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Weight Loss Composition: The Effects of Exercise following Obesity Surgery as Measured by Bioelectrical Impedance Analysis

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Background: Sudden weight loss following bariatric operations for morbid obesity, such as the duodenal switch (DS), can result in a concurrent decrease in lean body mass. Several methods for tracking body composition, such as bioelectrical impedance analysis (BIA), are available to monitor these changes. One method to offset the negative effects of sudden weight loss on body mass composition may be exercise.

Methods: 100 patients who had undergone the DS operation for morbid obesity were classified as *exercisers* and *non-exercisers* based on self-reporting. Their body mass compositions were measured using BIA preoperatively and at 0.75, 1.5, 3, 6, 9, 12, and 18 months postoperatively.

Results: At no study interval did postoperative percent changes in weight loss differ between the exercise and non-exercise groups. At 18 months postoperatively, the exercise group showed a 28% higher loss of fat mass and an 8% higher gain in lean body mass than the non-exercise group.

Conclusion: Exercise positively influences body mass composition following the DS. BIA can be successfully employed to monitor changes, diagnose deficiencies, and formulate treatment recommendations.

Key words: Morbid obesity, bariatric surgery, duodenal switch, body mass composition, bioelectrical impedance analysis, BIA

Abbreviations: Lean body mass – LBM; Fat mass – FM; Total body water – TBW

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Introduction

Surgical treatments for morbid obesity, such as the duodenal switch (DS), Roux-en-Y gastric bypass, and the gastric banding, are effective weight loss options, and have become increasingly popular concurrent with the United States' "obesity epidemic". Research by the Center for Disease Control and the National Center for Health Statistics indicates that 64.5% of Americans (127 million) are overweight, defined as having a body mass index (BMI) ≥25 kg/m^2; 30.5% (60 million) are obese, defined as a BMI ≥30 kg/m^2; and 4.7% (9 million) are morbidly obese, defined as a BMI ≥40 kg/m^2.[1] In accordance with National Institutes of Health (NIH) guidelines, those eligible for bariatric surgery have a BMI ≥40 kg/m^2 or a BMI ≥35 kg/m^2 with significant co-morbidities such as hypertension, diabetes, or sleep apnea.[2]

The DS combines moderate restriction with moderate malabsorption, as shown in Figure 1. It produces low perioperative and long-term morbidity and mortality rates, and has resulted in an average weight loss of 91% at 2 years[3] and of 73% at 10 years.[4]

Total body mass is composed of three compartments: lean body mass (LBM), body fat (BF), and total body water (TBW). Rapid and profound weight loss, such as that produced by the DS, is aimed at decreasing total body mass and fat mass (FM). Yet, it can also result in a loss of LBM.[5,6] The

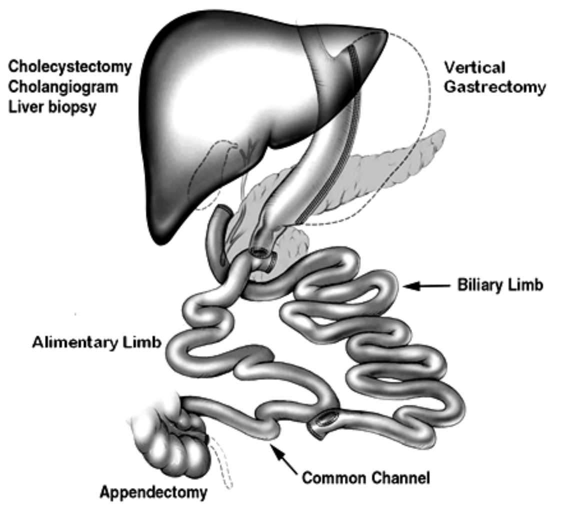

Figure 1. The operation, biliopancreatic diversion with duodenal switch (DS).

restrictive element of the DS operation decreases the volume of nutrients consumed, including the protein essential to building and maintaining LBM. Likewise, the malabsorptive element may decrease the ratio of total protein consumed to total protein absorbed. While previous study has demonstrated that the average patient's total protein and albumin levels remain within the normal range of 6.0-8.3 g/dl and 3.5-5.0 g/dl respectively,[7] it is important to maintain or increase postoperative LBM percentages.

Body impedance analysis (BIA) is based on the principle that different tissue types conduct and resist electrical currents at different frequencies.[8] Single-frequency or multi-frequency analyzers alike apply low-level alternating current to the body to measure the tissues' impedance. This impedance is then split into *tissue resistance*, which is correlated to fluid volume, and *reactance*, which is the reciprocal of the capacitance of cell membranes, tissue interfaces, and nonionic tissues.[9,10] Electrical BIA has been shown to be accurate when compared with the "gold standard" of the body immersion method, which is not practical for clinical use.[11] Published opinions of the effectiveness of BIA when judging obese versus non-obese subjects differ, with some studies showing that the accuracy of measuring TBW is dependent upon TBW levels, which differs between obese and non-obese subjects.[12] For the purpose of this investigation, possible differences in accuracy would not alter the validity of comparing our exercise versus non-exercise groups, as both rank in the obese status preoperatively. However, study interval results comparing body composition when subjects are obese versus when subjects enter a non-obese state, may contain a slight prediction error. BIA measurement can also be altered by patient dehydration.

Methods

Two sets of 50 patients, each of whom had undergone the DS operation between 1998 and 2003, were selected based on data availability and were designated as *exercisers* (Group E) or *non-exercisers* (Group NE) based on self-reporting from the first 6 postoperative months. In total, there were 14 males and 86 females, with an age range of 27-63 years. Group E was defined as those exercising in any form for at least 30 minutes per session three or more times a week during the first 6 months, while Group NE was defined as those exercising less than three times a week in the first 6 months.

Using a BIA tool produced by the Tanita Corporation (Body Composition Analyzer, Nutritional Science & Technology, Lake Worth, FL, USA), total body mass and body mass composition, including LBM and FM, were measured preoperatively and at 0.75, 1.5, 3, 6, 9, 12, and 18 months postoperatively. Height was measured and all patients were analyzed in bare feet. Subjects were not aware at the time of either forming postoperative exercise habits or during body composition measurement that they would be used as study subjects. Means for each group and for each study interval were calculated. Weight, FM, and LBM were considered as a percent change from preoperative values. Mean percent changes between Group E and Group NE were compared using Welch's methodology for a General Linear Model (GLM) for unbalanced designs, based on an Analysis of Variance *t*-test (ANOVA). We employed a standard GLM when the data met the assumption of homogeneity of variance. Because of the limited sample size, no outliers were cut. The model was not adjusted for differences in diet or nutritional markers such as total protein and albumin. The SAS program (The SAS Institute, Cary, NC, USA) was utilized for statistical analysis.

Results

As shown in Figure 2, total body mass percent changes from the preoperative period for Group NE measured 91%, 87%, 80%, 71%, 63%, 58% and 54%, while mean percent changes for Group E measured 91%, 87%, 80%, 69%, 62%, 57% and 51%, at postoperative months 0.75, 1.5, 3, 6, 9, 12 and 18, respectively. Differences between the means were not significant (*P*>0.05). As Figure 3 illustrates, mean FM percent change for Group NE was 95%, 84%, 68%, 52%, 40%, 33% and 28%, while those for Group E was 81%, 71%, 58%, 44%, 33%, 26% and 20%, with differences between the means stabilizing around month 6 at 7-8% (all *P*<0.05). Percent change in LBM for Group NE averaged 87%, 91%, 96%, 96%, 91%, 89% and 86% in the same time intervals and for Group E 111%, 116%, 121%, 116%, 113%, 115% and 114%, with all means significantly different from each other (Figure 4).

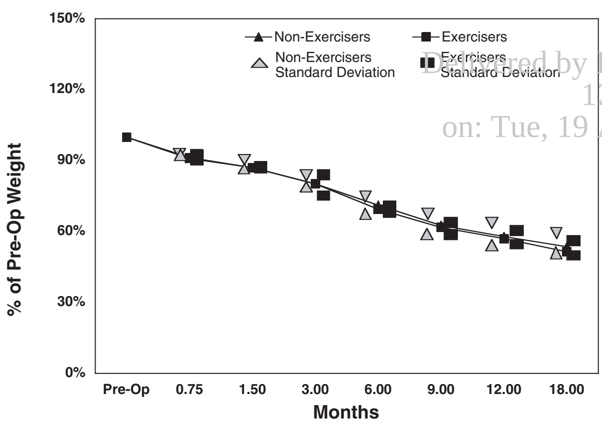

Figure 2. Percent change in total body mass over time.

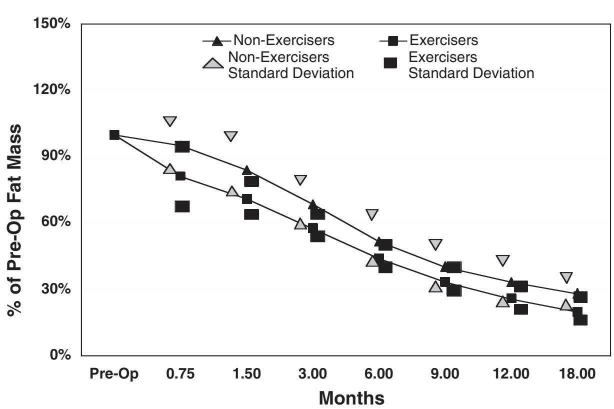

Figure 3. Percent change in fat mass over time.

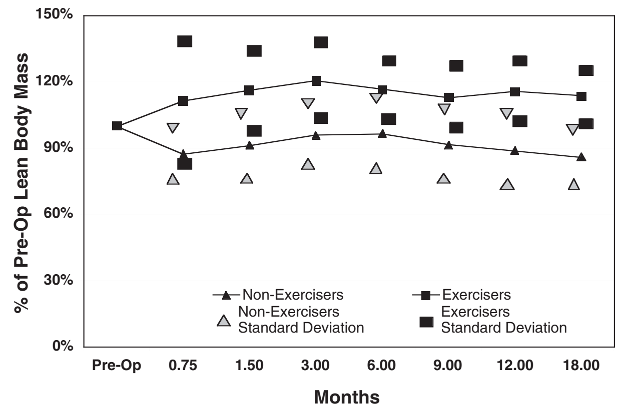

Figure 4. Percent change in lean body mass over time.

Case Studies

BD, a 56-year-old male, first presented with a total body mass of 206.8 kg and a BMI of 60. A former professional athlete, he established a daily athletic routine of 1-2 hours per day after 8 postoperative weeks that included bicycling and walking on a treadmill. After 10 postoperative weeks, he added weight training. Currently, the patient is more than 5 years postoperative and has decreased the duration of his workouts and excluded strength-training, entering a "maintenance mode". His % weight change vs his preoperative weight was 64% at 6 months, 52% at 18 months, and has currently has stabilized at 52%. His % change from preoperative FM decreased to 44% at 6 months, 8% at 18 months, and has remained in the 13% range 5 years following surgery. His LBM climbed to 124% over the preoperative values at 6 months, to peak at 131% at 18 months, and then decreased slightly after 5 years to 127%.

DL, a 63-year-old female, first presented with a total body mass of 125 kg and a BMI of 46. She introduced daily half-hour walks after 4 postoperative weeks, strength training three times per week, and salsa dancing twice a week. Her weight decreased against the preoperative period to 86% at 6 months and 49% at 18 months. Her % FM over her preoperative measurement decreased to 51% at 6 months and 42% at 18 months. Her % LBM versus the preoperative LBM increased to 103% at 6 months and 108% at 18 months.

Discussion

Exercise positively affects body composition following sudden weight loss, as induced by bariatric operations for morbid obesity such as the duodenal switch. Although exercise does not alter the percent of total body mass lost following surgery, it does alter body composition by increasing LBM and decreasing FM. The first 6 months following surgery are critical for building lean body mass and result in these changes in body composition stabilizing and persisting. Long-term results are needed to assess whether this effect endures and whether exercise will influence weight loss maintenance beyond the first 2 postoperative years.

Bioelectrical impedance analysis is essential in our practice. Monitoring body composition motivates patients to exercise, and can aid the practitioner in diagnosing conditions such as ketosis and dehydration. Other methods of measuring body composition, such as total body immersion, are expensive, time-consuming and impractical for clinical use on a large number of patients requiring repeated measurement. As earlier research has demonstrated, BIA is affordable and reimbursable, and the time and effort invested by patient and practitioner return substantial value for both retrospective analysis and prospective and concurrent clinical management.

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