.76***

Note: The bold values in the table are statistically significant results.

Abbreviations: BDI, Beck's Depression Inventory; BES, Binge Eating Scale; EPR, Eating for Physical Rather than Emotional reasons; IES, Intuitive Eating Scale Total score; RHS, Reliance on Hunger and Satiety cues; STAI, State-Trait Anxiety Inventory-Y form.; UPE, Unconditional Permission to Eat.

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

TABLE 4 Correlation analyses for individuals with obesity opting for nonsurgical weight loss (IOB).

	Not-worrying	Attention regulation	Emotional awareness	Body listening	Trusting	EPR	RHS	UPE	IES
EPR	0.23	0.24	-0.03	0.13	0.27*	-	-	-	-
RHS	0.21	0.11	0.06	0.02	0.13	0.47***	-	-	-
UPE	-0.05	0.20	0.09	-0.07	0.18	0.39**	0.19	-	-
IES	0.21	0.24	0.03	0.07	0.26	0.89***	0.76***	0.56***	-
BES	-0.37**	-0.27*	-0.10	-0.27*	-0.24	-0.68***	-0.58***	-0.04	-0.66***

Note: The bold values in the table are statistically significant results.

Abbreviations: BDI, Beck's, Depression Inventory; BES, Binge Eating Scale; EPR, Eating for Physical Rather than Emotional reasons; IES, Intuitive Eating Scale Total score; RHS, Reliance on Hunger and Satiety cues; STAI, State-Trait Anxiety Inventory-Y form.; UPE, Unconditional Permission to Eat.

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

perception of the body's energy status, enhanced attention to internal states such as hunger and satiety 1-month and 3-month post sleeve gastrectomy (Wang et al., 2020). Moreover, our results pinpoint the need to evaluate factors other than BMI which may explain the pre- and post-operative interoceptive differences.

Our results demonstrated that the Post group scored higher on the dimensions of 'Emotional Awareness', 'Trusting' and 'Reliance on hunger and satiety' compared to surgery candidates. We hypothesise that due to improved capacities to perceive and especially listen to

interoceptive sensations post-surgery, operated individuals may have a heightened capacity to categorise bodily sensations into emotion-related and food sensations. Indeed, this clarity would reduce emotional dysregulation and food-consumption in the face of unpleasant emotions (Willem et al., 2021). Alternatively, an increased capacity to attribute bodily signals to emotions (as reflected by the 'Emotional awareness' interoceptive sensibility component) would be associated to higher 'Reliance on hunger and satiety cues' among operated individuals. Among individuals with obesity, an

TABLE 5 Mediation effect of intuitive eating total score on interoceptive sensibility dimensions and binge eating among postoperative patients.

	Indirect effect (a*b)					Total effect (c)		Direct effect (c')		
	β	SE	t	p	CI	Mediation %	β	p	β	p
AR > IES > BES	-2.91	1.28	-2.28	0.02	-5.42, -0.407	54.2%	-5.37	<0.001	-2.46	0.078
SR > IES > BES	-3.14	1.40	-2.242	0.03	-5.89, -0.396	75.1%	-4.19	0.02	-1.04	0.471
BL > IES > BES	-2.642	1.04	-2.537	0.01	-4.68, -0.601	94.09%	-2.808	0.02	-0.166	0.88
TR > IES > BES	-3.459	1.23	-2.819	0.005	-5.86, -1.05	84.9%	-4.072	0.002	-0.613	0.65

Note: The bold values in the table are statistically significant results.

Abbreviations: AR, Attention regulation; BES, Binge Eating Scale; BL, Body-listening; IESIntuitive, Eating Scale-2 Total Score; SR, Self-regulation; TR, Trusting.

increased self-reported ability to be aware of internal signals without the capacity to trust, positively consider and use internal sensations in guiding eating behaviour would increase emotional dysregulation and emotional eating (Willem et al., 2021). In the Post group, discriminating emotion and food-related sensations would facilitate adaptive eating behaviour in comparison to the other groups. These findings suggest the significant role of multiple interoceptive sensibility dimensions in eating behaviour in obesity and weight loss and would merit further analysis.

Bariatric surgery candidates relied more on hunger and satiety sensations, showed higher intuitive eating ability, and lower scores on emotional and binge eating compared to the IOB group. Despite the pre-surgical group (Mean BMI = 42) having a higher mean BMI than the nonsurgical group (mean BMI = 37.9), higher intuitive eating and lower emotional and binge eating could be a result of preoperative care, behavioural modifications and weight loss prior to bariatric surgery required by insurance-mandated physicians in several countries, including the geographical area covered by the present study. Indeed, in France, bariatric surgery is considered as a second line treatment after a treatment period with an average duration of 6–12 months, which is composed of medical, dietary, nutritional, and psychological treatment. The initial treatment, in preparation for surgery, commences with a preliminary consultation with the referring surgeon or physician who evaluates the treatment appropriateness. The patient is then required to pursue somatic and psychological assessment and treatment via a personalised Therapeutic Education programme, implemented by a multidisciplinary team composed of obesity physician(s), dietician(s), psychologist(s) and/or psychiatrist(s), etc. Lastly, the patient is informed of the outcome of the multidisciplinary consultations, in terms of treatment appropriateness.

The main goals of the Therapeutic Education programme for bariatric preparation are to help the patient

modify his/her eating behaviour prior to surgery through food rebalancing, stabilise the individual's weight, optimise the potential surgery's efficiency, plan a physical activity programme, and receive necessary psychotherapeutic treatment, besides other individualised goals set during the programme (HAS, 2009). Previously, lifestyle based interventions have shown to promote weight loss prior to bariatric surgery compared to usual care (Kalarchian et al., 2013). Moreover, presurgical candidates' motivation to be cleared for and pursue bariatric surgery would reinforce these changes. Candidates believe surgery to improve obesity-related comorbidities, induce positive psychosocial impacts, strengthen personal identities, improve social status, as well as engagement in the public and professional domains, and only some candidates acknowledged the personal efforts required to maintain weight-loss (Cohn et al., 2019). The expected returns of bariatric surgery would explain the active engagement in presurgical modifications, explain higher adaptive intuitive eating and lower disordered eating among presurgical candidates. Despite the treatment course, intuitive eating would serve as a promising therapeutic target in obesity management associated with lower disordered and binge eating longitudinally, better psychological health (Hazzard et al., 2021) and higher weight-loss post bariatric surgery (Nogu e et al., 2019).

Interestingly, despite higher interoceptive sensibility and intuitive eating observed among operated individuals in the present study, no significant differences were observed in disordered eating in comparison with Pre and IOB groups. However, intuitive eating was found to play a mediating role in the relationship of interoceptive sensibility dimensions with binge eating, specifically 'Attention regulation' (54.2%), 'Self-regulation' (75.1%), 'Body Listening' (94.09%) and 'Trusting' (84.9%) only among the operated individuals. Surprisingly, no significant results were obtained for the mediational analyses in the Pre and IOB groups, despite the strong mediations observed in the Post group. These results could be

explained by the significantly lower scores of Pre and IOB groups on the interoceptive and intuitive dimensions. Thus, attending to, trusting and using general bodily signals for self-regulation but particularly food sensations of hunger and satiety seems to reduce binge eating among post-operative individuals, in line with previous work (Willem et al., 2021). In the current study, the mean postoperative duration was that of 28.6 months with a minimum postoperative duration of 7 months and a maximum of 109 months. In line with previous studies, it could be inferred that disordered eating reappears progressively long-term post-surgery (Ivezaj et al., 2021) despite the contributing, mediating role of intuitive eating in the relationship between subjective interoceptive dimensions and binge eating.

Other mediators and moderators of this relationship such as emotional regulation, impulsivity, self-esteem, postoperative body image, etc. would merit investigation. Along these lines, among presurgical candidates, a path starting from self-esteem which indirectly affects interoceptive deficits, then associated to impulse regulation difficulties contributing to binge eating, was identified (Cella, Cipriano, et al., 2019). These factors merit further research among postoperative patients. Additionally, the diminishing of hunger cues post-surgery and excessive dietary restraint to lose more weight might explain emotional and binge eating post-bariatric surgery (Ivezaj et al., 2021).

Definition and measurement of the development of post-operative binge eating or the persistence of preoperative binge eating is a complex task, given the varying physiological capacities due to postoperative anatomical changes. In the bariatric context, binge eating has been more broadly defined to include subjective binge eating along with objective binge eating, given that eating "objectively large amounts of food" might be subjectively perceived by operated individuals with significantly diminished ingestive capacities (Conceição et al., 2015). Emotional eating reduces 4–18 months post bariatric surgery whereas long-term results are mixed (Wong et al., 2020), given that patients appear to be able to accommodate increasingly large quantities of food over time (Sarwer et al., 2008). Thus, the treatment of disordered eating in postoperative weight management demands long-term therapeutic care. Intuitive eating has shown to be associated to weight-loss after bariatric surgery (Nogué et al., 2019). Moreover, higher intuitive eating post-bariatric surgery (3 months <5 years post-operation) was positively associated to higher meal satisfaction, mindful eating, self-efficacy pertaining to maintenance of and positive relationship with eating behaviours, taking time for relaxation, consistent physical activity; intuitive eating was negatively associated to emotional eating,

perceived stress, the fear of regaining weight, and prioritising others' needs before own's own (Virani et al., 2019).

The current study has some limitations. First, the study groups were unmatched on age and gender. However, age was controlled for as a covariate in our analyses. Indeed, obesity is most prevalent in women (Cooper et al., 2021) and males are particularly underrepresented in bariatric surgery populations, which is predominantly female (Olst et al., 2023). A potential confounding factor pertains to the medical, dietary, pharmacological, and psychological treatment received by the participants. Our samples were not screened for current or previous history of psychiatric diagnoses, other eating disorders (besides binge eating), and the effect of comorbid psychopathological conditions (besides anxiety and depression) was unaccounted for. Future longitudinal research would permit to establish causal links.

Assessing the present links amongst the same sample preceding and following the same surgical technique would provide an in-depth analysis of the relationships put forward by our current study. The present study is exploratory in nature and data replication on a larger sample, especially post-bariatric surgery, would shed light upon the interactions between variables.

To conclude, in the present study, we highlight the interoperability of subjective interoceptive and intuitive eating dimensions and their role in disordered eating behaviour especially post-bariatric surgery. Our data suggests the necessity of focussing upon bodily sensations, especially food-related sensations, in the management of eating behaviour. Future research should focus on the role of BMI, the development of refined measures of subjective interoception and accessible measures of gastrointestinal interoception, longitudinal assessment of the effect of specific bariatric procedures and obesity medication on subjective interoception, intuitive eating and disordered eating.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to report.

DATA AVAILABILITY STATEMENT

Data described in the manuscript, will be made available upon request pending.

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