Association between self-perceived body image and body composition in early adults

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Abstract

Objectives: This study aims to investigate the association between self-perceived body image and body composition.

Methods: The study sample consisted of 632 Spanish adults (238 men and 394 women), aged 20-30 years. Figure scale BIA-O designed by Williamson et al. (2000) was used to evaluate current body size (CBS). Anthropometric measurements (height, weight, arm, waist and calf circumferences) were taken. Bioelectrical values of resistance (R, ohm) and reactance (Xc, ohm) were obtained using a phase-sensitive 50 kHz bioelectrical impedance device. *Specific* BIVA analysis, which corrects bioelectrical values (Rsp, Xcsp, Zsp, ohm cm) for body height and body geometry, was applied.

Results: CBS was positively correlated with bioelectrical values in both sexes (Rsp men: r= 0.378, p<0.001; Rsp women: r= 0.482, p<0.001; Xcsp men: r= 0.352, p<0.001; Xcsp women: r= 0.444, p<0.001; Zsp men: r= 0.425, p<0.001; Zsp women: r= 0.483, p<0.001), with the exception of phase angle (men: r= 0.020, p=0.630; women: r= 0.073, p=0.152). Confidence ellipses showed a strong association between silhouettes and body composition: bigger silhouettes were characterised by longer vectors, i.e. higher %FM. The association was clearer in women.

Conclusions: A good agreement between body composition and the self-perceived body image was observed in in both sexes, especially in women. CBS was strongly related to adiposity, but not to muscularity. Williamson's silhouettes appear to be a suitable technique to give information about nutritional status in epidemiological studies in men and women.

Introduction

Body image is a multidimensional concept that includes subjective beliefs and feelings about physical appearance (1). It is influenced by factors such as sex, age, ethnicity, personality, family, media and nutritional status.

The study of body image is based on different methods, such as interviews, questionnaires and silhouette collections (2). Silhouettes generally include a range of body figures that represent increments in weight, from very thin to very obese (e. g. Williamson et al. (3)). They are usually used to assess self-perceived and ideal body image and body image satisfaction, for detecting obesity and thinness (4) and for nutritional assessment in epidemiological studies. Silhouettes are also used in the study of body image alterations in obese patients before and after weight loss, and in the assessment of behaviours related to body image (e.g. level of physical activity, eating behaviours, etc.) and their impact on physical and mental health (5).

It has been pointed out that men and women may perceive the silhouettes differently. In fact, according to literature, men would tend to identify larger silhouettes with higher content of muscle mass, while women would associate them with fat mass (6,7). Hence, at the biological level, differences in body image perception between men and women should be explained not only in relation to weight status, but also in relation to body composition.

However, up to the present day, silhouette collections have been compared to the percentage of fat mass calculated using anthropometric techniques to (e.g. (8,9)), or body mass index (BMI) (e.g. (3,10)). Although BMI is recognised as a valid epidemiological indicator of nutritional status and obesity (11), it is unable to discriminate between Fat Mass (FM) and Fat-Free Mass (FFM). To our knowledge, no studies have examined the association between body image assessed by silhouettes and body composition evaluated using an accurate technique.

Specific Bioelectrical Impedance Vector Analysis (BIVA*sp*; (12,13)) is a new methodology that has been validated against DXA and has demonstrated to accurately evaluate body composition.

Specific BIVA is based on the direct analysis of row bioelectrical data, adjusted for body length and transverse areas and projected as a vector in a Cartesian plane, without the need for predictive equations or assumptions on body composition. The vector length is positively related to the relative content of fat mass (12,13), while phase angle is positively related to body cell mass and integrity (14), and to intracellular water/extracellular water (ICW/ECW) ratio (12,15), thus giving information on skeletal muscle mass. *Specific* BIVA has shown to be able to detect different quantities of body fat in individuals with similar BMI (16).

The aim of this study was to assess the association between the self-perceived body image, evaluated through silhouettes, with body composition, evaluated by means of *specific* BIVA, in a sample of early adults, and to analyse if the association is different between sexes.

Methods

Subjects

This cross-sectional sample included 632 early adults from the Basque Country (Spain), 238 men and 394 women, aged 20-30 years (mean ages: 23.1 ± 2.36 and 22.5 ± 2.25, respectively). Data were collected at the University of Basque Country (UPV/EHU) (Spain). Participants were informed about the study design and signed their consent before the examination. Experimental protocols were approved by the Ethics Committee for Human Research (CEISH) of the UPV/EHU.

Anthropometric and bioelectrical measurements

Anthropometric measurements (height, cm; weight, kg; waist arm and calf circumference, cm) were taken following standards procedures (17). BMI was calculated as weight/ height^2 (kg/m^2).

Bioimpedance measurements were taken with a single-frequency phase sensitive impedance 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). Following standard procedures, subjects were asked to not drink and eat and void their bladder before the evaluations. Measurements were taken in an isolated cot with the volunteer in a supine position. Two pairs of detector and injector electrodes were placed in the right side of the body: on the hand and wrist, and on the foot and ankle, respectively.

The *specific* bioelectrical impedance vector analysis was applied (BIVA*sp*; (12,13)) to determine body composition. To minimize the effect of conductor dimensions *specific* BIVA adjusts bioelectrical values (R, Xc; Ω) for a correction factor (A/L): 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 (cm) is the circumference of each segment, and L is the length estimate, calculated as 1.1H, where H is the height in cm. Specific impedance (Zsp) was calculated as $(Rsp^2 + Xcsp^2)^{0.5}$ (Ω cm) and phase angle (PA) using the formula: arctan Xc/ R180/π (degree).

Body image

The figure scale BIA-O designed by Williamson et al. (3) was used to evaluate the current body size (CBS). Following the Williamson et al. (3) procedures, 18 silhouettes for each sex, ranging from very thin (number 1) to vey obese (number 18), were administered to participants and they were asked to choose the silhouette which was closest to their usual appearance. Based on the absence or low frequencies in the choice of silhouettes number 1 and numbers 12 to 18, 18 participants (seven men and eleven women) were excluded from the analysis.

Statistical analyses

Mann-Whitney U test was employed to evaluate sex differences in the chosen CBS. The associations between CBS and bioelectrical measurements were investigated by using Spearman correlation analysis. The relation between silhouettes and body composition was also studied using confidence ellipses by means of Hotelling's T^2. The differences between sexes and among groups representing subjects choosing two silhouette types (I= silhouettes 2-3; II= silhouettes 4-5; III= silhouettes 6-7; IV= silhouettes 8-9; V= silhouettes 10-11) were analysed using a two-way ANOVA.

Statistical analyses were performed using the SPSS program and the *specific* BIVA software (www.specificbiva.unica.it).

Results

The sample showed a normal nutritional status in mean, as indicated by the BMI within the range of normal weight (men: 23.60 ± 2.58; women: 22.33 ± 2.82), and the waist circumference values were below the thresholds for abdominal obesity (men: 79.28 ± 6.74; women: 69.61 ± 2.58). Only 14 participants (seven in each sex) were obese (BMI > 30 kg/m^2).

The individual bioelectrical values were normally distributed on the tolerance ellipses representing the variability of the young adult Spanish population (18): 53.7% of men and 59.3% of women fell within the 50% tolerance area; 78.8% of men and 85.1 % of women within the 75% area; 94.8% of men and 95.6% of women in the 95% area; 17 women (4.4%) and 12 men (5.2%) fell outside the 95% tolerance ellipses.

The sample showed a normal pattern of sexual dimorphism, with men characterized by higher height, weight, BMI, PA, and lower Rsp and Zsp compared to women (Table 1). Sexual differences were observed also in the CBS choice (p<0.001): men tended to choose larger silhouettes than women; the most chosen silhouette by men was the number 6 (18.2%) and by women was the number 4 (22.7%).

In both sexes, individuals choosing different groups of silhouettes showed similar height and PA values, while weight, BMI, Rsp, Xcsp, Zsp were significantly different, with greater values in those choosing bigger silhouettes (Table 1). In fact, bioelectrical variables were positively correlated with the silhouettes in both sexes (Rsp men: r= 0.378, p<0.001; Rsp women: r= 0.482, p<0.001; Xcsp men: r= 0.352, p<0.001; Xcsp women: r= 0.444, p<0.001; Zsp men: r= 0.425, p<0.001; Zsp women: r= 0.483, p<0.001), with the exception of PA, which was not correlated (men: r= 0.020, p=0.630; women: r= 0.073, p=0.152). Confidence ellipses (Figure 1) representing groups of chosen silhouettes also showed the good association with body composition, as the groups corresponding to bigger silhouettes were associated with longer vectors. The comparisons between subsequent groups were significant, with the exception of I-II groups in men (silhouettes 2 to 5), and IV-V groups in women (silhouettes 8 to 11). The association between Rsp and Xcsp with the selected silhouettes was more regular and defined in women, as indicated by the significant interaction between sex and group of silhouettes and the distribution of the ellipses in the RXc graph (Table 1 and Figure 1).

Discussion

In the analysed sample of young and normal weight individuals, current body size, estimated by Williamson's silhouettes, is associated with body size and composition variations in both sexes, especially in women. In fact, obtained results exhibited a positive and significant correlation between CBS and bioelectrical variables, particularly with Rsp, Xcsp, and Zsp, while PA was not correlated. According to specific BIVA (12,13), these associations indicate that individuals choosing bigger silhouettes are characterised, in mean, by higher %FM values (as indicated by longer vectors), but similar muscle mass (similar phase angles). The results also showed a positive relationship with BMI and weight, as their values increase as silhouette groups do, whereas height remains stable.

Previous studies, using different populations and figure collections, have already established a robust relationship between BMI and silhouettes collections, (e.g. (4,19)). Since *sp*ecific BIVA method is able to recognize differences in body composition that are not detected by BMI (16), this study has allowed us to clarify that the association is related to the fat mass component of the body, and not to the muscular one.

This is particularly evident in women, who interpreted silhouettes as a progressive increase in body fat, showing a more continuous increase of the vector length. Men understand silhouettes in the same way, but less clearly, as indicated by the less defined trend of confidence ellipses and by the interaction between sex and vector length.

Our research on current body size differs from the results obtained by McCabe and Ricciardelli (20) and Frederick et al. (6) on ideal body images, showing that men would tend to choose body silhouettes in relation to their desire to gain muscle. In fact, in our sample, we only observed a weak indication of a similar sex difference. It is possible that the differences are stronger for ideal than for current body image. Hence, more studies are needed to better understand this relationship, focusing on particular populations with higher contents of muscle mass, such as athletes.

In conclusion, Williamson's silhouettes collection used to assess the current body size is strongly related to body composition, particularly to adiposity and not to muscularity. The relationship is similar in both sexes, but more evident in women. Williamson's silhouettes appear to be a suitable technique to give important information about nutritional status, especially about %FM, in epidemiological studies.

This research has some limitations. The cross-sectional nature of the study and that the results are population, setting and time-specific. However, the main strength of the present study is that it represents the first attempt to analyse the association of body image perception by using silhouettes with body composition evaluated by means of an accurate technique. In addition, the sample includes both sexes, and the age range corresponds to a period in the human lifespan characterised by a relative physical stability, so age may have a limited influence on body image perception and body composition.

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Competing Interests

The authors declare that they have no conflict of interest.

References

1. Grogan S. Body Image: Understanding Body Dissatisfaction in men women and children. Routledge, UK, 2008.
2. Cuesta-Zamora C, Navas L. A Review of Instruments for Assessing Body Image in Preschoolers. *Univers J Educ Res* 2017; **5**:1667–77.
3. Williamson DA, Womble LG, Zucker NL, Reas DL, White MA, Blouin DC, et al. Body image assessment for obesity (BIA-O): development of a new procedure. *Int J Obes* 2000; **24**:1326–32.
4. Bulik CM, Wade TD, Heath AC, Martin NG, Stunkard AJ, Eaves LJ. Relating body mass index to figural stimuli: population-based normative data for Caucasians. *Int J Obes* 2001; **25**:1517-24.
5. Solomon-Krakus S, Sabiston CM, Brunet J, Castonguay AL, Maximova K, Henderson M. Body Image Self-Discrepancy and Depressive Symptoms Among Early Adolescents. *J Adolesc Heal* 2017; **60**:38–43.
6. Frederick DA, Buchanan GM, Sadehgi-Azar L, Peplau LA, Haselton MG, Berezovskaya A, et al. Desiring the muscular ideal: Men's body satisfaction in the United States, Ukraine, and Ghana. *Psychol Men Masculinity* 2007; **8**:103–17.
7. Streeter VM, Milhausen RR, Buchholz AC. Body image, body mass index, and body composition: In young adults. *Can J Diet Pract Res* 2012; **73**:78–83.
8. Costa L da CF, Silva DAS, Alvarenga M dos S, De Vasconcelos FDAG. Association between body image dissatisfaction and obesity among schoolchildren aged 7-10 years. *Physiol Behav* 2016; **160**:6–11.

9. Greeff N. Physical fitness, body composition and body image in female adolescents: The PAHL-study, 2016.

10. Stunkard AJ. Use of the Danish Adoption Register for the study of obesity and thinness. *Res Publ Assoc Res Nerv Ment Dis* 1983; **60**:115–20.

11. World Health Organization. Obesity: preventing and managing the global epidemic. World Health Organization; 2000.

12. Buffa R, Saragat B, Cabras S, Rinaldi AC, Marini E. Accuracy of Specific BIVA for the Assessment of Body Composition in the United States Population. *PLoS One* 2013; **8**:e58533.

13. Marini E, Sergi G, Succa V, Saragat B, Sarti S, Coin A, et al. Efficacy of specific bioelectrical impedance vector analysis (BIVA) for assessing body composition in the elderly. *J Nutr Health Aging* 2013; **17**:515–21.

14. Piccoli A, Rossi B, Pillon L, Bucciante G. A new method for monitoring body fluid variation by bioimpedance analysis: The RXc graph. *Kidney Int* 1994; **46**:534–39.

15. Marini E, Campa F, Buffa R, Stagi S, Matias CN, Toselli S, et al. Phase angle and bioelectrical impedance vector analysis in the evaluation of body composition in athletes. *Clin Nutr* 2019; https://doi.org/10.1016/j.clnu.2019.02.016

16. Buffa R, Mereu E, Succa V, Latini V, Marini E. Specific BIVA recognizes variation of body mass and body composition: Two related but different facets of nutritional status. *Nutrition* 2017; **35**:1–5.

17. Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Vol. 177. Human kinetics books, Champaign, 1988.

18. Ibáñez ME, Mereu E, Buffa R, Gualdi-Russo E, Zaccagni L, Cossu S, et al. New specific bioelectrical impedance vector reference values for assessing body composition in the

Italian-Spanish young adult population. *Am J Hum Biol* 2015; **27**:871–76.

19. Muñoz-Cachón MJ, Salces I, Arroyo M, Ansotegui L, Rocandio AM, Rebato E. Overweight and obesity: Prediction by silhouettes in young adults. *Obesity* 2009; **17**:545–49.

20. McCabe MP, Ricciardelli LA. Body image dissatisfaction among males across the lifespan. *J Psychosom Res* 2004; **56**:675–85.

Figure Legend

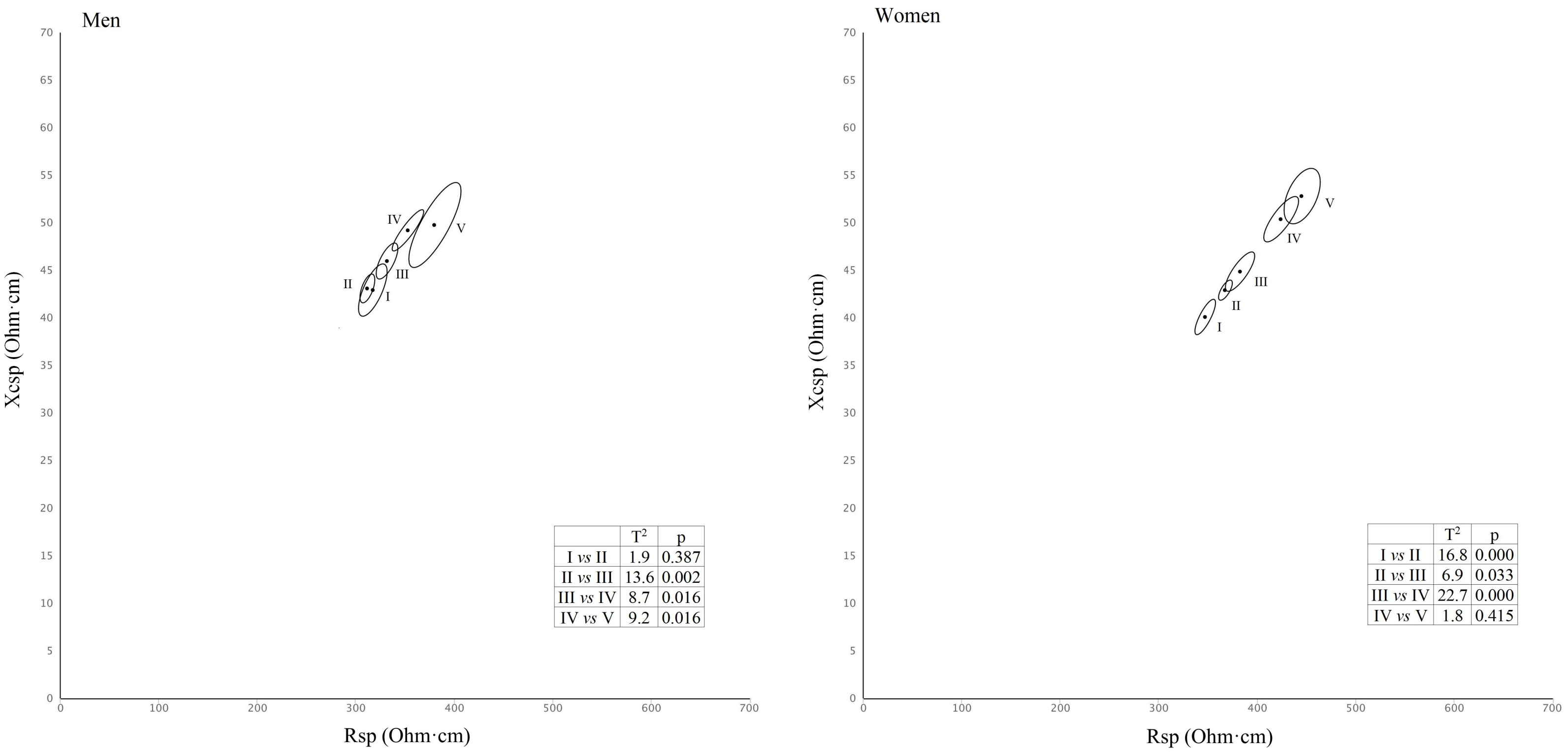
Figure 1. Total body specific BIVA confidence ellipses. Comparison between groups of CBS silhouettes (I= silhouettes 2-3; II= silhouettes 4-5; III= silhouettes 6-7; IV= silhouettes 8-9; V= silhouettes 10-11).

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		
	I		II		III		IV		V		I		II		III		IV		V				
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	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/m2)	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
Phase (°)	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

Groups: I= silhouette 2-3; II= silhouette 4-5; III= silhouette 6-7; IV= silhouette 8-9; V= silhouette 10-11.

BMI, body mass index; Rsp, resistance; Xcsp, reactance; Zsp, vector length; PA, phase angle.



Men

	T^2	p
I *vs* II	1.9	0.387
II *vs* III	13.6	0.002
III *vs* IV	8.7	0.016
IV *vs* V	9.2	0.016

Women

	T^2	p
I *vs* II	16.8	0.000
II *vs* III	6.9	0.033
III *vs* IV	22.7	0.000
IV *vs* V	1.8	0.415