Received: 18 July 2019 | Revised: 13 February 2020 | Accepted: 23 February 2020

DOI: 10.1002/erv.2730

WILEY

RESEARCH ARTICLE

Body-related attentional bias as mediator of the relationship between body mass index and body dissatisfaction

Bruno Porras-Garcia[1] | **Marta Ferrer-Garcia**[1] | **Lena Yilmaz**[1] | **Yigit O. Sen**[1] | **Agata Olszewska**[1] | **Alexandra Ghita**[1] | **Eduardo Serrano-Troncoso**[2] | **Janet Treasure**[3] | **José Gutiérrez-Maldonado**[1]

[1]Department of Clinical Psychology and Psychobiology, University of Barcelona, Barcelona, Spain

[2]Child and Adolescent Psychiatry and Psychology Department, Hospital Sant Joan de Déu of Barcelona, Esplugues de Llobregat, Spain

[3]Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK

Correspondence
José Gutiérrez-Maldonado, Department of Clinical Psychology and Psychobiology University of Barcelona, Passeig de la Vall d'Hebron, 171, Barcelona 08035, Spain.
Email: jgutierrezm@ub.edu

Funding information
AGAUR, Generalitat de Catalunya, Grant/Award Number: 2017SGR1693; Spanish Ministry of Science and Innovation, Grant/Award Number: PSI2015-70389-R

Abstract

Body image disturbance, consisting of an affective (body dissatisfaction) and perceptual (body distortion) component, is not only found in eating disorders, but is also present in healthy individuals, affecting their psychological well-being and everyday life. A higher body mass index is associated with higher body dissatisfaction, whereas results in relation to body distortion are mixed. Furthermore, body dissatisfaction is associated with a weight-related attentional bias. This study aimed to investigate the mediating role of a weight-related attentional bias in the relationship between body mass index and body image disturbance. Forty-one college women took part in a virtual reality and eye tracking procedure, in which the illusion of owning a virtual avatar with their body measurements was induced. During this procedure, body-related attentional bias was measured and afterwards body image disturbance was assessed. Mediation analysis revealed that weight-related attentional bias mediated the relationship between body mass index and body dissatisfaction (but not distortion). These findings suggest that modifying weight-related attentional bias would be a useful treatment target for improving body dissatisfaction. In addition, virtual reality technology could serve as an innovative method for modifying attentional bias in an ecologically valid way.

Highlights

1. This Virtual Reality and Eye-Tracking study expands our knowledge about the relation between body mass index, body-related attention and body image disturbances.
2. The results suggest that attentional bias towards weight-related body parts mediates the relation between BMI and body dissatisfaction.
3. On the contrary, the relation between BMI and body distortion was not significant.

KEYWORDS

body dissatisfaction, body mass index, body-related attention, eye-tracking, virtual reality

1 | INTRODUCTION

Previous research has suggested that individuals with a higher body mass index (BMI), such as overweight and obese individuals, are more susceptible to being highly stigmatized (Brownell, Puhl, Schwartz, & Rudd, 2005; Puhl & Brownell, 2001; Puhl & Heuer, 2009), and suffer misjudgments based on negative attitudes, beliefs or assumptions towards their weight or body shape—a phenomenon known as weight-bias (Alberga, Russell-Mayhew, von Ranson, & McLaren, 2016; Washington, 2011). Consequently, overweight and obese individuals may be affected by a poor body image representation of themselves (Puhl & Heuer, 2009), also known as body image disturbances (BIDs).

Individuals with BID, including its affective (body dissatisfaction) and perceptual (body distortion) components (Cash & Deagle, 1997), typically present dysfunctional cognitions and emotions (e.g., sadness, anger or disgust) related to the way in which they experience their own body shape or weight, producing significant body avoidance (e.g., wearing loose clothes) or negative body checking strategies (Legenbauer, Thiemann, & Vocks, 2014).

Following on from the previous statement, several studies have reported higher body dissatisfaction levels among overweight and obese individuals compared to normal-weight persons (Schwartz & Brownell, 2004; Weinberger, Kersting, Riedel-Heller, & Luck-Sikorski, 2016).

Moreover, BMI, among other psychological factors (e.g., weight-related teasing or self-esteem), may be an important predictor of body dissatisfaction in adult women (Pingitore, Spring, & Garfieldt, 1997), adolescents (Cattarin & Thompson, 1994; Stice & Whitenton, 2002; Wojtowicz & von Ranson, 2012) and children or young adolescents (Kelly, Patalay, Montgomery, & Sacker, 2016). In contrast, such a relation was only found among men with binge eating disorder (BED), while body dissatisfaction was not predicted by BMI among women with BED (Matz, Foster, Faith, & Wadden, 2002).

As for the relation between BMI and body size estimation, some studies have found that healthy participants with low BMI tended to overestimate their body size, while participants with high BMI tended to underestimated it (Cornelissen, Bester, Cairns, Tovée, & Cornelissen, 2015). Other studies have found the opposite relation, in which participants with low BMI underestimate their body size, while participants with high BMI overestimate it (Thaler et al., 2018). Finally, still other studies have found no relation between BMI and body size estimation in healthy individuals and anorexia nervosa (AN) patients (Hagman et al., 2015).

Therefore, based on the results from previous studies, it may be difficult to objectively define the role of BMI in BID (body dissatisfaction and body distortion). Suggesting that other variables may be influencing this relationship. Among those variables, body-related attention has received growing attention (Rodgers & DuBois, 2016). For instance, previous authors have suggested that a dysfunctional pattern of visual attention towards the body in individuals with higher BMI may maintain or even exacerbate their body dissatisfaction levels (Roefs et al., 2008).

Previous research focusing on the relation between dysfunctional body-related attention and BID suggested that all body information consistent with previous dysfunctional cognitive schema (e.g., 'I have big thighs') is more strongly noticed and processed, compared to schema-inconsistent information (e.g., 'I am getting thinner') which is not equally noticed or is even ignored (Rodgers & DuBois, 2016; Tuschen-Caffier et al., 2015; Williamson, White, York-Crowe, & Stewart, 2004).

In a phenomenon known as attentional bias (AB), described as the propensity to pay more attention to certain types of stimuli or information (e.g., disorder-relevant information) over other sorts of information (Williamson et al., 2004), adult patients with eating disorders (EDs) and individuals with high body dissatisfaction show a tendency to focus more on self-reported unattractive body parts than other body parts (Freeman et al., 1991; Jansen, Nederkoorn, & Mulkens, 2005; Roefs et al., 2008; Tuschen-Caffier et al., 2015). Similar results have been found in adolescents with different ED subtypes and healthy adolescents (Bauer et al., 2017).

In addition, previous studies suggest that individuals with a higher BMI (who typically present higher body dissatisfaction levels) exhibit AB towards self-reported unattractive body parts as well. Indeed, increased BMI in normal-weight women correlated with an AB towards their self-reported most unattractive body areas (Roefs et al., 2008). Similar results were found in individuals with obesity, who focused more on the waist (a weight-related body part) than did normal-weight individuals (Gardner, Morrell, Watson, & Sandoval, 1990). According to Svaldi, Caffier, and Tuschen-Caffier (2011) both individuals with and without BED revealed an AB towards their self-reported ugliest body parts compared with the most beautiful ones. Interestingly, BED individuals showed longer and more frequent fixations on their self-reported unattractive body parts, and their BMI levels correlated with the AB towards their self-reported unattractive body parts. On the other hand, Warschburger, Calvano, Richter, and Engbert (2015) reported that higher BMI levels predicted higher AB towards self-reported attractive body parts in normal weight and

overweight women and men. Consequently, this relationship between BMI and body-related attention requires further exploration in order to draw clearer conclusions.

Several studies have found that AB towards one's self-reported unattractive body parts elicits higher body dissatisfaction in women (Smeets, Jansen, & Roefs, 2011), adolescents with AN and bulimia nervosa, and in healthy adolescents (Bauer et al., 2017). These results were also found in a study in which AB was induced using negative body-related words (Smith & Rieger, 2009). On the contrary, when AB among body dissatisfied women was induced towards their self-reported attractive body parts it led to higher body satisfaction levels (Jansen et al., 2016; Smeets et al., 2011). Based on these results, AB modification has been proposed for use in ED treatments (Renwick, Campbell, & Schmidt, 2013).

To sum up, previous research suggests that, first, a higher BMI may elicit AB towards self-reported unattractive body areas in one's body; and second, this dysfunctional body-related attention elicits higher body dissatisfaction levels. Hence, body related-attention may mediate the relationship between higher BMI and body dissatisfaction, and body distortion as well. However, to the best of our knowledge, no study to date has assessed whether such relations exist.

We propose a new visual attention assessment methodology using a virtual reality (VR) head-mounted display (HMD) with an eye-tracker (ET) device add-on. Even though fixed ETs have proven to be useful tools for providing a direct and continuous measure of visual attention, and particularly sustained attention (Jiang & Vartanian, 2018), they also present some limitations such as the lack of external validity (Kredel, Vater, Klostermann, & Hossner, 2017). The combination of VR and ET devices provides the ability to generate more ecologically valid settings, for example, through the simulation of real-life situations, while the individual's visual attention patterns are measured in an accurate and objective way (Lutz et al., 2017). The use of VR-based embodiment techniques provides the chance to create a real-size 3D simulation of the body of the participants with their specific physical features (Gutiérrez-Maldonado, Ferrer-García, Dakanalis, & Riva, 2018) and to feel their artificial body as their own body, in a paradigm known as full body illusion (FBI). Furthermore, it even allows the manipulation of perceptual and emotional body representations (e.g., Porras Garcia, Ferrer Garcia, Olszewska, et al., 2019; Preston & Ehrsson, 2014; Serino et al., 2016). Two previous studies conducted by our group combined ET and VR technologies to assess gender differences in AB using a VR-based embodiment procedure. Women showed an AB towards weight-related body parts, while men showed the opposite gaze behaviour (Porras-Garcia et al., 2018) specifically towards muscular-related body parts (Porras Garcia, Ferrer Garcia, Olszewska, et al., 2019; Porras-Garcia, Ferrer-García, Ghita, et al., 2019).

The current study aimed to explore the relation between BMI, body-related AB (weight vs non-weight-related body parts) and BIDs in a sample of women. Specifically, the aim was to assess whether AB towards weight related body parts mediates the relation between BMI and body dissatisfaction/body distortion. The AB of participants was measured while they were embodied in a female virtual body (VB) with their actual body measurements (real-size VB). It was expected that women with a higher BMI would experience higher body dissatisfaction/distortion levels after owning the real-size VB. However, it was also expected a mediational effect of AB towards weight-related body parts, in this previous relation. Therefore, it was expected that, first, individuals with a higher BMI would spend more time looking at the weight-related body areas; second, those individuals who spent more time looking at weight-related body parts would experience higher body dissatisfaction and body distortion levels after owning the real-size VB.

2 | METHOD

2.1 | Participants

Forty-one college women (M_{age} = 23.89 years, SD = 3.25 years, M_{BMI} = 22.46 kg/m^2, SD = 2.81 kg/m^2) from the Campus Mundet of the University of Barcelona were recruited to participate in this study using social networks and flyers. Self-reported diagnosis of a current ED, a BMI value lower than 18.5 (underweight) or higher than 30 (obesity) (World Health Organization, 2004), and self-reported severe mental disorder were considered exclusion criteria. Similarly, to previous studies (e.g., Stice & Bearman, 2001) it was decided to use a restricted BMI range. Thus, individuals with underweight or obesity were excluded.

2.2 | Instruments

2.2.1 | Hardware and software

Each participant was exposed to an immersive virtual scenario using a HMD HTC-VIVE connected to a computer with enough graphic and processor power to move VR environments. Two programs were used to develop the virtual simulations: Blender v.2.78 software was used to create a 3D Caucasian female avatar wearing a standard black outfit (t-shirt, jeans and trainers; see Figure 1). In order to avoid

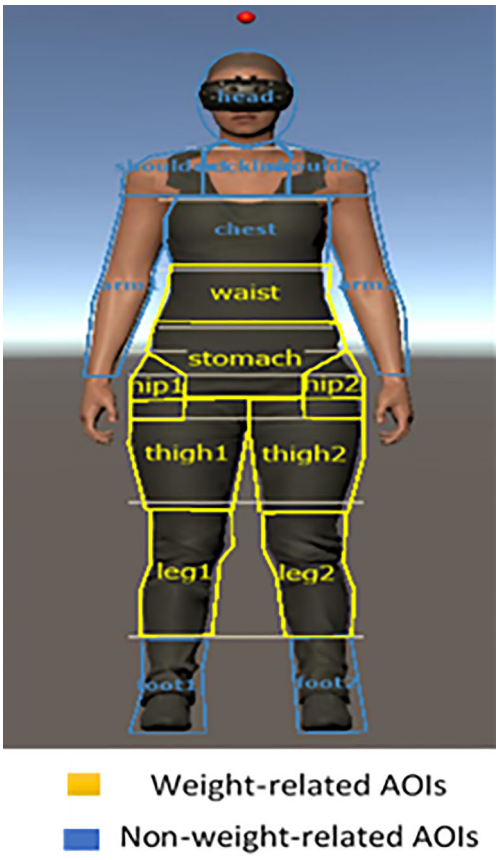

FIGURE 1 Visual description of the weight-related and non-weight-related areas of interest (AOIs), in the female and male virtual avatars

any influence of the individual's hairstyle on participants, the avatar's hair was covered with a swimming cap. Likewise, the avatar's face was covered, since it was wearing a Head Mounted Display (HMD), like the real HMD that participants were wearing during the task. Object-oriented programming code was developed using the Unity 3D 5.5.v software to place the avatar in the virtual environment, which consisted of a small room including only a large mirror situated on the wall, 1.5 m in front of the participant. HTC-VIVE HMD and VIVE controllers incorporate sensors which are tracked by the base stations mounted at opposite corners of the playing area, and which allow the software to capture the movement of the head and the arms of the participants and transfer it to the avatar. The mirror was visible only during the third person perspective condition (in which participants were instructed to look at their VB in the reflection) and throughout the ET assessment.

2.2.2 | Body-related AB assessment

Participants' selective visual attention was measured using the complete fixation time on the areas of interest (AOIs), as previously used in research on body-related attention (e.g., Bauer et al., 2017). Weight related body parts (W-AOIs) were chosen based on the Weight Scale of body items of the Physical Appearance State and Trait Anxiety Scale questionnaire (Reed, Thompson, Brannick, & Sacco, 1991), and drawn onto a picture of a female avatar in the frontal view. Body parts included in the W-AOIs were the legs, thighs, buttocks, hips, stomach (abdomen) and waist. As it is currently not possible to reproduce muscle tone, no representation of it was included. After the separation of W-AOIs, the remaining body parts (head, neck, chest, shoulders, arms and feet) were labelled as non-weight related body parts (NW-AOIs; Figure 1).

Visual fixation was defined by Jacob and Karn (2018) as the visual act of maintaining one's gaze at a single location for a minimum duration, usually 100–200 ms. The sum of the visual fixation times of each of the subjects was estimated using the complete fixation time on the AOIs. This was achieved by summing up separate fixation times spent on W-AOIs vs on NW-AOIs. Previous studies focusing on body-related attention used this specific gaze-behavioral measure, provided by ET technology, as a reliable and continuous measure of attention allocation towards specific body areas (Bauer et al., 2017; Jiang & Vartanian, 2018; Kerr-Gaffney, Harrison, & Tchanturia, 2018; Svaldi et al., 2016).

2.2.3 | Body image dissatisfaction and body image distortion assessment

The *Body Image Assessment Scale—Body Dimensions (BIAS-BD*, Gardner, Jappe, & Gardner, 2009) was used to assess BID in this study. The BIAS is a figural drawing scale questionnaire, which presents physical anthropometric dimensions of adult women in a series of human silhouettes. Participants selected the one that was perceived as their body size (perceived silhouette) and the one they desired to have (desired body size). Then, according to their BMI, the real silhouette was also selected. The scale allows researchers to estimate the participant's body dissatisfaction (discrepancy between perceived and ideal body size) and body distortion (discrepancy between perceived and real body size). This scale has been shown to have good psychometric properties, such as good test–retest reliability (r = .86) with data collection before and after a two-week interval, and good concurrent validity (r = .76), after comparing participants' perceived actual body size and self-reported BMI (Gardner et al., 2009).

2.3 | Procedure

This study was approved by the ethics committee of the University of Barcelona. Before the beginning of the study, each participant freely signed the consent form, which explained the procedure and informed participants about data confidentiality as well as their ability to withdraw from the study at any point without consequences. Additionally, confidentiality was ensured by assigning a different identification code to each of the participants. To calculate their BMI, each participant's weight and height were measured. Next, using a camera, the researcher took a photo of the participant. The participant was asked to stand with her arms slightly raised and legs separated on a fixed position 2 m from the camera. Researchers used Unity software to adapt the measures of the virtual avatar's silhouette to each of the body parts (e.g., arms, legs, hips, waist, chest, stomach, breast, shoulders, etc.) of the participant captured in the photo. Finally, the participant owned their avatar in the VR scenario using a HMD (HTC-VIVE). Two procedures were conducted:

- *Visuo-tactile stimulation procedure*: This procedure was used to enhance the FBI. The participant was asked to look at herself, in first person perspective, while the researcher applied a series of continuous touches to specific body parts (15 s for each arm, 30 s for the abdomen and 15 s for each leg) with the HTC-VIVE controller, which was also visible in VR. One and a half minutes later a mirror appeared on the wall in front of the participant in the VR scenario and the procedure was repeated, but, at that time, the participant was asked to look at herself in the mirror (third person perspective).

  After the visuo-tactile stimulation procedure, FBI levels were assessed in each VB condition using a visual analog scale ranging from 0 (none) to 100 (completely).
- *ET assessment task*: To record the eye movements the Pupil Labs HTC Vive ET device—a 120 Hz contact free binocular ET add-on for the VR HMD (HTC VIVE)—was used. It has a spatial accuracy of one degree and gaze precision of 0.08°. The accuracy of the ET recordings was measured using a nine-point calibration procedure. After the calibration and validation procedures spontaneous eye movements were recorded while participants were instructed to look for 30 s at the reflection of their avatar in the mirror (Jansen et al., 2005; Roefs et al., 2008). The participants were asked to try to avoid sudden head movements throughout the task. Previously, as a cover story, they were told to remain still while the virtual avatar position was being recalibrated.

After finishing both procedures, the participant left the VR environment and completed the BIAS-BD questionnaire.

2.4 | Statistical analysis

Ogama software (Open Gaze Mouse Analyzer) was used to transform the ET raw data into suitable quantitative data. Additional data transformation was conducted by calculating the difference between weight-related and non-weight-related AOIs (e.g., complete fixation time [W-AOIs: 2,515 ms—NW-AOIs: 2,510 ms = 5 ms]). Therefore, a positive outcome would mean that the participant had been looking at the weight-related body parts longer than at the non-weight-related body parts, while a negative outcome would mean the opposite.

The following analyses were conducted with the statistical software IBM SPSS Statistics v.23. Initially, a paired-sample *t-test* was used to determine whether there was a statistically significant difference between the amount of time that participants spent looking at weight-related vs non-weight-related AOIs. Then, based on previous research, the following mediational model was proposed: *BMI* (*X*) indirectly affects body dissatisfaction and body distortion levels (*Y*) through the mediating effect of a complete fixation time on body-related AOIs (M, mediator).

First, to test the total effect of BMI on body dissatisfaction and body distortion, two simple regression analyses were conducted. Additionally, indirect effects were tested using the software PROCESS (Hayes, 2013) and using an empirical bias-corrected bootstrapping procedure with 10,000 resamples and a 95% confidence interval. This is considered a suitable statistical procedure for conducting mediational analysis in a small sample size, in contrast to traditional approaches (e.g., Baron & Kenny, 1986). The indirect effect (paths $a \times b$) is considered statistically significant if the 95% confidence interval does not include zero (Hayes, 2013).

3 | RESULTS

The descriptive results revealed that, overall, participants spent more time looking at weight-related AOIs (M = 9,505 ms, SD = 4,154 ms) than non-weight related AOIs (M = 6,528 ms, SD = 539 ms; $t[36] = 2.831$, $p = .008$). Regarding the BIAS-BD questionnaire, participants reported an average body dissatisfaction score of 11.74 (SD = 14.30) and an average body distortion score of 12.79 (SD = 13.01).

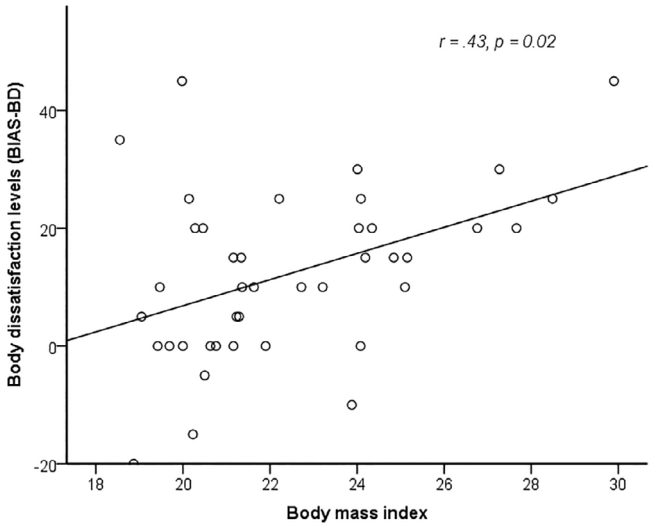

FIGURE 2 Scatter plot assessing the linear relation between BMI and body dissatisfaction values

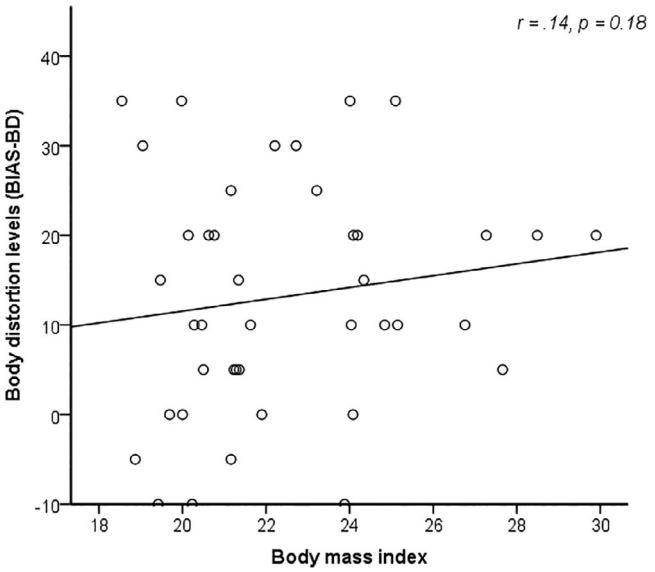

FIGURE 3 Scatter plot assessing the linear relation between BMI and body distortion values

All the requirements of the test were met. A linear relationship among the variables (BMI and body dissatisfaction) was apparent using a scatter plot (see Figures 2 and 3), and there was homoscedasticity and normality of the residuals. Finally, there was independence of the residuals, as assessed by Durbin–Watson statistics, and no outliers or extreme cases were detected. Simple regression analyses showed that BMI significantly predicted body dissatisfaction levels $F\ (1.40) = 9.019$, $p = .005$, accounting for 18.8% of the explained variability, but did not predict body distortion $F\ (1.40) = .80$, $p = .375$.

Consequently, there was a significant total effect of BMI on body dissatisfaction but not on body distortion. Since having a significant total effect is no longer a necessary requirement for an indirect effect to be present (Hayes, 2013), both body dissatisfaction and body distortion were included in two separated mediational models.

The results of the simple mediational analysis indicated that BMI was a significant predictor of fixation time on weight-related AOIs, and that complete fixation time on weight-related AOIs was a significant predictor of body dissatisfaction. In addition, the direct effect showed that BMI was no longer a significant predictor of body dissatisfaction after controlling for the mediator, complete fixation time, on weight-related AOIs. Approximately 30% of the variance in body dissatisfaction was accounted for by the predictors ($R^2 = .30$). The indirect effect was also significant. Having higher BMI scores was associated with ~1.07 points of higher body dissatisfaction scores as mediated by spending more time looking at the weight-related AOIs (see Figure 4).

As for the mediational effect of complete fixation time on weight-related AOIs on the relationship between BMI and body distortion, the results of the simple mediation analysis showed that complete fixation time was not a mediator of this relationship (see Figure 5).

4 | DISCUSSION

This study aimed to explore the relation between BMI, AB towards weight-related body parts, and BIDs, specifically body dissatisfaction and body distortion, in a college sample of women. To do so, we developed a new visual attention assessment methodology using a VR HMD with an ET device add-on, in which each participant was embodied in a female virtual avatar with their actual body measurements.

The results showed that a higher BMI significantly predicted higher body dissatisfaction, but not higher body distortion levels, after participants owned their real-size VB. These results are consistent with previous studies in which adults or adolescents with a higher range of BMI values reported higher body dissatisfaction (Cattarin & Thompson, 1994; Pingitore et al., 1997; Schwartz & Brownell, 2004; Stice & Whitenton, 2002; Weinberger et al., 2016; Wojtowicz & von Ranson, 2012). However, these results contrast with other studies that did not find such a relation in non-clinical samples (Bearman, Presnell, Martinez, & Stice, 2006; Stice & Bearman, 2001).

On the other hand, a significant relation between BMI and body distortion was not found, meaning that participants showed similar accuracy in estimating their body size independently of their BMI. This lack of

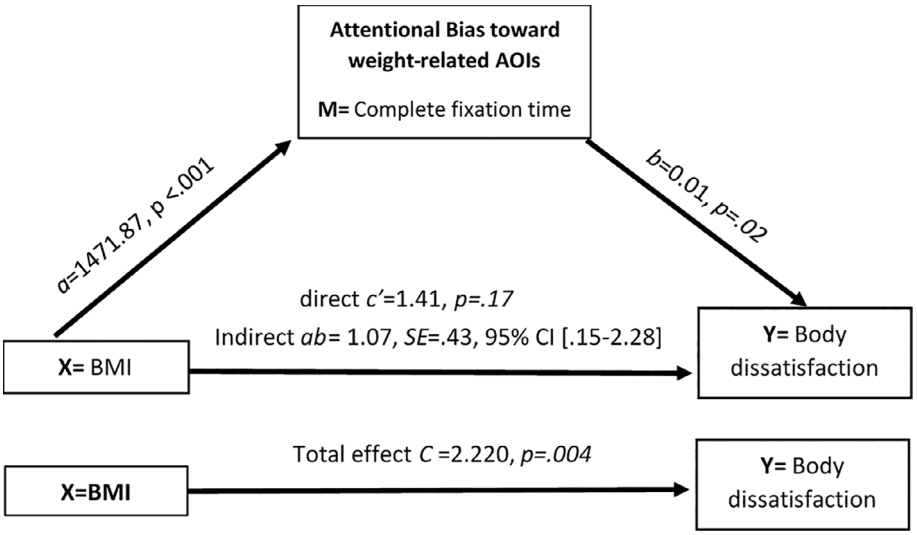

FIGURE 4 Mediational model analysis between BMI, body-related attention and body dissatisfaction

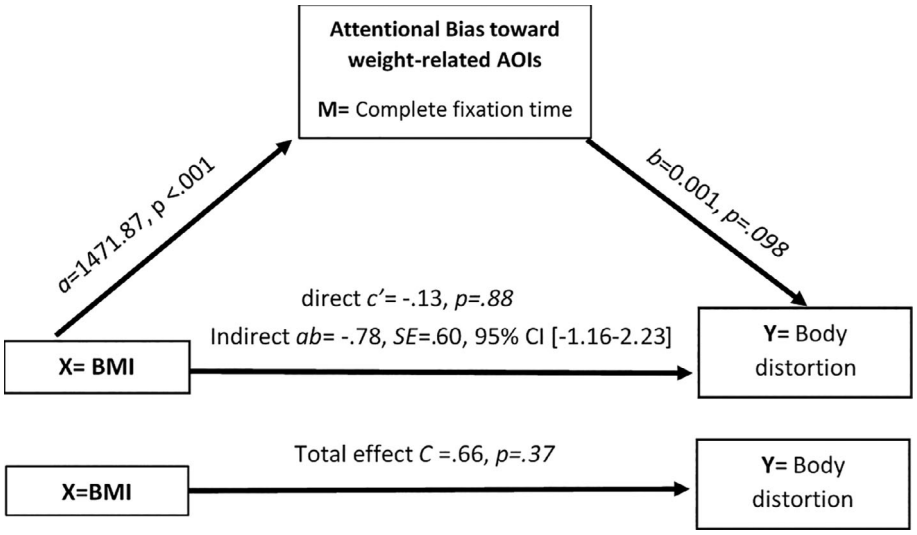

FIGURE 5 Mediational model analysis between BMI, body-related attention and body distortion

relation between body distortion and BMI has also been found in previous studies with non-clinical samples (Cornelissen, McCarty, Cornelissen, & Tovée, 2017; Hagman et al., 2015). However, they are inconsistent with the findings of Cornelissen et al. (2015). These authors found that non-clinical participants with a low BMI tended to overestimate their body size, while participants with a high BMI underestimated it. These contradictory results may be explained by the different procedures used to estimate body size in the reviewed studies. Thus, in our study, perceived and ideal body images were assessed using a silhouette test. This paper-based procedure (BIAS-BD), as well as that used by Cornelissen et al. (2017) in the second procedure, allows participants to see the full range of body sizes (from slimmest to largest) available for the assessment. In contrast, in Cornelissen et al. (2015) and in the first procedure in Cornelissen et al. (2017), all individuals were randomly presented with a single image of a female avatar that was larger or smaller than the participant's body, and they had to decide whether it matched their body size or not in a yes–no task (Cornelissen et al., 2015, 2017).

A significant mediation effect of AB towards weight-related body parts was also found in the relationship between BMI and body dissatisfaction, meaning that BMI was indirectly affecting body dissatisfaction levels only through the mediating effect of a complete fixation time on weight-related AOIs.

According to our results, individuals with a higher BMI paid more attention to the weight-related body areas, compared to individuals with a low BMI, when they were embodied in a real-size VB. Several studies have previously found an AB towards self-reported unattractive body parts or weight-related body parts in non-clinical women with a high BMI when exposed to

pictures of their own body (Gardner et al., 1990; Roefs et al., 2008; Svaldi et al., 2011), and in BED individuals (Svaldi et al., 2011). These results show a body checking visual attention strategy towards weight-related body parts usually perceived as problematic among women (Alfano, Hildebrandt, Bannon, Walker, & Walton, 2011). In contrast to our results, Warschburger et al. (2015) reported that overweight women and men paid more attention towards self-reported attractive body parts when they were exposed to pictures of their own or control bodies. The differences between studies may be explained by the following: even though our weight-related body areas were consistent with the self-rated unattractive body parts in Warschburger et al.'s (2015) study (e.g., waist, stomach and thighs), they used photographs of participants taken from a different angle and wearing underwear, while in our study, the virtual avatar wore tight standard clothes. Additionally, the two studies used completely different visual-attention assessment procedures, with different ET devices. In our study, an ET device add-on VR-HMD was used, and therefore gaze patterns were measured while participants were embodied in a virtual avatar with their real measures, and they could see their own VB when looking at themselves or their reflection in the mirror in front of them. On the other hand, Warschburger et al. (2015) used a fixed ET device in which participants were presented with a series of pictures of their own and control bodies. Consequently, our study allowed participants to reproduce real-life situations (e.g., looking at your own body in the mirror), while the individual was in their own body, providing a more ecologically valid experimental setting. However, it should also be considered that a VB does not represent all the realistic features of a person's own body as well as a photograph.

Furthermore, individuals who spent more time looking at weight-related body parts while they were embodied in the real-size VB rated body dissatisfaction levels as higher in the silhouette scale test after leaving the virtual environment. Previous studies that used a short-term body exposure intervention (less than a minute), as in our study, found similar results in which higher body dissatisfaction levels were elicited by inducing an AB towards self-reported unattractive body parts (Bauer et al., 2017; Smeets et al., 2011) or by using negative body-related words (Smith & Rieger, 2006, 2009) among high body-dissatisfied women or ED patients. Our study supports the relationship between AB towards unattractive body parts or areas of higher concern, and body dissatisfaction, after controlling for the BMI of our participants.

Different results were reported by Jansen et al. (2016), who proposed two different AB modification training procedures towards self-reported unattractive or attractive body parts in a group of women with high body dissatisfaction. It was observed that after five long-term exposure sessions (30 minutes each), all women, regardless of whether they were exposed to their self-reported unattractive or attractive body parts, reported higher body satisfaction levels. Even though our results seem to initially contradict this latter study, when we consider the initial unattractive body exposure sessions of Jansen et al. (2016), our results are not so different. More specifically, in the study conducted by Jansen et al. (2016) body satisfaction levels slightly decreased during the first 5 minutes of each session (even the last one), as happens in short-term body exposure interventions, showing a sensitization to unattractive body parts. However, during the session, participants tended to become used to the body discomfort experienced, and their body satisfaction levels progressively increased showing habituation to their unattractive body parts. Similar results were found in previous studies that reported that systematic desensitization towards one's own body was a successful strategy to reduce anxiety and to increase body satisfaction in obese participants (Jansen et al., 2008). To sum up, the number of sessions and the time of exposure to the body may play an important role in the relationship between AB towards unattractive body parts and body dissatisfaction.

In summary, our study presents new evidence for the mediational role of body-related attention in the relation between BMI and body dissatisfaction. However, even though the variables involved in the mediational model were assessed in an appropriate temporal order (BMI-AB-BD), the causality between body-related attention and BD might be debated. Since some participants may already present certain levels of BD before the VR task, it may be that AB towards weight-related body parts elicit higher BD levels, but the opposite effect is also possible, suggesting a bi-directional relationship between body-related attention and BD. Indeed, some studies have found that individuals with high BD present an AB towards self-reported unattractive body parts (e.g., Roefs et al., 2008; Tuschen-Caffier et al., 2015). Therefore, future studies should measure BD before and after the AB assessment task to establish whether an increase in BD levels after the ET assessment task is indeed related with the dysfunctional gaze-behavioural pattern towards the body.

Relatedly, future studies may focus on changing dysfunctional body-related attentional patterns as a successful way to improve body dissatisfaction levels among non-clinical individuals, as well as patients with eating and weight disorders. As previously suggested, AB modification training towards un/attractive body parts may be

considered as a suitable approach to reduce body dissatisfaction. Furthermore, in this study we propose a new selective visual assessment method based on using an embodiment-based VR technique with an ET device add-on. Future AB modification training may profit from this new approach by simulating emotionally salient real-life situations among individuals with body issues (e.g., looking in a mirror in a clothing store, or in a bathroom), or by modifying some body parts (e.g., increasing or reducing the weight-related body parts) while the individual's visual attention patterns are objectively measured.

Several limitations of this study should be noted. First, even though the participants already represented a wide range of BMIs (from 18.5 to 30), individuals within extreme BMI values, such as underweight participants (<18.5 BMI) or obese participants (>30 BMI) were not included in the study because the virtual avatar could not realistically reproduce extreme BMI values, for example, by displaying an important gain or loss of weight represented throughout the whole body. Consequently, the results are not generalizable to individuals with obesity or very low weight. Likewise, as our sample consisted of college-aged women without ED, the results found cannot be generalized to other populations, such as men, other age ranges or ED patients. More studies are necessary to assess whether this model fits clinical ED patients, including patients with AN, Bulimia Nervosa, BED patients, and persons with overweight or obesity. Given the gender differences in ideal body image representations (Alfano et al., 2011) and the consequent gender differences in AB towards specific body parts (Porras-Garcia, Ferrer-García, Ghita, et al., 2019), it would be interesting in future studies to assess the relation between BMI, AB towards muscular-related body parts, and BIDs among men. Finally, in order to measure BIDs, it was decided to use a classical figure drawing scale questionnaire. Even though this instrument presents robust psychometric properties (Gardner et al., 2009), recent studies have used newer procedures in which body image representations were assessed using more realistic human-based 3D scales (e.g., Cornelissen et al., 2015; Cornelissen et al., 2017). Future research may also use VR-embodiment techniques as an assessment tool to assess BIDs, in which participants could even change some body parts according to their perceived or ideal body representations, while owning a human-based 3D avatar.

Despite its limitations, this study expands our knowledge about the relation between BMI, body-related attention and BIDs. The results suggest that AB towards weight-related body parts mediates the relation between BMI and body dissatisfaction. On the contrary, the relation between BMI and body distortion was not significant. Therefore, future research focusing on assessing or treating body dissatisfaction and its associated clinical disorders should not only consider an individual's BMI value, but also their body-related AB. In addition, further research should address the question whether a relation between BMI, AB towards weight-related body areas and body dissatisfaction also exists among individuals with obesity and among ED patients. Finally, the combination of VR and ET technologies opens up new opportunities in body-related attention assessment and its treatment.

ACKNOWLEDGEMENTS

This study was supported by the Spanish Ministry of Science and Innovation (MINECO/Project PSI2015-70389-R: Development of virtual reality-based exposure techniques for improving anorexia nervosa treatment); and by the AGAUR, Generalitat de Catalunya, 2017SGR1693.

CONFLICT OF INTEREST

None of the authors of this article have a financial arrangement or affiliation with any product or services used or discussed in this article.

ORCID

Bruno Porras-Garcia https://orcid.org/0000-0001-6759-2547
Marta Ferrer-Garcia https://orcid.org/0000-0003-0529-3431
Janet Treasure https://orcid.org/0000-0003-0871-4596
José Gutiérrez-Maldonado https://orcid.org/0000-0001-7977-2051

REFERENCES

Alberga, A., Russell-Mayhew, S., von Ranson, K., & McLaren, L. (2016). Weight bias: A call to action. *Journal of Eating Disorders*, *4*(1), 34. https://doi.org/10.1186/s40337-016-0112-4

Alfano, L., Hildebrandt, T., Bannon, K., Walker, C., & Walton, K. (2011). The impact of gender on the assessment of body checking behavior. *Body Image*, *8*(1), 20–25. https://doi.org/10.1016/j.bodyim.2010.09.005

Baron, R., & Kenny, D. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037//0022-3514.51.6.1173

Bauer, A., Schneider, S., Waldorf, M., Braks, K., Huber, T., Adolph, D., & Vocks, S. (2017). Selective visual attention towards oneself and associated state body satisfaction: An eye-tracking study in adolescents with different types of eating disorders. *Journal of Abnormal Child Psychology*, *45*(8), 1647–1661. https://doi.org/10.1007/s10802-017-0263-z

Bearman, S., Presnell, K., Martinez, E., & Stice, E. (2006). The skinny on body dissatisfaction: A longitudinal study of adolescent girls and boys. *Journal of Youth and Adolescence*, *35*(2), 217–229. https://doi.org/10.1007/s10964-005-9010-9

Brownell, K., Puhl, R., Schwartz, M., & Rudd, L. (2005). *Weight bias: Nature, consequences, and remedies*. New York, NY: Guilford Publications.

Cash, T., & Deagle, E. (1997). The nature and extent of body-image disturbances in anorexia nervosa and bulimia nervosa: A meta-analysis. *International Journal of Eating Disorders*, *22*(2), 107–126. https://doi.org/10.1002/(sici)1098-108x(199709)22:2<107::aid-eat1>3.3.co;2-y

Cattarin, J., & Thompson, J. (1994). A three-year longitudinal study of body image, eating disturbance, and general psychological functioning in adolescent females. *Eating Disorders*, *2*(2), 114–125. https://doi.org/10.1080/10640269408249107

Cornelissen, K., Bester, A., Cairns, P., Tovée, M., & Cornelissen, P. (2015). The influence of personal BMI on body size estimations and sensitivity to body size change in anorexia spectrum disorders. *Body Image*, *13*, 75–85. https://doi.org/10.1016/j.bodyim.2015.01.001

Cornelissen, K., McCarty, K., Cornelissen, P., & Tovée, M. (2017). Body size estimation in women with anorexia nervosa and healthy controls using 3D avatars. *Scientific Reports*, *7*(1), 15773. https://doi.org/10.1038/s41598-017-15339-z

Freeman, R., Touyz, S., Sara, G., Rennie, C., Gordon, E., & Beumont, P. (1991). In the eye of the beholder: Processing body shape information in anorexic and bulimic patients. *International Journal of Eating Disorders*, *10*(6), 709–714. https://doi.org/10.1002/1098-108x(199111)10:6<709::aid-eat2260100609>3.0.co;2-n

Gardner, R., Jappe, L., & Gardner, L. (2009). Development and validation of a new figural drawing scale for body-image assessment: The BIAS-BD. *Journal of Clinical Psychology*, *65*(1), 113–122. https://doi.org/10.1002/jclp.20526

Gardner, R., Morrell, J., Watson, D., & Sandoval, S. (1990). Eye movements and body size judgments in the obese. *International Journal of Eating Disorders*, *9*(5), 537–544. https://doi.org/10.1002/1098-108x(199009)9:5<537::aid-eat2260090509>3.0.co;2-a

Gutiérrez-Maldonado, J., Ferrer-García, M., Dakanalis, A., & Riva, G. (2018). Virtual reality: Applications to eating disorders. In W. S. Agras & A. H. Robinson (Eds.), *The Oxford Handbook of Eating Disorders* (2nd ed., pp. 148–153). Oxford, UK: Oxford University Press.

Hagman, J., Gardner, R., Brown, D., Gralla, J., Fier, J., & Frank, G. (2015). Body size overestimation and its association with body mass index, body dissatisfaction, and drive for thinness in anorexia nervosa. *Eating and Weight Disorders—Studies On Anorexia, Bulimia And Obesity*, *20*(4), 449–455. https://doi.org/10.1007/s40519-015-0193-0

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: The Guilford Press.

Jacob, R., & Karn, K. (2018). Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. In R. Radach, J. Hyona, & H. Deubel (Eds.), *The mind's eye: Cognitive and applied aspects of eye movement research* (1st ed., pp. 573–605). North Holland: Elsevier Science BV.

Jansen, A., Bollen, D., Tuschen-Caffier, B., Roefs, A., Tanghe, A., & Braet, C. (2008). Mirror exposure reduces body dissatisfaction and anxiety in obese adolescents: A pilot study. *Appetite*, *51*(1), 214–217. https://doi.org/10.1016/j.appet.2008.01.011

Jansen, A., Nederkoorn, C., & Mulkens, S. (2005). Selective visual attention for ugly and beautiful body parts in eating disorders. *Behaviour Research and Therapy*, *43*(2), 183–196. https://doi.org/10.1016/j.brat.2004.01.003

Jansen, A., Voorwinde, V., Hoebink, Y., Rekkers, M., Martijn, C., & Mulkens, S. (2016). Mirror exposure to increase body satisfaction: Should we guide the focus of attention towards positively or negatively evaluated body parts? *Journal of Behavior Therapy and Experimental Psychiatry*, *50*, 90–96. https://doi.org/10.1016/j.jbtep.2015.06.002

Jiang, M., & Vartanian, L. (2018). A review of existing measures of attentional biases in body image and eating disorders research. *Australian Journal of Psychology*, *70*(1), 3–17. https://doi.org/10.1111/ajpy.12161

Kelly, Y., Patalay, P., Montgomery, S., & Sacker, A. (2016). BMI development and early adolescent psychosocial well-being: UK Millennium Cohort Study. *Pediatrics*, *138*(6), e20160967–e20160967. https://doi.org/10.1542/peds.2016-0967

Kerr-Gaffney, J., Harrison, A., & Tchanturia, K. (2018). Eye-tracking research in eating disorders: A systematic review. *The International Journal of Eating Disorders*, *52*(1), 3–27. https://doi.org/10.1002/eat.22998

Kredel, R., Vater, C., Klostermann, A., & Hossner, E. (2017). Eye-tracking technology and the dynamics of natural gaze behavior in sports: A systematic review of 40 years of research. *Frontiers in Psychology*, *8*, 1–15. https://doi.org/10.3389/fpsyg.2017.01845

Legenbauer, T., Thiemann, P., & Vocks, S. (2014). Body image disturbance in children and adolescents with eating disorders. *Zeitschrift für Kinder- und Jugendpsychiatrie und Psychotherapie*, *42*(1), 51–59. https://doi.org/10.1024/1422-4917/a000269

Lutz, H. O., Burmeister, C., Ferreira dos Santos, L., Morkisch, N., Dohle, C., & Krüger, J. (2017). Application of head-mounted devices with eye-tracking in virtual reality therapy. *Current Directions In Biomedical Engineering*, *3*(1), 53–56. https://doi.org/10.1109/ICVR.2017.8007455

Matz, P., Foster, G., Faith, M., & Wadden, T. (2002). Correlates of body image dissatisfaction among overweight women seeking weight loss. *Journal of Consulting and Clinical Psychology*, *70*(4), 1040–1044. https://doi.org/10.1037/0022-006x.70.4.1040

Pingitore, R., Spring, B., & Garfieldt, D. (1997). Gender differences in body satisfaction. *Obesity Research*, *5*(5), 402–409. https://doi.org/10.1002/j.1550-8528.1997.tb00662.x

Porras Garcia, B., Ferrer Garcia, M., Olszewska, A., Yilmaz, L., González Ibañez, C., Gracia Blanes, M., ... Gutiérrez Maldonado, J. (2019). Is this my own body? Changing the perceptual and affective body image experience among college students using a new virtual reality embodiment-based technique. *Journal of Clinical Medicine*, *8*(7), 925. https://doi.org/10.3390/jcm8070925

Porras-Garcia, B., Ferrer-García, M., Ghita, A., Moreno, M., López-Jiménez, L., Vallvé-Romeu, A., ... Gutiérrez Maldonado, J. (2019). The influence of gender and body dissatisfaction on body-related attentional bias. An eye-tracking and virtual reality study. *International Journal of Eating Disorders*, *52*, 1181–1190. https://doi.org/10.1002/eat.23136

Porras-Garcia, B., Ghita, A., Moreno, M., Ferrer-Garcia, M., Pla-Sanjuanelo, J., Bertomeu-Panisello, P., ... Gutiérrez-Maldonado, J. (2018). Gender differences in attentional bias after owning a

virtual avatar with increased weight. *Annual Review of Cybertherapy and Telemedicine*, *16*, 73–79.

Preston, C., & Ehrsson, H. H. (2014). Illusory changes in body size modulate body satisfaction in a way that is related to non-clinical eating disorder psychopathology. *PLoS One*, *9*(1), e85773. https://doi.org/10.1371/journal.pone.0085773

Puhl, R., & Brownell, K. (2001). Bias, discrimination, and obesity. *Obesity Research*, *9*(12), 788–805. https://doi.org/10.1038/oby.2001.108

Puhl, R., & Heuer, C. (2009). The stigma of obesity: A review and update. *Obesity*, *17*(5), 941–964. https://doi.org/10.1038/oby.2008.636

Reed, D., Thompson, J., Brannick, M., & Sacco, W. (1991). Development and validation of the Physical Appearance State and Trait Anxiety Scale (PASTAS). *Journal of Anxiety Disorders*, *5*(4), 323–332. https://doi.org/10.1016/0887-6185(91)90032-o

Renwick, B., Campbell, I., & Schmidt, U. (2013). Attention bias modification: A new approach to the treatment of eating disorders? *International Journal of Eating Disorders*, *46*(5), 496–500. https://doi.org/10.1002/eat.22107

Rodgers, R., & DuBois, R. (2016). Cognitive biases to appearance-related stimuli in body dissatisfaction: A systematic review. *Clinical Psychology Review*, *46*, 1–11. https://doi.org/10.1016/j.cpr.2016.04.006

Roefs, A., Jansen, A., Moresi, S., Willems, P., van Grootel, S., & van der Borgh, A. (2008). Looking good. BMI, attractiveness bias and visual attention. *Appetite*, *51*(3), 552–555. https://doi.org/10.1016/j.appet.2008.04.008

Schwartz, M., & Brownell, K. (2004). Obesity and body image. *Body Image*, *1*(1), 43–56. https://doi.org/10.1016/s1740-1445(03)00007-x

Serino, S., Pedroli, E., Keizer, A., Triberti, S., Dakanalis, A., Pallavicini, F., ... Riva, G. (2016). Virtual reality body swapping: A tool for modifying the allocentric memory of the body. *Cyberpsychology, Behavior, and Social Networking*, *19*(2), 127–133. https://doi.org/10.1089/cyber.2015.0229

Smeets, E., Jansen, A., & Roefs, A. (2011). Bias for the (un)attractive self: On the role of attention in causing body (dis)satisfaction. *Health Psychology*, *30*(3), 360–367. https://doi.org/10.1037/a0022095

Smith, E., & Rieger, E. (2006). The effect of attentional bias toward shape- and weight-related information on body dissatisfaction. *International Journal of Eating Disorders*, *39*(6), 509–515. https://doi.org/10.1002/eat.20291

Smith, E., & Rieger, E. (2009). The effect of attentional training on body dissatisfaction and dietary restriction. *European Eating Disorders Review*, *17*(3), 169–176. https://doi.org/10.1002/erv.921

Stice, E., & Bearman, S. (2001). Body-image and eating disturbances prospectively predict increases in depressive symptoms in adolescent girls: A growth curve analysis. *Developmental Psychology*, *37*(5), 597–607. https://doi.org/10.1037/0012-1649.37.5.597

Stice, E., & Whitenton, K. (2002). Risk factors for body dissatisfaction in adolescent girls: A longitudinal investigation. *Developmental Psychology*, *38*(5), 669–678. https://doi.org/10.1037//0012-1649.38.5.669

Svaldi, J., Bender, C., Caffier, D., Ivanova, V., Mies, N., Fleischhaker, C., & Tuschen-Caffier, B. (2016). Negative mood increases selective attention to negatively valenced body parts in female adolescents with anorexia nervosa. *PLoS One*, *11*(4), 1–18.

Svaldi, J., Caffier, D., & Tuschen-Caffier, B. (2011). Attention to ugly body parts is increased in women with binge eating disorder. *Psychotherapy and Psychosomatics*, *80*(3), 186–188. https://doi.org/10.1159/000317538

Thaler, A., Geuss, M. N., Mölbert, S. C., Giel, K. E., Streuber, S., Romero, J., ... Mohler, B. J. (2018). Body size estimation of self and others in females varying in BMI. *PLoS One*, *13*(2), e0192152. https://doi.org/10.1371/journal.pone.0192152

Tuschen-Caffier, B., Bender, C., Caffier, D., Klenner, K., Braks, K., & Svaldi, J. (2015). Selective visual attention during mirror exposure in anorexia and bulimia nervosa. *PLoS One*, *10*(12), e0145886. https://doi.org/10.1371/journal.pone.0145886

Warschburger, P., Calvano, C., Richter, E., & Engbert, R. (2015). Analysis of attentional bias towards attractive and unattractive body regions among overweight males and females: An eye-movement study. *PLoS One*, *10*(10), e0140813. https://doi.org/10.1371/journal.pone.0140813

Washington, R. L. (2011). Childhood obesity: Issues of weight bias. *Preventing Chronic Disease*, *8*(5), A94.

Weinberger, N., Kersting, A., Riedel-Heller, S., & Luck-Sikorski, C. (2016). Body dissatisfaction in individuals with obesity compared to normal-weight individuals: A systematic review and meta-analysis. *Obesity Facts*, *9*(6), 424–441. https://doi.org/10.1159/000454837

Williamson, D., White, M., York-Crowe, E., & Stewart, T. (2004). Cognitive-behavioral theories of eating disorders. *Behavior Modification*, *28*(6), 711–738. https://doi.org/10.1177/0145445503259853

Wojtowicz, A., & von Ranson, K. (2012). Weighing in on risk factors for body dissatisfaction: A one-year prospective study of middle-adolescent girls. *Body Image*, *9*(1), 20–30. https://doi.org/10.1016/j.bodyim.2011.07.004

World Health Organization. (2004). *International statistical classification of diseases and related health problems*, Tenth Revision, Vol. 2 (2nd ed.). Geneva: WHO.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Porras-Garcia B, Ferrer-Garcia M, Yilmaz L, et al. Body-related attentional bias as mediator of the relationship between body mass index and body dissatisfaction. *Eur Eat Disorders Rev*. 2020;1–11. https://doi.org/10.1002/erv.2730