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Desórdenes alimentarios y su asociación con la forma física y la composición corporal en adultos jóvenes: revisión sistemática

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RESUMEN
Objetivo: Dado que la forma física y la composición corporal se ven afectadas por las perturbaciones en el comportamiento alimentario, estos dos factores están relacionados teóricamente; sin embargo, no identificamos estudios cuyo objetivo principal sea estudiar estas relaciones. Esta revisión sistemática actualizada analiza los estudios publicados a partir de 2011 sobre trastornos alimentarios y cómo estos trastornos se asocian o modifican la forma física y la composición corporal de mujéres jóvenes (18-45 años).

Métodos: Se realizaron búsquedas en Scopus, MEDLINE y Science Direct utilizando las palabras clave “Trastornos alimentarios”, “Composición corporal”, “Forma corporal”, “Desnutrición”, “Obesidad” y “Anorexia”. De los 10 031 artículos identificados mediante selección independiente, tres investigadores seleccionaron 15 manuscritos que cumplían con los criterios de inclusión y exclusión.

Resultados: Ninguno de los manuscritos describió la forma física; solo se abordó la composición corporal. La densitometría de rayos X (DXA) fue el método de medición más utilizado, mientras que la antropometría se usó erróneamente para evaluar la composición corporal.

Conclusiones: Los cambios en la composición corporal, no en la forma del cuerpo, se asociaron con la presencia de trastornos alimentarios en mujeres adultas jóvenes, pero no con la severidad del comportamiento. No encontramos manuscritos que estudien los desórdenes alimentarios en hombres.

Palabras clave: anorexia nerviosa, trastorno por atracón, constitución corporal, desnutrición, salud mental, ejercicio físico

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INTRODUCTION

Eating disorders such as anorexia nervosa (AN), bulimia nervosa (BN) and binge eating are characterized by a distorted self-body image (Figure 1) that leads to somatic changes in addition to reduced physical and mental health (Mitchell & Crow, 2006). AN is a common disorder in both adolescents and young adults and causes obsessive behavior toward weight loss driven by the desire to be thin. As a result, people with AN reduce their caloric intake and/or perform excessive physical exercise (Bloch, Ish-Shalom, Greenman, Klein & Latzer, 2012). BN, on the other hand, triggers drastic binge eating in people who later self-induce vomiting (3); furthermore, to lose or maintain weight, people with BN engage in excessive physical exercise and use laxatives and diuretics (Shapiro *et al.,* 2007). BN is related to depression, hypokalemia and gastrointestinal difficulties (Polnay et al., 2014), and having a family history of obesity is a predisposing factor for the development of this disease (Fairburn, Welch, Doll, Davies & O'Connor, 1997).

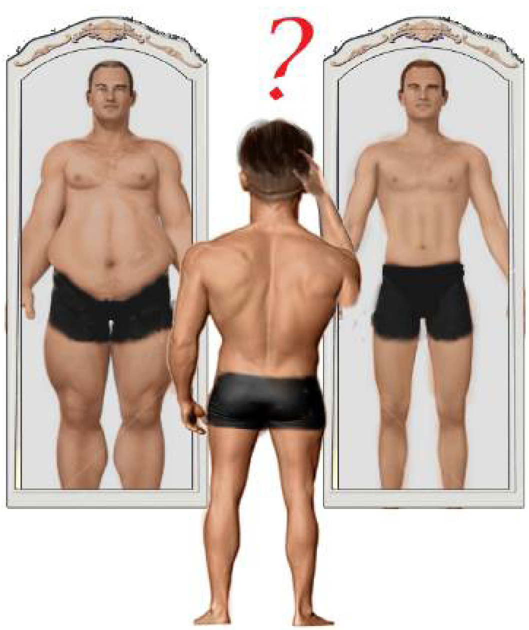

Figure 1. *distorted self-body image.*

Binge eating is another eating disorder currently acknowledged by the American Psychiatric Association (2013). It is characterized by recurrent and obsessive eating episodes in which people consume a large quantity of food —an amount that most people would not eat under similar circumstances— in a short period of time and is coupled with feelings of lack of control (Yanovski *et al.,*1992). Yanovski documented that people with binge eating disorder who are also obese consume more calories than people who suffer from obesity alone (Yanovski *et al.,*1992).

Studying body image, body shape and body composition enable an understanding of the impact of eating disorders on people's physical and mental health (Bredella *et al.,* 2014; Gómez-Ambrosi *et al.,* 2012). As Ramos-Jiménez *et al.* mentioned (2016), image shape and body composition are interrelated, as each explains the human body from a different aspect. Body image explains the subjective perspective, while the other two the objective; furthermore, body image represents the perception people have about their body, i.e., how I look, how I wish to be seen, how others see me and how I think others see me. To study body image, questionnaires in which the person selects the responses or figures that relate to their beliefs or their desired physical form are generally used. However, body shape is externally measurable, and physically tangible aspects of the body, i.e., weight, height, length, diameter, circumference and total or partial volumes, can also be obtained. Furthermore, body shape (somatotype) can be studied through anthropometric measurements, determination of somatotype and photogrammetry (Figure 2), anthropometry being the most common, inexpensive and simple procedure to use (Ramos-Jimenez *et al.,* 2016).

It is worth noting that although both image and body shape are commonly used in the same context, they are distinct from each other, as previously mentioned. Finally, body composition refers to existing proportions of our body in terms of fat mass, lean mass, bone mass and muscle mass (Ramos-Jimenez *et al.,* 2016; El Ghoch *et al.,* 2012). To determine composition in vivo, different indirect methods are used, the most reliable of which are image processing techniques that observe the inside of the body, such as computed tomography (CT) (Borkan *et al.,* 1982), nuclear magnetic resonance (NMR) (Fuller *et al.,* 1999) and X-ray densitometry (DXA) (Bredella *et al.,* 2013). The least reliable methods include densitometry, either by plethysmography (Bod Pod) or underwater weight (Collins *et al.,* 1999), bioimpedance (BIA)

(Elia *et al.,* 2000) and infrared rays (Conway, Norris & Bodwell, 1984). Although anthropometry is used as an additional method of determining body composition, it is mistakenly applied in this capacity, as it is a doubly indirect determination method and is unreliable (Silleras *et al.,* 2013). The only direct method of measuring body composition is cadaverous, hence it is not commonly used (Prior *et al.,* 1997). The study of the body image evolves from the publications of Fisher (1970) and Shontz (1969), which introduce this concept relating it to cognitive, behavioral and psychological problems. In fact, there is currently a scientific journal specialized in this interesting topic, which has spread this topic to various areas, such as social and medical (Cash, 2004).

Self-image, body shape and body composition are affected in people with eating disorders (Mitchell & Crow, 2006; Bloch *et al.,* 2012; Raymond *et al.,* 2012), forming a complex syndrome that is typically treated in parts (Mitchell & Crow, 2006;); thus, treating this problem has not always been effective (Bloch *et al.,* 2012). Consequently, multidisciplinary treatment approaches (psychological, diet, exercise and pharmacological) are suggested that simultaneously target the modification of negative behaviors; this type of treatment relies on the family inside the patient's homes as well as the recognition of this problem at an early age (El Ghoch *et al.,* 2015a; El Ghoch *et al,* 2015b; Marco, Perpina & Botella 2013). In two parallel studies after 20 weeks of multidisciplinary treatment to reduce eating disorder problems in patients with AN, El Ghoch (El Ghoch *et al.,* 2015a; El Ghoch *et al.,* 2015b) observed an increase of 10-17% in fat mass; however, a reduction of approximately the same proportion of lean mass was also observed. In both studies, fat mass recovered to a greater extent in the central area of the body, where the development of fat mass is known to favor metabolic disorders and cardiovascular complications (Wall-Medrano *et al,* 2016). Studies assessing treatments with a longer duration observed the same problem (Bloch *et al.,* 2012).

Finally, studies of the physical effects of this set of conditions have been equally incomplete to date. Most studies investigate either body shape or body composition, not both, and the procedure used most often to assess body composition is DXA. Therefore, the purpose of this study was to conduct an updated systematic review that analyzed papers published since 2011 on eating disorders and how these disorders are associated with or modify young (18-45 years) female adults' physical form and body composition.

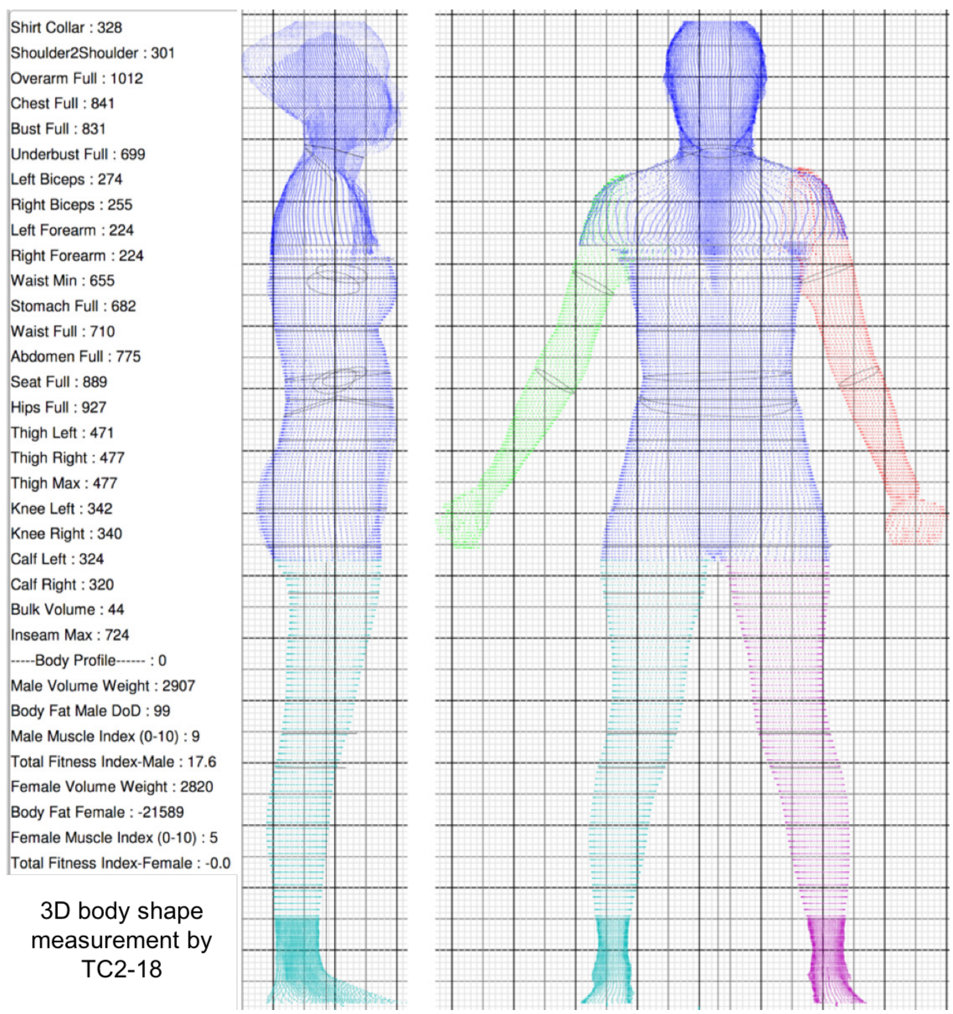

Figure 2. *3D Body shape measurements by Body Scaner.*

METHODS

In this study, a team of two investigators and two advanced medical-surgeon students was formed. The team was trained during the process of standardizing the criteria for information selection, which was conducted according to the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) criteria (Liberati *et al.,* 2009). The two methods currently used to perform systematic reviews, the Cochrane and PRISMA formats, were discussed, and the latter was chosen because it was more comprehensive and easier to understand (Liberati *et al.,* 2009). Study compilation and item selection were performed independently by two researchers; when there was a dispute regarding the inclusion of a manuscript, a third researcher participated in the final selection. The search for studies was performed from June 10 to 13, 2016, using the following databases: Scopus, MEDLINE and Science Direct. The following ten combinations were searched using the keywords listed below and the Boolean operators AND, OR, and NOT:

“Eating disorders” AND “Body composition” NOT children NOT elderly
“Eating disorders” AND “Body shape” NOT children NOT elderly
Malnutrition AND “Body composition” NOT children NOT elderly
Malnutrition AND “Body shape” NOT children NOT elderly
Undernutrition AND “Body composition” NOT children NOT elderly
Undernutrition AND “Body shape” NOT children NOT elderly
Obesity AND “Body composition” NOT children NOT elderly
Obesity AND “Body shape” NOT children NOT elderly
Anorexia AND “Body composition” NOT children NOT elderly
Anorexia AND “Body shape” NOT children NOT elderly

The inclusion criteria were as follows:

1. Original articles in humans, with results reported by validated methods.
2. Papers on young adults (17-44 years old) with eating disorders.
3. Studies published since 2011.
4. Articles in English, Portuguese or Spanish.

The exclusion criteria were the following:

1. Articles with unlocated full texts.
2. Studies with titles or abstracts that expressed having analyzed animals, cells, organs or bacteria.

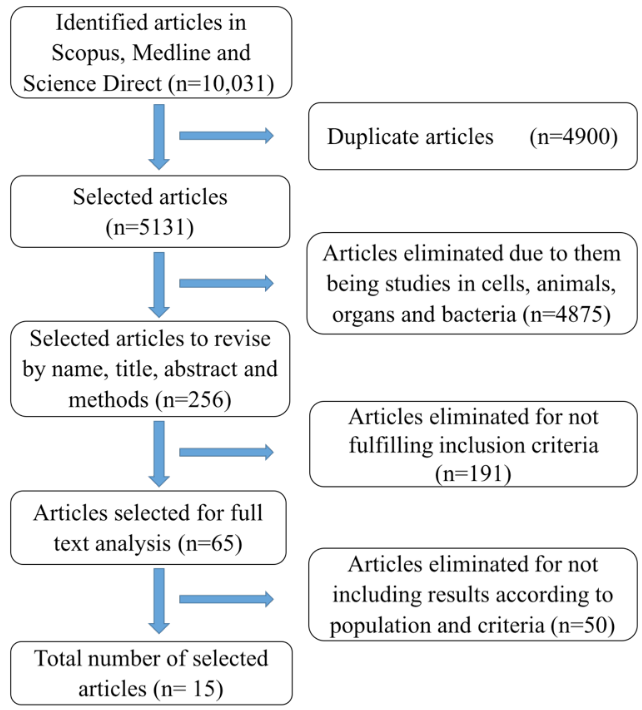

Figure 3. *Flowchart of the search strategy used in this review set out according to PRISMA.*

RESULTS

The systematic search identified a total of 10 031 items (Figure 3), which were processed in EndNote X7, resulting in the removal of 4,900 duplicate items. Of the remaining 5,131, studies with titles or abstracts that reported analyzing animals, cells, organs or bacteria were excluded. The remaining 256 manuscripts were found in full text to be analyzed by title, abstract and methodology; 191 did not meet the inclusion criteria. The full texts of the resulting 65 were analyzed again, and 48 were deleted for assessing a population that did not meet the inclusion criteria. The inclusion of 15 of these 65 manuscripts was disputed, and they were later included or eliminated after being completely read by three researchers. In total, this systematic review included 15 articles that were independently and jointly selected by the researchers according to the inclusion criteria (Table 1).

As shown in the summary of the manuscripts (Table 1), we found eleven manuscripts that reported weight and height anthropometric data, though only three of them performed skinfold measurements, and one of three determined body circumference; none of these eleven manuscripts reported body somatotype in any way. Of the 15 manuscripts, eleven performed body composition measurements with DXA, four with BIA, one with CT, one with MRI and one by air displacement plethysmography (Bod Pod). Three of the 15 assessed biochemical factors to determine bone mineral turnover and insulin sensitivity. Nine of the 15 were longitudinal studies and investigated the effect of different treatments on body weight and body composition. Six of the 15 were cross-sectional studies, two of which performed validations through convergence measurement methods.

DISCUSSION

Eating disorders are phenomena with psychological and social causes that affect both physical and mental health. People who suffer from these disorders have altered perceptions of athleticism and unhealthy distributions of different body components (fat mass, muscle mass, bone mass, lean mass and residual mass) comprising body composition. Since physical form and body composition are affected by disturbances in eating behavior, these two factors are theoretically related; however, we did not identify studies that primarily aimed to study these relationships. El Ghoch *et al.,* in four different papers (El Ghoch *et al.*, 2012; 2014; 2015a; 2015b) on body composition as well as its changes in people with AN, observed a marked decrease in the different components of body composition (fat mass, lean mass and muscle mass) after 20 weeks of a multidisciplinary treatment for weight regain. Weight gain in these areas increased at different, unequally distributed concentrations; i.e., recovery was greater for fat mass, followed by lean mass and finally muscle mass. The increase in fat mass occurred mainly in the trunk, and lean body mass in the extremities. We can infer that there is a positive correlation between the degree of food alteration and body shape and body composition disorders in people with AN.

More importantly, we did not find in the last seven years any studies on changes in body shape in people with eating disorders, although this parameter provides rich information and is also affected in this syndrome, as mentioned before. In addition, at least using this set of keywords, studies on physical form did not include assessments of somatotype; the most that was mentioned regarding these changes was that after recovering their body weight, people experienced central obesity with an android or gynecoid phenotype (El Ghoch *et al.,* 2015a). Although obesity is a type of caloric eating disorder, it is not included in the literature as such. Finally, we did not find any papers that studied eating disorders in men.

Regarding changes in body composition, of the 11 manuscripts found, only three considered anthropometrics to determine fat mass or tried to validate these measures against other more valid methods (El Ghoch *et al.,* 2012; Silleras *et al.,* 2013; Pattyn, Peeters, Balloey & Claessens, 2011); others only measured weight and height to determine the degree of obesity using body mass index (BMI). The other methods used for this purpose were DXA, BIA, ultrasound, CT, MRI and plethysmography, all of which have high validity and reliability (> 0.80) except for BIA and ultrasound (Miyatani, Kanehisa & Fukunaga, 2000; Gradmark *et al.,* 2010; Mijnarends *et al.,* 2013). All the manuscripts included in this paper, except one, used two or more methods to measure body composition.

One issue that could have led to the lack of information about the degree of association between the factors studied here is that no studies jointly assessed the severity of the eating disorder syndrome with the evaluation of shape and body composition. In the literature, we found several validated scales that assessed the severity of eating disorder (Fairburn *et al.,* 1997; Maïano, Morin, Monthuy-Blanc, Garbarino & Ninot, 2016); however, we did not find studies that used them simultaneously with assessments of form and body composition or that tried to determine their correlations.

It is worth noting that with the keywords used, we only found papers that addressed AN, as studies on BN and binge eating were missing. It is natural to not find papers related to binge eating, as it was only in 2013 when the Diagnostic and Statistical Manual of Mental Disorders (DSM) (American Psychiatric Association, 2013) included this condition as an eating disorder. For BN, it is surprising that authors have shown little interest in understanding the changes in fitness and body composition experienced by people with this disease.

Regarding the methods used to evaluate eating disorders, all manuscripts described assessing clinical determinations according to the classifications of the American Psychiatric Association (2013). In contrast, the methods used to assess body shape in these conditions were neglected by the authors or were not considered important. However, there was a wide variety of validated procedures, as described in the introduction, indicating that body shape is not yet evaluated within eating disorder syndromes.

Pharmacological and physiological associations

Of the three manuscripts that analyzed biochemical parameters in patients with AN, one of them mentioned that a single administration of the steroid prohormone dehydroepiandrosterone (DHEA) had no clinical effect on body weight gain, bone density or bone mineral, nor on patient mood (Lawson *et al.,* 2011). The second study (Bloch *et al.,* 2012) found positive correlations between serum concentrations of oxytocin and mineral bone density, lean mass and leptin ($r \sim 0.50$, $p < 0.05$). The third (Prioletta *et al.,* 2011) observed that a higher concentration of backbone fat mass, after recovering body weight, correlated to a decrease in insulin sensitivity ($r = -0.53$; $p = 0.04$). Furthermore, other authors (Kosmiski, Schmiege, Mascolo, Gaudiani & Mehler, 2013) have also noted that reductions in fat mass and lean mass decrease resting energy expenditure (REE). Summarizing the findings described above, we can conclude that decreases in both fat mass and lean mass decrease REE, which in turn affects the decrease in leptin hormone concentrations and oxytocin, along with decreases in bone mineral density. On the other hand, the small increases in trunk fat mass observed in individuals with AN undergoing therapy to gain body weight decreased insulin sensitivity. Therefore, we can say that biochemical and physiological analyses are important to identifying unconventional predictors of eating disorders and the severity of these conditions.

Treatment studies

As for treatment studies, most of them were intra-hospital, in which the patients experienced increases in both the number of meals and caloric intake; psychological-behavioral, nutritional, physical activity and pharmacological therapies were simultaneously incorporated, with modifications in eating behavior and increased body weight being the main purposes of treatment, giving little importance to increases in muscle mass. We found no long-term studies in which the impact of treatment on the restoration of proper eating behavior or body shape and composition was assessed.

CONCLUSIONS

Physical form or body shape has not been studied in eating disorders syndromes. Body composition has occasionally been assessed, with fat mass and fat-free mass being the most studied. We found one manuscript that evaluated muscle mass, and most papers evaluated bone density. The main method of body composition assessment was DXA, followed by BIA, CT, MRI and Bod Pod. Anthropometry was erroneously used to assess body composition rather than to determine body shape. For the studies above, it was the changes in body composition, and not in body shape, that demonstrated associations with the presence of eating disorders, but not with their degree of severity in young female adults. We did not find any papers that studied eating disorders in men.

Prospective analysis

Through the full identification of the three proposed constructs (image, shape and body composition), and the joint study of these three, we can propose better treatments of eating disorders; which include psychological, psychiatric, nutritional and physical activity approaches. Young adults are constantly attacked by the mass media for the perfection of body image and form, so we propose the creation of more complete programs, parallel to this mediatic information, that help reduce pathological nutritional behaviors and strengthen self-esteem.

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Table 1. Manuscripts included in the systematic review.

Author and year	Type of study	Population studied	Objective of the study	Measurement methods	Results
Agüera Z *et al.* (2015)	Longitudinal study by convenience	118 Spanish females with anorexia nervosa (AN) diagnosis (25± 8 years old) vs 143 healthy control group (28±8 years old).	To study the effect of a nutritional and behavioral treatment program (15 weeks) on body composition in patients with AN	Bioelectrical impedance (BIA) X-ray densitometry (DXA) Weight and height	After a year of treatment to correct eating behavior, an increase in fat mass (+ 4.26%), fat-free mass (+ 1.09 kg), muscle mass (+ 1.04 kg), and bone mineral density was observed ($p < 0.05$).
Bloch M, Sophialsh-Shalom, Greenman Y., Klein E., and Latzer, Y (2012)	Longitudinal, randomized double-blind study	26 Israelites females (17-47 years old) with an AN diagnosis.	To investigate the effect of drug treatment (3-6 months with dehydroepiandrosterone, DHEA) on changes in body weight, bone metabolism, bone mineral density and mood state in patients with AN	Weight and height DXA Biochemical determinations of bone mineral exchange Ultrasound	3 and 6 months of treatment with DHEA did not alter body weight, bone density, bone minerals or patient mood.
Bratland-Sanda S., W. Martinsen E., and Sundgot-Borgen J. (2012)	Longitudinal study by convenience	29 Norwegian women (over 18 years old) diagnosed with an eating disorder	To assess the effect of a multidisciplinary treatment program (12-24 weeks) on aerobic capacity, muscle strength, bone mineral density and body composition in women with AN	DXA Maximum O2 (VO2 max) consumption Maximum muscle strength	Treatment increased body weight, fat mass, lean mass, muscle strength and bone density, but not VO2 max. A lower body weight correlated with greater observed changes.
Bredella M. A. *et al.* (2013)	Cross-sectional study by convenience	135 women (18-45 years old): non-overweight (n=27), overweight and obese (n=89) and diagnosed with AN (n=19).	To validate DXA vs computed tomography (CT) as a method of quantifying abdominal fat in subjects with and without AN	Height and weight DXA TC	CT and DXA to determine abdominal fat had a high correlation (r=0.93). The highest correlation was observed when overweight and obese subjects were evaluated (0.88); the correlation was lower in non-overweight subjects (0.73) and in those with AN (0.64) ($p<0.01$).
Bredella M. A. *et al.* (2014)	Cross-sectional study by convenience	26 women (20-45 years old): 14 diagnosed with AN and 12 healthy controls.	To study the potential associations between the degree of unsaturated lipids in bone marrow, intracellular lipids and body composition in women with AN	Magnetic resonance spectroscopy: 1H-MRS and axial DXA	Compared with controls, women with AN had more saturated fat and unsaturated bone marrow fat ($p<0.05$), and bone mineral density decreased with greater amounts of saturated lipids (r=-0.52). Additionally, there was a direct relationship between unsaturated lipids in bone marrow cells and muscle cells (r=0.42, p=0.05).

De Mateo, Beatriz *et al.* (2013)	Longitudinal study by convenience	12 Spanish women (~ 24 years old) with AN vs 24 healthy controls (18-26 years old)	To assess the convergent validity between anthropometric and BIA measurements in assessing body composition (fat mass and fat-free mass) in people with and without AN before and after nutritional treatment (36 days)	Anthropometry: weight, height, skinfold and body circumference BIA	In healthy patients, the correlations between anthropemetric measurements and BIA regarding fat mass and fat-free mass were very high (r = 0.90), whereas in patients with AN, these associations were moderate (r=0.53 to 0.75).
El Ghoch M. *et al.* (2012)	Longitudinal study by convenience	27 Italian women diagnosed with AN and 42 healthy controls (18-45 years old).	To validate anthropometric equations that estimated body fat vs DXA in patients with AN before and after 20 weeks of treatment for weight gain	Anthropometry: weight, height and skinfold measurements DXA	Anthropometric measurements estimated a lower percentage of body fat than DXA. The correlations between both methods were low (r <0.5).
El Ghoch, M. *et al.* (2014)	Longitudinal study by convenience	50 Italian women (18-50 years old) with AN vs healthy controls	To evaluate the effect of a multidisciplinary treatment program (20 weeks) aiming to restore body weight on the distribution of fat mass and lean mass in patients with AN	Height and weight DXA	The increase in fat mass and lean mass was greater at the central level (trunk fat) than in the arms and legs.
El Ghoch M. *et al.* (2015)	Longitudinal study by convenience	132 Italian women: 66 with AN and 66 healthy controls (66 adolescents aged 13 to 19 years old and 66 adults over 20 years of age)	To evaluate the effect of a multidisciplinary treatment program (20 weeks) aiming to restore body weight and the distribution of fat mass in patients with AN	Height and weight DXA	The treatment increased body weight by 11.3 kg and fat mass and lean mass by ~14%. The distribution of body fat did not change during the study, neither in adolescents nor adults, an was preferentially located at the central level, showing an android phenotype.
El Ghoch M. *et al.* (2015)	Longitudinal study by convenience	90 Italian women with AN and 90 healthy controls (18-45 years old).	To evaluate the effect of a multidisciplinary treatment program (20 weeks) aiming to restore body weight and the distribution of fat mass, lean mass and muscle mass in patients with AN	Height and weight DXA	Recovery of fat mass was greater compared to the recovery in lean mass and muscle mass; furthermore, it was greater in patients with a lower initial body weight. Lean mass recovery was greater in the arms and legs than in the trunk.
Haas V. *et al.* (2012)	Longitudinal study by convenience	57 German women (18-54 years old) hospitalized with a diagnosis of AN vs healthy controls	To evaluate the effect of treatment to increase body weight (3-12 weeks) on the sensitivity (internal validation) of BIA in diagnosing changes in body composition in patients with AN.	Height and weight BIA	A 4 kg gain in body weight decreased electrical resistance (~ -70 Ohms/m) and increased reactance (~ + 3 Ohms/m) and phase angle (~ + 0.5 °) (p<0.05). BIA was a sensitive method for detecting small changes in body weight of people with AN; however, it still has little clinical utility.

Kosmiski L., Schmiege S.J., Mascolo M., Gaudiani J., and Mehler P.S. (2014)	Cross-sectional study by convenience	30 American women with AN and 25 healthy controls	To evaluate the effect of lean body mass on resting energy expenditure (REE) in patients with AN	DXA	AN patients had lower REE than healthy controls. Reduction in lean mass and fat mass were the main predictors of decline in REE.
Lawson E. A. *et al.* (2011)	Cross-sectional study by convenience	36 American women: 17 with AN and 19 healthy controls	To investigate the relationship between oxytocin levels, bone mineral density and body composition in women with AN	Height and weight DXA	Serum oxytocin concentrations were decreased in women with AN compared to healthy controls (14.3 ± 1.5 vs 31.8 ± 5.1 pg/mL, p=0.003). These concentrations had low or moderate associations with bone mineral density measurements (r=~0.40, p<0.05), fat mass (r=0.42, p=0.01) and leptin levels (r=0.55, p 0.001).
Pattyn N., Peeters M.W. Balloey E., Claessens A.L., and Probst M. (2011)	Cross-sectional study by convenience	23 Belgian women (17-44 years old) diagnosed with AN	To validate BIA and anthropometry vs air displacement plethysmography (ADP) for use in patients with AN	Anthropometry: weight, height and skinfold measurements BIA ADP	Body fat determinations differed when used simultaneously with anthropometry, BIA and ADP. The values only represented percentages between 10 and 12%. The correlations between the three methods were moderate (r=0.58 to 0.64). As they present bias, the three methods cannot be used interchangeably, at least in patients with AN.
Prioletta A. *et al.* (2011)	Cross-sectional study by convenience	40 Italian women with AN: 21 in the recovering phase, 19 in the acute phase, and 21 healthy controls.	To demonstrate that small differences in trunk fat mass affect insulin sensitivity in patients with AN who are undergoing therapy for body weight recovery	Height and weight DXA Glucose tolerance test	Although all participants had healthy insulin sensitivity, patients with AN who were in the body weight recovery stage (+ 3 kg of fat mass trunk) had lower insulin sensitivity than their counterparts (- 3.1 mg/kg/min of glucose uptake). A higher concentration of trunk fat mass correlated to lower insulin sensitivity (r=-0.53; P=0.04).