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# Body Image Software Programs: A Comprehensive Literature Review*

## Programas de imagen corporal: una revisión comprensiva de literatura

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**ABSTRACT**
The assessment of body image has evolved in recent decades through the development of various software programs. However, it is not yet known whether this technological advance has resulted in refined evidence or whether this assessment development has been extensively applied in the field. This study reviewed the body image software programs developed and applied from 2000 to 2020. Searches were systematically conducted in four scientific databases. A total of 35 articles were selected, and 13 body image software programs were identified. The main features comprising the variability of the software were the pattern of body stimuli presentation (avatars x real body x body drawings) and the procedures of body image manipulation (whole body adjustment x adjustment of separate body parts). Heterogeneity was prevalent among the studies reviewed and prevented a favorable conclusion regarding the use of software compared to other body image assessment strategies.

**Keywords**
body image; assessment; literature review; software; method.

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**RESUMEN**
La evaluación de la imagen corporal ha evolucionado en las últimas décadas a través del desarrollo de programas de software. Sin embargo, aún no se sabe si dicho avance ha implicado en mejor evidencia y si el desarrollo se ha aplicado ampliamente en el campo. El presente estudio revisó los programas de software de imagen corporal desarrollados y aplicados desde 2000 hasta 2020. Las búsquedas se realizaron en cuatro bases de datos científicas. Se seleccionaron 35 artículos y se identificaron trece programas de software de imagen corporal. Las características principales que comprenden la variabilidad del software fueron el patrón de presentación de estímulos corporales y los procedimientos de manipulación de la imagen corporal por parte de los participantes. La heterogeneidad de los resultados revisados fue frecuente y evitó una conclusión favorable para el uso de software en comparación con otras estrategias de evaluación de la imagen corporal.

**Palabras clave**
imagen corporal; evaluación; revisión de literatura; software; método.

Body image is a multidimensional concept involving the multimodal perception, emotional representation, and first-person experience of one's own body (DeVignemont, 2017). Due to its plural theoretical and historical background, body image assessment has successfully spread through diverse scientific fields, from basic science to applied research (Tylka, 2018). This diverse development has led to the creation of different body image quantification methods and approaches to qualitatively assess subjects' experiences of their own bodies (Marzola et al., 2018). Currently, body image is still extensively assessed based on self-report questionnaires and figure rating scales (DeCastro et al., 2017). With the advances of computer technology in recent decades, computerized measures have been specially developed to investigate of body image. As a consequence, there has been a growing discussion regarding the rates of accuracy and precision of body image evaluation, along with particular concern about how to compare or contrast results from different methodological approaches (Caspi et al., 2017; Shroff et al., 2009).

One way to produce a pragmatic empirical response to the question of a diverse set of theoretical backgrounds is the production of robust methods that simultaneously tackle different dimensions of the variable under evaluation. Even though conceptual plurality is registered in the body image literature, more general and inclusive definitions have been advocated since the mid-1990s and the beginning of 2000 (Pruzinsky & Cash, 2002; Paillard, 1999). In these versions, body image was defined as a multidimensional construct comprised of cognitive, emotional, and perceptual dimensions (Cash & Grasso, 2005). Both figure rating scales and technological tools for body image assessment have sought to evaluate more than one dimension of body images, such as dissatisfaction and perceptual distortions in body recognition (Kakeshita et al., 2009; Ralph-Nearman et al., 2019). However, body image software applications could promote a greater standardization in body stimulus presentation and provide ways of interacting for body size adjustments that are absent in figure rating scales and self-report measures. Consequently, they could amplify the assessment dimension of the body image phenomenon, potentially creating greater ecological validity.

The variety of stimuli of widely used body image measures (e.g., words and schematic/drawn figures) has made comparing studies with similar purposes difficult (Moussally et al., 2017). In addition, some measures lack of body stimuli realism has prevented generalization to real-life situations (Swami et al., 2008). As a result, several researchers have justified their application of technology, portraying bodies more similar to the human body as a resource to minimize research bias and limitations.

Different computer programs have been used to assess body image in recent decades. Some studies have applied general image editing programs to create body stimuli for experimental tasks that assess the relationship between perceptual variables and body image (Alexi et al., 2019; Owen & Spencer, 2013). Some studies have even applied images of bodies in three-dimensional formats, using computer-generated imagery with the help of a full-body scanning system (Mölbert et al., 2018; Irvine et al., 2019). In contrast, some computer programs have been created with the specific aim of investigating body image (Ferrer-García & Gutiérrez-Maldonado, 2008; Docteur et al., 2010). This software specificity is what defines the body image application program. These applications have targeted specific instructions for the participant to manipulate the body stimuli. Technical instructions are generally constructed to assess different dimensions of the body image, asking participants, for example, to adjust the visualized bodies to their perception of their own real body and their desired body.

Despite the methodological advances in body image research, few studies have extensively reviewed and compared different body image

measures. Past reviews have mainly focused on methods that assess body size estimates (Farrell et al., 2005) or the psychometric properties of body image self-report measures (Kling et al., 2019). To the best of our knowledge, there has not been a comprehensive review that has assessed body image application software and its results with clinical and non-clinical samples. The lack of summarized information regarding the variability of software techniques and the results from the application of body image software programs prevents any conclusion regarding the accuracy and behavior of these measures. Furthermore, the concept plurality associated with the field and its consequent diverse set of assessment procedures requires synthesizing the knowledge regarding potential interactions between assessment methods and different body image dimensions. Accordingly, the present study aimed to comprehensively review the technical characteristics of the body image software applications available and their results from scientific literature published from 2000 to 2020. Furthermore, when feasible, it aims to describe comparisons made in the literature between body image software programs and other strategies to assess the construct.

## Method

### *Search strategy and selection criteria*

A literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines ([PRISMA]; Moher et al., 2009). In June 6, 2020, a search was conducted in the Scopus, Web of Science, PsycINFO, and ScienceDirect databases to investigate studies that applied body image software using images of the entire body.

Exclusion criteria were defined to filter out: 1) articles duplicated between databases, 2) reviews and meta-analysis articles, 3) theoretical articles, book chapters, conference presentations, comments, dissertations, and theses, 4) articles unrelated to the topic, 5) articles that were not peer-reviewed, 6) articles without full access to online text, 7) articles published in languages other than English, Spanish and Portuguese, and 8) articles that used measures not considered body image software, such as self-report scales, computer-only measurement versions of software programs not programmed for body image evaluation (*e.g.*, image editing).

The first step of the review consisted of a search in the aforementioned databases, considering a publishing interval from 2000 to 2020. This extended period was defined to capture eventual technological transitions from the beginning of body image software research to recent publications. The search terms and their recombination were: ["body image" OR "body perception" OR "body size" OR "body awareness"] AND ["software" OR "assessment"]. These terms were chosen based on the terminology indexed by the Thesaurus-APA. The term "human body" was also indicated by the Thesaurus; however, it was omitted because results using this term referred to articles with content other than body image assessment.

The results were uploaded to Rayyan QCRI (Ouzzani et al., 2016), a web application that supports the integration of results from systematic searches among different databases. Articles duplicated between databases were excluded, and the resulting list was screened (identification). Two judges independently reviewed the abstracts on this list, following exclusion criteria 2, 3, and 4 (eligibility screening). Next, the full text of the remaining articles was examined, and exclusion criteria 5 to 8 were applied in the analysis (included). In cases of doubt, a third judge carried out an analysis. In addition to the resulting list of articles included, additional records were searched based on cross-reference checking, considering only citations of the original articles that introduced the software programs identified in this review. Two software programs did not disclose their original reference, and one software program referenced a presentation at an annual meeting in Germany. In these cases, all articles that used the software identified by the review were included in the citation analysis. Cross-reference

checking for this set of articles was carried out on the Google Scholar platform. Results of this selection process are presented in Figure 1.

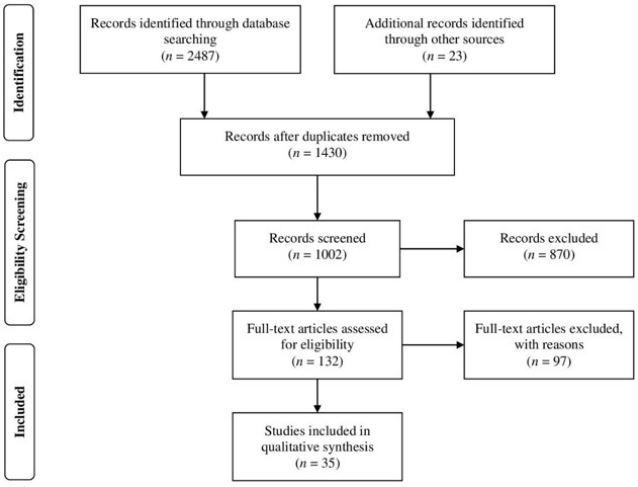


**Figure 1**
*PRISMA flowchart of the screening process for the review.*

## Results

### *Selected articles*

The first search in the databases retrieved 2487 records and the Google platform cross-reference search included another 23. Following the exclusion criteria, 35 articles were selected for inclusion in the review. In total, 13 articles referred to software development, two of which only presented the software, and the other 11 presented and tested the body image software. The remaining articles were applications of these software programs in different populations. The majority of the articles reviewed were conducted at universities in the United States (31.4%) and published after 2010 (62.8%). The original field of research of the journals publishing these studies was mainly the broad scope of Psychology. However, the present study did not delimit this area of research as an inclusion criterion. In addition to Psychology, journals encompassed areas such as health sciences, sports, aesthetics, and combined areas of psychology and computer science. Information regarding the software name and articles that applied each program is presented in Table 1.

**Table 1**
*Selected articles*

| Software | Authors and Year of Publication |
|---|---|
| Body self-discrepancies (BSD) | Arciszewski et al. (2012) |
| Computerized Assessment of Body Image (CABI) | Caspi et al. (2017), Harari et al. (2001) |
| Body Size Distortion Program (BSDP) | Cornelissen et al. (2013), Eubanks et al. (2006), Gardner and Boice (2004), Gardner and Brown (2010), Hagman et al. (2015), Hagman et al. (2011), Jappe and Gardner (2009), Van Paasschen et al. (2015) |
| Anamorphic Micro Software (AMS) | Docteur et al. (2012), Docteur et al. (2010), Kolka and Abayomi (2012), Urdapilleta et al. (2010), Urdapilleta et al. (2007), Yamamotova et al. (2017) |
| Body Image Assessment Software (BIAS) | Ferrer-García and Gutiérrez-Maldonado (2008), Ferrer-García and Gutiérrez-Maldonado (2010), Gutiérrez-Maldonado et al. (2010), Letosa-Porta et al. (2005), Manjrekar and Berenbaum (2012), Owen and Spencer (2013) |
| Novel morphing technique (NMT) | Johnstone et al. (2008), Stewart, Benson et al. (2003), Stewart et al. (2014), Stewart et al. (2012) |
| Quantification of Body Image Distortion (Q-BID) | Roy and Forest (2007) |
| 3D-avatar software (3D-AS) | Schneider et al. (2013) |
| Body Image (BI) | Shibata (2002) |
| Body Morph Assessment 2.0 (BMA 2.0) | Stewart et al. (2009), Stewart et al. (2011) |
| Body-shape software (BSS) | Tovée et al. (2003) |
| VR standardized 3D avatars (VR-3D) | Fisher et al. (2020) |
| Somatomap (SM) | Ralph-Nearman et al. (2019) |

### *Software programs results*

Most software programs allow the simultaneous assessment of more than one dimension of body image, with two programs evaluating only the perceptual dimension of body recognition. Of the 543 citations linked to the 13 software programs identified, the program was applied to 23 studies, representing 4.2% of the total citation index. Figure 2 shows the time frame of software program citation and application between 2000 and 2020. The Body Size Distortion Program was the most applied software, followed by the Anamorphic Micro Software and the Body Image Assessment Software. All the programs used a depictive method to evaluate the body image dimensions. In general, the main technique used among the software programs was widening and

thinning the images displayed by means such as the morphing technique, as shown in Figure 3. Only the VR Standardized 3D Avatars software did not have its technique described in the articles reviewed.


**Figure 2**
*Time frame of software programs citation and application*
*Note*. Search was conducted in June of 2020

The acquisition of visual stimulus varied among the software programs. Of the 13 software applications, seven used the participant's own photo to acquire the stimulus, five used an avatar, and one program used figures of silhouettes. Image manipulation within each program was divided between the manipulation of the whole body and the manipulation of parts of the body. Around half of the programs identified have validation and reliability studies. Table 2 presents a detailed description of the software.

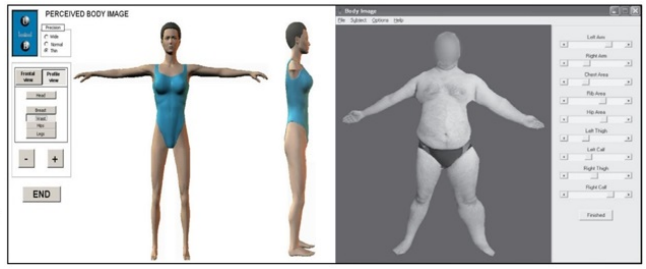


**Figure 3**
*Example of the software interface*
*Note*. Left image: Interface of Body Image Assessment Software. Reproduced from htt p://www.ub.edu/personal/rv/ecic.htm. Right image: Interface of Novel Morphing Technique. Reproduced from Johnstone et al. (2008). Images provided by the authors of the studies.

**Table 2**
*Description of the software programs*

| Software | Year | Technique | Interface | Reliability/ Validity | Total Citations | Actual software use |
|---|---|---|---|---|---|---|
| BSDP | 2004 | Photo/Video Distortion | Whole body | No/No | 68 | 7 |
| AMS | NI | Photo/Video Distortion | Whole body | Yes/Yes | 91 | 6 |
| BIAS | 2005 | Avatar/Morphing | Body parts | Yes/Yes | 31 | 5 |
| NMT | 1999/ 2003** | Photo/Distortion vectors for body segments | Body parts | Yes/Yes | 58 | 3 |
| CABI | 2001 | Photo/Biological Shape Modification | Whole body* | No/Yes | 20 | 1 |
| BMA 2.0 | 2009 | Avatar/Morphing | Whole body | Yes/Yes | 27 | 1 |
| BI | 2002 | Photo/Image Distorting | Whole body | No/No | 19 | 0 |
| BSD | 2012 | Photo/Morphing | Whole body | No/No | 28 | 0 |
| Q-BID | 2007 | Silhouettes/ Visual Basic Language | Body parts | Yes/Yes | 25 | 0 |
| BSS | 1999/ 2003** | Photo/Biometric data on real body shapes | Body parts | Yes/No | 118 | 0 |
| 3D-AS | 2009/ 2013*** | Avatar/Morphing | Whole body | No/Yes | 58 | 0 |
| VR-3D | NI | Avatar/NI | Whole body | No/No | 1 | 0 |
| SM | 2019 | Avatar/Blend Shape | Body parts | No/No | 0 | 0 |
| **Total** | | | | | 543 | 23 |

*Note*. NI = No information. *Body parts are independently modified while maintaining the natural appearance and overall characteristics of the body shape in a semi-automatic process. **First and second versions. ***Year of the original presentation of the software at a conference (Hoffmann et al., 2009) and year of the article identified in the analysis.

Two of the three most used software programs, the BSDP (Gardner & Boice, 2004) and the AMS (Urdapilleta et al., 2007), apply a distorting video technique (DVT), which alters the image provided by stretching or compressing the figure along either the X- or Y-axis. Participants adjust their own photos to give a wider or thinner perception of their respective sizes. They may also be required to adjust the image to their ideal body size, with discrepancies between perceived and ideal size used as a measure of body dissatisfaction. The BSDP can be applied using different and separate psychophysical methods. These methods permit a determination of the sensory and nonsensory components that contribute to body size judgments. Similar to software developed by Shibata (2002), the BI also uses a DVT, called the image-distorting technique, to estimate only the body size perception, in which participants can adjust the width of their own image to match the perception of its actual width.

Other software programs used various computational techniques, such as the morphing technique (MT). Letosa-Porta et al. (2005) developed the BIAS, which displays side and front views of a female avatar on a computer screen. Through the MT, the image can be adjusted by independently modifying body parts in the front and the side view. It measures both body image distortion and dissatisfaction by asking the subject to manipulate the body parts to look like their actual body and their ideal bodies. In the BMA 2.0 (Stewart et al., 2009), the MT is applied to an avatar form to measure estimates of perceived current body size, ideal body size, and body size dissatisfaction. It employs a continuous response scale with 100 figures from the thin endpoint to the obese endpoint that increase in size throughout the measurement tool. Participants can select the body size picture they believe corresponds to their real and ideal body size. This application software was a reliable and valid measure of body image for Caucasian and African-American women and men, whose Body Mass Index (BMI) ranged from 18 to 48.

Arciszewski et al. (2012) also used MT for the development of the BSD. However, this application software uses a photograph of the participant as the stimuli. The experimenter selects the neckline of the subject's image by clicking with the computer mouse. The program's algorithm changes the body shape below that line according to two main computing rules, one for the trunk and one for the arms and legs. Participants are asked to change their shape to reach their actual, ideal, and ought body image. Similarly, Tovée et al. (2003) applied MT to a picture of the subject in the BSS. However, it works by creating a series of templates for

each body part at different points along the BMI spectrum. These templates are based on the biometric data gathered from a sample of 213 British women. Participants are asked to estimate their body size, shape, and ideal body image by adjusting the sliders corresponding to nine different body parts. Stewart et al. (2003) also developed the NMT to manipulate body parts. It distorts the participant's image in nine body regions using algorithms based on perpendicular vectors from body segment midpoints. Participants manipulate interactive slider controls to adjust each body feature, recreating their perceived image and indicating their desired image. The BSS and NMT were adaptations of the same original software (Benson et al., 1999). However, both articles did not refer to each other and presented different software names; therefore, they were treated as distinct software tools.

Software programs with unique characteristics were also identified. Roy and Forest (2007) were the only researchers that used female silhouette figures to acquire body image stimulus in the Q-BID. Morphological silhouettes are presented (face, side, and back) to the subjects, and the task is to modify the silhouettes to reach what seems most like their own body in two steps. The first step of the modification is made on the shoulders/hips ratio and breast. In the second step, the participants have to modify the weight of the silhouettes until they correspond best to the perception of their own bodies. Harari et al. (2001), in turn, used a body weight-change simulation algorithm in the CABI that subdivides the subject's photo into principal body parts, which have different patterns of shape change when a weight gain or loss process takes place. The body parts are independently modified and then merged back into a whole body, maintaining the overall characteristics of the body shape in a semi-automatic process. Participants can adjust their body shapes until they achieve their self-perceived appearance and ideal body shape.

A few software programs use 3D avatars as the visual stimulus. The 3D avatar software (Schneider et al., 2013) presents 19 front-facing images of computer-generated nude female Caucasian bodies in a frontal view, as well as images of it rotated 25° to the left and right, ranging from 12 to 30 BMI through MT. In turn, VR 3D (Fisher et al., 2020) is the only software program developed for immersive conditions. It uses 10 standardized 3D female avatars arranged in a circle with an angle of 36° between each avatar. Participants can observe in a circle spanning 360° avatars numbered from 1 to 10 based on an increasing BMI of 10 to 30 kg/m2, masked from them. However, the authors did not reveal the technique used to modify the visual stimulus. The Somatomap (Ralph-Nearman et al., 2019) is the only software application developed for measuring body image perception in 2D and 3D. The 2D assessment displays a picture of an androgynous manikin on which the user is asked to mark areas where they perceive a body concern. The 3D assessment displays a virtual avatar in 3D, which participants can rotate from different angles and adjust the skin and hair color as well as the size of individual body parts to reflect the perceived characteristics of their current body. 13 different regions of the body can be modified independently using the blend shape functionality. These software tools assess the accuracy of the body perception and dissatisfaction or concern with the body itself.

This pool of software programs observed a trend representing the evolution of technical manipulations of the body stimuli. In the beginning, body image software programs were built upon video distortion and morphing techniques. However, from 2013 onwards, the three reviewed software programs were all designed to operate with 3D manipulations. Figure 4 indicates a time frame of this technical feature evolution.

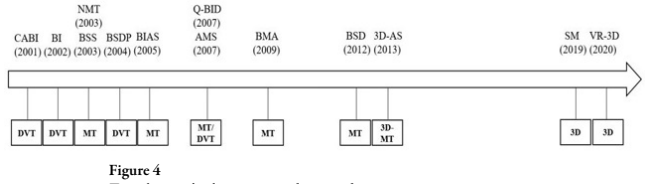


**Figure 4**
*Time frame of software manipulation techniques*

*Comparison with other measures*

Of the 35 articles, 11 studies made comparisons between the applied software and body image self-report measures. Eight different software tools were used in these comparisons. However, no article compared more than one software program in the same study. These articles used a total of 16 different body image self-report instruments. In addition, two studies evaluated how experimental tasks affected the responses to the body image software.

Gardner and Brown (2010) compared the BSDP to the Body Image Assessment Scale-Body Dimensions scale drawings (Gardner et al., 2009), which evaluates body image perception and dissatisfaction with the body image. According to the authors, the scale was less accurate in evaluating the body image distortion and dissatisfaction of male and female undergraduate students than the software program. The authors found that the participants overestimated body size more robustly in the self-report measure than in the body image software and presented significantly higher levels of dissatisfaction. This software was also used by Hagman et al. (2015), presenting similar results when compared to the Eating Disorder Inventory-2-Body Dissatisfaction scale ([EDI-2]; Garner, 1991). Both measures evidenced that women with anorexia had significantly greater body dissatisfaction than controls, with large effect sizes.

Hagman et al. (2011) also used the BSDP to investigate the effect of Risperidone on the body image of anorexic women. The study tested body image using this software along with the EDI-2 and the Color-A-Person-Test ([CAPT]; Wooley & Roll, 1991), a scale of frontal and lateral contours of a female adolescent figure used to assess body image dissatisfaction. The results did not show significant differences between anorexic and placebo groups in the EDI-2, CAPT, and the software outputs. There were also no significant differences in body image distortion assessed by the software. Cornelissen et al. (2013) applied the BSDP to low and average BMI women along with the Body Shape Questionnaire ([BSQ]; Cooper et al., 1987). The results identified significant positive correlations between overestimation of the body size output from the BSDP and eating and body shape concerns evaluated by the BSQ. However, there was no correlation between the BMI and the degree of participants' overestimation.

Yamamotova et al. (2017) used the AMS along with the Body Attitude Test questionnaire ([BAT]; Probst et al., 1995) to assess body image in women patients diagnosed with anorexia and bulimia and a control group with no diagnosis. The BAT questionnaire represents a mixture of perceptual and emotional attitudes toward one's body. Results from the two instruments showed that the BAT was, in all groups, more related to body dissatisfaction than to body image perception. More specifically, the BAT and the software perceptual dimension were positively correlated in the patients with bulimia and the controls, but not in those with anorexia.

The BIAS software was applied together with the figure rating scale Body Image Assessment-Revised ([BIAS-R]; Beebe et al., 1999), the EDI-2, and the BSQ for female university students and female patients with an eating disorder (Ferrer-García & Gutiérrez-Maldonado, 2008). Positive and significant correlations were observed between the BIAS and BIA-R in the eating disorder and control groups. The body dissatisfaction scores of the software positively correlated with the self-report scales' dissatisfaction scores, indicating that all participants would have liked to be thinner. However, the measures could not discriminate between the eating disorder and control groups.

Caspi et al. (2017) used the CABI software along with the EDI-2 and the Contour Drawing Rating Scale ([CDRS]; Thompson & Gray, 1995) with women with eating disorders (restrictive anorexia, purgative anorexia, and bulimia) and healthy women. The patients scored significantly higher than healthy participants in the perceptual and affective dimensions of the CABI and EDI-2. The CDRS discriminated only patients with bulimia from controls in the perceptual and

affective dimensions. Only the CABI evidenced differences in the perceptual and affective dimensions between the three groups with eating disorders and the healthy participants. These differences were maintained when controlling for age, years of education, BMI, depression, and anxiety. The other instruments only maintained the differences between the groups when controlling age, years of education, and BMI.

The body image of women with and without eating disorders was investigated by Roy and Forest (2007) using the Q-BID software, the Eating Disorder Examination Questionnaire ([EDE-Q]; Fairburn & Beglin, 1994) and the Physical Appearance State and Trait Anxiety Scale ([PASTAS]; Reed et al., 1991). The control group participants were adolescents. The clinical group consisted of two groups diagnosed with restrictive anorexia, one composed of hospitalized patients and the other of patients undergoing outpatient treatment. The software program was positively correlated with the other body image measures in the anorectic samples; however, not in the control group. Body image distortion was positively correlated with the global EDE-Q score, shape concern, and weight concern subscales and with the global score of the PASTAS only in the anorectic samples.

Stewart et al. (2009) evaluated the BMA 2.0 together with the silhouettes scale Body Image Assessment-Obesity ([BIA-O]; Williamson et al., 2000) and the Body Satisfaction Scale questionnaire ([BSS]; Slade et al., 1990) in Caucasian men and women and African-American men and women. The results showed positive correlations between the dimensions of dissatisfaction and body size estimation of the BMA 2.0 and the corresponding BIA-O subscales. However, concerning the BSS, there was a selective positive and significant correlation between the software dissatisfaction index for women only and a positive correlation trend for men.

The body image of lean, obese, and lean regular exercise participants was evaluated by Johnstone et al. (2008) using the NMT together with the Body Image Ideal Questionnaire (Cash & Szymanski, 1995) and the traditional Figural Stimuli Questionnaire Silhouette Scale (Stunkard et al., 1983). The results evidenced a significant and positive correlation among the body image dissatisfaction instruments in all three groups. The correlation was higher between the NMT and the Figural Stimuli Questionnaire.

Fisher et al. (2020) compared the VR-3D with the paper-based Figure Rating Scales ([FRS]; Sala et al., 2012) in female adolescents with anorexia. The results showed that the participants overestimated their own body size regardless of the assessment tool used. Body perception and body dissatisfaction did not differ significantly between the FRS and the software.

In addition to the correlational analysis, two other studies analyzed the influence of experimental tasks on the body image evaluated by the software program. Arciszewski et al. (2012) used the BSD to examine the effect of a threat aroused by the perception of thin-ideal images combined with beliefs about the malleability of the body-on-body image perception and dissatisfaction in female psychology students. The results showed that the women had greater body self-discrepancies when confronted with threatening thin ideals, regardless of their body mass index. Owen and Spencer (2013) used the BIAS to verify whether the visualization of healthy and lean body models influenced the subjective body ideal in female university students. The results indicated that the subjective body ideals increased after viewing images of healthy weight models.

## Discussion

Although the modern notion of body image dates back to the early 20th century (DeVignemont & Alsmith, 2017), a robust advance in evaluation tools was first observed at the beginning of the 1980s with the development of self-report and figure rating scales. The use of software programs, in turn, is recent, with most of the studies identified in this review having been published after 2010. In addition, most publications applying body image software were originally from northern hemisphere countries. This is

significant since many developing countries in the southern hemisphere present high rates of obesity and body dissatisfaction and still are not well represented in this scientific branch (Austin et al., 2017; Fradkin et al., 2018).

No fields of the investigation were specified as criteria for the database search, considering that body image research has a multidisciplinary root. However, a specific publication trend in Psychology journals was found, which can be explained by the long history of body image investigation in this field. However, all the body image software programs were based solely on depictive methods, which implies that the evaluation of the construct relies heavily on previous theoretical models of visual body representation. These theoretical assumptions were not necessarily discussed when the software packages were presented.

According to Longo and Haggard (2012), there are two main classes of body image dimension evaluation. One class involves comparing the actual body with a model body figure, such as methods of mirror distortion and silhouette figures. The other class involves comparing the size or shape of a part of the body with some non-physical pattern, such as the mobile caliper technique and visual size estimation procedures. These two classes represent the so-called "depictive" and "metric" methods, respectively, and seem to evaluate distinct aspects of the body image (Tavacioglu et al., 2019). While metric methods involve implicit bodily representations of somatosensory processing, representative methods are related to the conscious body image. As the focus of the present review was body image programs that present images of the entire body, software programs that produce and evaluate body segmentations were not included. Due to the association between metric methods and the assessment of body parts, it seems logical that the body image software identified in this review covers only the assessment of the conscious body image. Some tools, such as software for clinical use with patients who have undergone amputation, evaluate the body image of a specific body part (Prahm et al., 2019). However, it was considered that this type of tool would include another class of body image assessment.

Even with the technological advances represented by the introduction of software in body image research, the articles reviewed did not conclude that these tools are superior to other body image measures such as self-report or figure rating scales. Studies that used both software and other body image measurements did not reveal a tendency for greater accuracy and better discrimination for one assessment method. While some studies indicated a greater accuracy and validity of a particular program concerning self-report scales (Caspi et al., 2017; Gardner & Brown, 2010), other studies revealed that the software and self-report scales were associated and able to adequately discriminate the clinical groups from control groups under analysis (Ferrer-García & Gutiérrez-Maldonado, 2008; Roy & Forest, 2007). None of the studies applied the same measures or homogeneously investigated the same population, which prevents any conclusive comparison or statement indicating a research trend for the cumulative evidence in the field.

Although the citation analysis identified a large number of articles referring to body image software, only a minority of these studies applied the software reviewed. This may be explained by the fact that most of the programs identified are not freely available, while some were developed for a particular study. Charging fees for using these software programs contrasts with other body image measures, which do not entail financial costs for researchers.

Among the most used programs in the literature reviewed were the Body Size Distortion Program (Gardner & Boice, 2004), the Anamorphic Micro Software (Urdapilleta et al., 2007), and the Body Image Assessment Software (Letosa-Porta et al., 2005). These software programs apply the video distortion technique, which has been criticized by part of the body image literature, specifically the morphing technique literature. One of the alleged advantages listed by many articles of using software with the morphing technique is the possibility of manipulation or semiautomatic

modification of parts of the body. According to Letosa-Porta et al. (2005), whole body estimation methods have been criticized for not allowing independent modification of different body parts, making it impossible to detect distortion or dissatisfaction related to one specific body part. Accordingly, recent software has been developed with 3D imaging technology that allows more realistic changes to body parts at different angles (Fisher et al., 2020; Ralph-Nearman et al., 2019). However, despite technological advances and the possibility of greater methodological control and ecological validity, few studies have compared the effectiveness of these tools with other traditional measures of body image.

Some limitations of the present review were the use of a restricted language scope for the search procedure and the option to exclude other computerized programs not identified as body image software. Restricting reviewed articles to English, Spanish and Portuguese may have produced a search bias. The decision to include only software programs in the review may also have generated a methodological bias since studies applying computerized programs to evaluate body image other than software applications were not included. However, we have no knowledge of any other study that has reviewed software programs developed exclusively for this purpose, making this article innovative and enabling the identification and summarization of body image software applications.

The results of the reviewed studies showed a lack of homogeneity, comprising different characteristic samples and analyzing various measurements. In addition, no replicability study was identified. These results represent a well-known difficulty in comparing different studies of body image. Future studies should further address the advantages and disadvantages of applying body image software programs over other strategies of body image assessment.

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## Notes

* Review article.

** Studies included in the review