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Association between self-perceived body image and body composition between the sexes and different age classes

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Highlights

- The whole sample composed of mostly normal weight individuals showed a coherent perception of their current body size, evaluated by means of Williamson's silhouettes.
- Current body size perception, ~~evaluated by means of Williamson's silhouettes,~~ was correlated with the percentage of fat mass, but not with muscle mass, estimated by specific BIVA
- The relationship was similar in the two sexes and in different age classes (young and older adults ~~and middle-aged and elderly people~~)
- ~~Williamson's silhouettes appear to be a suitable technique for screening %FM in epidemiological studies~~

Association between self-perceived body image and body composition between the sexes and different age classes

Submission type: Research Article

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Keywords: body image, body composition, silhouettes, *specific* BIVA

Running head: Self-perceived body image and body composition

Abstract

The aim of this study was to investigate~~d~~ the association between self-perceived body image and body composition in the sexes and in different age classes.

The ~~study~~ sample consisted of 632 young adults (238 men and 394 women; age 22.8 ± 2.3~~,~~ years), and 162 middle-aged and elderly adults (96 men and 66 women; age 61.4 ± 7.6 years). The figure scale designed by Williamson et al. (2000) was used to evaluate current body size (CBS). Anthropometric measurements (height, weight and waist, arm and calf circumferences) were taken, and the body mass index (BMI) was calculated. A *specific* bioelectrical impedance vector analysis was applied to evaluate body composition.

Our results suggest that in both age classes CBS was positively correlated with weight, BMI, and vector length, indicating a higher percentage of fat mass, but not with phase angle, indicative of the intracellular/extracellular water ratio and a proxy of muscle mass. The association was similar in the sexes, but clearer in women. Confidence ellipses confirmed the strong association between the silhouettes and adiposity.

In conclusion, Williamson's silhouettes appear to be a suitable technique to screen for adiposity in epidemiological studies and for routine applications.

Introduction

Body image is a multidimensional concept that includes subjective beliefs and feelings about physical appearance (Grogan, 2008). It is influenced by factors such as sex, age, ethnicity, personality, family, media and nutritional status (Grogan, 2008).

Studies of body image are based on different methods, such as interviews, questionnaires and silhouette collections (Cuesta-Zamora & Navas, 2017). Silhouettes generally include a range of body figures that represent increments of weight, from very thin to very obese ~~(e. g. Williamson et al., 2000)~~. ~~In particular, Williamson et al., 2000)~~ In particular, BIA-O scale (Williamson et al., 2000) is a validated collection of silhouettes to measure body image, which includes a large number of figures (eighteen silhouettes for each sex) representing body size of individuals from very thin to very obese. This method was enhanced from a previous body image assessment, which included nine silhouettes only for women (BIA) (Williamson et al., 1989). The new scale developed in 2000 also incorporates silhouettes for men and covers different degrees of obesity; it has been widely used not only in research on obesity, but also in studies of populations in which overweight and obesity are not very common (e.g., Muñoz-Cachón et al., 2009).

Silhouettes are usually used to assess self-perceived and ideal body image and body image satisfaction, well as to detect obesity and thinness in epidemiological studies (Bulik et al., 2001). Silhouettes are also used to study body image changes in obese patients before and after weight loss, and to assess behaviours related to body image perception, and their impact on physical and mental health (Solomon-Krakus et al., 2017).

Men and women may perceive silhouettes differently. In fact, men tend to identify larger silhouettes with higher muscle mass content, while women associate them with fat mass (FM) (Frederick et al., 2007).

However, only a few studies have examined the actual association between body image assessed by silhouettes and body composition estimated with an accurate technique (Zaccagni et al., 2020).

Some authors have analysed the relationship between silhouette collections and the percentage of FM calculated using anthropometry (e.g. Costa et al., 2016; Greeff, 2016), or to the body mass index (BMI) (e.g. (Stunkard, 1983; Williamson et al., 2000). Other studies investigated different methods for assessing body image (mainly questionnaires) in relation to body composition using anthropometry (Altintaş et al., 2014; Brodie & Slade, 1988; Buscemi et al., 2018), bioimpedance (Duncan, & Schofield, 2011) or dual-energy X-ray absorptiometry (Streeter et al., 2012). The research has been mainly focused on young individuals, and few studies on the elderly have been based on BMI (Bricio-Barrios et al., 2020; Evans et al., 2015; Knight et al., 2009; Pinto et al., 2017; Runfola et al., 2013; Sánchez et al., 2015; Schuler et al., 2004).

~~Considering the gaps in the literature,~~ This study focused on the association between Williamson's silhouettes and body composition estimated by *specific* bioelectrical impedance vector analysis (BIVA*sp*; (Buffa et al., 2013; Marini et al., 2013) in a sample of young and older subjects of both sexes. BIVA*sp* has been considered adequate as it has been validated against dual-energy X-ray absorptiometry, showing high sensitivity and specificity in the evaluation of %FM (Buffa et al., 2013).

Methods

Subjects

This cross-sectional sample included 632 young adults aged between 20 and 31 years (238 men and 394 women; age, 23.1 ± 2.36 and 22.5 ± 2.25 years, respectively), from the Basque Country (Spain), and 162 middle-aged and elderly adults aged between 48 and 81 years (96 men and 66 women; age, 61.43 ± 7.72 and 61.40 ± 7.51 years, respectively) from Sardinia (Italy). The exclusion criteria were the presence of pathologies (e.g., significant cardiovascular or pulmonary disease, endocrine or renal diseases, cancer or sever inflammatory conditions), the presence of metal prostheses, or limb amputations. Pregnant women and individuals of no Caucasian descent were not included in the sample.

The participants were informed about the study design and signed consent before the examination. The experimental protocols were approved by the Ethics Committee for Human Research (CEISH) of the UPV/EHU and by the Independent Ethical Committee of the A.O.U. of Cagliari.

Anthropometric and bioelectrical measurements

Anthropometric measurements (height, cm; weight, kg; waist arm and calf circumference, cm) were taken following standards procedures (Lohman, Roche, & Martorell, 1988). BMI was calculated as weight/ height^2 (kg/m^2).

Bioimpedance measurements were obtained using a single-frequency phase-sensitive 50 kHz device (BIA 101 Anniversary, Akern, Florence, Italy). For each session the BIA device was checked with a calibrated circuit (R = 380 Ω, Xc = 47 Ω; ±2% error). Subjects were asked not to drink or eat, and to void their bladder before the evaluations. Two pairs of detector and injector electrodes were placed on the right side of the subject lying supine: on the hand and wrist, and on the foot and ankle (NIH, 1996). BIVA*sp* (Buffa et al., 2013; Marini et al., 2013) was applied to evaluate body composition. BIVA*sp* is based on a direct analysis of bioelectrical data, without the need for predictive equations or assumptions on body composition, hence avoiding a potential source of error. Furthermore, the bioelectrical values were adjusted for body length and transverse area, which allowed a comparison of body composition among subjects with different anthropometric characteristics. The correction factor (A/L) was calculated as follows: A is the area estimate (0.45 arm area + 0.10 trunk area + 0.45 calf area, cm^2), with the segments area (arm, trunk and calf) calculated as $C^2/4\pi$, where C is the circumference of each segment in cm; and L is the length estimate, calculated as 1.1 H, where H is height in cm. Bioelectrical vectors are projected on the Cartesian plane, which are defined by their length (impedance, Zsp: $(Rsp^2 + Xcsp^2)^{0.5}$, Ω cm) and inclination angle (phase angle, PA: arctan Xc/ R180/π, degree). Compared to reference techniques, the vector length is positively related to relative FM content ~~of~~ (Buffa et al., 2013; Marini et al., 2013), and PA to body cell mass and integrity (Buffa et al., 2013), and to the intracellular/extracellular water ratio (ICW/ECW) (Buffa et al., 2013; Marini et al., 2020), thus providing information on skeletal muscle mass.

Body image

The BIA-O figure scale designed by Williamson et al. (2000) was used to evaluate the current body size (CBS) perception. As previously stated, this scale was initially used in studies on obesity and eating disorders, but it is a reliable method for assessing body image in the general population and "provides a quick, unobtrusive measure of different aspects of body image (e.g. dissatisfaction) for clinicians and researchers" (Stewart et al., 2009). Eighteen silhouettes of each sex, ranging from very thin (number 1) to very obese (number 18), were presented to participants and they were asked to choose the one that best represented their actual shape (https://www.nature.com/articles/0801363/figures/1). Silhouettes chosen by fewer than 5 subjects (silhouettes number 1, 12-18, plus 10-11 among older women) were not included in the analysis of the confidence ellipses, which excluded 18 young adults and 6 older subjects. The silhouettes were categorised into ~~in~~ five main groups (I = silhouettes 2-3; II = 4-5; III = 6-7; IV = 8-9; V = 10-11) to increase the number of cases per group after checking the absence of significant differences within groups.

Statistical analyses

The Mann-Whitney U-test was employed to evaluate sex differences in the chosen CBS. The associations between CBS and anthropometrical or bioelectrical measurements were investigated using Spearman's correlation analysis. The relationships between the silhouettes and body composition were studied using confidence ellipses and Hotelling's T^2. The differences between the sexes and among groups of silhouettes were analysed separately by two-way analysis of variance in the sample of young adults and older adults. Statistical analyses were performed using the SPSS programme (SPSS Inc., Chicago, IL, USA) and *specific* BIVA software (www.specificbiva.unica.it).

Results

The sample showed normal nutritional status in mean with a tendency for overweight in the older group, as indicated by the BMI (young men: 23.60 ± 2.58; women: 22.33 ± 2.82; older adult men: 25.19 ± 2.92; women: 24.30 ± 4.20 kg/m^2). The mean waist circumference values were below the thresholds for abdominal obesity (young men: 79.28 ± 6.74, women: 69.61 ± 2.58; older adult men: 88.36 ± 9.30, women: 77.26 ± 9.0 cm). A few participants (14 young and 8 older adults) were obese (BMI > 30 kg/m^2). Accordingly, very few individuals' chose large silhouettes numbered 12 or more.

The entire sample showed a normal pattern of sexual dimorphism, with men characterised by higher height, weight, BMI, PA, and lower Rsp and Zsp compared to women (Table 1). Sexual differences were also observed in the CBS choices by the young adults (Mann-Whitney U-test; $p < 0.001$). Men tended to choose larger silhouettes than women; the most chosen silhouettes were number 6 by the men (18.2%) and number 4 by the women (22.7%). In the older group, sex differences in the CBS choice were not significant (Mann-Whitney U-test; $p = 0.070$), with both sexes choosing silhouette number ~~most frequently~~ 7 most frequently (21.9% in men; 16.7% in women).

In both sexes, individuals choosing different groups of silhouettes had similar mean height and PA values, while weight, BMI, Rsp, Xcsp and Zsp were significantly different, with greater values in those choosing bigger silhouettes (Table 1). In fact, weight, BMI and the bioelectrical variables, with the only exception of PA, were positively correlated with the silhouettes (Table 2). The pattern was similar between the sexes, but more regular in women (Figure 1). Men choosing larger silhouettes (group V) tended toward a declining phase, which was significant among younger subjects ($p < 0.05$).

Discussion

In the analysed sample, CBS, estimated by Williamson's silhouettes, was associated with variations in body size and body composition in both age classes and sexes, but particularly in women. In fact, CBS was positively correlated with weight and BMI, and with bioelectrical vector length, while it was unrelated to PA and height. According to BIVA*sp* (Buffa et al., 2013; Marini et al., 2013), the observed associations indicate that individuals choosing bigger silhouettes are characterised by higher %FM values (longer vectors), but similar muscle mass (similar PAs).

Previous studies, using different populations and figure collections established a robust relationship between BMI and silhouette collections (e.g. Bulik et al., 2001; Muñoz-Cachón et al., 2009). As BIVA*sp* recognises differences in body composition that are not detected by the BMI (Buffa et al., 2017; Marini et al., 2020), this study allowed us to clarify that the association is due to the FM component of the body, and not to the muscular component. A similar result was reported by Zaccagni et al. (2020) in a sample of Italian students of both sexes, where self-perceived body image was consistent with FM measured using conventional bioimpedance, although with a weakening of the relationship in underweight and overweight individuals.

In our study, we also observed that the association was similar between the sexes, although it was more regular among women. Men who chose the bigger silhouettes of group V, especially the youngest men, despite a similar BMI to women (27.3 vs. 27.9 kg/m^2), were characterised by a decrease of their PAs. The different trend between the fattest men and women can be interpreted in view of their body composition differences, with overweight men characterized by a reduction of muscle mass not appreciable among women. ~~Such a different trend between the fattest men and women suggested a poorer estimate of body composition, of muscle mass in particular, among overweight men, which could be interpreted in view of sex differences in variations of body composition associated with increasing body mass. Indeed, n et al., (2005) detected a stronger FM contribution to weight increases among obese women than obese men.~~

We observed similar relationships between body composition and CBS among young and older adults. This result is insightful as it suggests a possible application of self-perceived body image among elderly people, who are prone to the risk of malnutrition (Morley, 2012) and where other techniques ~~for body composition assessment~~ may be more difficult to use. Other studies on body satisfaction detected no significant differences between younger people and older adults (Evans et al., 2015), and observed that ideal body image remains quite unchanged across the lifespan, particularly in women (Pruis & Janowsky, 2010; Runfola et al., 2013; Schuler et al., 2004). However, some authors have observed that elderly people, especially the heaviest and fattest women, tend to underestimate their actual weight (Bricio-Barrios et al., 2020; Knight et al., 2009; Pinto et al., 2017; Sánchez et al., 2015).

The main strength of the present study is that it represents one of the few attempts ~~(the first with Williamson's silhouettes)~~ to analyse the association between CBS, that is a broad construct that includes perceptual, attitudinal, behavioural, and cognitive dimensions (Roy & Payette, 2012), and body composition evaluated using an accurate technique. In particular, this is the first study applying specific BIVA, that is a validated technique for the evaluation of %FM, also sensitive to ICW/ECW. In addition, the sample included both sexes and two different age groups, thus allowing an analysis of the relationships from a large perspective.

However, this research has some limitations. The sample was mainly composed of normal weight individuals, with very few cases choosing large silhouettes. Hence, we were unable to analyse if the relationship remained similar at the extreme of body composition variability.

In conclusion, this study showed that Williamson's silhouettes used to assess the CBS, are strongly related to body fat in both sexes and until an older age. The whole sample composed of mostly normal weight individuals, including both sexes and classes of age, showed a coherent perception of their current body size. ~~Williamson's silhouettes appear to be a suitable technique to obtain information about nutritional status, particularly about %FM, in epidemiological studies.~~

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Competing Interests

The authors declare that they have no conflict of interest.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Credit author statement:
Conceptualization, S.S., E.M and E.R; Data curation, S:S, E.R. M.E.IZ., A.J. and E.M.; Formal analysis, S.S. and M.E.IZ.; Investigation, S:S, E.R. M.E.IZ. and E.M.; Supervision, E.M., E.R.; Visualization, S.S. M.E.IZ. and E.M.; Writing—original draft, S:S, E.R. M.E.IZ. and E.M.; Writing—review and editing, S:S, E.R. M.E.IZ., A.J. and E.M. All the authors have read and agreed to the published version of the manuscript.

Figure 1. Confidence ellipses representing body composition in the groups of current body size silhouettes (I = silhouettes 2-3; II = silhouettes 4-5; III = silhouettes 6-7; IV = silhouettes 8-9; V = silhouettes 10-11) in young men and women. The older adults showed a similar trend.

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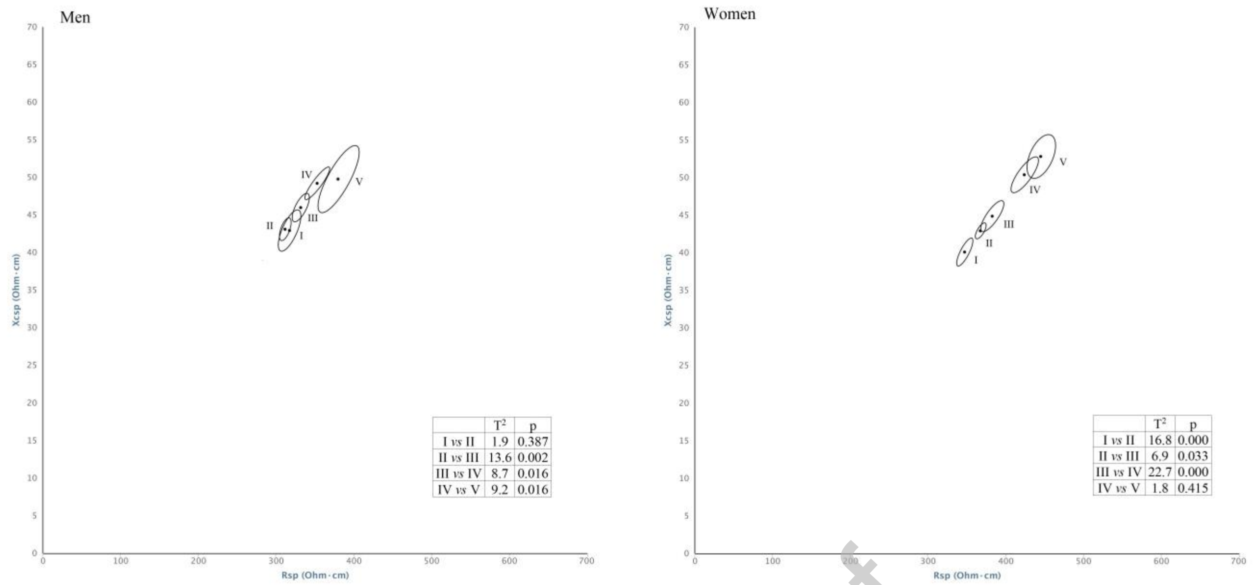

Table 1. Descriptive statistics and two-way ANOVA of bioelectrical and anthropometrical values by groups of CBS silhouettes.

	Men (N= 231)					Women (N= 383)					ANOVA		
Young adults	I (N=34) Mean s.d.	II (N=67) Mean s.d.	III (N=79) Mean s.d.	IV (N=42) Mean s.d.	V (N=9) Mean s.d.	I (N=72) Mean s.d.	II (N=170) Mean s.d.	III (N=72) Mean s.d.	IV (N=56) Mean s.d.	V (N=13) Mean s.d.	F_{sex}	F_{group}	$F_{sex \cdot group}$
Height (cm)	175.02 (7.24)	175.62 (6.12)	175.32 (5.78)	176.99 (5.90)	176.72 (4.28)	162.23 (5.07)	161.68 (5.41)	161.96 (6.31)	163.66 (6.36)	161.41 (5.60)	0.000	0.163	0.884
Weight (kg)	65.94 (8.01)	68.39 (6.86)	73.56 (7.28)	82.51 (9.90)	85.29 (7.03)	52.61 (5.11)	56.86 (5.61)	60.27 (8.02)	67.13 (8.76)	72.89 (11.56)	0.000	0.000	0.313
BMI (kg/m^2)	21.46 (1.50)	22.16 (1.69)	23.91 (1.74)	26.29 (2.45)	27.33 (2.61)	19.96 (1.42)	21.75 (1.89)	22.93 (2.26)	25.06 (2.89)	27.92 (3.68)	0.002	0.000	0.084
Rsp (ohm·cm)	316.99 (32.48)	311.47 (24.35)	331.41 (38.93)	352.67 (40.26)	380.07 (55.21)	346.90 (35.20)	367.45 (36.71)	382.27 (50.14)	424.06 (52.04)	445.38 (50.87)	0.000	0.000	0.009
Xcsp (ohm·cm)	42.93 (6.15)	43.11 (4.90)	45.98 (6.70)	49.21 (5.46)	49.77 (9.30)	40.11 (6.27)	42.93 (5.58)	44.87 (6.97)	50.38 (7.02)	52.82 (8.07)	0.978	0.000	0.126
Zsp (ohm·cm)	319.92 (32.77)	314.46 (24.53)	334.62 (39.25)	356.10 (40.52)	383.35 (55.72)	349.24 (35.52)	369.97 (36.88)	384.92 (50.44)	427.06 (52.31)	448.56 (51.03)	0.000	0.000	0.009
PA (°)	7.72 (0.79)	7.89 (0.70)	7.91 (0.75)	7.96 (0.48)	7.45 (0.84)	6.59 (0.67)	6.68 (0.67)	6.70 (0.63)	6.79 (0.64)	6.79 (0.89)	0.000	0.166	0.503
	Men (N= 95)					Women (N= 61)							
Middle-aged and elderly	I (N=10) Mean s.d.	II (N=21) Mean s.d.	III (N=38) Mean s.d.	IV (N=19) Mean s.d.	V (N=7) Mean s.d.	I (N=14) Mean s.d.	II (N=17) Mean s.d.	III (N=18=) Mean s.d.	IV (N=12) Mean s.d.		F_{sex}	F_{group}	$F_{sex \cdot group}$
Height (cm)	168.23 (6.43)	170.00 (7.50)	170.06 (6.95)	168.72 (6.30)	168.97 (4.65)	154.90 (8.01)	156.74 (6.88)	155.54 (7.00)	154.24 (5.14)		0.901	0.098	0.883
Weight (kg)	64.60 (8.59)	66.70 (6.95)	72.07 (8.46)	80.03 (9.03)	80.07 (6.65)	50.61 (3.94)	55.21 (6.45)	60.23 (8.42)	66.88 (10.08)		0.000	0.775	0.989
BMI (kg/m^2)	22.76 (2.01)	23.13 (2.46)	24.89 (2.23)	28.06 (2.00)	28.01 (1.57)	21.26 (2.91)	22.48 (2.34)	24.94 (3.36)	28.11 (3.96)		0.000	0.000	0.853
Rsp (ohm·cm)	330.49 (64.07)	328.08 (34.03)	338.74 (34.25)	377.89 (64.15)	376.21 (66.72)	343.78 (57.18)	362.64 (40.68)	390.60 (77.88)	425.97 (54.53)		0.000	0.000	0.676
Xcsp (ohm·cm)	41.85 (7.38)	41.91 (6.27)	42.34 (7.07)	50.95 (10.44)	43.29 (7.99)	38.27 (7.03)	41.67 (8.57)	44.05 (7.43)	43.53 (7.38)		0.468	0.011	0.091
Zsp (ohm·cm)	333.22 (63.91)	330.77 (34.35)	341.46 (34.09)	381.54 (63.53)	378.78 (66.54)	345.96 (57.28)	365.13 (40.68)	393.18 (77.66)	428.22 (54.83)		0.000	0.000	0.674
PA (°)	7.33 (1.44)	7.27 (0.72)	7.18 (1.39)	7.86 (2.32)	6.67 (1.43)	6.40 (1.01)	6.59 (1.41)	6.61 (1.54)	5.83 (0.63)		0.001	0.978	0.193

Groups: I= silhouettes 2-3; II= silhouettes 4-5; III= silhouettes 6-7; IV= silhouettes 8-9; V= silhouettes 10-11.
BMI, body mass index; Rsp, resistance; Xcsp, reactance; Zsp, vector length; PA, phase angle.

Table 2. Correlation between bioelectrical variables and CBS in the two groups and sexes.

	Young adults		**Middle-aged and elderly**	
	Men	Women	Men	Women
Height (cm)	0.081	0.054	-0.040	-0.040
Weight (kg)	0.589**	0.544**	0.610**	0.682**
BMI (kg/m^2)	0.687**	0.618**	0.723**	0.642**
Rsp (ohm·cm)	0.378**	0.482**	0.374**	0.409**
Xcsp (ohm·cm)	0.352**	0.444**	0.267**	0.313*
Zsp (ohm·cm)	0.379**	0.483**	0.375**	0.405**
PA (°)	0.032	0.073	-0.006	-0.080

r values are reported in the table: Rsp, resistance multiplicated for coefficient; Xcsp, reactance multiplicated for coefficient; Zsp, vector length multiplicated for coefficient; PA, phase angle.
**. The correlation is significant at 0.01 level.
*. The correlation is significant at 0.05 level.