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ORIGINAL CONTRIBUTIONS

Changes in Physical Activities and Body Composition after Roux-Y Gastric Bypass Surgery

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Abstract

Purpose Given the importance of physical activities for health outcomes, it is still unclear whether bariatric surgery per se and the standard care after surgery would result in an increase of physical activity level. This study aimed to determine physical activities preoperatively and at 6 and 12 months postoperatively among female patients who underwent bariatric surgery, and to investigate its relationship with body composition changes.

Material and Methods Thirty-four women who had Roux-Y gastric bypass (RYGB) surgery completed the study. Physical activity was measured objectively for 7 consecutive days by using an ActiGraph GT3X+ accelerometer. Body composition was estimated by using multifrequency bioimpedance analysis.

Results The percentage of time spent in moderate-to-vigorous physical activity (MVPA) changed significantly from preoperatively to 6 months postoperatively; however, no difference was observed at 12 months. No significant changes were detected for other physical activity variables. Multivariable regression analysis suggested that the percentage of time spent in sedentary activity was associated with fat-free mass loss at 6 months ($\beta = -0.323$; 95% CI = -0.649 to 0.003) and 12 months ($\beta = -0.510$; 95% CI = -0.867 to -0.154) postoperatively.

Conclusion The overall MVPA increased at 6 months post-RYGB surgery; however, this change was not maintained at 12 months. Despite the considerable body mass loss postoperatively, most of the subjects were classified as being physically inactive and did not change their sedentary behavior. These findings indicate that female patients undergoing bariatric surgery should be encouraged to increase their physical activity level.

Keywords Physical inactivity · Sedentary behavior · Accelerometer · Fat-free mass · Fat mass · Bariatric surgery

Introduction

Physical inactivity is a term used to indicate failure to achieve the recommended minimum moderate-to-vigorous physical activity (MVPA) for developing and maintaining physical fitness and health [1, 2]. In this context, important research associations have recommended the practice of achieving a minimum of 150 min/week of MVPA accumulated in bouts of ≥ 10 min [3–6].

Another important variable is sedentary behavior, which is characterized as any activity during waking hours that results in low energy expenditure (< 1.5 metabolic equivalents [METs]) while in a sitting or reclining posture [1]. In general, physical inactivity and sedentary behavior are independent risk factors that may be associated with the development of noncommunicable chronic diseases [2] and should be monitored in clinical practice.

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Concerning patients undergoing bariatric surgery, a meta-analysis study reported an association between the increase of physical activity level and body mass loss after the surgery [7, 8]. Additionally, bariatric patients who became more physically active after the surgery showed improved quality of life parameters [9], mental health, and depressive symptoms [10].

Although the available evidence indicates a positive relationship between physical activity level and body mass loss after bariatric surgery, an important limitation of these related studies [7–10] was the use of self-report questionnaires to assess physical activitiess. In this context, Bond et al. [11] compared the changes in MVPA intensity between before and 6 months after the operation, by using a self-report questionnaire (Paffenbarger Physical Activity Questionnaire) and a triaxial accelerometer. The results obtained by the questionnaire showed a fivefold increase in MVPA; however, no difference was detected with the accelerometer [11]. These contradictory results indicate that bariatric patients can overreport physical activities, and that results from studies that use self-report questionnaires should be interpreted with caution.

Given the importance of physical activity level for health outcomes and surgical success, more valid methods for objectively measuring the intensity of physical activities are necessary. A triaxial accelerometer measures body movement acceleration in three axes (vertical, horizontal right to left, and horizontal front to back planes) and allows quantifying the frequency, duration, and intensity of physical activities. This direct assessment provides a more accurate and reliable tool for monitoring physical activities [12].

Although the importance of physical activity in reducing the risk factors for chronic diseases and improving physical and psychological conditions has been previously established [2, 5], obese subjects have reported several barriers (internal and external) to performing regular physical activity and becoming physically active owing to their excess body mass [13].

The main aim of this study was to verify if bariatric surgery per se and the standard care after surgery would result in a decrease of sedentary behavior and increase of MVPA. Additionally, this study aimed to verify if any physical activity variable could be better associated with the attenuation of fat-free mass loss and an increase of body fat loss in the postoperative period. Therefore, in this study, we determined the physical activities among female bariatric patients preoperatively and postoperatively (6 and 12 months) and investigated its relationship with body composition changes.

Methods

Subjects

Forty-two female candidates for bariatric surgery volunteered to participate in this study. The inclusion criteria were as follows: (a) age between 20 and 40 years and (b) body mass index (BMI) $\geq$40 kg/m^2. The noninclusion criteria were as follows: (a) presence of joint and muscular limitations, (b) diseases that affect functional capacity, or (c) genetic syndromes associated with obesity. All patients were recruited from the same bariatric center in Piracicaba (São Paulo), Brazil (from January through February 2014), and data collection was completed in November 2015. All subjects underwent Roux-Y gastric bypass (RYGB) surgery performed by the same medical staff (from August through November 2014). This study was approved by the local research ethics committee (protocol no. 74/13). All participants were informed about the research procedures and signed an informed consent form prior to participation.

Study Design

This prospective study was designed to compare the preoperative and 6 and 12 months postoperative changes in physical activities and body composition in female bariatric patients. To this end, each subject was instructed to wear a triaxial accelerometer during 7 consecutive days (5 weekdays and 2 weekend days) in the preoperative (~2 months before) and 6 and 12 months post-RYGB surgery periods. Additionally, body composition parameters were estimated by using multi-frequency bioimpedance analysis in the same periods.

Physical Activity Assessment

Physical activities were monitored by using a triaxial accelerometer. The device (GT3X+ model; ActiGraph, Pensacola, FL, USA) was calibrated for each subject by using ActiLife 6 software (ActiGraph, Pensacola, FL, USA) according to the manufacturer's instructions. The device (~27 g; 3.8 × 3.7 × 1.8 cm) was attached to the waist (right side) by using an elastic belt. The subjects were instructed to engage in their normal physical activity routine while wearing the device and to remove it only during bathing and physical activities involving water. The data collected by the accelerometer were transferred to and analyzed with ActiLife 6 software. A minimum of 10 h of wear time per day was required to validate the data. Nonwearing time was excluded from analyses (≥ 60 consecutive minutes of zero counts). Sedentary activities were considered as activities with ≤ 100 cpm; light activity, between 101 and 1952 cpm; and MVPA ≥ 1953 cpm [14].

Body Composition

Body composition was estimated by using a vertical bioimpedance analyzer. The equipment (InBody 230; BioSpace, Seoul, Korea) uses multifrequency bioelectrical impedance on eight tactile points. The measurements were conducted with subjects wearing light clothing and without shoes and socks. The tests for preoperative and postoperative analyses were conducted in the morning at the same time of the day in a temperature-controlled (24 °C) room.

The following instructions were provided to the subjects before the assessments: (a) to fast and (b) to not drink water 3 h before the test, (c) to not take diuretics 24 h before the test, (d) to not perform physical exercises 24 h before the test, (e) to not take a bath in the morning, (f) to urinate and/or defecate at least 30 min before the test, and (g) to not wear metal accessories (e.g., earrings and watches) during the evaluation [15].

Statistical Analysis

The Friedman repeated measures test was used to compare the preoperative and postoperative (6 and 12 months) physical activities and body composition changes. When a significant interaction effect was found, a Dunn post hoc test was performed. The interaction between study variables, by using body composition (percentage changes of body mass, fat mass, and fat-free mass) as the dependent variable, was assessed by means of multivariate linear regression tests. The significance level adopted was $p \leq 0.05$. Data were expressed as median and interquartile range (IQR, 25th–75th percentile).

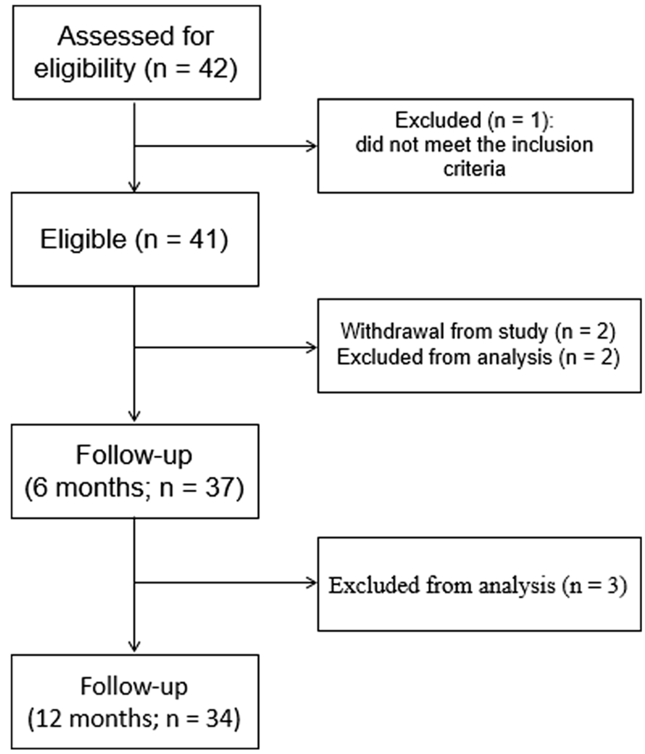

Fig. 1 Flowchart of the study

Results

Figure 1 illustrates the flowchart of the study. A total of 42 patients were eligible for and agreed to participate in this study. At 6 months after surgery, two patients dropped out. Two patients at 6 months and three patients at 12 months after surgery did not properly use the accelerometer, and their data were excluded from the analyses.

The subjects had a median age of 31.56 (26.25–36.75) years; height, 1.59 (1.55–1.63) m; and BMI, 44.43 (41.90–46.44) kg/m^2 before the surgery. Table 1 shows the preoperative and 6 and 12 months postoperative body composition parameters. Significant decreases ($p < 0.001$) were evident for body mass, fat mass, and fat-free mass at 6 and 12 months after surgery, compared with the preoperative values. Significant decreases ($p < 0.001$) were found in body mass and fat mass, in the comparison between 6 and 12 months after surgery. However, no difference ($p > 0.05$) was detected for fat-free mass between 6 and 12 months after RYGB.

The median daily time (accelerometer) values were 1210.0 min/day (1166.0–1247.0) preoperatively, 1183 min/day (1119.0–1241.0) at 6 months postoperatively, and 1160.0 min/day (1103.0–1227.0) at 12 months postoperatively ($p = 0.08$).

No significant differences were found between the preoperative and postoperative values for the variable step count ($p = 0.57$), percentages of time spent in sedentary activity ($p = 0.81$), percentages of time spent in light activity ($p = 0.28$), sedentary bouts of ≥ 30 min/day ($p = 0.24$), MVPA in bouts of ≥ 10 min/day ($p = 0.64$), and in MVPA in bouts of ≥ 10 min/week ($p = 0.47$).

The post hoc test indicated significant increases in the percentage of time spent in MVPA at 6 months postoperatively compared with the preoperative values ($p < 0.05$); however, no significant difference ($p > 0.05$) was observed at 12 months postoperatively (Table 2).

The percentage of subjects achieving ≥ 150 min/week of MVPA in bouts of ≥ 10 min was 5.9, 11.8, and 14.7% preoperatively, 6 months postoperatively, and 12 months postoperatively, respectively. The percentage of subjects who did not perform any single MVPA in bouts of ≥ 10 min was 52.9, 41.2, and 47.1% preoperatively, 6 months postoperatively, and 12 months postoperatively, respectively.

Multivariate regression analysis suggested that sedentary activity was associated with fat-free mass loss (%) at 6 months (− 0.323; 95% confidence interval [CI] = − 0.649 to 0.003) and 12 months (β = − 0.510; 95% CI = − 0.867 to − 0.154) after RYGB surgery. Additionally, there was a significant association of light physical activity (β = 0.642; 95% CI = − 0.239 to 1.045) and sedentary activity in bouts of > 30 min (β = − 0.052; 95% CI = − 0.098 to − 0.007) with fat-free mass loss at 12 months. MVPA was associated with fat-free mass loss at 6 months (β = 1.714; 95% CI = 0.422 to 3.006) after RYGB surgery (Tables 3 and 4).

Table 1 Body composition variables pre- and post-RYGB surgery

Variables	Preoperative	6 months	12 months	6-month changes (%)	12-month changes (%)
Body mass (kg)	111.0 (103.6 to 121.3)	78.5* (74.2 to 91.0)	73.8*# (66.2 to 84.9)	− 27.7 (− 29.2 to − 26.5)	− 33.4 (− 36.5 to − 29.6)
Fat mass (kg)	57.9 (54.5 to 64.2)	33.2* (29.0 to 38.1)	27.0*# (23.6 to 33.6)	− 44.6 (− 47.9 to − 39.4)	− 52.4 (− 57.6 to − 47.0)
Fat-free mass (kg)	51.5 (49.6 to 56.6)	46.5* (44.7 to 49.6)	46.8* (44.1 to 50.5)	− 10.9 (− 12.5 to − 8.0)	− 10.9 (− 14.0 to − 8.5)

RYGB, Roux-Y gastric bypass

* $p < 0.001$ compared with preoperative values; # $p < 0.001$ compared with 6-month values

Discussion

This study aimed to investigate the preoperative and 6 and 12 months postoperative changes in physical activities among female bariatric patients and to investigate the relationship between body composition changes and triaxial accelerometer variables. The main findings were as follows: (a) the percentage of time spent for MVPA increased only at 6 months postoperatively, (b) most of the subjects were classified as being physically inactive both before and after surgery, (c) no changes in sedentary behavior was observed in the postoperative period, and (c) sedentary activity was inversely associated with fat-free mass loss at 6 and 12 months after surgery.

Bariatric surgery is recognized as an effective method for the treatment of morbid obesity, and its success is often indicated by the percentage of excess weight loss (%EWL) [16]. On the other hand, the ideal body mass reduction must be associated with fat mass loss and maintenance of fat-free mass, an important parameter that can be assessed with bioimpedance analysis. In our study, accentuated body mass reduction was evident during the postoperative period (6 and 12 months), with higher percentage changes in fat mass (median values of − 44.28 and − 52.33%, respectively) than fat-free mass (median values of − 11.11 and − 10.88%, respectively) (Table 1). These data show that fat mass loss was the major contributor to body mass reduction, showing a positive effectiveness on body composition during 6 and 12 months post-RYGB surgery.

Concerning physical activity changes, in our study, the percentage of time spent in MVPA increased from preoperatively to 6 months postoperatively; however, this change was not evident at 12 months after surgery. Furthermore, no significant changes were observed from preoperatively to 6 and 12 months postoperatively for the following variables: time spent in sedentary activity, time spent in light activity, MVPA in bouts of ≥ 10 min (per day or week), and in sedentary activity in bouts of ≥ 30 min (per day) (Table 2).

An important aspect that needs to be highlighted is the MVPA recommendation (≥ 150 min/week) for developing and maintaining physical fitness and health [3–6]. In this study, the percentage of subjects achieving ≥ 150 min/week of MVPA in bouts of ≥ 10 min was 5.9% (two subjects) in the preoperative period. The current results are consistent with those of Bond et al. [17] and King et al. [18], who reported percentages of 4.5 and 3.4% among American women with obesity in the waiting list for bariatric surgery. However, the current study data are lower than those of other studies in European women with obesity that report percentages of 18 [19] and 14.2% [20] in the preoperative period. The differences among studies may be due to distinct environmental and cultural characteristics among countries and regions.

Table 2 Physical activities pre- and post-RYGB surgery

Variables	Preoperative	6 months	12 months
Step count (per day)	7553.5 (5379.0–8901.0)	8090.5 (6285.0–9480.0)	8039.5 (5970.0–9590.0)
Sedentary activity (%)	77.0 (72.5–81.1)	77.0 (72.1–80.8)	77.8 (73.2–79.9)
Light activity (%)	20.0 (17.0–24.6)	19.1 (16.8–23.4)	19.8 (16.6–22.5)
MVPA (%)	2.3 (1.9–3.5)	3.4 (2.4–4.7)*	3.2 (2.0–4.1)
MVPA in bouts of ≥ 10 min/week	0.0 (0.0–23.0)	19.0 (0.0–72.0)	15.5 (0.0–78.0)
MVPA in bouts of ≥ 10 min/day	0.0 (0.0–3.3)	2.7 (0.0–9.4)	0.9 (0.0–10.3)
Sedentary activity in bouts of ≥ 30 min/day	163.7 (140.2–207.9)	189.9 (156.8–220.1)	172.3 (147.7–198.9)

Data are expressed as median (interquartile range)

RYGB, Roux-Y gastric bypass; *MVPA*, moderate-to-vigorous physical activities

* $p < 0.05$ compared with preoperative values

Table 3 Associations between body composition changes and physical activities at 6 months after RYGB surgery

	Body mass loss (%)	Fat-free mass loss (%)	Fat mass loss (%)
Sedentary activity (%)	− 0.046 (− 0.446 to 0.352)	**− 0.323 (− 0.649 to 0.003)***	− 0.052 (− 0.546 to 0.442)
Light activity (%)	0.054 (− 0.406 to 0.515)	0.291 (− 0.095 to 0.677)	0.104 (− 0.464 to 0.672)
MVPA (%)	0.148 (− 1.508 to 1.803)	**1.714 (0.422 to 3.006)#**	− 0.333 (− 2.378 to 1.712)
MVPA in bouts of ≥ 10 min/day	− 0.056 (− 0.271 to 0.159)	0.066 (− 0.120 to 0.253)	− 0.021 (− 0.288 to 0.246)
Sedentary in bouts of ≥ 30 min/day	0.021 (− 0.019 to 0.062)	− 0.015 (− 0.051 to 0.020)	0.031 (− 0.019 to 0.081)

Multiple regression analysis adjusted for baseline body mass index and age. Data are expressed as unstandardized regression coefficients (β) with 95% confidence intervals in parentheses

RYGB, Roux-Y gastric bypass; *MVPA*, moderate-to-vigorous physical activity

* $p > 0.05$; # $p > 0.01$

Nevertheless, these related studies [18–20] showed no significant changes in accumulated MVPA (in bouts of ≥10 min) per week in the postoperative period, indicating that most bariatric patients remain physically inactive after the surgery. Indeed, the current results showed that only 11.8 (four subjects) and 14.7% (five subjects) met the MVPA recommendations at 6 and 12 months after surgery, respectively.

Moreover, in our study, half of the subjects did not perform any single MVPA in bouts of ≥10 min in the preoperative period (52.9%), with no substantial changes at 6 months (41.2%) and 12 months (47.1%) postoperatively. These data *are comparable to the results of other studies* [17, 21] *that report that most bariatric patients did not accumulate any MVPA in continuous bouts of* ≥ 10 min.

Concerning sedentary behavior, there are no specific recommendations and threshold values in the literature. In this study, the female bariatric patients spent a higher proportion of time in sedentary activities before and after surgery (median values ~ 77%), and no significant changes were observed in sedentary activities in bouts of ≥ 30 min. Our results are in line with those of other studies that indicate that bariatric patients spent a major proportion of daytime hours in sedentary activities (> 70%), with no significant change after surgery [19, 22, 23].

Therefore, the considerable body mass loss observed during the short-term periods (6 and 12 months) after bariatric surgery is not a determining factor for increase in MVPA in bouts of ≥ 10 min and decrease in sedentary behavior. Thus, behavioral interventions to increase the physical activities should be considered. In this context, recent randomized controlled trial studies indicated that face-to-face physical activity counseling was an effective method for increasing daily bouts of MVPA among candidates for bariatric surgery [24, 25], and these changes are maintained at 6 months after surgery [25].

Some studies [9, 26, 27] indicated a positive association between MVPA assessed by using self-report physical activity questionnaires and body mass loss after bariatric surgery. On the other hand, in bariatric patients, these data cannot be considered conclusive once self-report physical activity questionnaires were not in agreement with accelerometer data [11, 28]. The first evidence to show an interaction between physical activity assessed by using an accelerometer and body mass loss after bariatric surgery was provided by Josbeno et al. [29]. In their study, the authors investigated subjects who had undergone RYGB surgery, at different times after the surgery (2, 3, 4, and 5 years). Their results indicated that MVPA was related ($r = 0.44$) to the %EWL, and subjects that accumulated > 150 min/week of MVPA had greater %EWL than physically inactive subjects [29].

Table 4 Associations between body composition changes and physical activities at 12 months after RYGB surgery

	Body mass loss (%)	Fat-free mass loss (%)	Fat mass loss (%)
Sedentary activity (%)	− 0.233 (− 0.755 to 0.289)	**− 0.510 (− 0.867 to − 0.154)***	− 0.073 (− 0.779 to 0.633)
Light activity (%)	0.540 (− 0.039 to 1.120)	**0.642 (0.239 to 1.045)#**	0.423 (− 0.381 to 1.227)
MVPA (%)	− 1.424 (− 2.961 to 0.113)	0.178 (− 1.063 to 1.419)	− 1.849 (− 3.909 to 0.211)
MVPA in bouts of ≥10 min (day)	− 0.101 (− 0.284 to 0.082)	0.020 (− 0.122 to 0.163)	− 0.143 (− 0.387 to 0.101)
Sedentary in bouts of ≥30 min (day)	− 0.025 (− 0.090 to 0.039)	**− 0.052 (− 0.098 to − 0.007)***	0.014 (− 0.073 to 0.100)

Multiple regression analysis adjusted for baseline body mass index and age. Data are expressed as unstandardized regression coefficients (β) with 95% confidence intervals in parentheses

RYGB, Roux-Y gastric bypass; *MVPA*, moderate-to-vigorous physical activity

* $p > 0.05$; # $p > 0.01$

In the current study, regression analysis demonstrated that the percentage of time spent in sedentary activity, and MVPA was associated with fat-free mass loss at 6 months after surgery. In addition, the percentage of time spent in sedentary activity, light activity, and sedentary activity in bouts of ≥ 30 min was associated with fat-free mass loss at 12 months after surgery. No significant values were observed when body mass loss or body fat mass loss was used as a dependent variable (Tables 3 and 4).

These findings suggest that replacing the time spent on sedentary activities (< 1.5 METs) with MVPA (> 3.0 METs) and light physical activities (1.5–2.99 METs) in the postoperative period may be a strategy to induce positive changes in body composition for female bariatric patients, and this result warrants further investigation.

The major strength of this study lies in the facts that the physical activities were assessed by using a triaxial accelerometer, the patients underwent the same surgical procedure (RYGB surgery, performed by the same medical staff), and the patients received the same counseling about nutrition and physical activity before and after surgery from the same interdisciplinary team. On the other hand, some limitations of this study need to be addressed. First, a small sample size was investigated. Second, body composition was estimated by using a double-indirect method (bioelectrical impedance analysis). Although the multi-frequency bioimpedance technique is a valid method for assessing body composition [30], it is not as accurate as more sophisticated methods such as dual-energy x-ray absorptiometry.

In conclusion, the overall MVPA increased at 6 months post-RYGB surgery; however, this change was not maintained at 12 months. Despite the considerable body mass loss after surgery, most of the subjects were classified as being physically inactive and did not change their sedentary behavior. These findings indicate that female bariatric patients should be encouraged to increase their physical activity level post-RYGB surgery.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Statement Informed consent was obtained from all individual participants included in the study.

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