Journal of Aging Research & Clinical Practice©
Volume 2, Number 2, 2013

THE EFFECTS OF WEIGHT LOSS ON BODY COMPOSITION, MUSCLE STRENGTH AND PHYSICAL PERFORMANCE IN ELDERLY WOMEN WITH MORBID OBESITY

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Abstract: *Objectives:* The risk/benefits ratio of weight loss in morbid obese elderly is still debated. Our aim was to analyse the effects of an important weight loss on body composition, muscle strength and physical performance in a group of elderly morbid obese women as compared to younger female patients. *Design:* Intervention study. *Setting:* Bariatric Unit of the Padua University Hospital. *Participants:* 6 morbid obese women with age range 61-75 years were recruited for a 6 months weight loss treatment with the use of an intra-gastric balloon. Control group: 6 female morbid obese women with age range 20-60 years. *Intervention:* Elderly patients were treated with intra-gastric balloon and younger ones with laparoscopic adjustable gastric banding (LAGB). *Measurements:* Patients were evaluated before and after weight loss. The baseline evaluation was performed immediately before the procedure. The after weight loss evaluation was performed shortly after the removal of the intra-gastric balloon in the elderly group and after obtaining a similar level of weight loss in the control group. Body composition by densitometry (DEXA), muscle composition by peripheral quantitative computed tomography (CT), muscle strength by dynamometer and physical performance by the Short Physical Performance Battery (SPPB) test were determined. *Results:* No significant differences between the two groups were found before treatment. A 14% weight loss was obtained in both groups and weight loss was associated with a loss of both fat mass and fat free mass. Peripheral quantitative CT showed no significant changes in muscle area or muscle density. A reduction in muscle strength, but a mild improvement in functional tests was found in both groups. *Conclusion:* Weight loss in morbid obese elderly women was associated with a significant reduction in fat free mass and muscle strength, but with a mild improvement in physical performance. These modifications were similar to those obtained in younger subjects.

Key words: Obesity, voluntary weight loss, fat free mass, muscle strength, physical performance.

Introduction

In western countries, the prevalence of obesity is increasing in the elderly as well as in general adult population. In a recent survey of the incidence of overweight and obesity in the US population, 42.5% of women and 31.9% of men between 60-69 years old were obese. In the same study, 31% of women and 29% of men between 70-79 years old were obese (1). A clear association has been demonstrated between obesity and disability in the geriatric age group (2-7). However, the effects of obesity on life expectancy and premature mortality are less firmly established in the elderly than in middle aged patients, with some studies showing an increased mortality at increasing BMI values in the elderly population (8-10) and other studies demonstrating that a higher BMI value may actually decrease mortality risk (11, 12).

The open debate about the relationship between excess body weight and mortality in the elderly population probably hampered or delayed the development of specific therapeutic strategies and guidelines for obesity at older ages and very few studies indeed specifically evaluated obesity treatment in elderly (13, 14). Furthermore, even basic therapeutic approach is controversial, because the known association between obesity and disability is counterbalanced by the fear that the loss of lean body mass that usually accompanied voluntary weight loss in obese patients could accelerate the normal loss of muscle mass related to aging and create a situation of sarcopenia, another known risk factors of disability in the elderly (15).

Very few interventional studies analyze directly the effects of voluntary weight loss on muscle mass, muscular strength and physical performance in elderly obese patients (16). In this study, we evaluated the effect

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Received January 31, 2013
Accepted for publication March 6, 2013

of an important weight loss, obtained with the temporary use of an intra-gastric balloon in a small group of old morbid obese women, on body composition, muscular strength and physical performance, and we compared the same parameters in a group of younger women obtaining the same level of body weight reduction with a restrictive bariatric procedure.

Patients and methods

Patients selection and design of the study

Between June 2007 and May 2011, six female morbid obese patients with age ranging from 61 to 75 years were recruited among the patients attending the outpatients obesity services of the Bariatric Unit of the Padua University Hospital for a 6 months weight loss treatment with the use of an intra-gastric balloon. Patients were enrolled applying to the elderly the standardised international inclusion criteria for bariatric surgery in adults (17): only patients with body mass index (BMI) higher than 40 kg/m^2 or less severely obese patients (BMI between 35 and 40 kg/m^2) with at least one high-risk comorbid conditions or physical problems interfering with lifestyle could be considered. Repeated failures of medical obesity treatments were mandatory. Before the procedure, all patients were evaluated by a multidisciplinary (geriatric and surgical) team, were extensively screened to exclude endocrine disorders, severe psychiatric disorders, neoplastic diseases, heart failure class NYHA III-IV, and received detailed information on the benefits and risks of treatment. None of the subjects were treated with drugs known to affect the variables measured in the study. As a control group, six female morbid obese patients with age ranging from 20 to 60 years were recruited with the use of the same inclusion criteria (17) and screening procedures among the patients being in the waiting list for laparoscopic adjustable gastric banding (LAGB) at our institution. All patients gave their written informed consent to the experimental and clinical procedures. The ethical committee at our institution approved the study protocol.

Patients both in the elderly and in the control group were evaluated before and after weight loss. The baseline evaluation was performed immediately before the procedure in both groups. None of the patients had shown weight changes greater than 2 kg during the 3 months before the baseline evaluation. The after weight loss evaluation was performed shortly after the removal of the intra-gastric balloon (mean follow-up time 7±1 months, range 6-8 months) in the elderly group and after obtaining a similar level of weight loss in the control group (mean follow-up time 12±3 months, range 8-14 months). All evaluations were performed in the morning, in a 12 to 14-h post absorptive state, on an outpatient basis. In the same morning, anthropometry, total body composition, muscle strength, muscle composition, and physical performance were determined.

Anthropometric measurements

All anthropometric measurements were made with the subjects wearing only light clothes without shoes. Height was measured to the nearest 0.01 m using a wall-mounted stadiometer. Body weight was determined to the nearest 0.05 kg using a calibrated balance beam scale. BMI was calculated as weight (kg) divided by the height-squared (m^2). Body circumferences were measured with a flexible tape, with the subject in the upright position at the end of a gentle expiration. Waist circumference was measured midway between the lower rib margin and the superior anterior iliac spine (18). Hip circumference was measured as the widest circumference over the great trochanters (18). Arm circumference was measured in both arms midway between the acromion process and the elbow (18). Thigh circumference was measure in both thighs midway between the inguinal fold and the knee (18). Leg circumference was measured in both legs as the widest circumference between the knee and the ankle (18). Finally, sagittal abdominal diameter (SAD), a further index of visceral fat accumulation, was determined at the highest point of the abdominal surface with the subject in the supine position and during normal breathing by mean of a specifically made instrument (19).

Body composition

Total and segmental (arms, trunk and legs) body composition was assessed by Dual Energy X-Ray Absorptiometry (DEXA) with fan-beam technology (Hologic QDR 4500 W). Fat mass (FM) and fat-free mass (FFM) were determined. A standardized procedure for patient positioning and utilization of the QDR software was used. The DEXA scans were analysed with the Hologic software for body composition evaluation, version 8.21. The method had a good reproducibility (coefficient of variation) for total body fat mass (2-3%), total body fat-free mass, total body lean soft tissue (1-2%), arm lean soft tissue (3-4%), and leg lean soft tissue (1-2%) (20-22) and it is sensitive in assessing minimal changes in body composition (23).

Muscular strength tests

Handgrip strength and knee extensor isometric and isotonic strength were tested on the dominant side using the Dynatronic 100 ergometer (Nuova Meccanica Pastorelli, Gallarate, VA, Italy) and recorded in kg. For each 3 measurements, patients were asked to perform their maximum voluntary contraction. Three to five seconds after reaching their maximum effort, they were asked to stop the contraction. Each measurement was repeated 3 times and patients rested for 2–3 min between trials. The mean peak torque emerging from three trials was calculated and used for the analysis. Coefficients of variation for double determinations in our experience were 3.3% for handgrip and 7.7% for knee extension (24).

Muscle composition

Muscle composition was evaluated by using a peripheral quantitative computer tomography (pQCT), performed at left distal radius. A XCT 3000 instrument (Stratec Medizintechnik GmbH, Pforzheim, Germany) was used. pQCT analysis provides information about arm composition, including data on fat mass (as expressed by fat tissue transversal area), muscle mass (as expressed by muscle tissue transversal area), and muscle density (an expression of fat content in skeletal muscle). In a recent study, our group performed 10 consecutive measurements in the same voluntary and demonstrated a good reproducibility, with coefficients of variation of 3.3% for muscle area and 1.27% for muscle density (25). Muscle composition was measured only in the arm and not in the leg because of the impossibility for most of the elderly obese subjects to enter the leg in the pQCT gate and to maintain a fixed leg position during data acquisition.

Physical performance tests

Physical performance was analyzed with the use of the Short Physical Performance Battery (SPPB) (26). The SPBB consists of three components: 4-meter walking speed, repeated chair stands, and standing balance in progressively more challenging positions. Walking speed was defined as the better (time) of 2 walks over a 4-meter course at usual pace. For the chair stand test, participants were asked to rise 5 times from a seated position as quickly as possible with their hands folded across the chest, and performance was expressed as the total time taken to complete the test. For the standing balance tests, participants were asked to stand in 3 progressively more difficult positions for 10 s each: with feet side by side, and in semi-tandem and full tandem positions. Each test was scored from 0 (inability to complete the test) to 4 (highest level of performance). The scores from all three tests were summarized in a total score of 0 to 12, with higher scores reflecting better physical performance.

Procedures

An intra-gastric liquid-filled balloon system (BIB, Allergan, Irvine, CA, USA) was used in all the patients in the elderly group. The intra-gastric balloon is an inflatable smooth elastic silicone balloon that can be filled with 500 to 700 mL of saline solution. Both the intra-gastric placement and the removal were performed by endoscopy after sedation. After sedation, the patient was placed in a lateral decubitus position and the BIB was inserted into the stomach and inflated under direct endoscopic vision. After 6 months, the BIB was removed by endoscopy with a dedicated instrument after complete deflation. LAGB surgery (Swedish Adjustable Gastric Band, Ethicon Endosurgery, Johnson and Johnson, New Brunswick, NJ, USA) was performed in the control groups. Briefly, a retro-gastric tunnel is created and the band is applied around the stomach, just below the cardia, creating a small upper pouch and a narrow stoma. The band forms a circular ring with a 360° inflatable section. A tube connects the inflatable section of the band to a self-sealing subcutaneous reservoir containing sterile saline. The subcutaneous reservoir is placed outside the abdominal cavity and it can be used to adjust the band diameter to the patient's needs postoperatively, by the simple addition or removal of a few ml of sterile saline. Both procedures have been performed in a inpatients setting with a median hospital stay of three days.

After both procedures, patients were instructed to follow a modified liquid diet for 4 weeks. Thereafter, they graduated to a solid diet, with a list of rules specifically developed for patients having gastric restriction. Both diets were designed to provide 24-h energy intake of 2.5 MJ (40% proteins, 25% fats, and 35% carbohydrates). Physical activity was encouraged.

Statistical analysis

Results are expressed as means ± standard deviation. Differences between elderly and control patients in the baseline values were tested by unpaired Student's t-test. Values before and after weight loss were compared within groups with the use of paired Student's t-test. In all statistical analysis, a P value <0.05 was considered to indicate statistical significance. Statistical analysis was performed by using the Statistical Package for Social Sciences, version 18.0 (SPSS, Chicago, IL).

Results

Mean age at enrolment was 65.5±3.7 years (range: 61-71 years) in the elderly group and 39.0±12.6 years (range: 22-59 years) in the young group ($p<0.001$). The comorbidities burden was higher in the elderly (2/6 patients with type 2 diabetes, 6/6 with hypertension, 2/6 with sleep apnea syndrome, and 5/6 patients with limiting osteoarthritis) than in the young group (1/6 patients with type 2 diabetes, 2/6 with hypertension, 1/6 with sleep apnea syndrome and 2/6 patients with limiting osteoarthritis). Anthropometric characteristics before and after weight loss in elderly and young patients are reported in Table 1. No significant differences were found between the groups in any of the baseline values.

A substantial and similar level of weight loss was obtained in both groups (-13.9±6.7% of the baseline body weight in the elderly group; -14.5±9.6% in the control group). Weight loss was accompanied in both groups by significant reductions in anthropometric indexes of visceral fat accumulation (waist circumference and SAD). A significant reduction of arm and thigh circumferences, a possible marker of muscle mass loss, was observed in the elderly, but not in the control group.

Table 1

Anthropometric characteristics before and after weight loss in 6 morbid obese elderly and in 6 morbid obese control young female patients

	ELDERLY		CONTROL	
	Before	After	Before	After
Weight, kg	105.2±9.5	91.0±15.0**	109.9±15.4	93.8±14.9**
BMI, kg/m²	41.8±2.9	36.0±4.7**	41.0±5.3	35.0±4.1**
SAD, cm	29.2±2.6	26.4±4.5*	28.4±3.1	24.0±3.6**
Circumferences				
Waist, cm	127.2±13.6	111.1±15.9**	120.8±7.1	98.2±15.4**
Hip, cm	127.5±11.5	120.0±12.3*	134.0±10.8	118.0±17.0*
Right arm, cm	37.2±5.7	32.7±5.5**	37.0±3.0	34.2±3.9
Left arm, cm	37.7±6.2	33.2±5.9**	36.2±3.8	34.3±4.4
Right thigh, cm	60.0±3.9	53.8±4.6**	63.7±7.0	61.7±9.1
Left thigh, cm	60.1±4.4	53.5±4.5***	63.3±7.4	61.7±10.6
Right leg, cm	41.3±2.0	39.8±2.2**	43.2±5.1	39.3±4.3**
Left leg, cm	41.3±1.7	39.8±2.3*	42.5±5.0	39.7±4.8*

Data are expressed as mean ± SD. Values before and after weight loss were compared within groups with the use of paired Student's t-test. * = p<0.05; ** = p<0.01; *** = p<0.001. BMI: Body mass index. SAD: Sagittal abdominal diameter

Total and segmental (arms, trunk and legs) body composition, as evaluated by DEXA, and arm composition, as evaluated by pqCT, before and after weight loss in elderly and young patients are reported in Table 2. No significant differences were found between the groups in the baseline body and arm composition values. In both groups, a substantial a significant reduction of total fat mass (-22.4±10.0% in the elderly; -17.7±15.0% in the controls), but also a significant reduction of fat free mass (-4.7±3.9% in the elderly; -10.0±6.6% in the controls) were observed. The analysis of segmental body composition showed that the loss of fat free mass was in both groups more evident at the appendicular level (-11.9±7.0% at the arms and -7.4±4.1% at the legs in the elderly; -11.5±10.6% at the arms and -12.8±6.6% at the legs in the controls) than at the trunk level (-1.2±4.9% in the elderly; -6.5±8.5% in the controls). Analysis of arm composition data obtained by pqCT did not demonstrate any significant change of muscle area or muscle density in neither group. A significant reduction of fat area and fat/muscle area ratio was observed in the elderly.

Table 2

Total and segmental (arms, trunk and legs) body composition, as evaluated by DEXA, and arm composition, as evaluated by pqCT, before and after weight loss in 6 morbid obese elderly and in 6 morbid obese control young female patients

	ELDERLY		CONTROL	
	Before	After	Before	After
DEXA Fat Mass				
Total, kg	47.3±4.8	37.0±8.1**	52.4±9.5	42.8±9.6*
Arms, kg	6.8±0.8	4.9±1.2**	7.9±4.3	5.5±1.3
Legs, kg	15.0±2.8	11.5±2.2**	19.1±5.1	16.3±4.5*
Trunk, kg	24.5±3.7	19.6±5.5**	24.6±5.5	19.9±6.5*
DEXA Fat Free Mass				
Total, kg	55.2±5.7	52.5±5.4*	57.3±7.0	51.6±6.8*
Arms, kg	5.8±0.6	5.1±0.6*	5.9±1.4	5.0±0.8
Legs, kg	17.7±1.7	16.4±1.7**	19.9±3.9	17.2±2.5*
Trunk, kg	27.6±3.5	27.2±3.1	27.7±3.6	25.9±4.0
Arm pqCT				
Muscle area, cm²	32.8±4.9	31.8±14.9	32.8±5.2	30.6±4.3
Fat area, cm²	29.2±11.4	22.7±7.8*	32.1±7.4	27.4±6.6
Fat/Muscle Area Ratio, %	93.7±46.6	74.8±33.8*	100.3±30.3	90.1±23.5
Muscle density, mg/cm3	73.1±4.3	73.0±2.8	73.9±2.7	74.6±3.0

Data are expressed as mean ± SD. Values before and after weight loss were compared within groups with the use of paired Student's t-test. * = p<0.05; ** = p<0.01. DEXA: dual energy x-ray absorptiometry. pqCT: peripheral quantitative computed tomography.

Table 3

Muscular strength and physical performance before and after weight loss in 6 morbid obese elderly and in 6 morbid obese control young female patients

	ELDERLY		CONTROL	
	Before	After	Before	After
Muscle strength tests				
Handgrip, kg	20.4±6.1	17.7±6.0*	19.5±6.1	18.6±5.6*
Isometric leg extension, kg	25.2±9.4	21.6±8.5	32.8±24.0	28.6±12.5
Isotonic leg extension, kg	14.8±7.0	15.2±9.4	15.2±10.9	19.2±6.5
Physical Perfomance tests				
4-m walking, sec	5.1±2.1	4.4±0.7	4.1±1.2	3.2±0.7
Chair stand, sec	13.3±3.9	11.3±3.2*	10.9±7.2	9.2±2.3
4-m walking, score	2.0±0.9	2.3±0.5	2.3±0.8	3.3±0.8*
Chair stand, score	2.8±1.2	2.7±1.6	3.5±1.2	3.8±0.4
Balance test, score	3.8±0.4	4.0±0.0	3.8±0.4	3.8±0.4
Total SPPB, score	8.7±2.0	9.0±2.0	9.7±2.0	11.0±1.5

Data are expressed as mean ± SD. Values before and after weight loss were compared within groups with the use of paired Student's t-test. * = p<0.05. SPPB: Short Physical Performance Battery.

Muscular strength and physical performance data before and after weight loss in elderly and young patients are reported in Table 3. No significant differences were found between the groups in the baseline values. In both groups a significant reduction of muscular strength in the upper limbs (handgrip test) was observed (-13.7±9.4% in the elderly; -4.4±1.4% in the controls; p<0.05), without significant changes of muscular strength in the lower limbs (leg extension test). The analysis of physical performance test results showed a mild not significant improvement of total performance score in both groups (+8.5±31.9% in the elderly; +18.4±33.5% in the controls). No significant worsening in any of the single performance test was observed in neither of the groups. The time needed to rise five times from a chair was significantly improved in the elderly.

Discussion

The treatment of morbid obesity in geriatric patients is still controversial. While the association between obesity and disability is well known, it is also known that the progressive loss of lean body mass in the elderly is associated with disability. Therefore, it is possible that a significant weight loss in elderly patients with severe obesity may cause a substantial loss of muscle mass and increase, rather than decrease, the risk of loss of functional autonomy. As the prevalence of morbid obesity increases in older subjects (1), how should we behave towards morbid obesity in the elderly?

Very few studies have been published on the treatment of obesity in geriatric patients, and the type of therapeutic approach remains controversial. Moderate weight loss therapy in the elderly, obtained with a combination of moderate caloric restriction and physical exercise, may control medical complications related with obesity, improving physical function and the quality of life (27). Regular physical exercise in older obese patients following a diet may reduce the loss in muscle mass and may improve muscle strength (28). Finally, in a recent study, which evaluated the independent and combined effects of weight loss and exercise in 107 adults who were 65 years of age or older and obese (BMI≥30 kg/m^2), it has been demonstrated that in the group treated with diet and physical exercise there was a major improvement in physical performance (16). However, physical exercise may be very difficult to be performed in elderly severely obese patients and the level of weight loss needed to obtain a clinically relevant benefit may be more demanding in morbid obesity. To our knowledge, no previous studies have analyzed specifically the changes of body composition, muscle strength and physical performance in elderly obese patients with morbid obesity treated with a sustained caloric restriction.

In this study we analyzed the effects of an important weight loss, obtained with the use of intra-gastric balloon, in a small group of morbid obese elderly women and we compared the effects with those obtained in a group of young women treated with adjustable gastric banding. Body composition, muscle strength and physical performance have been analyzed with standard and accurate methodologies. The two groups did not differ in weight and body composition at the beginning of the therapy and they obtained a similar 14% of baseline body weight loss. In both groups, weight loss was accompanied by a significant 20% reduction of fat mass, but also a significant 5-10% loss of fat free mass, mainly located at the appendicular level. Loss of muscle mass did not seems to be higher in the elderly than in the young patients and it was associated in both groups with a reduction of muscle strength, particularly evident at the handgrip test in elderly subjects. Despite loss of muscle mass and strength, no significant worsening in the physical performance was observed in both groups and the time needed to rise five times from a chair was significantly improved in the elderly. Changes of physical performance after weight loss in morbid obese patients, and in particular changes in the ability to stand up, may be the result of a balance between the benefits derived by the reduction of fat mass and the weight that needs to be pull up and the negative effects derived by the loss of muscle mass and strength. The fact that in the elderly group there was an improvement in the chair stand test seems to suggest a positive net balance, at least in the short terms. However, the ability to re-gain muscle differs in elderly versus young persons and therefore we cannot exclude the possibility that the loss of muscle mass observed in the elderly group in this study may be maintained over time and exerts detrimental effect later in life.

Major limitation of our study was the low number of subjects that may limits the power of the study and the significance of the results. Enrollment of morbid obese elderly patients without any contraindications to bariatric surgery, a reasonable procedural risk and a willingness to be treated with intra-gastric balloon was difficult in our experience. At the end, we enrolled a small number of elderly women with a good functional status and a baseline body composition not significantly different from the control group. This selection bias limits the applicability of our results to elderly subjects with a less brilliant baseline performance status and muscle mass. Furthermore, a large age variation within the groups and a very different comorbidity burden were present and both these factors may also significantly affect the results. Moreover, two different treatment strategies (intra-gastric balloon in the elderly and laparoscopic gastric banding in the young group) have been used. The decision to treat elderly morbid obese patients with temporary endoscopic gastric restriction and not with restrictive permanent bariatric surgery as for the younger control group has been made for reasons of safety. Standardised international inclusion criteria for bariatric surgery do not apply to patients over 60 years of age (17) and the use of bariatric surgery in elderly patients is still debated (27). However, the use of two different intervention strategies remains a limitation. Finally, we decided to examine the subjects after similar levels of weight loss. In our setting, weight loss was more rapid in the elderly subjects treated with the intra-gastric balloon than in the younger patients treated with LAGB and therefore the follow-up time was longer in the young then in the elderly group. No tests were performed during the intervention to monitor the gradual change in muscle strength and physical performance and therefore we have no precise information about the effect of time on these parameters. The difference in weight loss rate may further limit the comparability of the changes observed in the two groups. Indeed, the proportion of weight lost represented by FFM tends to increase as the rate of weight loss increases (29). However, it should be noted that a more rapid weight loss should theoretically disadvantage elderly patients in terms of muscle mass loss.

In conclusion, our preliminary study indicates that in elderly patients with severe obesity and a good functional status, an important weight loss, here obtained with the temporary use of an intra-gastric balloon, may be followed by mild improvements in physical performance.

Disclosure of potential conflicts of interest: Luca Busetto declares to have received support for travel to meetings and payment for lectures by Allergan. Fabio De Stefano declares to have received support for travel to meetings by Allergan. Giulia Pintore, Francesco Bolzetta, Mariangela Marangon, Giuseppe Sergi and Enzo Manzato declare no conflicts of interest.

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