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Obesity and interoceptive awareness: a preliminary qualitative study of hospitalized adolescent girls with obesity

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Abstract

Objectives: Childhood obesity has increased tenfold over the past 40 years. People with obesity present alterations of their bodily perceptions and a discrepancy between their actual body and their perceived body. One of the explanations advanced by neuroscience is the difficulty of integrating and processing sensory information, particularly the interoceptive information. There has been little research on this question in adolescent populations, although it is suggested that an atypical interoceptive mechanism is positively associated with the onset of psychopathologies and decreased socio-emotional skills in adulthood.

We present here the first results of a qualitative research study that explores the experiential dimension of interception by obese adolescent girls in a hospitalization context and that assesses the main factors that influence interoceptive self-awareness: anxiety and pain.

Method: Exploratory qualitative research. T0 (30min): Initial assessments: State trait anxiety Inventory for Children (STAIC Scale), visual analog scale for pain and Multidimensional Assessment of Interoceptive Awareness (MAIA Self-Questionnaire). T1 and T2 (60min): perform three simple poses, each 1min (T1) alternated with an explanatory interview exploring the interoceptive experience (T2).

Results: This study highlights that: i) the severity of obesity is not positively associated with the level of interoceptive awareness; ii) the correlation of influencing factors (pain and anxiety) and the level of awareness interoceptive is weak; iii) the thematic categorization according to Mehling's eight interoceptive criteria demonstrates, for the participants: 1 / the ability to identify their bodily perceptions by the majority of them; 2 / the uneven capacity to maintain a level of attention on the body in its ensemble; 3 / the ability not to worry about feelings of discomfort is influenced by hyper-rationalization or the negation of perceptions; 4 / breathing appears to be the most mobilized lever to regulate attention; 5 / the links between bodily perceptions and felt emotions are influenced by

rationalization, bodily experience, or mood decline; 6 / self-regulation is influenced by bodily experience, which enables awareness and postural readjustment; 7 / listening to the body is influenced by the transfer of past bodily practices; 8 / the notion of confidence in one's bodily perceptions is not always well understood and is not related to subjects' ability to identify their internal manifestations, while perceived confidence is related to the level of rationalization and can be improved through postural practice.

Discussion: As reported in the literature, the interoceptive level of patients interviewed is generally low on the rating scales, but it appears that the MAIA results do not always reveal the perceived reality of body-self of the adolescent girls interviewed; guiding the participants in explaining their bodily experience reveals a much greater interoceptive dimension. We qualify this guided field of exploration as an interoceptive proximal zone or an interoceptive preconception zone.

Conclusion: We suggest that a better understanding of the interoceptive mechanisms experienced by obese people helps guide patients towards a safer experiential dimension of their body. Future research should enrich this qualitative perspective of interoception and open up more embodied dimensions of care.

Key Words: interoception, obesity, adolescent, body

1. Introduction

Over the past 40 years, the number of cases of obesity has almost tripled and represents a public health challenge on a global scale [1]. As of 2016, more than 340 million children and youth were considered overweight or obese [1]. The most commonly invoked explanations for this phenomenon are, above all, behavioral and societal [1]. The majority of treatments offered today focus on aspects

of hygiene and diet, or use a psycho-behavioral approach. The results of these therapies are, at best, moderately effective in the short term [2].

People with obesity have a dysmorphic perception of their bodies and experience discrepancies between their actual body and their perceived body [3-5], as can be observed in other pathologies such as eating disorders [6,7]. This dissonant perception is barely taken into consideration by treatment programs for obese patients. The most common therapeutic orientations still involve behavioral injunctions such as “move more” or “eat less,” even though studies have suggested that an erroneous perception of one’s weight could be associated with a disengagement in weight-loss programs [8].

It would seem, however, that this “*atypical self-representation*” [9] is linked to a perceptual deficit of internal, or interoceptive, sensations [10,11]. This hypothesis has been corroborated by several studies that demonstrate a deficit in the treatment of bottom-up information [12].

2. Interoception and bodily self-awareness

Over the past few years, interoceptive consciousness has become a major preoccupation in the neurosciences [13,14], as it is understood to be one of the fundamental elements that constitutes one’s bodily self-awareness, along with proprioception and exteroception [15]. Sensorial perceptions contribute to the feeling of ownership of one’s body [16].

Bodily perceptions cover three dimensions (Fig. 1): proprioception, which takes place *via* receptors in the muscles and ligaments; exteroception, which integrates external stimuli through the five senses; and interoception, or the perception of internal bodily signals. These corporal perceptions respond to a double mechanism of information processing: bottom-up processes are determined by a neurosensorial and perceptive stimulus, and top-down processes are constituted by a lost stimulus, founded on earlier knowledge or experience. These mechanisms are related to the *living body* and to the *lived body*, the former of which can be described as “a dynamic bio-cultural process” manifested

by a phenomenon of ecologization [17]. The subjective and experiential side of events is linked to the lived body (Fig. 2).

Conscious perception is not only the multisensorial experience of an object but is also “the implicit and prereflexive experience of being the subject of a given experience” [18]. The experience of ourselves as incarnated subjects is called the “bodily self” [19].

3. Experiential, interoceptive dimension

In neuroscience, interoception has long been explored from the point of view of *interoceptive precision* (for example, the ability to effectively auto-evaluate the number of one’s heartbeats) [20].

Advances made by research today allow scientists to affirm that interoception is not limited to interoceptive precision, but that its domain is much larger and more inclusive [14,21,22].

The taxonomy of interoception has become richer over the last few decades, with appearance of new fields such as *metacognitive consciousness* (one’s level of trust in one’s interoceptive precision), *sensibility*, *attention*, and *interoceptive regulation* [21-23] (Fig. 3).

Interoceptive sensibility characterizes the sensations of bodily states; it refers to an “individual’s personal account of how they experience internal sensations” and includes “both the individual’s belief in their interoceptive ability and the degree to which they feel engaged by interoceptive signals” [20].

Interoceptive sensibility is influenced by the style of attention, which can be maladaptive or beneficial [14]; one is “associated with somatization and anxiety disorders; the other has been viewed as healthy, adaptive, resilience-enhancing” [23].

Finally, the notion of interoceptive regulation characterizes the possibilities for the subject to adapt to an interoceptive signal [22]; today, this is considered an essential element of the interoceptive process.

Today, interoception is no longer studied in terms of performance, but also as a subjective experience; in the present study, we will concentrate on the experiential side of interoception, through a first-person exploration.

4. Interoception and obesity

People with obesity present alterations of their bodily perceptions [24] and a discrepancy between their actual body and their perceived body [3,8]. One of the explanations advanced by neuroscience is the difficulty of integrating and processing sensory information [25], particularly the integration of bottom-up sensorial information [11]. This deficit would then be responsible for a reduction in interoceptive sensibility [26]. Today, it is recognized that a dysfunctional interoception is implicated in different mental illnesses, such as eating disorders [27], and is linked to difficulties in emotional regulation [28].

4.1 Studied population

For this study, we set out to study the interoceptive mechanisms in a cohort of adolescents who have been hospitalized for obesity; these mechanisms have not benefitted from study [29], even though an atypical interoception has been positively associated with the appearance of psychopathologies, risky behaviors, and the diminution of socio-emotional skills observed in adults [29]. The few studies of obese adolescents' interoception have explored interoceptive *precision* [30]. However, the subjective bodily dimension of adolescents presenting obesity has not yet been studied, even though it is recognized that “subjective well-being is associated only with the self-reported (perceived) aspect of interoception but not related to the sensory measures of interoceptive accuracy” [31].

The literature that explores adolescent subjects' interoception underscores that “accurate perception and recognition of interoceptive signals is necessary for learning and decision-making” [29]. Better understanding how interoception is experienced by adolescent subjects presenting obesity could enrich our understanding of these subjects' difficulties in committing to treatment in the

medium and long term [2,32]. In addition, puberty is a propitious moment for contextualizing new visceral sensations [29].

Finally, let us not forget that adolescents' development has consequences on their lifetime health, and that it is up to adults to understand the processes that play out during adolescence [33]. Even though it is difficult to precisely define the adolescent period [33], we will make use of the age categories proposed by other studies on obese adolescent populations [2], wherein adolescence is defined as the period from 12 to 17 years of age.

Subjects between five and 19 years old are considered obese when their BMI (Body Mass Index) is greater than two standard deviations above the WHO Growth Reference median [1]. Our study will use this definition.

Our research focuses on a clinical, hospitalized population. The choice of this population is based on the hypothesis of the potential severity of interoceptive disorders in this population. For ethical and/or scientific reasons, the profiles of certain patients could not be included in this study. Thus, patients presenting dissociative or depressive disorders, hyperalgesic patients, or those presenting somatognosic disorders could not be integrated.

This study presents the preliminary results based on the inclusion of five subjects. Our evaluation is that at least ten patients would be necessary for a complete study.

Since this is a qualitative study that aims to be comprehensive, the sample should make evident certain divergences that exist among the chosen cohort. The choice of a clinical population allows us to select participants who can be considered typical of target population using judicious sampling. This procedure guarantees the external validity of the results. Subjects were included after discussion with the medical team, with an eye to criteria of inclusion.

4.2 Method

Our study focuses on the exploration of the experience of lived interoceptive mechanisms, through identification and bodily description. The current literature underscores the multisensorial dimension

of bodily self-awareness based on the integration of interoceptive, but also motor and exteroceptive, signals [18]. We chose to focus on the interoceptive dimension. In order to carry out this exploration with adolescents presenting obesity, we chose to use a method that allows for the mobilization of the interoceptive dimension by a plurimodal entry during the practice of power posing.

Let us take a moment to clarify the style of attention being mobilized. The style of attention is recognized in the literature as constituting interoceptive self-awareness [23]. Two styles are possible: beneficial or maladaptive. The two recognized principal factors of influence are pain [23] and anxiety [23].

4.3 Research objectives

Our study is monocentric, exploratory, transversal, and qualitative. The study was carried out in a hospital service that treats adolescent patients presenting obesity. The subjects who were asked to participate in this study are adolescents who were hospitalized for a minimum duration of 15 days. They were recruited with the approval of each patient's pediatrician and psychiatrist. The doctor invited the adolescent and her family to participate in the study, and an informational interview was proposed. Before the study began, we met with the families of each of the patients. During the first part of this encounter, we gave oral and written information (in French) on the study. The investigator made sure that the family members understood the general conditions of the study, their right to refuse participation or to end their participation without there being a negative consequence for the treatment of their child; they were likewise informed of the absence of risk associated with participation in the study. The investigator was present in order to respond to any questions. This presentation lasted for approximately 30 minutes, based on the number of questions asked by the participants. The investigator proposed a time for reflection (one hour) before the patients and their parents gave their written consent. The investigator also validated the criteria for inclusion/non-inclusion.

The principal objective is to explore the experience of interoceptive mechanisms in adolescent subjects hospitalized for treatment of obesity. The secondary objectives are: an evaluation of the level of interoceptive self-awareness in the participant sample and an evaluation of the principal factors of influence on interoceptive self-awareness, i.e. anxiety and pain. The estimated total time is 90 minutes (Fig. 4).

The principal criterion of evaluation is a thematic grid that describes the experience of interoceptive mechanisms experienced by the subjects through an experimental exploration of the eight interoceptive criteria defined by Mehling. Here, we present the first results that will be completed and enriched by further inclusion in the study. The thematic grid is obtained through crossing:

- the results of the evaluation of interoceptive self-awareness using the Multidimensional Assessment of Interoceptive Awareness (MAIA) questionnaire [14,34];
- the qualitative exploration of the narrative of interoceptive experience collected during explicitation interviews after a session of power posing.

4.4 Criteria of inclusion

To be included in the study, the adolescents must: be aged between 12 and 17 years at the beginning of the study; present obesity, that is, a BMI greater than two standard deviations above the WHO Growth Reference median for their age group; be hospitalized for treatment of obesity; be able to read and speak in French, a necessity for conducting in-depth interviews and for responding to the items on the exploratory questionnaires. Finally, neither of the patient's parents or legal guardians can oppose her participation in the study.

Subjects presenting any of the following could not be retained for the current study: secondary obesity caused by an endocrinian or syndromic pathology (such as Prader-Willi syndrome); psychopathological disorder (psychotic disorders, major depressive disorder, borderline personality disorder, binge eating disorder); somatognosic illness (parietal syndrome); an osteoarticular disease

that prevents them from standing; acute hyperalgesia. Young women who were pregnant or nursing could not participate, nor could adolescents who manifested a refusal to participate.

4.5 Presentation of the tools

- socio-demographic questionnaire

- State Trait Anxiety Inventory for Children (STAIC) [35]: The STAIC is a self-declarative measure that has been widely used for children and adolescents to evaluate anxiety linked to their general state and to character traits. The inventory contains two scales of 20 items each, with each sub-scale ranging from 20 to 60. The STAIC-State is used to ask children how they are feeling at a particular moment. The STAIC-Trait is used to ask them how they feel in general. The validity and the trustworthiness of these measures have been tested in numerous studies on children eight years old and older, adolescents, and adults [36].

- visual analogue scale (VAS) for pain and qualitative description of pain (localization, form, type of sensation): the VAS is validated and recognized by the French HAS (*Haute Autorité de Santé*, High Health Authority) for use with adult and child patients. It is a measure of self-evaluation on a scale of 0 to 10 or 0 to 100 [37].

- Multidimensional Assessment of Interceptive Awareness (MAIA), a self-questionnaire for a multidimensional evaluation of self-awareness. The MAIA presents a good level of internal validity [14,34]. The first version of the tool was translated into French and approved for use in 2014 [38]. The tool's internal consistence is judged to be acceptable (Cronbach's alpha superior to 0.7 for five of the eight dimensions of the MAIA, comparable to the original version) and coherent correlations with other scales confer a good validity [38].

- practice of power posing, followed by explicitation interviews.

4.6 The steps of the study

The study was carried out in the following manner: during a first phase of approximately 30 minutes, the adolescents are asked to complete the socio-demographic questionnaire, the two STAIC scales, the VAS – combined with a qualitative evaluation –, and the MAIA. This tool, which allows for a multidimensional exploration of interoception, is based on eight criteria [14] (Fig. 5): 1) *noticing* (awareness of uncomfortable, comfortable, or neutral bodily sensations); 2) *not-distracting* (the tendency to not ignore oneself or to not use distraction when confronted with sensations of pain or discomfort); 3) *not-worrying* (the tendency to not react with emotional distress or to not become worried when feelings of pain or discomfort arise); 4) *attention regulation* (the ability to maintain and control attention on bodily sensations); 5) *emotional awareness* (the capacity to attribute specific physical sensations to emotional states); 6) *self-regulation* (the ability to regulate psychological distress by concentrating on physical sensations); 7) *body listening* (the tendency to actively listen to one's body in order to understand one's state); 8) *trusting* (feeling that one's body is safe and trustworthy).

During a second phase of approximately one hour, the participants are invited to partake in a session of power posing (15 minutes), which consists of three poses held for one minute each (Fig. 6). This duration was chosen based on earlier studies that demonstrate the beneficial effects after 60 to 120 seconds of holding a pose [39]. Since we included three different positions, we chose hold times of 60 seconds per pose, as it was suggested that holding postures too long could risk embarrassing the participants, bringing about unwanted effects [39]. The poses were presented with a printed image and, upon request, were demonstrated by the experimenter. The participants were then invited to hold the poses themselves after a short training session, whose length varied based on the time needed for the participants to understand and correctly reproduce the postures (around one to two minutes). A period of recuperation (one to two minutes) was proposed before moving on to interviews (T2), explained below. In general, around five minutes were spent on each pose.

This approach allows for the explicitation of the interoceptive mechanisms experienced by the participants. Indeed, the literature demonstrates that a plurimodal and congruent perceptual

exploration fosters the mobilization of a bodily self-awareness [15,40]. A recent study of interoception by Weineck et al. [41] uses this exploratory tool, originally developed in the field of social psychology, which consists of a session of power posing. This method would facilitate subjects' centering their attention on their interior, as well as self-focus [41, 42]. Contemplative practices based on sensorimotor integration (without judging the physical sensations that arise) have been suggested as a tool for improving self-confidence, functionality, and quality of life [43].

An explicitation interview that explores the participant's interoceptive experience is carried out between each of the poses (approximately 45 minutes). The guide to the interview is constructed in such a way that it touches on the eight interoceptive criteria defined by the MAIA.

In order to respect the required ethical recommendations, this non-interventionist research protocol of degree 3 began after having received a favorable opinion from the Committee for the Protection of Persons (CPP).

4.7 Description of the analytic methods

Our method for exploring the interoceptive mechanisms experienced by patients presenting obesity is double: a numerical external evaluation (using clinical scales: MAIA, anxiety, pain), and a qualitative internal evaluation of bodily experiences (explicitation interview). A similar, double approach (numerical and qualitative evaluation) has already been explored in other studies of the representation of and the experience of self in patients presenting severe obesity [9].

We analyzed the results using a cross-referenced method based on the exploration of the eight criteria of interoceptive self-awareness defined by Mehling [14,34]. We cross-referenced the numerical results obtained using the scale of evaluation of bodily self-awareness with the verbatim responses extracted from the three explicitation interviews [44,45] that allow for a first-person verbal articulation of the subject's experiences in the experimental situation. This mixed approach allows us to refine and clarify the information obtained while reducing the effect of potential biases.

The analysis of the interviews was carried out following the thematic analysis method developed by Paillé and Muccielli [46]. The themes studied are defined using the model of the eight criteria of interoceptive self-awareness, cited above, defined by Mehling [14].

The scales of anxiety and of pain (analogue and qualitative evaluation) bring further clarification of the style of interoceptive attention (beneficial or maladaptive) mobilized at the moment of the study.

The data extracted from the interviews corroborate or nuance the numerical data from the self-evaluation (MAIA), thus allowing a richer understanding of the objet of study.

5. Results

All of the participants were females, although the protocol is not limited: the sample corresponds to the profiles of the subjects hospitalized during the period of inclusion. Their ages ranged from 14 to 17; age does not appear to have an incidence on the expression of interoceptive experiences. The levels of obesity ranger from moderate to severe (BMI of 30 to 54). Among the participants, the severity of obesity is not positively associated with a diminution of interoceptive awareness. The subjects have different levels of physical activity: two of the teenagers get regular physical exercise, including one participant who practices karate four times a week (Participant 1); the others either don't or no longer practice a regular physical activity; all of them have no experience or a single experience with mind-body practices such as sophrology or yoga (Table 1).

5.1 Weak correlation of factors of influence and the interoceptive self-awareness expressed

5.1.1 Moderate impact of pain

The results of the VAS (visual analogue scales) of pain vary from 0 to 5 out of 10 (Table 2). Two subjects have a VAS of 0, and two have a VAS between 1 and 2. One adolescent presents low back pain evaluated at 5. We requested the opinion of the head pediatrician, and we reiterated our request for consent with each adolescent before beginning the experiment. While four participants expressed

experiencing chronic pain (pain in the knee, headache) or acute pain (a fall the night before for one participant, an operation for paronychia for another), all of them were able to participate without difficulty in the session of power posing. These pains were infrequently mentioned during the part of the study dedicated to exploratory questioning. The participant presenting a VAS of 5 said that she wasn't bothered by her pain (a pain that appears "when [she] get[s] low") during the pose and instead spoke more at length about other parts of her body:

"In my head, there was something heavy, as if there was a liquid, later, during the breathing it's like I was out of breath and in the shins, it was like I was getting taller" (Participant 2).

Participant 3 briefly invoked a painful feeling when she placed a hand on her hips during a posture, but which did not impact the explicitation of her bodily perceptions:

"Besides when I put my hand there, no, there wasn't any pain" (Participant 3).

While Participant 1 declared herself painless during the VAS numerical evaluation, she was nevertheless bothered during a standing pose by a moderate pain in her knee, already familiar to the patient:

"I started feeling pain in my knee, in fact, it was pressing on the 'bubble' [...] I was only focused on my knee" (Participant 1).

5.2 High level of habitual anxiety, low level of situational anxiety

The scales of anxiety present heterogeneous overall results, ranging from low to high (Table 3). The ensemble of the participants presents notable differences between the results obtained for the STAIC-Trait, reflecting the level of anxiety habitually experienced by the subject, and the level of situational anxiety (STAIC-State), that is, the anxiety experienced at the moment of the participation in the study. Four participants out of five present a high level of trait anxiety (STAIC-T), while all reveal low to medium results for the STAIC-S, which suggests that despite generally experiencing anxiety in their daily lives, their participation in the study did not cause situational anxiety.

The comments collected during interviews about the participants' experience are coherent with the results of the STAIC-S and reveal a low level of anxiety (for Participants 2, 4, and 5) or a medium level (Participants 1 and 3):

“It was normal... no stress... no panic” (Participant 2).

“Before [the pose] my palms were sweating and now it's the same thing” (Participant 1).

5.3 Low level of interoceptive self-awareness

The results obtained through the MAIA questionnaires reveal a level of interoception lower than the average for three of the five participants, and a significantly low level for one of them (Table 4).

Among the eight multidimensional criteria of interoceptive self-awareness, three appear to be homogenous for the five participants, that is: 1) *noticing*, 2) *not-distracting*, and 4) *attention regulation*. On the other hand, the results varied among the participants for the criteria: *not-worrying*, 5) *emotional awareness*, 6) *self-regulation*, 7) *body listening*, 8) *trusting*.

The results for the criteria 6) *self-regulation* and 7) *body listening* appear significantly low, with a mean between 1.7 and 1.53 out of 5 (Table 5).

5.4 Significant level of interoceptive pre-consciousness

The interviews conducted after each posture allow us to clarify, in a qualitative manner, the numerical data from the MAIA and to have access to the first-person lived experience of the participants. The collected verbatim responses show the young patients' ability to access a pre-reflexive dimension of their internal bodily perceptions.

Only one participant had difficulty in connecting to and expressing her bodily sensations (Participant 5), revealing discordances between the results of the MAIA self-questionnaire and the verbalization of her experience of the postures.

5.5 Thematic exploration of the eight interoceptive criteria

5.5.1 Criterion 1) Noticing

In correlation with the results obtained from the MAIA self-questionnaire, the majority of the participants demonstrates an ability to identify and to name their bodily sensations, experienced as uncomfortable, comfortable, or neutral. The participants focus on sensations that are unpleasant or unexpected:

“I felt something warm” (Participant 1).

“I was breathing heavily” (Participant 2).

“I was focused on what was holding me up” (Participant 4).

5.5.2 Criterion 2) Not-distracting

The adolescents' discourse on criterion 2, that is, the tendency to not ignore oneself or to not use distraction when confronted with sensations of pain or discomfort, clarify the results obtained through the MAIA. Two profiles stand out among the participants: one in which it is difficult to sustain a level of attention on the body in its entirety, and another in which physical adaptive strategies enable the participant to avoid distraction:

“I was focused on my knee, and I didn't at all pay attention to the rest” (Participant 1).

“I closed my eyes like this, I concentrate more on the rest of my body because vision distracts me from what I'm feeling” (Participant 4).

5.5.3 Criterion 3) Not-worrying

This criterion, corresponding to the tendency to not react with emotional distress or to not become worried when feelings of pain or discomfort arise, revealed experiences that varied widely among the participants. Participant 1's particularly low score on the MAIA can, in particular, be illustrated by her anxious comments about her bodily perceptions, and are coherent with the results on the STAIC scale:

“I was afraid of hurting myself” (Participant 1).

Other participants express worry, but reveal effective coping strategies, which are made evident by the analysis of their perceived sensations. This mode of analysis is structured in the following way: anxious perception – motor exploration – perceptual analysis – rationalization – diminution of the emotional charge:

“I said to myself, what’s wrong? What if I hurt myself? Then I tried to move it to see and I saw that it didn’t hurt, so I said to myself, OK, it’s not serious, and now I feel better” (Participant 2).

It should be noted that Participants 3 and 5 obtained particularly high results for this criterion on the MAIA. These numerical results could lead us to think that the participants didn’t experience a heightened emotional charge regarding their sensorial experiences, but their words reveal a tendency to distance themselves from their bodily sensations that could explain the numerical results:

“I forget when my body tells me to pay attention” (Participant 3).

“What do I feel in my body? I feel that I don’t like my body” (Participant 5).

5.5.4 Criterion 4) Attention regulation

Regarding the capacity to maintain and control attention on bodily sensations, the results obtained on the MAIA are generally stable (between 2 and 3 out of 5) for the five participants. Several of them describe a method for self-exploration that recalls a body scan, going from the head to the feet or from the feet to the head:

“I looked at my head [...], then I went down into my breathing, I was having trouble breathing... then... I went down into my throat, that was fine, then I went down into the stomach, the chest, that was fine, then I went down into the legs, into the shins, that hurt a little, and then into the feet” (Participant 2).

“I start with the feet, then I go up to the head and then I went back down” (Participant 4).

The discordances between the result obtained on the MAIA for this criterion and the verbatim responses given by Participant 5 should be noted. She obtained the best numerical result on the self-

questionnaire, while giving the following response to the question “how would you describe your attention to your body during the pose?”:

“To my body? On a scale of one to ten, I’d say one” (Participant 5).

She justified this “one” by saying that she “concentrated a little bit,” but that her concentration remained focused on “negative thoughts and sadness” (Participant 5). It seems that, in her experience, there was a confusion between perceptual and emotional experiences.

For this patient, the only type of attention that proved to be effective was the attention paid to her breathing:

“For the breathing, I was just calm” (Participant 5).

5.5.5 Criterion 5) Emotional awareness

In their results on the MAIA questionnaire, the participants’ average deviation from this criterion is the most prevalent (1.38 out of 5). This underscores the participants’ differences regarding their ability to attribute specific physical sensations to emotional states. Participant 2 presents an especially low numerical value; and Participants 4 and 5 present significantly high results. Based on the comments given during interviews, the following explanations can be suggested: Participant 2’s relationship to her body is more rational than it is emotional:

“I concentrated and I asked myself, ‘hey, what’s that?’, I thought about what kind of a symptom it could be in order to explain it” (Participant 2).

When she is asked about her emotional experience:

“Normal... no stress... no panic [laughter], I know that everything will be alright” (Participant 2).

Participant 4 demonstrates her ability to control her breathing and her awareness of the impact of this on managing her emotions:

“When I’m calmer, my breathing becomes calmer, and that gives me a sense of well-being” (Participant 4).

Participant 5 doesn't articulate physical sensations that could be attributed to emotional states, but registers a strong impact of her emotions on her difficulty in accessing her bodily perceptions:

"What did I feel in my body? My hang-ups [...] and I felt sadness, too, that's all" (Participant 5).

5.5.6 Criterion 6) Self-regulation

Almost all of the participants registered low scores for criterion 6, self-regulation, understood as the ability to regulate psychological distress by concentrating on physical sensations. Only Participant 4 gave a positive evaluation to this criterion, by presenting a good mastery of her breathing:

"The more I breathed, the more I relaxed" (Participant 4).

Participant 3 describes her experience during a standing posture with the chin raised as providing her with a sense of security, of calm, comparing it positively to a posture she usually adopts when she feels insecure:

"If you stay like that, it's not good, you'll end up deformed, it won't end well. But like this it's okay, I know that I'm good like that and that nothing can happen to me" (Participant 3).

5.5.7 Criterion 7) Body listening

Likewise, the majority of participants obtained significantly low scores on this criterion, with the exception of Participants 2 and 4. This criterion measures the tendency to actively listen to one's body in order to understand one's state.

Participant 2's propensity for listening to her body is linked to an earlier bodily experience, one shared with a sick relative.

"I analyze myself: I go up [sic] from my head to my feet and I check to see if I have pain anywhere. [...] I did the same thing with my mother" (Participant 2).

Participant 4 explains her ease in being aware of her body by linking it to her intensive practice of karate:

“I’m used to becoming aware of my stability points in general [...] and it’s become more present with karate” (Participant 4).

Other participants expressed a major difficulty in listening to their bodily perceptions:

“My body simply tells me what I’m feeling for real, but I don’t listen to it” (Participant 3).

5.5.8 Criterion 8) Trusting

The MAIA’s final criterion evaluates the way in which the subject experiences her body as secure and trustworthy. Participants 2 and 3 present high results for this criterion while Participants 1 and 4 present a low level of perceptual trust.

The notion of trust in one’s bodily perceptions is not always well understood and is not linked to the subject’s ability to identify her internal manifestations. Regarding this criterion, Participant 4 declares:

“I don’t really know, I didn’t notice it, I don’t really know how to respond” (Participant 4).

For Participant 2, trust is linked to a rationalization of the perceptions she’s identified:

“I was already familiar with these pains” (Participant 2).

Participant 3 describes a reassuring experience during the session:

“I felt reassured [...] when I looked to the right, I was confident [...], I was proud [...] I felt like a superhero” (Participant 3).

Even though Participant 1 achieved a very low result for this criterion, she recognized physical capacities that she hadn’t previously identified:

“My body made it through [the exercise]” (Participant 1)

Despite a near-average score for this criterion (2.33 out of 5), Participant 5’s bodily experience did not reveal the same level of trust in her perceptions during the session of power posing. It seems that, in her experience, there is still a confusion between the perceptual and emotional dimensions:

“No, I didn’t feel confident [...] not at all” (Participant 5).

6. Discussion

The initial results of this study demonstrate that:

- the severity of obesity is not positively linked with the level of interoceptive consciousness;
- the correlation of factors of influence (pain and anxiety) and of perceived interoceptive self-awareness is weak;
- the thematic categorization according to the eight interoceptive criteria defined by Mehling underscores that:

- the majority of the participants is able to identify and define their bodily perceptions;
- the participants' ability to maintain a level of attention to their bodies in their entirety is unequally perceived, but reveals strategies of bodily adaptation;
- the evaluation of the criterion that studies the capacity for not-worrying about sensations of discomfort justifies a qualitative exploration, since negation or hyper-rationalization of bodily perceptions can give a false interpretation of the numerical results of the MAIA, and several participants experienced attention regulation; in this first sample, breathing appears to be the activity that is easiest to mobilize and engage, the links between bodily perceptions and felt emotions are unequally perceived and are influenced by rationalization, physical experiences (karate), or a change in mood;

- self-regulation is also very unequally scored in the MAIA; the bodily experience proposed by the study raised participants' awareness and provoked postural readjustments;

- most of the participants obtained significantly low results for the "body listening" criterion; it is influenced by earlier physical experiences (recollection involving a sick family member or the practice of a martial art);

- the notion of "trust" in one's bodily perceptions is not always well understood and appears to be unrelated to the subjects' capacity to identify their internal manifestations; the perceived trust is linked to the level of rationalization of these perceptions and can be reinforced by power posing.

As the literature suggests, there does not appear to be a difference between moderately and severely obese patients' abilities to regulate their emotions and their interoceptive capacities [47].

The impact of the principal factors of influence of interoceptive perceptions (pain and anxiety) appears to be quite weak. While pain is recognized as being fundamental to the definition of the style of attention (beneficial or maladaptive) and to the regulation of internal perceptions [48], the scores given by the adolescents, when questioned, are not correlated to their interoceptive experience. Thus, Participant 2, despite a relatively high VAS, was not bothered by pain during the postural experiment, while Participant 1, a self-declared analgesic at the moment of the experiment, described kinesiphobic perceptions, which has also been recognized in the literature [18]. The situational anxiety (STAIC-State) experienced during the study could have increased the perceived pain. Moreover, we should note the weak impact of the level of trait anxiety (STAIC-Trait) on the participants' interoceptive awareness; as has been demonstrated by previous studies, the MAIA presents significant negative associations between its sub-scales and the level of trait anxiety for subjects presenting eating disorders [49].

Our study reveals that Participant 4, the only one of the cohort to engage in regular physical activity (karate), has a beneficial style of attention and the capacity for interoceptive awareness, both in her description of her anchor points and in her management of her emotions through breathing. This is explained by the bidirectional relationship between physical posture and mental states, amply explored in studies of psychological well-being among practitioners of related disciplines such as Tai Chi and Qi Gong [50,51].

Participant 2 also presents a certain ease of exploration and of putting her experience of the postures into words: she describes a kind of rationalized, head-to-toe body scan performed every two weeks in order to "analyze if everything's okay." This practice was initially used on another person (her sick mother), then used for herself, thus displaying the practice's transferability. The principal interoceptive criterion reinforced by this practice is the trust in one's bodily perceptions, but the

emotional dimension (emotional awareness and the regulation of psychological distress through concentration on one's physical sensations) reveals significantly low results.

The postural experience mobilizes a form of bodily anamnesis that can either foster the subject's exploration of her physical self or generate resistances; this is the case for Participant 1, who was initially opposed to reproducing the poses, which reminded her of her father (described as "authoritarian" and "violent"). Before this participant could allow herself to physically experiment with the postures in a non-traumatic way, it was necessary for her to articulate her negative projections.

The results obtained, in this preliminary study, by the participants on the MAIA self-questionnaire concord with those found in earlier studies on interoceptive awareness among subjects presenting eating disorders [49]: *self-regulation* and *body listening* are the criteria most strongly associated with symptoms of disordered eating, and, in a less significant way in our study, *not-distracting* and *trusting*.

While the MAIA self-questionnaires reveal a level of interoceptive awareness that is, overall, weak, the explicative interviews highlighted perceptual and emotional experiences of which the participants were not initially consciously aware. One of the participants could feel that her body "made it through" (Participant 1), while another felt like "a superhero" (Participant 3). The dimension of the interoceptive bodily self to which the subject can have conscious access appears to be inferior to the field of exploration to which she can have access if she is accompanied. This guided experience of the self can allow the subject to access what we might call a proximal interoceptive zone, or a zone of interoceptive pre-consciousness.

A number of potential biases can be noted. Firstly, with regards to the ethical dimension and to the respect of the participants' abilities, the pain and/or discomfort caused prevented the participants from reproducing the first posture (seated in a chair, legs up on a table). Secondly, since the population in this study was exclusively female, future studies could study the way in which male adolescents experience their bodies. Moreover, the addition of a scale of evaluation for depression to

the protocol could have explained the significant gaps between the results for the MAIA and Participant 5's verbatim responses, since certain depressive symptoms can result from a disturbance in interoceptive-exteroceptive integration [52].

7. Conclusion

Recent studies that explore interoceptive mechanisms and their stakes unanimously suggest that the understanding of interoceptive processes influences subject's self-representation in the world, and that self-regulation can lead to better therapeutic models [22]. The exploration of the qualitative dimension is a window into the physicality of the subject, as a first-person lived experience, and could also lead to more precise, targeted therapies.

The interviews that we carried out in this study of adolescents hospitalized for obesity seem to be in conformity with these conclusions. Today, we know that interoceptive plasticity can be improved by multimodal interventions.

We suggest that the study of interoceptive mechanisms, as experienced by patients presenting obesity, can contribute to our understanding of interoceptive disorders for this patient population and can enrich our therapeutic perspectives, hopefully moving us towards more body-centered therapeutic propositions. This type of accompaniment requires a qualitative evaluation of interoceptive activity [53] and the development of a caregiver-patient relationship that allows patients to feel secure in their bodies and in their relationships.

Declaration of conflict of interests: The authors declare having no conflicts of interest to disclose.

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Figure 1. Model of the three dimensions of bodily self-awareness

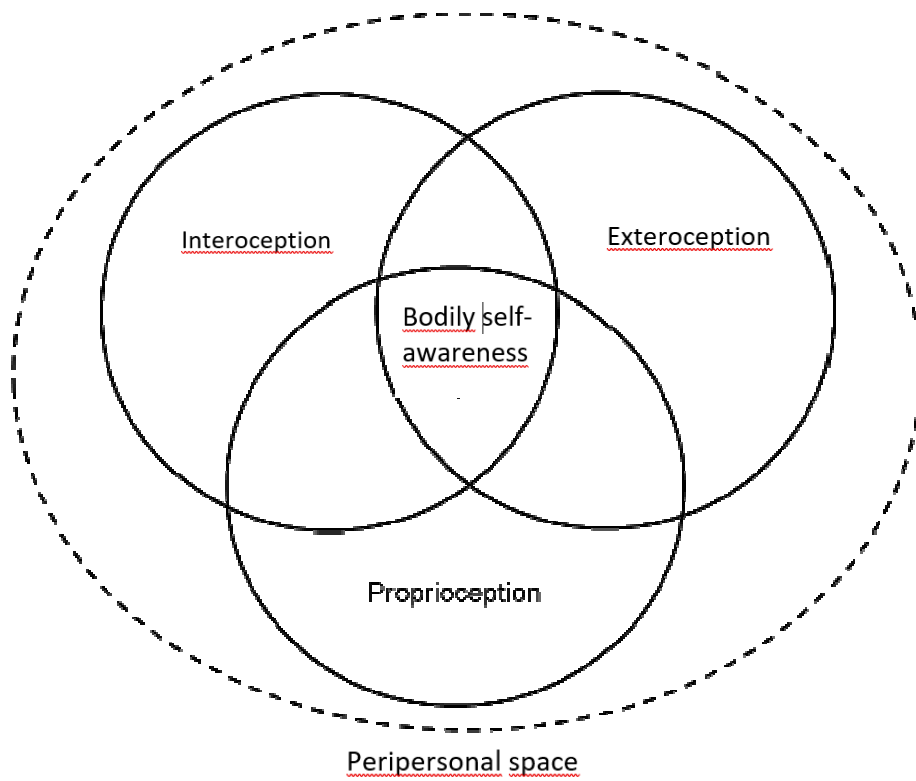


Figure 2. Model inspired by J. Panksepp & J. B. Panksepp’s model of nested brainmind hierarchies (2015) and by B. Andrieu’s theory of emersion (2016)

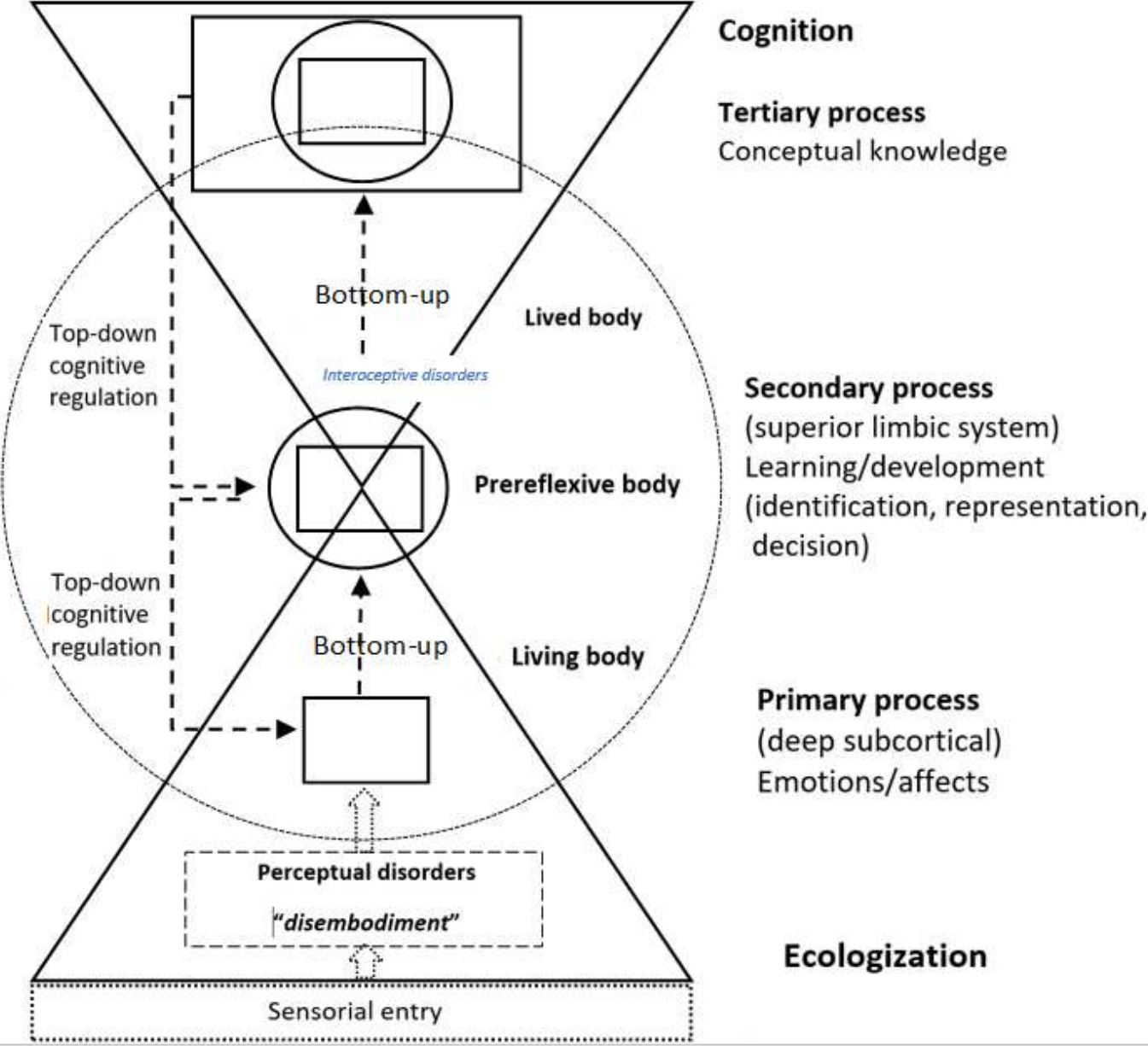
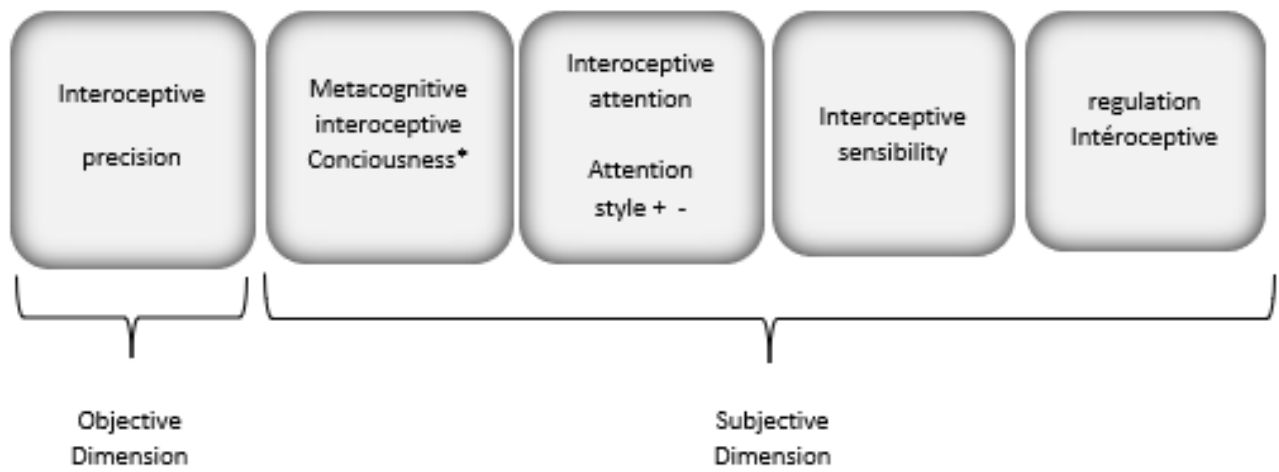


Figure 3. Modalities of interoceptive self-awareness



- = Trust in one's interoceptive precision

Figure 4. Research Methodology

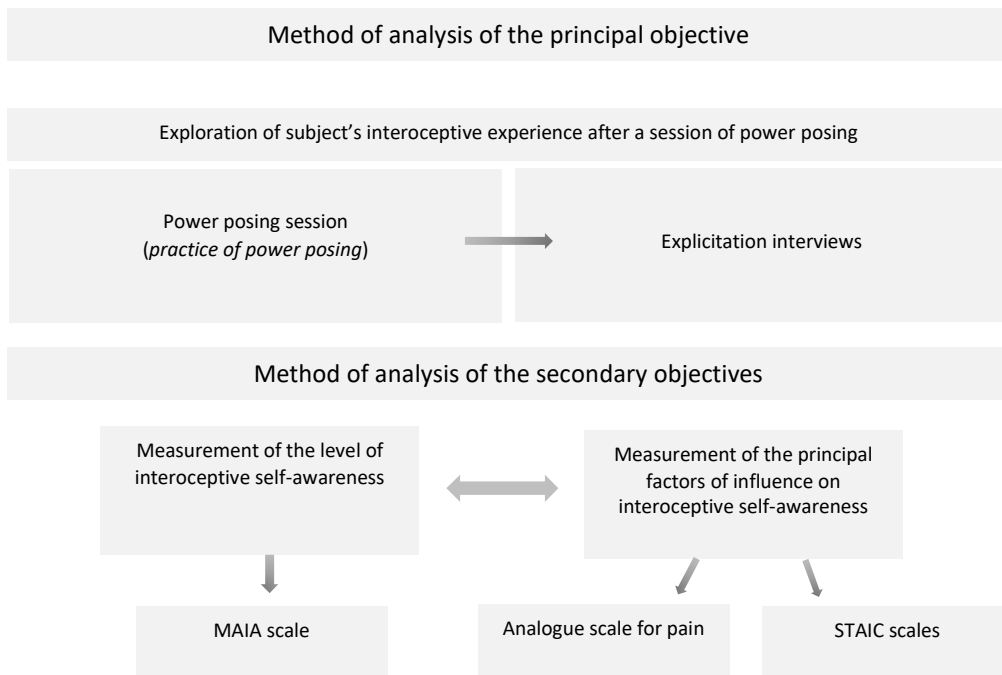


Figure 5. The MAIA's eight criteria of interoceptive self-awareness [17]

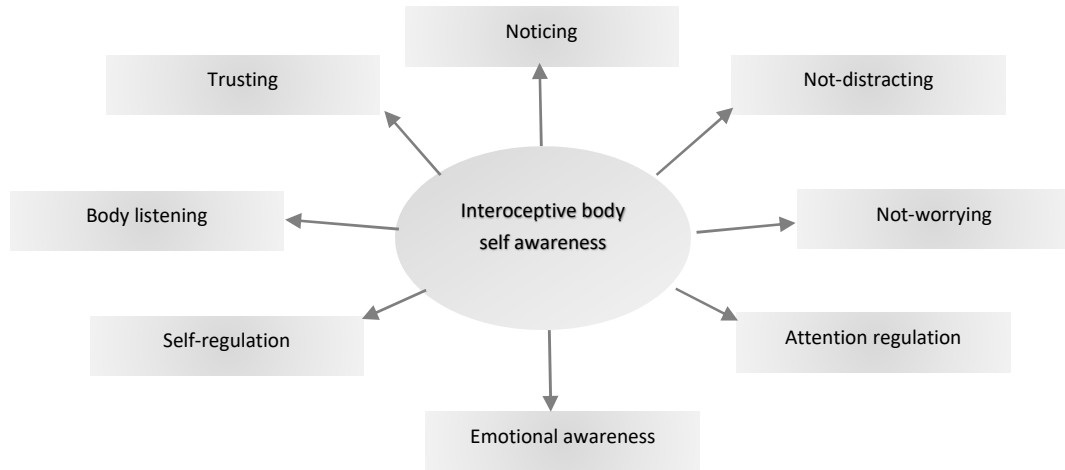


Figure 6. Power posing session

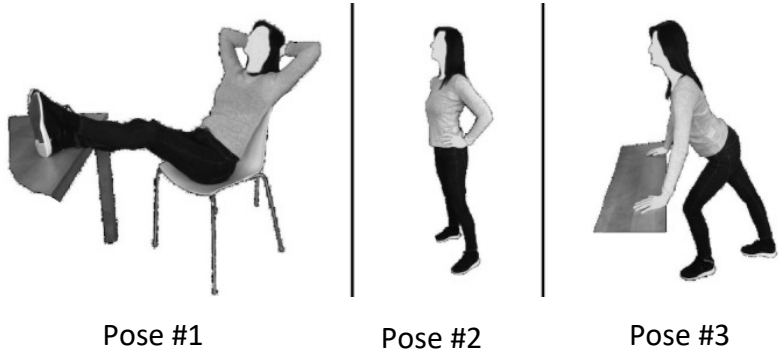


Table 1. Sociodemographic Questionnaire

	Age	BMI	Regular physical activity	Type of activity	Frequency	Previous mind-body experiences (yoga, sophrology, etc.)
Participant 1	15	30	no	-	-	1 time
Participant 2	16	34.53	no	-	-	no
Participant 3	13	54	yes	piscine	45 min./week	no
Participant 4	15	33.23	yes	karaté	90 min. x4 /week	no
Participant 5	14	33.96	no	-	-	no

	VAS	Location	Commentary
Participant 1	0	-	Occasional blockage of the left knee in a standing position
Participant 2	5	Low back pain	Following a fall the previous evening
Participant 3	2	Left ring finger	Paronychia operated on the previous evening
Participant 4	0	-	-
Participant 5	1	Headache	After getting up abruptly

Table 2. Pain Evaluation

Average score from 0 to 10

	STAI-C State	STAI-C Trait	Total Average	Overall Level of Anxiety
Participant 1	38 (average)	49 (high)	43.5	High
Participant 2	30 (low)	43 (high)	36.5	Average
Participant 3	35 (average)	50 (high)	42.5	High
Participant 4	31 (low)	47 (high)	39	Average
Participant 5	31 (low)	36 (average)	33.5	Low

Table 3. Anxiety Evaluation: STAI-C State (situational) et STAI-C Trait (habitual)

Average score per item from 0 to 3

Total of each scale and overall average (minimum score of 20 to a maximum score of 60)

	MAIA Score out of 160	Level of Overall Interoceptive Self-Awareness
Participant 1	44	Low
Participant 2	71	Below Average
Participant 3	73	Below Average
Participant 4	100	Normal
Participant 5	93	Average

Table 4. Level of Overall Interoceptive Self-Awareness

Average score by criterion from 0 to 5

Table 5. Multidimensional Criteria of Interoceptive Self-Awareness

Average score per item from 0 to 5

	1/ Noticing	2/ Not-distracting	3/ Not- worrying	4/ Attention regulation	5/ Emotional Awareness	6/ Self- regulation	7/ Body listening	8/ Trusting
Participant 1	2	2	0.33	2.28	2.2	0	0	0.67
Participant 2	3.25	1	2.33	3	0.8	0.5	3	4
Participant 3	2.75	2.33	4.67	2	1.6	2	0	3.67
Participant 4	3.75	2.33	2.67	2.43	4.8	4	3.33	1
Participant 5	2.75	3	4	3.14	4	2	1.33	2.33
Average	2.9	2.13	2.8	2.57	2.68	1.7	1.53	2.33
Mean deviation	0.48	0.5	1.23	0.4	1.38	1.16	1.31	1.20