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RESEARCH ARTICLE

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The Body Image Virtual Reality Assessment (BIVRA): Measuring the body representation through virtual reality

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Abstract

Our physical and psychological well-being is significantly influenced by how we perceive our body, in addition to our thoughts and emotions associated with it. Dysfunctional body perceptions and attitudes play a key role in the development and maintenance of severe conditions such as eating disorders in both males and females. Given its relevance, some attempts have been made to improve body image assessment methods in terms of perceptual accuracy and body satisfaction taking advantage of technological advances such as virtual reality. However, existing applications have mainly focused on women and clinical conditions. In this study, we presented the Body Image Virtual Reality Assessment (BIVRA), a virtual reality figure rating scale to assess body image in both male and female subjects. We tested BIVRA's ability to measure perceptual accuracy and compared its results with a standardized body satisfaction questionnaire. Additionally, we investigated gender differences. BIVRA was found to be effective in assessing body image. We observed that a perceptually based task successfully captured both low and high levels of body representations, shedding light on the significant gender differences. The association between BIVRA and the body satisfaction questionnaires was moderated by gender, with a stronger association for women. While further validation of BIVRA is needed to fully exploit its potential, our results suggest that the integration of virtual reality into the assessment of body image and related disorders may significantly enhance our understanding of individuals struggling with body image issues and has the potential to advance current methods and techniques.

KEYWORDS

assessment, body image, body satisfaction, virtual reality

INTRODUCTION

Body image is a complex and multi-dimensional concept that involves not only how we see and perceive ourselves physically but also the thoughts, beliefs, and emotions we hold about our bodies (Glashouwer et al., 2019). In other words, it reflects the combination of our mental representation of the body and the feelings we hold about it (Slade, 1994). As a consequence, body image was traditionally considered composed of a perceptual and emotional component, where the first one identifies specifically the estimation of the size of the body and the second one identifies the affects and thoughts associated with it (Slade, 1994).

Body image disturbance (BID; Gruszka et al., 2022) refers to dysfunctional perceptions, cognitions, and attitudes related to how individuals experience their bodies (Kronenfeld et al., 2010; Quittkat et al., 2019). A crucial aspect of BID is the presence of a distorted perception of one's own body (Ciwoniuk et al., 2022). This distortion often involves an inaccurate perception of body size and shape; that is, individuals with BID may perceive themselves as larger or smaller than they are, leading to a discrepancy between their subjective perception and objective reality. Another key component is body dissatisfaction, which instead refers to negative feelings and evaluations of the body (Ciwoniuk et al., 2022).

Studies from different cultural backgrounds have shown a sharp rise in the incidence of body misperception and dissatisfaction, indicating that a distorted body–self relationship is increasingly becoming a common experience, especially among young people (Alharballeh & Dodeen, 2023; Hosseini & Padhy, 2019; Moehlecke et al., 2020). This trend is particularly alarming given the established connection between distorted body image and negative consequences in terms of psychological health and life quality (Gruszka et al., 2022).

Indeed, high levels of BID have been found to be associated with harmful health-related behaviours (e.g., restrictive dietary patterns and excessive exercise) and mental health problems, such as depressive symptoms and anxiety (Barnes et al., 2020; Cash et al., 2004). Moreover, it has been shown to be also a critical factor for the development of severe physical and mental illnesses (Eck et al., 2022; Grogan, 2016; Sattler et al., 2020). In particular, a large number of studies have highlighted the pivotal role of BID in weight and eating disorders, and specifically, it appears to be a transdiagnostic experience in anorexia and bulimia nervosa (Anitha et al., 2019). As a consequence, beyond specific features, disturbances in the way individuals experience their bodies have been included as diagnostic criteria for these conditions according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (American Psychiatric Association, 2013). Remarkably, BID is not only critical for the onset of these pathologies, but it is also a key determinant of disease progression and treatment effectiveness: body image alterations indeed predict the recurrence rate of eating disorder symptomatology (Dakanalis et al., 2016; Riva et al., 1996).

Furthermore, dysfunctional body–self relationships have been described in neurological conditions such as stroke and chronic pain (Berlucchi & Aglioti, 1997; Keppel & Crowe, 2000; Lotze & Moseley, 2007; Moreira et al., 2017). For example, research has shown that stroke survivors who suffer from chronic pain are significantly more likely to experience distorted perceptions of their bodies, with negative consequences for self-esteem and depressive symptoms, which interfere with daily activities and overall quality of life (Haslam et al., 2022). As a result, it has been proposed that targeting body image could be a beneficial addition to existing rehabilitation programmes aimed at improving functionality and reducing pain in these individuals (Haslam et al., 2022).

In light of these considerations, body image has received increasing attention in health care, for both prevention and intervention efforts, and its proper assessment is fundamental (Fisher et al., 2019).

Body image assessment tools

Several measurement techniques were developed to evaluate body image in terms of perceptual accuracy and body dissatisfaction. Among the most widely used tools, there are deforming mirrors (Traub

& Orbach, 1964) and figure rating scales (FRSs; Arkenau et al., 2020). The latter remained widely used since they are quick and easy to administer. In FRSs, respondents are asked to choose the body that they think better reflects their current (i.e., real) or desired (i.e., ideal) body from a series of figures representing bodies of different shapes and weights (Gardner & Brown, 2010; Riva, 1998). Stimuli in this case could be handmade silhouettes, drawings, or computer-generated bodies varying in size to approximate a continuous unidimensional scale, generally ranging from low body mass index (i.e., underweight body) to high body mass index (i.e., overweight body; Gardner & Brown, 2010). This method provides information on both the size perception accuracy with which individuals recognize the stimulus that better matches their own body (i.e., the BMI of the chosen stimulus correlates with the individual's actual body mass index) and body dissatisfaction (i.e., the discrepancy between the actual BMI and the chosen ideal body shape; Talbot et al., 2020).

Some variants of these depictive approaches were also developed by using single body parts instead of whole bodies (e.g., it was possible to adjust the arm or leg length of the bodily stimuli; Perpina et al., 1999). However, whole-body methods showed greater consistency of results, differently from body part approaches (Cornelissen et al., 2017).

Questionnaires have been also developed by side of these measures, such as the Body Shape Questionnaire-14 (BSQ-14; Matera et al., 2013), the Body Satisfaction Scale (BSS; Slade et al., 1990), and the Body Image Questionnaire (Koleck et al., 2002). Noticeably, these approaches specifically target the cognitive and affective components of body image – namely body satisfaction – and do not provide information about perceptual accuracy and/or the presence of possible perceptual misperceptions.

Virtual reality and body image

Even though paper-based tests have shown robust psychometric properties, technological advancements such as virtual reality (VR) have been used to improve figure rating scales by proposing more realistic stimuli (i.e., 3D avatars compared to drawings), under the assumption that high-quality graphics might allow for higher accuracy and sensitive assessment tools (Riva et al., 1996). Indeed, it has been hypothesized that the use of 3D avatars, as opposed to low-quality drawings and pictures, may help subjects to better discriminate stimuli and thus provide more accurate responses and estimates (Riva et al., 1996).

The first attempt to use VR for body image assessment was conducted by Riva (1998). The research group proposed the Body Image Virtual Reality Scale (BIVRS), which was a non-immersive software to treat body image distortions in patients affected by eating disorders where participants were asked to choose between seven 3D avatars – ranging from underweight to overweight – the ones that better matched their perceived and ideal body shapes. Perpina et al. (1999) proposed an immersive VR application in which 3D human figures can be adjusted in different body parts and used it as body image treatment in a sample of patients affected by eating disorders compared to standard body image treatment. More recently, Mölbert et al. (2018) compared biometric modelized self-avatars of female adults with standardized ones to investigate body image differences between patients affected by anorexia nervosa and healthy controls. Here, they found that both patients and controls tended to underestimate their actual body weight and that the control group's desired body weight fell within the normal and healthy weight range, whereas women affected by anorexia nervosa desired an unhealthy and extremely low body weight (Mölbert et al., 2018). Overall, these studies consistently supported the appropriateness of virtual reality for evaluating and treating BID (Aime et al., 2012; Ferrer-García & Gutiérrez-Maldonado, 2012).

Nonetheless, it is important to highlight that much of the existing literature in this context has focused primarily on clinical samples of patients affected by eating disorders, thus skewing the available data towards clinical populations and females, with limited information on non-clinical samples and males. Though men are experiencing more and more societal pressure to conform to an idealized body as females (Gültzow et al., 2020), they are susceptible to BID and its consequences too (Talbot et al., 2020). Then, there is a need for gender-sensitive tools and more research involving both male and female participants.

In addition, because of the link between body image and psychosocial functioning, there is a need to develop and implement free and easy-to-use screening and assessment tools. Indeed, prevention and early detection of subclinical conditions could significantly reduce the progression to more serious health problems and improve the overall well-being of individuals.

Based on these considerations, the current study has three objectives: (a) to develop an immersive virtual reality-based tool to assess body image (Body Image Virtual Reality Assessment; BIVRA), namely a software to measure body perception accuracy and body dissatisfaction in both female and male subjects; (b) to compare questionnaire scores to assess body satisfaction (i.e., Body Shape Questionnaire) with data obtained from virtual tasks; and (c) to investigate possible gender differences in body image in terms of ability to accurately perceive and recognize own body shape and body satisfaction level when using virtual reality assessment tools.

METHODS

Participants

A total of 84 participants took part in the experiment. Descriptive characteristics are reported in Table 1.

The sample size was estimated based on a power analysis run in G*Power software to determine a sample size ($a = .05$; power $= .8$) that would allow us to detect a minimum medium effect size ($r = .3$). The only exclusion criterion was the current or past diagnoses of eating disorders or other body image-related disorders self-reported by participants.

Participants were recruited through the research participation system (SONA System) of the Psychology Department of the University of Milano-Bicocca, social media, and snowball sampling (Sedgwick, 2013). Students from the University of Milano-Bicocca were rewarded with .1 educational credit, while participants from outside the university received no benefit for their participation. All participants signed a written informed consent before the start of the experiment. The study received ethical approval from the Commissione per la Valutazione della Ricerca del Dipartimento di Psicologia (CRIP) of the University of Milano-Bicocca.

Procedure

Participants were first asked to complete the Simulator Sickness Questionnaire (SSQ; Kennedy et al., 1993) to assess sickness before the virtual experience. They were then immersed in a virtual environment by using a head-mounted display (Oculus Quest 2) connected to a portable computer (Lenovo Legion 5 Pro with CPU Intel® Core i7). In this environment, subjects were surrounded by virtual bodies from an allocentric (i.e., third-person) perspective, while they did not see their own body in an egocentric spatial frame. In this way, we avoided potential anchoring effects due to having seen an embodied avatar. During the experimental procedure, there were two different tasks: one in which participants had to choose the body that better represented their ideal body shape and

TABLE 1 *N*, means, and standard deviations for age and BMI variables.

	BMI			Age		
	Males	Females	Total	Males	Females	Total
N	48	36	84	48	36	84
Mean	23.6	22.4	23.1	25.7	25.1	25.4
Standard deviation	3.36	2.32	3.0	4.0	3.6	3.8

Note: The table presents sample characteristics of the total sample, split by gender.

size and a second one in which they had to choose the body that better represented their current (real) body shape and size. Specifically, they were asked to choose between 7 avatars varying in body size – ranging from underweight to overweight – the one that they felt better reflected their current and ideal bodies. Instructions were directly reported in the virtual environment before starting each block of trials (i.e., ideal and real) as follows: in the next scenes, we will ask you to select which body *you think better fits your [current/ideal] body size and shape. Use the trigger button of the left controller to answer, and click on the next button to continue.* Participants were presented with 5 trials for each task (i.e., they chose 5 times what they felt was their real body and 5 times their ideal body). They all started choosing the real body before the ideal body. After the virtual experience, they were asked to complete the Simulator Sickness Questionnaire to assess symptoms associated with the immersive experience, in addition to the Body Shape Questionnaire-14 (BSQ-14; Matera et al., 2013), and some socio-demographic information (i.e., age, gender, height, and weight). Half of the participants completed the BSQ-14 before the virtual exposure and the other half after the immersive experience. The entire session lasted approximately 15 min.

Body Image Virtual Reality Assessment (BIVRA) Scale

The avatar scale was developed by using three different software: Daz Studio 4.15 (https://www.daz3d.com) to develop the avatar, 3ds Max Studio (autodesk.com) to approximate the BMI of each avatar, and Unity 2020.3.15f (https://unity.com) to create the immersive environment. We created gender-specific scales, each consisting of seven different avatars, according to Ambrosi-Randić et al. (2005). We used Genesis 8.0 Essential Asset in Daz Studio 4.15 to create seven bodies that were manipulated in terms of emaciated, pear-shaped, bodybuilder-sized, and portly parameters. The selection of manipulation parameters was grounded in their impact on the overall body mass index (BMI), with the goal of spanning a range from underweight to overweight as classified by the World Health Organization's guidelines (Adami et al., 2012; Jalali-Farahani et al., 2022). This approach facilitated the creation of a discriminable range akin to traditional figure rating scales and contour drawing scales (Arkenau et al., 2020; Gardner & Brown, 2010).

The BMI of each avatar was estimated using the method proposed by Crossley et al. (2012). Each scale model was imported into 3ds Max to calculate its volume. Once the volume was known, weight was estimated by multiplying the volume by the density of the average young adult female body (1.04 g/cm^3) or the average young adult male body (1.06 g/cm^3). Finally, BMI was calculated as weight divided by height squared. For the female scale, BMI ranges from 17 to 30 kg/m^2, and for the male scale, BMI ranges from 18 to 31 kg/m^2. The minimum BMI was due to technical constraints, as the software did not allow characters to have a lower BMI than those used without applying specific additional assets. Consequently, the maximum BMI was adjusted to obtain stimuli separated by regular intervals. However, this range allowed us to limit possible perceptual biases (cfr., Cornelissen et al., 2017).

Once the body shapes were established, we created five aesthetically different avatars for each gender to have stimuli for multiple trials. By conducting multiple trials with different avatars, we minimize the potential impact of aesthetic features (e.g., hair colour, eye colour, and clothing) on the dependent variable[1] (Figure 1).

Once the scales had been created, the final virtual environment was created using Unity 3D. The space represented a basic office environment, with all furniture sourced from Sketchfab (https://sketchfab.com/tags/fbx). The avatar representing the scales was positioned in a circular formation around the observer's perspective (radius = 2 units), centred in the room (Figure 2). Thus, the user has a

[1]Internal consistency of BIVRA. Cronbach's alpha: VR real = .962; ideal = .943. Convergent validity was calculated as the correlation between BIVRA and figure rating scale by Thompson and Gray (1995), and results showed a satisfactory significant correlation for both ideal, $r(82) = .653$, $p < .001$ and real, $r(82) = .762$, $p < .001$ estimations.

FIGURE 1 Examples of gender-specific avatar scales. 7 corresponds to the body shape with the highest BMI (extreme left), whereas 1 corresponds to the body with the lower BMI (extreme right). Upper panel shows female avatars. Parameters adopted: 1 = 100% emaciated, 2 = 80% emaciated, 3 = 20% bodybuilder size, 4 = 20% pear figure, 5 = 20% bodybuilder size, 20% pear figure, 6 = 40% bodybuilder size, 50% pear figure, and 7 = 60% pear figure. Lower panel shows male avatars. Parameters adopted: 1 = 100% emaciated, 2 = 70% emaciated, 3 = 10% emaciated, 10% portly, 4 = 30% bodybuilder size, 5 = 30% portly, 6 = 20% bodybuilder size, 40% portly, and 7 = 60% portly, 20% bodybuilder size.

perspective located in the centre of the room, surrounded by the avatars in a 360-degree arrangement. It is worth noting that the 10 trials (consisting of 5 choices of real bodies and 5 choices of ideal bodies) were presented in separate scenes. We predetermined the specific placements of the avatars, while the assignment of the avatars to each position varied randomly across trials. That is, participants selected the avatar and then had to click on a "next" button for the next choice, with the avatar varying in order of presentation and aesthetic features. The software automatically recorded the subject's responses, and then, body satisfaction was calculated by subtracting the real body from the ideal body.

Body Shape Questionnaire-14 (BSQ-14)

The Body Shape Questionnaire (BSQ; Cooper et al., 1987; Dowson & Henderson, 2001; Matera et al., 2013) is a widely used unidimensional scale used to assess body dissatisfaction. Originally consisting of 34 items, a shorter version (BSQ-14) has been validated showing good convergent and discriminant validity (Dowson & Henderson, 2001; Matera et al., 2013). Responses are collected on a 6-point Likert scale ranging from 1 (never) to 6 (always). Examples of items included in the scale are as follows: *Have you ever felt ashamed of your body? Has worrying about your shape made you diet? Has being around thin people made you feel self-conscious about your shape?*

FIGURE 2 Examples of scenes from BIVRA. The left panels show the environment and the location of the camera from which participants viewed the scene. The camera is placed in the centre of the scene so that the users saw the avatars around them during the virtual experience. The right panels show examples of what respondents saw during the virtual tasks.

Simulator Sickness Questionnaire (SSQ)

The Simulator Sickness Questionnaire (SSQ) is a self-report instrument designed to assess the occurrence of cybersickness associated with virtual reality experiences (Kennedy et al., 1993). It consists of a 16-item Likert scale that assesses various symptoms, with individuals rating their experiences on a scale ranging from none (0) to severe (3). These 16 symptoms can be categorized into three different groups: oculomotor, disorientation, and nausea symptoms (Brown et al., 2022; Kennedy et al., 1993). It was proposed both before and after the virtual exposure to test the sickness and symptoms associated with BIVRA use.

Data analysis

Our analysis strategy was designed to address a series of interrelated research questions.

First, we assessed the validity of the BIVRA. This was done by calculating Pearson's correlation between the results of the VR tasks and the participants' BMI, which served as an objective measure of their actual body size. If there was a significant correlation between the BIVRA-real body question and the participants' BMI, this would suggest that the BIVRA is associated with individual differences in body mass. This would also allow us to assume that the ideal body question within BIVRA reflects individual differences concerning ideal body representation, similar to what the real body question does.

Second, we wanted to investigate whether the disparity between perceived body and ideal body, as assessed by BIVRA, effectively captures body dissatisfaction. To do this, we calculated a delta score representing the difference between the desired body and the actual body. This score was then converted to an absolute value, as any deviation from the real body – whether a desire to be slimmer or thicker (e.g., more muscular) – indicates dissatisfaction. We called this measure the BIVRA body dissatisfaction index. We then calculated Pearson's correlation between the BIVRA body dissatisfaction index and the BSQ, which measures body satisfaction at an explicit level.

Third, we asked whether gender differences play a critical role. To do this, we first assessed the effect of gender on the BIVRA measures using a series of *t*-tests on the different scores. Then, we performed an analysis of covariance (ANCOVA) to weigh the influence of gender differences on the relationship between BIVRA and BSQ scores. The dependent variable was the total score obtained in the BSQ, while the factorial independent variable was gender and the continuous independent variable was the BIVRA body dissatisfaction index.

Lastly, we ensured that the virtual reality experience did not cause discomfort to participants, by performing a non-parametric paired sample *t*-test (Wilcoxon's signed-rank test) to compare the SSQ scores before and after the VR tasks.

RESULTS

BIVRA-real and BIVRA-ideal measures exhibited significant correlations with participants' BMI, with coefficients of $r = .87$ ($p < .001$) and $r = .54$ ($p < .001$), respectively. It is noteworthy that the BIVRA-real correlation was remarkably strong, suggesting that it captures the individual differences of the real body size properly. A substantial correlation was also observed between the BIVRA body dissatisfaction index and the Body Shape Questionnaire, with a coefficient of $r = .68$ ($p < .001$).

T-tests show no significant gender differences in terms of real body (BIVRA-real; $t(82) = 1.09$, $p = .28$, Cohen's $d = .24$), whereas significant differences between the two genders emerged in the BIVRA-ideal measure, $t(82) = 4.17$, $p < .001$, Cohen's $d = .92$. Specifically, females reported wanting a body with a lower BMI as compared to males (female ideal body mean value = 2.51, $SD = 1.14$; male ideal body mean value = 3.50, $SD = 1.03$). Coherently, differences emerged in the BIVRA body dissatisfaction index, $t(82) = 4.89$, $p < .001$, Cohen's $d = 1.08$.

The ANCOVA results show a significant interaction between gender and body dissatisfaction index, suggesting that the relationship between BIVRA and BSQ is conditional to gender with a stronger relationship between the two variables for female participants than males (Figure 3 and Table 2).

No significant differences were found in the SSQ scores before and after the virtual reality tasks ($Z = -2.023$, $p = .06$). Mean scores are around 0 at both times (mean = .02, $SD = .21$, and mean = .15, $SD = .63$, respectively), and no relevant discomfort emerged during the virtual experience.

DISCUSSION

In the present study, we have introduced a new tool (BIVRA), which uses a virtual reality-based avatar rating scale to assess body image. BIVRA proved to be a good measure of body perceptual accuracy. Indeed, we observed a significant correlation between the real bodies selected by the participants and their corresponding BMIs, meaning that they were able to accurately recognize their body shape. This is consistent with findings from a recent review, which indicated that healthy individuals could accurately estimate their bodily dimensions when using depictive methods such as figure rating scales (Mölbert et al., 2017). Consequently, we could infer that BIVRA was able to capture individual differences when considering ideal body selection. This was also supported by the association between the BIVRA body dissatisfaction index and the body dissatisfaction questionnaire score. Finally, BIVRA appeared to be able to detect body image gender variations and differences.

Previous VR scales have been developed under the assumption that the high graphical quality and ecological validity of virtual reality allow participants to accurately perceive stimuli, leading to highly precise and sensitive measures (Fisher et al., 2019; Perpina et al., 1999; Riva, 1998). Stating that it is true, it is noteworthy that the interactive and novel nature of VR likely increases participants' engagement and attention during the task, which might in turn enhance response reliability and accuracy too (Dubovi, 2022; Weiss & Merlo, 2020). Even though usually undervalued, these factors may become critical, especially when investigating constructs that are possibly sensitive for respondents as

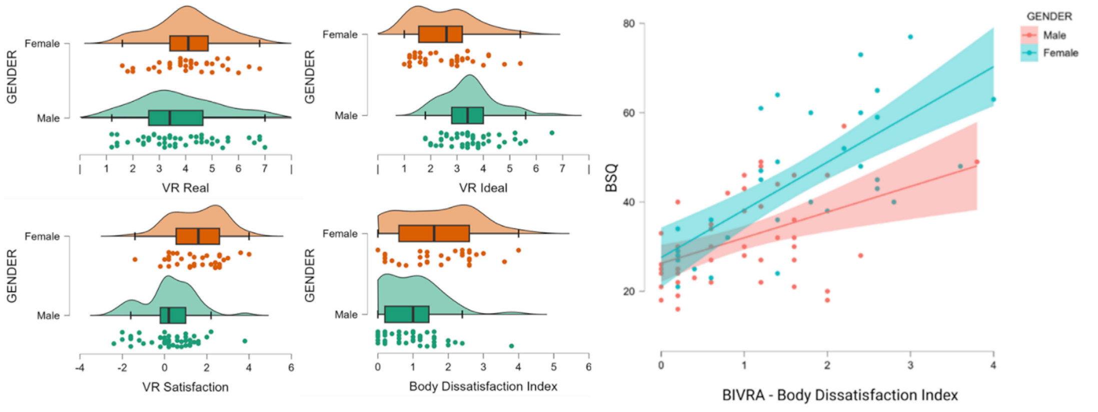

FIGURE 3 The right panel shows the ANCOVA results examining the relationship between the BIVRA body dissatisfaction index and the Body Shape Questionnaire (BSQ) total score, taking into account the possible influence of gender. Shades represent 95% confidence intervals. The raincloud plots in the left and central panels show the differences by gender in the VR real and ideal (upper graphs) as well as in the satisfaction score (i.e., the difference between real and ideal) and the body dissatisfaction index (i.e., the absolute value of the satisfaction score) (lower graphs).

TABLE 2 ANCOVA results.

ANCOVA-BSQ_TOT					
Cases	**Sum of squares**	***df***	***F***	***p***	η^2
Gender	11.824	1	.122	.728	<.001
Body dissatisfaction index	4728.036	1	48.762	<.001	.274
Gender × body dissatisfaction index	428.096	1	4.415	.039	.025
Residuals	7756.937	80			

Note: Type III sum of squares.

the experience of one's own body. Furthermore, differently from previous studies, we exploited VR advantages to administer the same task multiple times, which allowed us to increase the accuracy and reliability of responses on the one hand and minimize the potential impact of aesthetic features on the other hand.

By choosing to repeat the task multiple times, we also verified that our system does not cause discomfort to the user. This aspect has not been investigated in previous applications, but we argue that VR sickness may be a significant barrier to the adoption of VR technology, especially in clinical practice, and therefore deserves special attention (Salimi & Ferguson-Pell, 2021; Saredakis et al., 2020).

Another feature of the proposed tool is its ability to exploit VR flexibility: the accessibility of virtual reality software offers the opportunity to develop tools to target specific populations of interest while maintaining comparability of results across studies. Previous scales were developed using expensive and complex software since they were proposed at the birth of VR technology. Nowadays, hardware and software have become cheaper and more accessible: BIVRA was indeed developed by using simple and freely available programs. Consequently, future studies might use BIVRA body parameters while adjusting avatars' features according to the target population (for instance, in terms of age or ethnical aesthetics; Kronenfeld et al., 2010). This is essential to overcome the multitude of instruments that make it difficult and inappropriate to compare results (Skrzypek et al., 2001).

A significant finding of our study was the substantial correlation between the explicit measure of body satisfaction, as measured by the questionnaire, and the implicit measure provided by the virtual task. We intended the virtual task to be an implicit measure, as it did not require participants to directly estimate their level of body satisfaction. In addition to supporting BIVRA validity, this correlation suggests that depictive scales effectively capture both perceptual and cognitive–affective aspects related to individuals' self-evaluation of their appearance. That is, we found that a perceptually based task was able to account for higher-level body representations (Fisher et al., 2019). This result emphasizes the association between the perceptual and cognitive–affective components of body image. Indeed, even though from a theoretical level body image comprehends three different components, previous research showed that the way individuals perceive their body (the perceptual component) affects their emotional responses and attitudes towards it (the cognitive–affective component) and vice versa (Carey & Preston, 2019). This link may be due to the way we construct our representation of the body: body perception is not an isolated sensory experience, but it is interpreted through pre-existing cognitive schemas and priors, that is, ingrained patterns of thoughts, previous experiences, and expectations that shape our understanding and evaluation of the body (Altabe & Thompson, 1996; Lewis-Smith et al., 2019). This idea of body image as a cognitive self-schema suggests that the way information about the body is processed and organized around a self-concept can significantly influence both how we perceive our body and our emotional response to it (Altabe & Thompson, 1996).

Then, BIVRA could be a quick screening approach to assess body satisfaction, while also overcoming inherent limitations of questionnaires and explicit measures such as social desirability bias, subjective interpretation of items, or language issues in translating the items (Keatley et al., 2012).

It is worth noting that we analysed BIVRA's ability to measure the parameters of interest in healthy participants to provide preliminary support for BIVRA validity. Previous systems have instead been used directly in clinical populations or introduced the system as treatments (Perpina et al., 1999), without preliminary testing in a healthy sample or an initial comparison with standard measures. However, for any tool to be introduced into clinical routine and practice, there should be a rigorous validation process (Fisher et al., 2019). This is essential to disclose the benefits and drawbacks of VR applications. A recent study highlighted this issue and attempted to compare immersive virtual reality scales with paper-based figure rating scales (Fisher et al., 2019) finding the use of standardized 3D avatars to work well as paper-based procedures. Even though this result supports the use of avatar rating scales, the study was limited in that it only included female patients with anorexia nervosa.

Concerning gender differences, our study found solid differences in the choice of ideal body shape, which translates into significant differences in body satisfaction levels. Consistent with previous research (Arkenau et al., 2020; Voges et al., 2019), men reported lower dissatisfaction levels with their bodies than women. This might be due to the use of different coping strategies: while men are more likely to adopt self-serving mechanisms and be optimistic about their bodies, women tend to be more self-critical (Avci & Keven Akliman, 2018; Voges et al., 2019). Furthermore, previous research suggests that men may be less influenced by body image ideals than women because societal masculine stereotypes require them to be proud, strong, dominant, and successful (Voges et al., 2019). However, our findings may be tied to the use of a scale in which avatars were mainly created to target drive for thinness rather than muscularity. Indeed, research suggested that women tend to internalize the societal ideal of slimness and low body weight, whereas men tend to internalize the ideal of muscularity (Thornborrow et al., 2020). Hence, the development of specific scales to specifically target these two different body parameters (i.e., body fat and muscularity) might be appropriate. The study by Steinfeld et al. (2020) took a step forward in this regard by developing a 3D-FRS varying stimuli in terms of both muscularity and BMI to better reflect body structure. However, this type of manipulation made it impossible to discriminate the impact of each parameter (i.e., thinness and muscularity), and they included only female participants.

As previously introduced, few studies investigated body image in males, especially when using rating scales in virtual reality. This dearth of gender-specific assessment tools (Drewnowski & Yee, 1987; McCabe & Ricciardelli, 2004) constitutes a significant gap: although body image issues have often been seen as a problem that disproportionately affects women, this is no longer the case (Avci & Keven Akliman, 2018; Franzoi et al., 2012; Grogan, 2021). Just to make an example, the Campaign Against Living Miserably (CALM) in 2021 reported that 48% of men aged 16–40 in the United Kingdom had struggled with body image issues, with this number even larger after the coronavirus pandemic, and similar results were also reported by the recent study by Swami et al. (2021). Remarkably, similarly to what has been observed for females, negative body image has been linked to dieting behaviours, excessive exercising, and an increased risk of developing an eating disorder in males (Dakanalis et al., 2015; Mitchison & Mond, 2015). Therefore, we contend that BIVRA would enable future research to delve deeper into understanding gender similarities and differences in body perception and satisfaction, as well as offer a possible tool to reveal risk situations. This is even more in light of the increasing societal pressures promoted by social media platform use (Ormsby et al., 2019).

We also found a significant interaction between gender and BIVRA body dissatisfaction index, suggesting that the relationship between body dissatisfaction (as measured by BIVRA) and concerns about body shape (as measured by BSQ) differs across genders. Specifically, this relationship was stronger for females than for males. This might suggest that while body dissatisfaction does impact both males and females, there might be gender-specific differences in body concerns. For instance, it might be that a general and global measure of body satisfaction – as the ones used in this study – might not be suitable to fully capture strategies to define body satisfaction based more on specific parts of the body, as has been observed in men (Thornborrow et al., 2020). Hence, this might suggest the need for more nuanced tools that can assess body image to meet gender-specific differences.

Finally, there are some limitations to this study. Establishing the validity of a measure is a complex, lengthy, and multifaceted process, and although our results are encouraging, they can only provide preliminary evidence for the BIVRA. However, similar results support the use of this kind of method. In line with our primary research question and aims, in this study we focused on body image assessment. Future research should then include additional measures of body-related attitudinal components to strengthen the validity of the BIVRA and assess stability over time. In addition, we recommend future studies to explore potential correlations between BIVRA scores and indicators of the presence of body image disturbances using instruments with different subscales and factors, such as the Eating Disorder Inventory (Cumella, 2006) in both non-clinical and clinical populations. Such analyses would allow us to better understand the strengths and limitations of using virtual reality to assess body image. Moreover, in this study all participants were presented with the real and ideal selection tasks in the same order because of software constraints. Future updates of the system might improve this aspect to avoid possible, although unlikely, sequential effects.

In terms of future possible BIVRA implementations, it might be possible to present selection tasks from both allocentric (third-person perspective) and egocentric (first-person perspective) spatial frames (Monthuy-Blanc et al., 2020; Ouellet et al., 2022). A similar approach has been recently proposed by the research group led by Porras-Garcia et al. (2020). In their pilot study, the authors asked participants to choose their real and ideal bodies when embodying different avatars from either a first-person perspective or a third-person perspective. This becomes relevant in light of most recent neuropsychological results and theories (Riva & Gaudio, 2012) suggesting that body image disturbances may originate from a failure to optimally integrate first- and third-person perspective bodily information (Brizzi, Sansoni, Di Lernia, et al., 2023; Brizzi, Sansoni, & Riva, 2023; Riva, 2012; Riva & Gaudio, 2012). Supporting this idea, a study by Provenzano et al. (2019) reported differences between egocentric and allocentric body perceptions when using virtual reality systems in patients with anorexia nervosa as compared to controls. Additionally, Monthuy-Blanc suggested that different spatial perspectives might reflect different aspects of body image in virtual environments: whereas egocentric perspective may reflect a perceptual–sensory–affective component, allocentric perspective may capture cognitive–affective–attitudinal components (Monthuy-Blanc et al., 2020, 2022). Despite the limited data available, we argue that this implementation could deeply exploit the full potential of VR-based approaches in targeting body experience in its complexity.

In conclusion, the results from this study suggest that BIVRA might be a suitable tool for evaluating the two crucial dimensions of body image, namely perceptual accuracy and body dissatisfaction, as well as able to detect gender differences. While further research is needed to validate these results, they have relevant implications for optimizing body image assessment methods.

Concerns about body size and shape have become increasingly common after the exponentially growing use of social media platforms that promote unattainable beauty standards, constituting a widespread issue in modern societies. A growing body of research is indeed highlighting how body image concerns have become a normal and normative experience that cuts across genders, ages, and socioeconomic lines (Riva et al., 1996; Saiphoo & Vahedi, 2019).

Thus, there is a valuable opportunity for future studies to harness the capabilities of virtual reality technology to promptly identify individuals at risk for body image disturbances and to monitor changes in body image over time, such as during therapeutic interventions. The promise is twofold: to early identify individuals who are struggling with their body image, promptly assisting them to develop a more functional and healthy relationship with their own bodies before the onset of symptoms such as anxiety, depression, or unhealthy eating behaviours, and to introduce new assessment tools into clinical practice to meet the needs of new generations. This aligns with the embodied medicine approach (Riva et al., 2017) and can significantly enhance our understanding and treatment of individuals grappling with body image issues.

AUTHOR CONTRIBUTIONS

Giulia Brizzi: Conceptualization; methodology; software; data curation; formal analysis; writing – original draft; visualization. **Giuseppe Riva:** Writing – review and editing; supervision. **Daniele Romano:** Conceptualization; methodology; formal analysis; supervision; writing – review and editing.

CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

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

Data S1.

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