ORIGINAL ARTICLE

Difficulties in emotion regulation and deficits in interoceptive awareness in moderate and severe obesity

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Abstract

Purpose Difficulties in emotion regulation and deficits in interoceptive awareness may be responsible for overeating and weight gain in obesity by increasing the risks of problematic eating behaviors. This study aimed to: (1) examine emotion regulation difficulties and interoceptive deficits in obesity; (2) compare the emotion regulation and interoceptive abilities of moderately and severely obese patients.

Methods Participants were recruited through the university, diabetology centers and bariatric surgery departments. A total of 165 participants were categorized in three groups, matched by age and gender, according to their Body Mass Index (BMI). The severely obese (SO), moderately obese (MO) and normal weight (NW) groups were constituted of 55 participants each. Self-report questionnaires were used to assess emotion regulation difficulties (CERQ-DERS) and interoceptive awareness (MAIA-FFMQ).

Results Overall, obese participants reported more emotion regulation difficulties and less interoceptive awareness than NW participants did. They also reported a lack of planning strategies and emotional awareness, as well as less ability to observe, notice and trust body sensations. No differences in emotion regulation and interoceptive abilities were found between MO and SO participants.

Conclusions Emotion regulation and interoceptive awareness should be targeted in the psychotherapeutic care of obese people, regardless of their BMI.

Level of evidence Level III, case-control analytic study.

Keywords Obesity · BMI · Emotion regulation · Difficulties in emotion regulation · Interoception · Interoceptive awareness

Introduction

Despite improvements in the prevention and treatments available for obese people, the prevalence of men and women suffering from obesity has dramatically increased over the past decades [1, 2], underlining the fact that

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new understanding of obesity and its management is still needed. Obesity is associated with a wide range of negative physical and psychological outcomes that tend to increase with the severity of obesity [3, 4]. Since the latter is associated with more comorbidities, new insights into the functioning of obese people with various forms and severity of obesity are required.

Among the numerous genetic, environmental and psychological factors involved in the etiology of obesity [5], emotion regulation difficulties and deficits in interoceptive awareness are increasingly thought to be co-occurring risk factors in its onset and maintenance [6, 7].

Emotion regulation can be defined as the combination of processes and skills involved in the management of emotional states, from their processing to their actual regulation [8, 9]. An appropriate processing of emotions implies being able to identify, understand and accept emotions, while an appropriate regulation of emotion involves the ability to use adaptive emotion regulation strategies, depending on the situation encountered and one's goals and values [10, 11]. Adaptive emotion regulation strategies are cognitive and behavioral processes that are used to modify emotions, without increasing the risks of negative outcomes. This is in contrast to maladaptive emotion regulation strategies, which are associated with negative long-term consequences if they are used too often or too rigidly [12, 13]. Such difficulties in emotion regulation have been linked with a wide range of mental and behavioral disorders [14].

Regarding obesity, a recent meta-analysis by Fernandes et al. [15] identified several impairments in emotion processing and regulation in obese people with and without binge-eating disorder. When compared to normal weight (NW) people, obese people do not have difficulties in identifying emotions in facial expressions or in describing their emotions [16–18]. However, they report more alexithymia, especially more difficulty in identifying emotions, less emotional awareness and less emotional intelligence abilities reflecting their effort to pay attention to, understand and regulate emotions [18–22]. Obese people, and particularly those with comorbid binge-eating disorders, also report limited access to adaptive emotion regulation strategies, such as cognitive reappraisal and acceptance [23–25]. Finally, compared to NW people, obese people report using more maladaptive emotion regulation strategies, especially emotional suppression [18, 23], which is known to increase the risk of negative affect and psychological distress [26]. The Body Mass Index (BMI) of obese participants in the studies included in the review by Fernandes et al. ranged between 31 and 47 and no studies have examined differences between moderate or severe forms of obesity. However, a recent study by Andrei et al. [27] found that the use of emotion suppression was a valid variable to differentiate the emotional functioning of moderately obese (MO) and severely obese (SO) people, the latter being more prone to suppress emotion.

It is well known that emotional states can affect eating processes such as motivation to eat, hunger, satiety and food intake [28]. Accordingly, several studies have linked emotion regulation difficulties with eating disorders and weight gain in both NW and obese people. Studies carried out in the general population found that an adaptive emotion regulation predicts healthier food choices and greater ability to resist overeating [29, 30] while emotion regulation difficulties such as alexithymia, a low level of emotional intelligence and the use of emotion suppression are associated with a greater tendency to overeat [31–34]. In addition, the longitudinal study carried out by Shriver et al. [35]. in adolescents suggests that a lack of emotion regulation abilities predict future increase in adiposity through more emotional eating. Meanwhile, difficulties in identifying and tolerating emotions, as well as overall emotion regulation difficulties, were associated with more problematic eating behaviors in obese people with and without binge-eating disorder [20, 36–39].

Beyond these emotion regulation difficulties which can lead to overeating and weight gain, a deficit in interoceptive awareness should also be addressed in obesity, particularly because of its links with emotion regulation skills and with the development or the maintenance of eating disorders [40–42]. Interoception corresponds to the perception of internal states and signals. Therefore, interoceptive awareness can be defined as the ability to precisely identify and discriminate bodily states and sensations [43, 44]. A recent model by Garfinkel et al. [45] identifies three components of interoception: interoceptive accuracy, i.e., objective ability to detect body signals; interoceptive sensitivity, i.e., the subjective view or knowledge that people have about their interoceptive abilities; and interoceptive awareness, i.e., the ability to make a correct prediction about interoceptive accuracy. Most of the previous literature assessed only some of these dimensions and used the general term "interoceptive awareness".

As reiterated in a recent review on interoception and psychopathology, interoceptive awareness plays a role in many higher-order abilities such as memory, learning, decision-making, and emotion processing [7]. A deficit in interoceptive awareness is associated with more difficulties in identifying emotions, which might increase the risk of emotion regulation difficulties [40]. Accordingly, several studies carried out in the general population have found that a deficit in interoceptive awareness is associated with more alexithymia, less differentiation of emotion in others, less empathy, less emotional reactivity, and less ability to downregulate negative emotions [46–52].

Regarding eating and weight gain, efficient interoceptive awareness is known to be crucial for regulating food intake [53, 54]. Studies conducted in participants suffering from

eating disorders found that a deficit in interoceptive awareness mediated the relationship between negative emotions and emotional eating [55]. Few studies have investigated the presence and the impact of low interoceptive ability on the onset and maintenance of obesity, but they shown that individuals with obesity have less interoceptive awareness than NW people and less mindfulness ability known to reflect interoceptive skills, especially the ability to observe and describe bodily states [56–58].

In accordance, mindfulness-based interventions, which goals are to increase the ability to focus on, approach and experience inner sensations such as hunger or emotions in an accepting/nonjudgmental manner, were successful in improving bodily awareness and reducing psychological distress as well as problematic eating behaviors in both eating disorders and obesity [59–61]. However, the BMI of participants in the studies exploring interoceptive awareness and mindfulness abilities in obesity were very heterogeneous and no distinctions were made between MO and SO.

The primary aim of our study was to examine both emotion regulation difficulties and interoceptive awareness in obese people. We expected obese people to present more emotion regulation difficulties and less interoceptive awareness than NW people. In addition, even though MO and SO people do not report the same psychological and physical burden and are often treated separately in different structures and with different objectives, very few studies have compared the psychological functioning of MO and SO [62, 63]. To our knowledge, only one study began to explore differences in emotion regulation of obese people by taking the severity of obesity into account [27], and no studies have yet addressed this question in the field of interoceptive awareness. Therefore, the second aim of our study was to assess and compare the levels of emotion regulation difficulties and interoceptive awareness of SO people and MO people. While negative outcomes of obesity tend to increase with its severity, we expected SO people to present more emotion regulation difficulties and less interoceptive awareness than MO people.

Methods

Participants and procedure

A total of 229 adult participants completed the study's self-report questionnaires on a voluntary basis. Participants who were identified as overweight ($25 \leq BMI < 30$) and those who have had a bariatric surgery were considered ineligible. Three groups were established on the BMI variable (calculated from self-reported height and weight) and a group-matching procedure was performed on age and gender. The final sample included 165 participants (mean age 41.83 ranging from 18 to 73; 76.4% female). The "normal weight" group (NW) included 55 participants with normal weight ($BMI < 25$; Mean BMI 21.9; mean age 38.64 ranging from 18 to 72; 80% female). The "moderately obese" group (MO) included 55 participants suffering from moderate levels of obesity ($30 \leq BMI < 40$; mean BMI 35.49; mean age: 43.71 ranging from 18 to 73; 74.5% female). The "severely obese" group (SO) included 55 participants suffering from a severe or morbid form of obesity ($BMI \geq 40$; mean BMI 45.54; mean age 43.15 ranging from 18 to 68; 74.5% female). 25.5% of participants in the NW group, 45.5% of participants in the MO group and 49.1% of participants in the SO group reported having psychological care in the past, while 12.7% of participants in the NW group, 41.8% of participants in the MO group and 49.1% of participants in the SO group reported having psychological care at the time of the study.

Data collection was carried out in the north of France. The NW sample was recruited trough the University of Lille. It was constituted of students, but also of university staff and of relatives of both students and university staff. The SO and MO participants were recruited in diabetology centers and bariatric surgery departments in the region. The participants had to certify being adult (age ≥ 18) and French-speaking before completing the study's questionnaires. The clinicians involved in the recruitment of obese participants were asked to assess that the participants did not present a severe comorbid disorder such as neurologic impairments, psychosis or characterized BED. All the participants provided their written informed consent. The study received the prior approval of the ethical committee of the University of Lille (2017-5-S57).

Measures

Emotion regulation

The Cognitive Emotion Regulation Questionnaire (CERQ) [64, French validation—65] was used to assess the cognitive aspect of emotion regulation. The CERQ is a 36-item self-report questionnaire with a 5-point Likert response format (from 1 "almost never" to 5 "almost always") evaluating nine cognitive emotion regulation strategies. Five of them are considered "adaptive strategies": (1) "acceptance" ($\alpha = 0.66$), (2) "positive refocusing" ($\alpha = 0.66$), (3) "refocus on planning" ($\alpha = 0.81$), (4) "positive reappraisal" ($\alpha = 0.74$), (5) "putting into perspective" ($\alpha = 0.74$). The other four are considered "maladaptive strategies": (6) "self-blame" ($\alpha = 0.73$), (7) "rumination" ($\alpha = 0.81$), (8) "catastrophizing" ($\alpha = 0.72$), (9) "blaming others" ($\alpha = 0.71$). Higher total scores indicate greater use cognitive emotion regulation strategies.

The Difficulties in Emotion Regulation Scale (DERS) [11, French validation—66] was used to assess difficulties in emotion regulation in a comprehensive manner. The DERS is a 36-item self-report questionnaire with a 5-point Likert format (from 1 "almost never" to 5 "almost always"), evaluating difficulties in six domains of emotion regulation: (1) nonacceptance of emotional response (nonacceptance) ($\alpha = 0.87$), (2) difficulties in adopting goal-directed behaviors (goal-directed) ($\alpha = 0.90$), (3) difficulties in controlling impulsive behaviors (impulses) ($\alpha = 0.85$), (4) lack of emotional awareness abilities (emotional awareness) ($\alpha = 0.84$), (5) limited access to emotion regulation strategies (limited access) ($\alpha = 0.87$), (6) lack of emotional identification or clarity (clarity) ($\alpha = 0.74$). Higher total scores indicate greater emotion regulation difficulties.

Interoceptive awareness

The Five Facets Mindfulness Questionnaire (FFMQ) [67, French validation—68] was used to assess interoceptive awareness through the filter of the mindfulness concept. The FFMQ is originally a 39-item self-report questionnaire with a 5-point Likert format (from 1 "never or very rarely true" to 5 "very often or always true"), evaluating five dimensions of mindfulness. For the purpose of the study, only two dimensions were used in the statistical analysis: (1) observing inner states (observe) ($\alpha = 0.78$), (2) describing inner states (describe) ($\alpha = 0.88$). Higher total scores indicate greater mindfulness abilities.

The Multidimensional Assessment of Interoceptive Awareness (MAIA) [69] was used to assess interoceptive awareness in a comprehensive way. The MAIA is a self-report questionnaire with a 6-point Likert format (from 0 "never" to 5 "always"), evaluating eight aspects of interoceptive awareness: (1) noticing ($\alpha = 0.69$), (2) not distracting ($\alpha = 0.66$), (3) not worrying ($\alpha = 0.67$), (4) attention regulation ($\alpha = 0.87$), (5) emotional awareness ($\alpha = 0.82$), (6) self-regulation ($\alpha = 0.83$), (7) listening ($\alpha = 0.82$), (8) trusting ($\alpha = 0.79$). Higher total scores indicate greater interoceptive awareness.

Statistical analyses

All analyses were performed using IBM SPSS statistics 23. A multivariate analysis of variance (MANOVA) was conducted on emotion regulation and interoceptive awareness variables, with BMI as the between-subject factor. Given its robustness to violation of assumptions in case of equal sample size [70]. Pillai's trace test statistic was used. For further investigation, univariate analysis of variance (ANOVAs) was conducted on emotion regulation and interoceptive awareness variables with BMI as the between-subject factor. Helmert contrasts, allowing the comparison of each group

with all subsequent group combined [70], were conducted to compare, as aimed, the NW group with the two other groups, and the MO group with the SO group. Applying Bonferroni correction for multiple testing, the level of significance was set to $\alpha = 0.02$. Following Cohen's guidelines [71] the effect size as measured by partial eta squared (η_p^2) was considered small when equal to 0.01, medium when equal to 0.06 and large when equal to 0.14.

Results

Group comparison

The MANOVA run on emotion regulation and interoceptive awareness variables using Pillai's trace showed a main group effect $V = 0.527$, $F(50;278) = 1.99$, $p = 0.00$. The effect size for this analysis was large, $\eta_p^2 = 0.26$. Separate univariate ANOVAs run on cognitive emotion regulation (measured by the CERQ) showed only a medium main group effect on the "refocus on planning" strategy and the "catastrophizing" strategy (see Table 1). Separate univariate ANOVAs run on emotion regulation difficulties (measured by the DERS) showed only a small main group effect on "impulse control" and a medium main group effect on "emotional awareness" (see Table 1). Separate univariate ANOVAs run on interoceptive awareness (measured by the MAIA and the FFMQ) showed a small main group effect on the abilities "observing" and "noticing" as well as a medium main group effect on the ability "trusting" (see Table 2).

Normal weight vs moderately and severely obese

Helmert contrasts conducted on cognitive emotion regulation (measured by the CERQ to compare NW and obese participants as a whole showed that NW displayed more "refocus on planning" $t(162) = 1.92$; $p = 0.00$, less "catastrophizing", $t(162) = -1.61$; $p = 0.00$, and more overall "adaptive strategies", $t(162) = 5.37$; $p = 0.01$, than obese participants (see Fig. 1a, b).

The comparison of difficulties in emotion regulation (measured by the DERS) between NW and obese participants as a whole showed that NW displayed less "impulse control" difficulty, $t(162) = -2.9$; $p = 0.00$, less "emotional awareness" difficulty $t(162) = -2.55$; $p = 0.00$, less "emotional clarity" difficulty $t(162) = -1.44$; $p = 0.01$, and less overall emotion regulation difficulty $t(162) = -9.27$; $p = 0.01$, than obese participants. (see Fig. 1c).

When NW and obese participants as a whole were compared on their interoceptive awareness (measured by the MAIA and the FFMQ) using Helmert contrasts, NW participants displayed more "observing" $t(162) = 2.44$; $p = 0.00$, "noticing", $t(162) = 1.55$; p = 0.02 and "trusting"

Table 1 Comparison of emotion regulation scores in normal weight (NW), moderately obese (MO) and severely obese (SO): mean (standard deviation), ANOVAs and Helmert contrasts

Measures	NW (N=55) M (SD)	MO (N=55) M (SD)	SO (N=55) M (SD)	F statistic	Significant Helmert contrasts	Effect size η_p^2
CERQ						
Acceptance	13.67 (3.08)	13.07 (3.37)	12.29 (3.33)	2.47		
Positive refocusing	10.80 (4.00)	10.51 (3.62)	10.65 (3.70)	0.08		
Refocus on planning	15.07 (2.72)	13.93 (3.54)	12.38 (3.98)	8.40**	NW > MO/SO	0.09
Positive reappraisal	13.44 (3.57)	12.53 (3.97)	12.35 (3.84)	1.30		
Putting into perspective	13.93 (3.49)	13.09 (3.54)	12.27 (3.67)	2.95		
Self-blame	10.62 (3.13)	10.45 (3.71)	9.53 (3.76)	1.51		
Rumination	13.38 (3.69)	12.55 (3.78)	11.85 (3.68)	2.32		
Catastrophizing	6.84 (2.48)	8.33 (3.18)	8.56 (3.09)	5.60*	NW < MO/SO	0.06
Blaming others	7.93 (2.37)	8.07 (2.76)	7.62 (3.44)	0.35		
Adaptive strategies	66.91 (12.62)	63.13 (12.98)	59.95 (14.9)	3.64	NW > MO/SO	
Maladaptive strategies	38.76 (7.53)	39.40 (9.73)	37.56 (10.41)	0.55		
DERS						
Nonacceptance	13.53 (5.46)	14.31 (5.88)	14.18 (6.45)	0.27		
Goal-directed	14.36 (5.22)	14.69 (5.05)	13.38 (4.89)	0.99		
Impulses	11.51 (4.10)	14.51 (5.72)	13.69 (6.21)	4.49*	NW < MO/SO	0.05
Limited access	17.89 (6.43)	20.16 (6.74)	20.22 (8.25)	1.87		
Emotional awareness	15.29 (4.21)	17.73 (4.47)	17.96 (4.53)	6.19*	NW < MO/SO	0.07
Clarity	10.15 (3.10)	11.76 (3.19)	11.10 (4.15)	3.20	NW < MO/SO	
Total score	82.73 (21.05)	93.16 (22.62)	90.84 (26.13)	3.02	NW < MO/SO	

*$p < 0.02$; **$p < 0.001$ for ANOVA

Table 2 Comparison of interoceptive awareness scores in normal weight (NW), moderately obese (MO) and severely obese (SO): mean (standard deviation), ANOVAs and Helmert contrasts

Measures	NW (N=55) M (SD)	MO (N=55) M (SD)	SO (N=55) M (SD)	F statistic	Significant Helmert contrasts	Effect size η_p^2
FFMQ						
Observing	27.67 (5.04)	25.91 (5.04)	24.56 (5.92)	4.26*	NW > MO/SO	0.05
Describing	27.87 (6.77)	26.09 (6.78)	25.85 (6.37)	1.51		
MAIA						
Noticing	13.65 (3.64)	11.45 (4.32)	12.75 (4.44)	3.89*	NW > MO/SO	0.04
Not distracting	7.14 (2.33)	7.11 (2.85)	6.49 (2.76)	1.78		
Not worrying	7.24 (2.86)	6.36 (3.34)	7.44 (3.25)	1.79		
Attention regulation	19.80 (6.95)	17.55 (7.06)	18.33 (8.33)	1.29		
Emotional awareness	16.40 (5.79)	15.45 (5.55)	16.42 (6.08)	0.49		
Self-regulation	11.11 (4.54)	9.22 (5.10)	10.95 (5.32)	2.41		
Body listening	7.65 (3.81)	5.87 (3.81)	7.27 (3.86)	3.55		
Trusting	8.91 (3.65)	6.24 (4.14)	7.13 (4.57)	5.93*	NW > MO/SO	0.06
Total score	92.20 (21.93)	79.25 (23.97)	86.76 (27.28)	9.19	NW > MO/SO	

*$p < 0.02$; **$p < 0.001$ for ANOVA
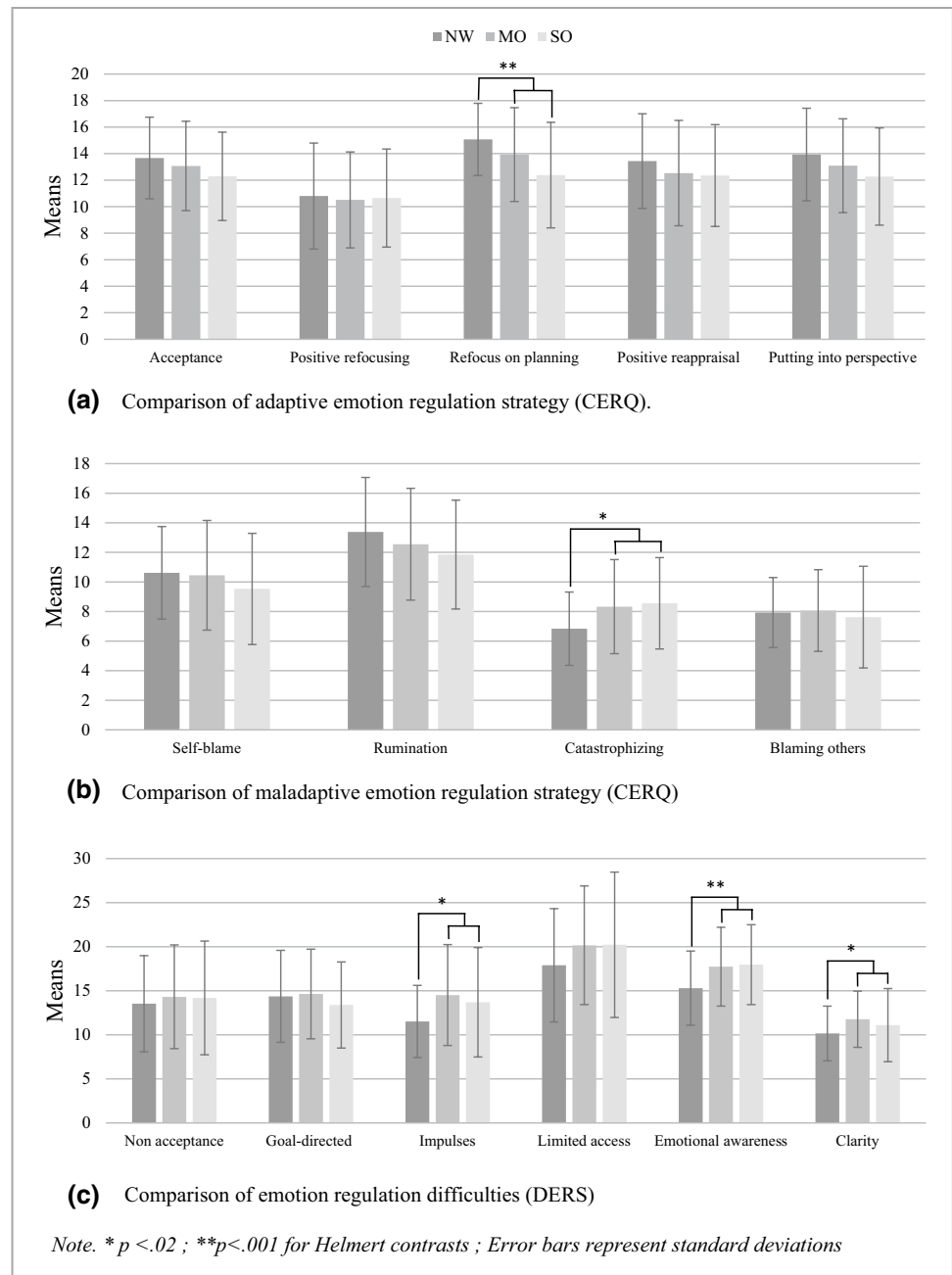
abilities $t(162) = 2.23$; $p = 0.00$, as well as more overall interoceptive awareness ability, $t(162) = 9.19$; $p = 0.02$, than obese participants (see Fig. 2a, b).

Moderately obese vs severely obese

Helmert contrasts conducted on cognitive emotion regulation measured by the CERQ to compare MO and SO groups showed no significant differences in terms of "adaptive

Fig. 1 Comparison of emotion regulation in normal weight (NW), moderately obese (MO) and severely obese (SO) groups
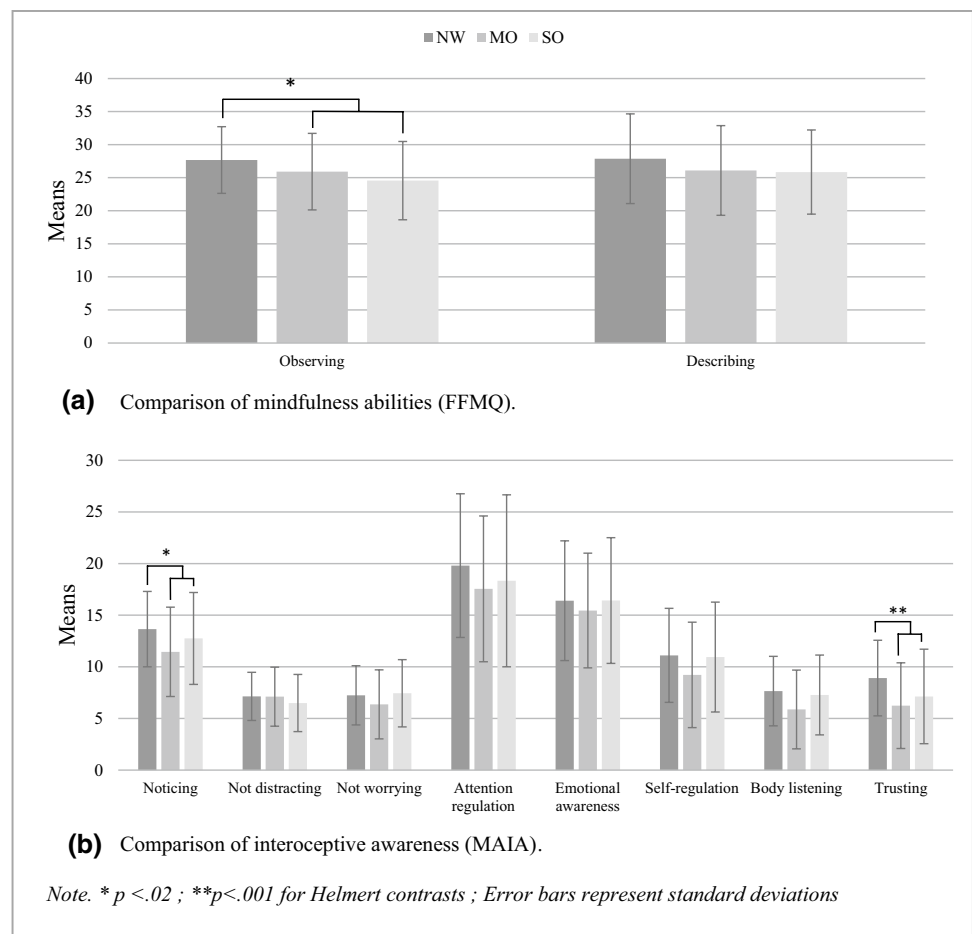

(a) Comparison of adaptive emotion regulation strategy (CERQ).

(b) Comparison of maladaptive emotion regulation strategy (CERQ)

(c) Comparison of emotion regulation difficulties (DERS)

*Note. * p <.02 ; **p<.001 for Helmert contrasts ; Error bars represent standard deviations*

strategies" $t(162) = 3.18$; $p = 0.24$, or "maladaptive strategies" $t(162) = 1.84$; $p = 0.38$. They showed no significant differences regarding "acceptance" $t(162) = 0.78$; $p = 0.23$, "positive refocusing" $t(162) = -0.15$; $p = 0.84$, "refocus on planning" $t(162) = 1.55$; $p = 0.03$, "positive reappraisal" $t(162) = 0.18$; $p = 0.25$ and "putting into perspective" $t(162) = 0.82$; $p = 0.25$, "self-blame" $t(162) = 0.93$; $p = 0.20$, "rumination" $t(162) = 0.69$; $p = 0.37$, "catastrophizing" $t(162) = -0.24$; $p = 0.67$ and "blaming others" $t(162) = 0.45$; $p = 0.47$.

The comparison of difficulties in emotion regulation (measured by the DERS) between MO and SO groups

showed no significant differences in terms of overall emotion regulation difficulties $t(162) = 2.33$; $p = 0.62$. They showed no significant differences regarding "nonacceptance of emotions" $t(162) = 0.13$; $p = 0.90$, "goal-directed" behaviors, $t(162) = 1.31$; $p = 0.16$, "impulse control" $t(162) = 0.82$; $p = 0.49$, "limited access" to adequate emotion regulation strategies $t(162) = -0.05$; $p = 0.97$, "emotional awareness" $t(162) = -0.24$; $p = 0.78$ and "emotional clarity" $t(162) = 0.36$; $p = 0.62$.

When MO and SO participants were compared on their interoceptive awareness (measured by the MAIA and the FFMQ) using Helmert contrasts, no significant differences

Fig. 2 Comparison of interoceptive awareness in normal weight (NW), moderately obese (MO) and severely obese (SO) groups

(a) Comparison of mindfulness abilities (FFMQ).

(b) Comparison of interoceptive awareness (MAIA).

*Note. * p <.02 ; **p<.001 for Helmert contrasts ; Error bars represent standard deviations*

in terms of overall interoceptive abilities were found $t(162) = -7.51$; $p = 0.13$. They showed no significant differences regarding the abilities "observing" $t(162) = 1.35$; $p = 0.23$, and "describing" $t(162) = 0.24$; $p = 0.86$, "noticing" $t(162) = -1.29$; $p = 0.13$, "not distracting" $t(162) = 0.62$; $p = 0.23$., "not worrying" $t(162) = -1.07$; $p = 0.10$, "attention regulation", $t(162) = -0.78$; $p = 0.61$, "emotional awareness" $t(162) = -0.96$; $p = 0.39$, "self-regulation" $t(162) = -1.73$; $p = 0.08$, "body listening" $t(162) = -1.40$; $p = 0.07$, and "trusting" $t(162) = -0.89$; $p = 0.28$.

Discussion

The first aim of our study was to examine both emotion regulation difficulties and interoceptive awareness in people suffering from obesity. We expected obese people to exhibit both more emotion regulation difficulties and less interoceptive awareness than NW people. Compared to the latter, obese people used significantly fewer cognitive emotion regulation strategies regarded as adaptive. These results are in line with the meta-analysis of Fernandes et al. [15] and the study of Kass et al. [22], supporting a limited access to

adaptive emotion regulation strategies and a lesser tendency to try to alter negative emotions in obesity. In addition, obese people used less refocusing on planning than NW people, which suggests that they are less prone to regulating their emotional states by thinking of how they can cope with a negative event. The medium effect size of the differences between the three groups NW, MO and SO moreover suggests that refocus on planning account for a substantial part of BMI variation, with lower refocus on planning being associated with higher BMI. These results are consistent with previous findings that showed deficits in problem-solving and planning skills in obese individuals that played a role in their weight maintenance [72–74].

Unlike previous authors studying adolescents and adults suffering from obesity [23–25, 75], we did not evidence less reliance on reappraisal and acceptance strategies in obese people. However, our data are concordant with the recent results of Andrei et al., [27] who did not find any significant difference between NW and obese people regarding the use of reappraisal. In their meta-analysis, Fernandes et al. also suggested that a limited access to reappraisal and acceptance strategies might be more typical of obese people with comorbid BED than those without. Clinicians involved in

the recruitment of obese participants were careful to propose the study only to patients who did not have comorbid major disorders, such as BED. Although BED was not directly assessed in the present study, it is likely that only a very low percentage of our obese participants presented BED. However, additional psychometric assessment of BED would have been required to confirm the results.

Unexpectedly, we did not find greater general use of cognitive emotion regulation strategies regarded as maladaptive in obese people. However, they may resort to other maladaptive emotion regulation strategies than those measured by the CERQ, such as emotional eating. Indeed, many overweight and obese people are known to present emotional eating [20, 76, 77], and emotional eating can itself be regarded as a maladaptive emotion regulation strategy in which the consumption of food serves to downregulate negative emotions. If the favorite emotion regulation strategy of obese people is to eat to alleviate their negative emotions, it is likely that they do not resort to other maladaptive strategies.

Moreover, our results show that obese people report significantly more catastrophizing than NW people do, which suggests that they are more likely to attempt to regulate their emotions by overestimating the severity and the negativity of unpleasant events. This result is not surprising given that the catastrophizing strategy is known to be strongly associated with depressive symptoms [78] and that obese people have an increased risk of depression [79, 80]. It would also be interesting in further studies to control levels of depression in obese people, to determine whether catastrophizing should be considered more a risk factor for comorbid depression in obesity or rather a consequence of depressive symptoms.

The DERS showed that obese people presented more overall emotion regulation difficulties than NW people. Obese people reported greater difficulty in controlling impulsive behaviors if they experienced negative emotions, which is consistent with previous studies linking impulsiveness and negative urgency with obesity, overeating tendencies, and weight gain [81–85].

Emotional processing was also impaired in obese people, who reported significantly less emotional awareness and less emotional clarity than NW people did. These findings are concordant with previous results highlighting difficulties in paying attention to, identifying and understanding emotions in obesity [18–20, 22]. The "emotional awareness" subscale of the DERS also revealed a deficit in emotional awareness in obese people. However, the results of the MAIA's subscale "emotional awareness" did not confirm this deficit. This could be due to the fact that several items of the MAIA subscale refer to the awareness of positive emotions (e.g., item 21: *"I notice that my breathing becomes free and easy when I feel comfortable"*), whereas the DERS subscale items refer to the awareness of more negative emotions. Therefore,

obese people might exhibit significant difficulties in being aware of negative emotional states but are still able to notice positive ones. This would be concordant with the results of Cserjési et al. [86], who found that obese people were less able to process facial expression reflecting negative emotions, but experienced no deficits in processing positive facial expressions. Consequently, we hypothesize that some of the emotional awareness deficits observed in obesity may be due to a mechanism whereby negative affects are avoided rather than to a global impairment of emotion information processing. Further research comparing the levels of emotional awareness of positive and negative emotions in obesity are needed to confirm this hypothesis. It would be interesting from a clinical point of view to go even further and investigate the way obese people process specific emotions such as anger or sadness, to adjust and enhance psychotherapeutic interventions.

Regarding other interoceptive awareness abilities, our results show that obese people are significantly less attentive to their bodily sensations and have greater difficulty in noticing their bodily states than NW people. This is in line with previous studies that revealed a deficit in interoceptive awareness in obesity [56, 57, 87].

Unlike Nikoogoftar (2018), we did not evidence greater difficulty in describing bodily sensations in obese people. However, this preserved ability to describe bodily sensation is concordant with the results of studies on alexithymia in obesity, which found that obese people did not find it more difficult to express and describe their feelings than NW people [17, 18]. This suggests that obese people have difficulty in paying attentions to their bodily signals and in noticing when a change occurs in their bodily sensations, but that they are able to put words on the sensations they still perceive.

In addition, our obese subjects had greater difficulty in trusting and using their bodily sensations to adjust their behaviors. The medium effect size of the differences between our three groups indicate an accountable implication of the ability to trust bodily states on BMI variation. Few studies have used the MAIA to assess interoceptive awareness so far and, to our knowledge, no previous studies have used the MAIA in a sample of obese individuals. However, in their study on eating disorders, Brown et al. [88] found that the MAIA subscale "trusting" was strongly associated with eating disorder symptoms and that the participants who had the highest ability in trusting their bodily state also reported the lowest levels of emotion dysregulation, alexithymia and anxiety. In addition, Calì et al. [89] found that the presence of both attention regulation and trusting abilities, as measured by the MAIA, predicted less emotional susceptibility and vulnerability in the general population. The ability to trust bodily sensations appears to be highly relevant for assessing interoceptive awareness and its consequences. Beyond an

actual deficit in interoceptive accuracy or awareness, if obese people do not consider the messages sent by their body as useful, it could explain why they do not pay more or sufficient attention to their bodily states and why they experience difficulties in adjusting their emotion regulation. Calì et al. even argued that increasing the observation of bodily sensations might increase the risk of emotional distress if self-regulation and trusting abilities are not increased as well. Therefore, it appears essential to help obese people listen to, but especially to trust and use efficiently, their bodily signals when receiving psychological treatment.

The second aim of our study was to compare the levels of emotion regulation difficulties and interoceptive awareness of severely and moderately obese people. We expected severely obese people to exhibit more emotion regulation difficulties and less interoceptive ability than moderately obese people. Contrary to our hypothesis, we did not evidence any significant differences between moderately and severely obese people in terms of emotion regulation difficulties or interoceptive awareness. To our knowledge, very few studies have compared the psychological functioning of moderately and severely obese people. Andrei et al. found that people with class III obesity (BMI $\geq$ 40) were more prone than obese people in the lowest obesity class and NW people to use emotion suppression, but did not find any other significant differences between BMI class regarding emotion regulation. Our result is somewhat counterintuitive, but is interesting from a clinical point of view. Indeed, the medical and psychological care available for obese people appears to be very different depending on the degree of obesity. For instance, severely obese people may be candidates for bariatric surgery, are often treated differently from moderately obese people and usually find it easier to obtain medical and psychological treatment. This suggests that obese people could benefit from psychotherapeutic interventions targeting emotion regulation and interoceptive abilities regardless of their BMI. Such interventions could even take the form of psychotherapeutic groups including both moderately and severely obese patients. The emotional and interoceptive difficulties of these patients could be caused by different mechanisms and have different consequences depending on the severity of the symptoms. Severely and moderately obese people may also differ in terms of other psychological mechanisms and psychological risk factors than those we assessed. These issues need to be addressed in future research.

Although our study has several strengths including the examination of psychological processes across the spectrum of severity, it has some limitations. First, the use of self-report questionnaires to evaluate emotional and interoceptive abilities may induce several biases, such as those related to social desirability and discrepancies between perceived and actual abilities. In addition, the BMI of the participants were calculated from self-reported height and weight. Adult participants having tendency to overestimate their height and under-estimate their weight [90], it is possible that the actual BMI of some participants were higher than those we calculated. More objective and ecological measures of emotion regulation and interoception could be used in future studies, e.g., Schandry's test [91], mood induction procedures [92] or Ecological Momentary Assessment [93]. Second, as previously stated, our study paradigm did not allow us to control for levels of depression. Additional measures, such as measures of depression and anxiety, but also measures of BED, emotional eating and illness duration should be included in further studies investigating emotional and interoceptive difficulties in obese people. Additional demographical measures, such as education level, should also be added to improve the demographic matching of the groups. Third, given that our obese samples were recruited in health centers and that obese people seeking treatment or not may exhibit differences in their psychological functioning [94], our results may not be generalized to obese people not seeking treatment. Then, some NW participants reported having received psychological care in the past or at the time of the study. Those participants may have had mental health disorders, which may have affected their interoception or emotion regulation and could explain why some expected differences between NW and obese participants were not found. In addition, even if the sex ratio between our groups was well balanced, most participants were women. This observation is consistent with the fact that the prevalence of obesity is higher in women than in men and that women tend to seek treatment more often than men [95, 96]. However, differences in emotion regulation and interoception between obese men and women may exist and should be examined in the future.

Conclusion

In conclusion, our study is one the few to investigate conjointly emotion regulation difficulties and interoceptive deficits in obesity. To our knowledge, it is the first to do so by taking the severity of obesity into account. It confirms the difficulties in emotion regulation experienced by obese people and highlights a deficit in their interoceptive awareness, regardless of their BMI. Obese people use planning strategies less, lack awareness of negative emotions and experience increased difficulties in observing, noticing and trusting bodily sensations. These issues need to be targeted in psychotherapeutic interventions.

interpretation or publication. The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards All procedures performed in studies involving human participants were in accordance with the ethical standards of an institutional research committee (Ethical committee of the University of Lille; Reference number: 2 017-5-S57) 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.

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