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Eric Bertin, Farid Benzerouk, Benoit Gavlak, Delphine Bernard, Rémi Gagnayre, Aude-Marie Foucaut

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1 **Title : Body misperception : a complex, multifaceted issue to be taken into**
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3
4 **Authors:** Eric BERTIN¹, Farid BENZEROUK^{1,2}, Benoit GAVLAK¹, Delphine BERNARD³,
5 Rémi GAGNAYRE⁴, Aude-Marie FOUCAUT⁴

6

7 1. Centre Specialized in Obesity of Champagne-Ardenne, University hospital of Reims,
8 France

9 2. Cognition Health Socialization Laboratory (C2S - EA 6291), Reims Champagne-Ardenne
10 University, Reims, France

11 3. Association « Le Regard du Miroir », Reims, France

12 4. Health Education and Practices Laboratory, EA 3412, Université Paris 13, Sorbonne Paris
13 Cité, Bobigny, France.

14

15 **Corresponding author**

16 Eric Bertin, MD, PhD, professor of nutrition

17 Hôpital Robert Debré, Unité 63 Nutrition, 45 rue Cognacq Jay, 51092 Reims, France.

18 Tel : +33326787157 ; E-mail: ebertin@chu-reims.fr

19

20 **Author Emails:**

21 - Farid Benzerouk , MD : fbenzerouk@chu-reims.fr

22 - Benoit Gavlak : bgavlak@chu-reims.fr

23 - Delphine Bernard : leregarddumiroir51@gmail.com

24 - Rémi Gagnayre, MD, PhD : remi.gagnayre@univ-paris13.fr

25 - Aude-Marie Foucaut, MD, PhD : audemarie.foucaut@univ-paris13.fr

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28

29 **Abstract :**

30

31 Body misperception could predispose to obesity, by masking excess weight and/or
32 hunger and satiety signals, and by promoting emotional eating and difficulties engaging
33 in physical activity. Thus, it may also be an obstacle to the management of persons with
34 obesity. This narrative review describes the different types of troubles of the
35 relationship with the body that can be encountered in obese subjects, and groups them
36 into three main categories, namely: silhouette distortion, alteration of internal bodily
37 signals pertaining to food, and impaired perception of interoceptive input. Each of these
38 categories is detailed in terms of its clinical phenotypes and potential mechanisms
39 involved. The therapeutic challenges posed by these various disorders are also
40 developed, as well as the limitations of the main instruments available to identify them.
41 The authors conclude that body misperception should be systematically investigated in
42 the clinical management of obesity.

43

44 **Key Words :** obesity, silhouette, perception, interoception, body image

45

46

47 **Introduction**

48

49 Obesity is generally defined as a multifactorial disease that leads to an increase in fat
50 mass that is a source of multiple complications⁽¹⁾. This increase in body size is
51 universally measured by the body mass index (BMI). It is a source of social
52 stigmatisation and low self-esteem, which may generate or perpetuate emotional eating,
53 thereby contributing in turn to excess weight gain⁽²⁾. However, excess weight is not
54 always associated with negative stigma⁽³⁾, and on the contrary, may actually be

55 considered as a marker of social rank^(4,5), which in turn may hamper recognition of
56 obesity as a health problem.

57

58 In addition to these issues, the relationship to and with one's body is likely to be
59 perturbed by excess weight, and can negatively influence the main factors regulating
60 weight (namely eating and physical activity). The relationship of an individual with their
61 body is a multi-dimensional concept and is the combined result of sensitivity to
62 exteroceptive stimuli (sensory aspect), interoceptive input (internal body sensations
63 related to the autonomic nervous system functions such as heartbeat, digestive
64 functions...) and proprioceptive information (sensations relating to the position of one's
65 body in space)⁽⁶⁾. All these different elements combine to constitute an unconscious
66 image of the body that is the reflection of the emotions generated by these various
67 sensibilities all through one's life⁽⁷⁾. Body image is not a static phenomenon, but is also
68 an action-image (when the body is moving) that plays an essential role, not only in
69 defining the boundaries of the self, but also in differentiating the self from the
70 surroundings being perceived⁽⁷⁾.

71

72 In psycho-analysis, body image and perception of sensations are constituent elements of
73 the psychological self⁽⁸⁾ but are always somewhat out of synch with the objective reality,
74 and this can create narcissistic gaps or an anxiogenic interpretation of certain bodily
75 manifestations^(9,10). Thus, body image is necessarily subjective and varies between
76 individuals.

77 According to Hilde Bruch⁽¹¹⁾, a distorted body image and an impaired appreciation by
78 the subject of their own capacity are important issues in obesity.

79

80 Furthermore, Stunkard et al^(12,13) showed that in adults with obesity, more than half of
81 those who developed obesity before or during puberty, had a distorted image of their
82 body, accompanied by impaired interpersonal relationships, which is rarely the case in
83 those who become obese during adulthood.

84

85 A significant association has been shown between body image disturbance and binge
86 eating disorder (BED) in a sample of obese females⁽¹⁴⁾. Poor interoceptive awareness
87 has been shown to be associated with the presence of eating disorders ⁽¹⁵⁾, whereas
88 greater interoceptive awareness is a protective factor against the development of
89 disordered eating⁽¹⁶⁾. Indeed, it has been reported that sensitivity to interoceptive input
90 is associated with the activation of specific brain areas, in particular the anterior insular
91 cortex⁽¹⁷⁾, which plays a key role in the regulation and appraisal of emotions^(18,19).

92

93 The relationship of an individual to their body therefore seems to be an avenue worthy
94 of further investigation in obese subjects. However, the evaluation of this relationship is
95 not standardized in clinical practice.

96

97 The objective of this narrative review is not to perform a systematic or an exhaustive
98 review of studies concerning body perception in subjects suffering from obesity, but
99 rather to describe the state of knowledge in terms of the different disorders that exist, to
100 describe them and to explain why it is relevant to take them into account in the clinical
101 practice of obesity management.

102

103 To this end, a Working Group composed of experts from various disciplines and
104 backgrounds was constituted and convened on three occasions. The group was

105 comprised of: a psychiatrist-addictologist specialised in obesity; a nutrition physician
106 specialised in the management of subjects with eating disorders; specialists in education
107 science with experience of learning and body perception in chronic disease; a teacher of
108 adapted physical activities specialised in working with obese subjects and who has
109 previously developed various approaches to body-oriented therapies, a specialist in
110 sports science, and a therapist for victims of psycho-sexual trauma specialised in helping
111 victims reclaim their body.

112

113 The different types of body misperception likely to be encountered in obese subjects
114 were classed by the Working Group. In addition, a detailed and focused search of the
115 literature in Medline and PsychInfo was performed to ensure that all relevant categories
116 were identified, and also to enrich descriptions of the categories identified by the
117 Working Group. A non-exhaustive review of instruments used to evaluate body
118 perceptions in adults was also performed.

119

120 The disturbances to the relationship with the body identified by this Working Group as
121 most likely to be encountered in subjects with obesity were classed into three
122 overriding dimensions, namely: Distortion of the silhouette; Alterations to internal food-
123 related signals; and Impaired perception of interoceptive bodily input. Our search of the
124 literature did not reveal any additional categories likely to be of clinical relevance in this
125 population.

126

127

128

129

130 **Distortion of the silhouette**

131 The majority of studies investigating silhouette distortion have reported that the
132 parents of obese children tend to under-estimate their child's weight⁽²⁰⁻²²⁾. This finding,
133 widely reported in the literature, certainly cannot in its own right justify considering
134 overweight as a health problem, but may be a contributing factor to weight gain⁽²³⁻²⁵⁾.
135 The under-estimation by parents of their child's weight can be explained by the parent's
136 desire to think that larger infants indicate good health, or reserves to protect against
137 possible shortage⁽²⁶⁾. The fact that children with obese parents are more likely to have
138 misperceptions about what normal weight is⁽²⁷⁾ suggests that this is an acquired
139 disturbance of body image stemming from their environment, where they integrate the
140 family's visual norms⁽²⁸⁾. Accordingly, repeated exposure to heavy body weights was
141 shown to cause overweight men to underestimate their own body weight⁽²⁹⁾, and a
142 positive association has been reported between the prevalence of obesity and the level
143 of weight underestimation in the population⁽³⁰⁾. Failure to perceive a change in weight is
144 frequent in the months following bariatric surgery, whereby the person continues to
145 head for the "large sizes" clothes rack despite having lost a massive amount of
146 weight^(31,32). This pleads in favour of the hypothesis that it takes time to integrate a new
147 extrinsic or intrinsic body weight. However, it has been reported that during weight loss
148 programmes, some patients expressed concerns about their change in body weight, and
149 possible ego boundary permeability⁽³³⁾. Furthermore, people from underprivileged
150 socio-economic groups more frequently tend to under-estimate their body weight^(34,35),
151 which pleads in favour of the idea that the reality of the body is effaced, unconsciously
152 supporting the benefits of eating⁽³⁶⁾ and/or the symbolic dimensions (e.g. social status,
153 protection) that are inherent to large body size^(11,37,38). This situation is similar to
154 anorexia nervosa, where overestimation of body weight serves to legitimize the control

155 behaviour⁽³⁹⁾. The arguments that underpin this effacing process include the fact that
156 people with obesity often underestimate their own weight⁽⁴⁰⁾, and may suddenly
157 become aware of their weight gain through coincidental discovery of their real image
158 through social networks, for example. Some authors have postulated that this under-
159 estimation could be a protective mechanism against depression^(41,42). However, other
160 mechanisms could also be implicated, such as impaired accuracy estimating tactilely-
161 perceived cutaneous stimuli⁽⁴³⁾.

162

163

164 **Alterations to internal food-related signals**

165 Intuitive eating involves physiological regulation of food intake in response to the body's
166 needs based on internal physiological cues (hunger and satiety)⁽⁴⁴⁾, but these cues may
167 be subject to a range of impairments. Hunger signals are often poorly recognized, or
168 confused with just wanting to eat in subjects with obesity^(45,46). As reported by Hilde
169 Bruch⁽¹¹⁾, the construction of hunger cues is not innate and is acquired during early
170 interpersonal experiences, which, when appropriate, make it possible to identify that
171 specific bodily sensation in the same way as other bodily needs. A failure to properly
172 integrate the hunger signal can generate confusion between actual hunger and other
173 bodily events (such as those induced by stress and anxiety), leading the person to eat in
174 order to relieve any perceived internal or external sensation of discomfort⁽¹¹⁾. The
175 feeling of hunger can sometimes generate anxiety (archaic anxieties) further to
176 inappropriate responses during early feeding experiences, or due to a period of
177 prolonged starvation, leading the person to systematically eat in anticipation (and thus,
178 excessively) in order to avoid feeling hungry⁽¹¹⁾. Other works have underlined that the
179 feeling of satiety can also be suppressed by "forced" feeding, unconsciously intended to

180 relieve a mother's anxiety about a potential lack of food for her child⁽⁴⁷⁾. Research by
181 Françoise Dolto showed that certain areas of the organism were not mentally integrated,
182 and the body image was thus incomplete, when the functionality of those areas was not
183 respected⁽¹⁰⁾.

184

185 Impaired integration of internal hunger and satiety cues is not, however, the only causal
186 factor in obesity. Indeed, other environmental factors occurring later in life and at
187 different ages can interfere with these signals, such as sleep disorders and stress⁽⁴⁸⁻⁵⁰⁾.
188 Similarly, cognitive restriction, fostered by restrictive diets and the thin-ideal culture,
189 makes it impossible to align with internal signals, and the frustration this creates can in
190 turn foster the onset (or maintenance) of impulsive eating behaviours⁽⁵¹⁾.

191 Increased eating rate (tachyphagia) is now established as a risk factor for over-eating
192 during meals, and should systematically be screened for, because it mitigates sensitivity
193 to food signals and contributes to altering satiety signals⁽⁵²⁾. Impaired external sensory
194 stimulation, linked to an affective deficiency, may also lead to hyper-hedonic eating and
195 thus, excess weight gain⁽³⁶⁾.

196

197

198 **Impaired perception of interoceptive bodily input**

199 A number of emotions can cause a person ingest food to relieve them. This emotional
200 eating, in a more or less impulsive manner, is frequent in case of a feeling of boredom,
201 whose true origin warrants investigation. The boredom in question may indeed often be
202 a feeling of "emptiness" or loneliness reflecting a lack of affection or a history of
203 traumatic abandonment that is relieved by eating, both literally and figuratively, albeit
204 temporarily^(36,53,54).

205 Based on our own experience and on literature data, poor interoceptive awareness
206 (considered as difficulty identifying internal bodily signals) is associated with
207 alexithymia and contributes to increasing anxiety in these situations⁽⁵⁵⁾.

208

209 The intensity and interpretation of emotions are strongly influenced by interoceptive
210 input^(56,57). People who are sensitive to their internal bodily cues have been shown to be
211 better at dealing with their emotions than those who are less sensitive to interoceptive
212 input^(58,59). The most anxious patients are those who are least adept at perceiving their
213 internal bodily cues⁽⁶⁰⁾. Evaluating anxiety sensitivity may contribute to improving our
214 understanding of greater calorie consumption and physical activity avoidance in
215 persons with obesity⁽⁶¹⁾. Indeed, anxiety sensitivity refers to the fear of experiencing
216 anxiety-related symptoms due to the belief that somatic stimulation, and the anxiety
217 itself, will have catastrophic consequences⁽⁶²⁾.

218

219 Poor interoceptive sensitivity is also associated with increased body ownership
220 malleability which may influence security perception towards others⁽⁶³⁾. This may be
221 explained by neurophysiological findings showing that body representation requires
222 multi-sensory stimulation (seeing, touching, proprioception)⁽⁶⁴⁾. Feelings of body
223 ownership and kinesthetic memory are related to bodily aptitudes generally acquired
224 through movement- and feelings-based stimulations, such as play, physical/sports
225 activities, physical education⁽⁶⁵⁾.

226

227 People with obesity appear to have impaired interoceptive sensitivity compared to
228 normal-weight subjects⁽⁶⁶⁾, although their pain threshold does not appear to be
229 decreased⁽⁶⁷⁾. Obese individuals also appear to have a reduced ability to decode their

230 emotions than normal-weight individuals⁽⁶⁸⁾.

231

232 It is probable that the pervasive pain caused by osteo-articular complications of obesity
233 contributes to amplifying this poor interoceptive awareness. Indeed, the higher the body
234 mass index, the more likely the person is experiencing pain in the lumbar or cervical
235 region, or the feet, hands or hips⁽⁶⁹⁻⁷³⁾. This may lead a person with obesity to engage in
236 eating as a means to respond to the emotions caused by the pain⁽⁷⁴⁾. In addition,
237 kinesiophobia may develop, namely a fear of pain due to movement. This phenomenon
238 needs to be taken into account in the management of patients with obesity⁽⁷⁵⁾,
239 particularly those with morbid obesity (BMI \geq 40 kg/m²)⁽⁷⁶⁾. Kinesiophobia may be
240 present even in individuals who have no real functional impairment of amplitude or
241 strength⁽⁷⁷⁾. This fearful behaviour can be caused by reactions to exercise commonly
242 experienced in people with obesity (that is discomfort, dyspnea, musculoskeletal or joint
243 pain). Cooper *et al.* showed that pain was firstly an important factor in the decision and
244 motivation of obese patients to lose weight, but secondly, it was also a limiting factor on
245 the type and amount of physical activity, and thus, a barrier to weight-loss efforts. This
246 latter effect seems to stem from the belief that physical activity incurs a risk of injury
247 and additional pain⁽⁷⁸⁾.

248

249 A history of sexual abuse at the root of obesity, notably when the abuse occurred during
250 childhood⁽⁷⁹⁾, frequently leads to the suppression of sensations that spontaneously arise
251 in the body, such as hunger and satiety (respectively generating a feeling of “filling”
252 while eating, and “relaxation” afterwards), via a phenomenon of disconnection or
253 dissociation from the body^(80,81). This may be improved by approaches based on body-
254 oriented therapy⁽⁸²⁾.

255

256 The bodily “me” schematically corresponds to the perception of feelings generated by
257 multiple mental, emotional and physical inter-connections; if all of these stimuli are not
258 harmoniously integrated, then the individual may feel disconnected from their
259 body^(83,84). A distinction has been described between the body one has, and the body one
260 is, in the case of excess body weight^(85,86). The body is under-employed, cumbersome,
261 useless, and becomes a problem. Body awareness is progressively losing its importance
262 in today’s society. Restrictions in both physical activities and sensations, due to this
263 body disconnection, result in limitations on the field of action and initiative and this can
264 cause unhappiness⁽⁸⁷⁾. In the case of obesity, the body comes to the individual’s
265 attention again in the form of symptoms. Thus, certain bodily cues can be felt to
266 generate anxiety, such as the perception of one’s heart beat during exercise^(88,89). This
267 acts as a barrier to the implementation of therapeutic modifications in lifestyle,
268 particularly physical activity, which is recommended in obesity as well as in several
269 other chronic diseases.

270

271

272 **Discussion**

273 This narrative review shows that the relationship to the body is complex and
274 multifaceted in individuals with obesity, and there is the potential for disorders among
275 any of the three dimensions identified. The presence of a disordered relationship to the
276 body should prompt suspicion of an impaired overall body image, although without
277 prejudging the semiological heterogeneity of such an impairment, either among the
278 different dimensions, or within each individual dimension.

279 Accordingly, a subset of individuals with obesity may present, for example, a lack of
280 awareness of the real size of their body, difficulties identifying hunger and satiety cues, a
281 feeling of insecurity towards certain bodily sensations that lead to emotional eating
282 and/or difficulty performing physical activity.

283

284 In spite of these important points, which have been well established in the literature in
285 recent years, the majority of diagnostic tools habitually used in the clinical management
286 of obese subjects are mainly focused on diet, physical activity and the various
287 complications of excess weight. The evaluation of the relationship to the body in obese
288 individuals is primarily considered once its consequences are apparent, notably the
289 disability or handicap that it may entail.

290

291 ***Identifying body misperception***

292 Integrating management of body misperception into the pathway of care for subjects
293 with obesity calls for easy and clear identification of such disorders.

294 Indeed, 43 different means of assessment were found in the non-exhaustive literature
295 review, including scales, questionnaires, one simple question, or other evaluation
296 processes using mirrors or video recording.

297 Identifying impaired perception of interoceptive bodily input seems the most difficult.

298 The evaluation of interoceptive capacity classically relies on the heartbeat-perception
299 task, which calculates the difference between the number heartbeats counted by the
300 subject (without feeling for their pulse) and the number of heartbeats actually recorded
301 on the ECG, at rest⁽⁹⁰⁾. Specific psychometric scales for interoception have also been
302 developed. The Scale of Body Connection (SBC) is one of the first such tools to have been
303 validated. It includes items measuring body awareness, but also bodily dissociation⁽⁹¹⁾.

304 Another such tool is the Multidimensional Assessment of Interoceptive Awareness
305 (MAIA), designed to evaluate mind-body awareness⁽⁶⁾, and the MAIA has become a
306 widely-used tool in research in the fields of behavioural therapy and neuropsychology.
307 The 44-item Body Attitude Questionnaire (BAQ) was also developed with a view to
308 assess the range of attitudes women hold towards their bodies⁽⁹²⁾. It explores six distinct
309 dimensions, including feelings of overall fatness, self-disparagement, strength, salience
310 of weight, feelings of attractiveness and consciousness of lower body fat, with this latter
311 dimension being of particular interest in obesity⁽⁹³⁾.

312 Kinesiophobia or fear of movement can be evaluated using the 17-item Tampa Scale for
313 Kinesiophobia (TSK)⁽⁹⁴⁾. Questionnaires have also been designed to assess the efficacy of
314 therapies specifically intended to address interoceptive impairment (e.g. mindfulness
315 interventions), such as the Five Facet Mindfulness Questionnaire (FFMQ)⁽⁹⁵⁾.

316

317 ***Limitations of instruments to detect a disordered relationship to the body***

318 The main criticism levelled at these different tools is that they fail to clearly distinguish
319 between two dimensions of the supposed interoceptive deficit, namely 1, the failure to
320 perceive the signals; and 2, non-acceptance of these sensations in case of affective
321 arousal⁽⁹⁶⁾. According to Merwin and colleagues, non-acceptance of affective arousal,
322 rather than difficulty identifying affective states, was significantly associated with
323 avoidance behaviours, which may take the form of binge eating in obese individuals.
324 This is of particular relevance in the management of eating disorders, where therapy
325 mainly targets the regulation of emotions⁽⁹⁶⁾. Recently, a three-dimensional
326 characterisation of interoception was proposed, comprising: 1, interoceptive accuracy
327 (performance on objective behavioural tests of heartbeat detection); 2, interoceptive
328 sensibility (self-evaluated assessment of subjective interoception, gauged using

329 interviews/questionnaires); and 3, interoceptive awareness (metacognitive awareness
330 of interoceptive accuracy, e.g. confidence-accuracy correspondence). These three
331 dimensions appear to be relevant, given that they are independent and dissociable⁽⁹⁷⁾.

332

333 A further criticism of these psychometric tests is that they fail to explore certain aspects
334 of the deficits in bodily perception described above. Prior sexual abuse is substantially
335 under-estimated, even by the most experienced psychiatrists, due to the phenomenon of
336 post-traumatic dissociation⁽⁹⁸⁾. This generally leads to unconscious resistance to weight
337 loss, or even psychiatric decompensation after bariatric surgery, fully justifying the
338 development of clinical tools that would make it possible to diagnose this type of
339 “defensive” reactional obesity. To this end, the bodily dissociation subscale of the SBC
340 may be relevant to assess bodily dissociation (i.e. disconnection between sensations and
341 emotions), and merits further investigation, since an improvement in the bodily
342 dissociation score has been reported after body-oriented therapy in victims of childhood
343 sexual abuse⁽⁸²⁾.

344

345 Improved detection of body misperception in the form of silhouette distortion, should
346 also be explored in the search to deepen our understanding of this category of
347 misperception, often present in individuals with obesity. Detecting distorted body image
348 based primarily on the use of Stunkard’s Figure Rating Scale⁽⁹⁹⁾ is relatively easy to
349 implement, but not very sensitive in clinical practice of obesity management, due to
350 weight cue reactivity^(100,101).

351

352 Therefore, it is clearly necessary to better identify body misperception, in order to
353 propose targeted therapeutic solutions, and thus, better meet the needs of individuals
354 with obesity.

355

356 ***Therapeutic avenues towards addressing body misperception***

357 In perspective, several supportive cares can be highlighted, and could be explored in
358 regards to body misperception management.

359

360 Therapeutic approaches for silhouette distortion correction have been shown to be
361 promising, such as those based on improving the integration of proprioceptive cues⁽³¹⁾
362 or body perception using a virtual reality body-swapping protocol⁽¹⁰²⁾.

363

364 The body scan, a method derived from mindfulness-based stress reduction techniques
365 was shown to improve interoception⁽¹⁰³⁾ and could have potential for use among obese
366 subjects who eat to control boredom or anxiety. Mindfulness contributes to improving
367 emotion regulation by increasing interoceptive awareness⁽¹⁰⁴⁾, thereby enabling
368 improved integration of psychological distress, limiting the propensity to eat in this
369 context, even reducing binge eating⁽¹⁰⁵⁾. The practice of yoga or meditation has also been
370 shown to be associated with increased mental awareness of, and reactivity to bodily
371 cues⁽¹⁰⁶⁾. Body consciousness and mental representations are often impaired in obese
372 subjects, and these dimensions, as well as body perception at rest or in motion can be
373 improved through a dance therapy workshop, for example, in the framework of specific
374 management programmes⁽¹⁰⁷⁾. Engaging in adapted physical activity could be a
375 promising intervention to reduce kinesiophobia, in addition to being one of the
376 fundamental recommended practices for the management of obesity⁽¹⁰⁸⁾. In addition,

377 optimising interoceptive awareness could increase the individual's motivation to engage
378 in physical activity by reducing the physical load, and reduce the incidence of musculo-
379 skeletal injury⁽¹⁰⁹⁾.

380

381 The identification and integration of hunger and satiety signals is a therapeutic strategy
382 that is becoming common practice, and has been used in specific studies targeting meal
383 time to foster more intuitive eating regulation⁽¹¹⁰⁾. The educational approach deserves
384 to be broadened since non-intuitive eating may potentially be the expression of a
385 widespread interoception impairment. Indeed, as Herbert et al. reported, the cardiac
386 awareness was positively related to greater sensitivity for gastric filling⁽¹¹¹⁾.

387

388 It should also be underlined that the non-acceptance of their body by obese individuals,
389 because of its "size", is a potential limiting factor that can hamper the efficacy of
390 interventions targeting interoceptive awareness, and can require prior intervention to
391 improve self-esteem. Excess weight limits physical activity⁽¹¹²⁾, while the depressed
392 mood that results from painful comorbidities reduces the feeling of self-efficacy in this
393 population⁽⁷⁸⁾. These are not the only factors involved in cutting off obese individuals
394 from their body, since individuals who have experienced past trauma, or whose
395 education from their parents favoured concealing emotions and ignoring bodily
396 sensations, tend to have a relational deficit with their body, and poorer interoceptive
397 awareness^(113,114).

398

399 **Conclusion**

400 Body misperception in individuals with obesity is complex, multifaceted and person-
401 dependent. They should be screened for systematically using multidimensional

402 instruments, in order to offer the most appropriate therapeutic strategies. Such an
403 approach would not only favour multidisciplinary management of obesity, but would
404 also be more meaningful for the patients, and could help the patients to perceive the
405 recommendations given to them as being less restrictive.

406

407

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409

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