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Original article

Regional fat distribution in adolescent and adult females with anorexia nervosa: A longitudinal study

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SUMMARY

Background & aims: No study has yet compared body fat distribution before and after weight restoration in adolescent and adult patients with anorexia nervosa (AN) treated according to the same protocol. The study was set up to measure body fat distribution before and after short-term weight restoration in adolescent and adult patients with AN treated according to the same protocol in a specialist inpatient unit.

Methods: We recruited 33 consecutive adolescent female patients with AN, and 33 controls matched by age and post-treatment BMI centile, as well as 33 adult female patients with AN, and 33 controls matched by age and post-treatment BMI. Dual-energy X-ray absorptiometry (DXA) was used to assess body composition before and after short-term weight restoration (BMI $\geq$ 18.5 kg/m^2).

Results: Compared with controls, both adolescents and adults with AN showed that a greater amount of fat was lost from the extremities than the trunk before weight restoration, and that there was a central adiposity phenotype after short-term weight restoration. There were no significant differences in body fat distribution between adolescents and adults with AN before or after short-term weight restoration.

Conclusions: Adolescent and adult females with AN have similar body fat distribution both before and after short-term weight restoration, and show a central adiposity phenotype after short-term weight restoration. The clinical implications of this finding are as yet unknown.

Clinical Trials Registry— Regional Fat Distribution in Adolescent Girls and Adults with Anorexia Nervosa (ISRCTN73572502).

1. Introduction

The major clinical features of the eating disorder anorexia nervosa (AN) are loss of weight and reduction of lean and fat masses [1–3]. Although weight restoration is considered the key strategy of treatment [4], recent studies suggest that change in body composition may also influence the outcome of this disorder. For example, two studies showed an association between poor long-term outcome and a lower total fat percentage after short-term weight restoration in females with AN [5,6], while other studies found that regional fat distribution abnormalities are related to lower physical fitness [7] and negative metabolic consequences [8]. If confirmed, these findings indicate that studying body composition before and after weight restoration in patients with AN, aside from being of interest to physiologists, could have some important clinical implications.

Both body composition and body fat distribution before and after weight restoration have been widely assessed in adult females with AN, and four main conclusions can be drawn, namely [9]: (i) before weight restoration patients have lower peripheral than central (trunk) body fat; (ii) there is an association between short-term weight restoration and a central adiposity phenotype [8,10,11]; (iii) there is an association between central fat distribution and increased insulin resistance [8], but this causes no change in psychological distress levels, nor does it have an adverse effect on

Abbreviations: DXA, dual-energy X-ray absorptiometry; CBT, cognitive behavioural therapy; BMI, body mass index; kg, kilogram; kcal, kilocalorie.

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the psychopathology of the eating disorder [11]; and (iv) there appears to be a normalization in the centralization of body fat during long-term maintenance of weight [12].

Fewer studies have been conducted in adolescents with AN, but available data [13] indicate that they tend to lose more central than peripheral fat before weight restoration [14–16], and do not develop a central adiposity phenotype during weight restoration [13]. However, due to a paucity of data, no definitive conclusions can yet be drawn about the differences between adolescents and adults with AN in terms of body composition before and after weight restoration. Indeed, the research conducted on adolescents with AN to date has suffered from various methodological limitations, such as cross sectional designs [16], small sample groups and subgroups [13,14], incomplete weight restoration [17], and lack of a control group [17]. Furthermore, studies have differed widely in terms of design and measurement timing [9]. Last, but by no means least, no studies have yet compared adolescent and adult populations with AN assessed and treated according to an identical protocol.

Hence, the aims of our study were: (i) to assess regional fat distribution in adolescent and adult females with AN and controls matched by age and post-treatment Body Mass Index (BMI) or BMI centile; (ii) to assess changes in these parameters after short-term weight restoration (i.e., BMI $\geq$ 18.5 kg/m^2); and (iii) to compare body composition of adolescent and adult females with AN treated using the same protocol and a uniform methodology (i.e., body composition assessment).

2. Methods

2.1. Participants

We recruited 33 consecutive adolescent females with AN, 33 adolescent controls matched by age and post-treatment BMI centiles, 33 adult females with AN, and 33 adult controls matched by age and post-treatment BMI. Patients were consecutive and voluntarily admitted to the Villa Garda Hospital eating disorder inpatient unit from 2012 to 2014. The following inclusion criteria were applied: (i) age, 13–19 years for adolescents [18] and $\geq$20 years for adults; (ii) baseline BMI $\leq$ 18.5 kg/m^2 in adults, or the corresponding BMI centile in adolescents; (iii) diagnosis of AN according to DSM-5 criteria [19]; (iv) patients whose eating disorder was deemed too severe to be managed in an outpatient programme, and those who had previously been unsuccessfully treated via a less intensive outpatient approach; and (v) post-treatment BMI $\geq$ 18.5 kg/m^2 in adults, or the corresponding BMI centile in adolescents. Patients with any of the following were excluded: schizophrenia, any other psychotic disorders, or current substance misuse. School and university listservs and advertisements were used to randomly recruit control subjects, who were all in good health and of stable weight, reporting regular menstruation. Exclusion criteria for the control group comprised: history of eating disorders, other significant psychiatric or medical conditions, and ongoing psychotropic treatment. Eligibility (inclusion and exclusion criteria) of both patients and controls was determined by means of interviews conducted by an expert in the field (RDG).

The Institutional Review Board of Villa Garda Hospital, Verona, reviewed and approved the study design. All participants (or their legal guardians if under 18) provided informed written consent for their personal information to be used anonymously.

2.2. Inpatient treatment protocol

More details regarding the inpatient treatment can be found elsewhere [20], but, in brief, it comprises an adapted version of CBT-E – an enhanced form of cognitive behavioural therapy designed for eating disorders [21]. Patients are treated for 13 weeks as inpatients, then 7 weeks in day hospital, making a total of 20 weeks. Patients attend both individual and group sessions in which all the main strategies and procedures of CBT-E are delivered. Patients also receive dietician-assisted eating in the first weeks of the programme, a strategy not foreseen in the original outpatient CBT-E. Assisted eating is continued until patients' BMI reaches $\geq$18.5 kg/m^2 in adults (the corresponding centile in adolescents). This is achieved by increasing the dietary energy content given to patients from 1500 to 2500 kcals in 500 kcal/week increments. Subsequently the dietary intake is adjusted so that a steady weight gain rate of 1–1.5 kg/week is achieved. When BMI reaches $\geq$ 19.0 in adults (the corresponding centile in adolescents), the daily calorie content is continually adjusted to maintain a body weight within a 2-kg range of this target. The diet was designed to conform to the Italian National Guidelines for Healthy Eating [22] and contain all the main food groups. Adult patients of BMI $\geq$ 15.0 and adolescents with the corresponding BMI centile of stable medical condition also attended 60-min physiotherapist-led exercise sessions twice per week. Exercises included calisthenics for posture and to help restore muscle strength and flexibility, and aerobics for cardiovascular fitness. No patients were prescribed any psychotropic medication, and regimens (i.e., selective serotonin reuptake inhibitors) that were ongoing at admission (by 12 patients in both groups) were gradually phased out in the first 2 weeks of the programme.

2.3. Measurements

Collection of data was performed during the first week of inpatient treatment, and in the final week of day hospital.

2.3.1. Body weight and height

A medical doctor affiliated to the study measured body weight and height by means of medical weighing scales and a stadiometer, respectively. Weighing was conducted before breakfast with participants without shoes and wearing only underwear. Adult BMI was calculated using the standard formula, i.e., body weight in kilograms divided by height in metres squared. Adolescent BMI centiles were calculated according to the growth charts provided by the Centre for Disease Control and Prevention (www.cdc.gov/growthcharts).

2.3.2. Body composition

A dual-energy x-ray absorptiometry (DXA) scanner and software (Prodigy Primo Lunar, A223040501, General Electric Company, Madison. WI 53707-7550, USA-EnCORE TM 2009 (v13.31) software) was used to measure total and regional fat, and lean and bone masses, as described previously [11]. In brief, scans were performed in the morning with no special preparation. Participants were scanned in their underwear and without any metallic jewellery, etc. Fat masses were measured in the arm, trunk, leg, android and gynoid regions. The whole body DXA was used to calculate percentage trunk and extremity fat, and the trunk-fat-to-extremity-fat ratio, via the following formulas:

1. Total fat mass (FM): total FM in kg.
2. Total FM percentage (%): total FM/total body weight $\times$ 100.
3. Total lean mass: total lean mass in kg.
4. Total lean mass percentage (%): total lean mass/total body weight $\times$ 100.
5. Trunk fat percentage = trunk fat/total body fat $\times$ 100.
6. Extremity fat percentage = (arms fat + legs fat)/total body fat $\times$ 100.