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Physical Activity and Physical Function in Individuals Post-bariatric Surgery

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Abstract

Background—A better understanding of the physical activity behavior of individuals who undergo bariatric surgery will enable the development of effective post-surgical exercise guidelines and interventions to enhance weight loss outcomes. This study characterized the physical activity profile and physical function of 40 subjects 2–5 years post-bariatric surgery and examined the association between physical activity, physical function, and weight loss after surgery.

Methods—Moderate-to-vigorous intensity physical activity (MVPA) was assessed with the BodyMedia SenseWear® Pro (SWPro) armband, and physical function (PF) was measured using the physical function subscale of the 36-Item Short Form Health Survey instrument (SF-36PF). Height and weight were measured.

Results—Percent of excess weight loss (%EWL) was associated with MVPA ($r = 0.44$, $p = 0.01$) and PF ($r = 0.38$, $p = 0.02$); MVPA was not associated with PF ($r = 0.24$, $p = 0.14$). Regression analysis demonstrated that MVPA was associated with %EWL ($\beta = 0.38$, $t = 2.43$, $p = 0.02$). Subjects who participated in 150 min/week of MVPA had a greater %EWL (68.2 ± 19 , $p = 0.01$) than those who participated in <150 min/week (52.5 ± 17.4).

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Conclusions—Results suggest that subjects are capable of performing most mobility activities. However, the lack of an association between PF and MVPA suggests that a higher level of PF does not necessarily correspond to a higher level of MVPA participation. Thus, the barriers to adoption of a more physically active lifestyle may not be fully explained by the subjects' physical limitations. Further understanding of this relationship is needed for the development of post-surgical weight loss guidelines and interventions.

Keywords

Physical activity; Physical function; Bariatric surgery; Obesity

Introduction

Severe obesity (defined as having a body mass index (BMI) ≥ 40 kg/m²) is reaching epidemic proportions and increasing at an exponential rate [1]. This increased prevalence is one of the many factors that has resulted in an increased growth in bariatric surgery, with the most commonly performed procedure being laparoscopic Roux-en-Y gastric bypass surgery (RYGB) [2].

There is evidence to support the effectiveness of weight loss and reduction of co-morbidities associated with RYGB in the short term, but there are limited data on long-term weight loss with RYGB [3–6]. Individuals typically lose 65–80% of their excess body weight following RYGB. The peak of this weight loss is usually between 12 and 18 months and generally levels off by 2 years [7]. Despite the fact that most people lose a significant amount of weight, preliminary studies are suggesting that an ample amount of patients have weight regain and have the return of co-morbidities post-bariatric surgery [8–10]. Specifically, Karlsson et al. reported that approximately 30% of the initial weight reduction was regained within 5 years in individuals who had undergone bariatric surgery [11]. The long-term impact of bariatric surgery and the medical and behavioral factors that lead to less than optimal surgical weight loss are not fully understood. Failure to lose a significant amount of weight as well as weight regain have typically been attributed to poor adherence to postoperative modifications such as limiting caloric intake and increasing energy expenditure. Most research has focused on examining the patient's eating behaviors after surgery (such as dietary adherence and eating disorders) [12–14], whereas questions remain with respect to the impact of physical activity on long-term weight loss and the contribution of one's physical capabilities to long-term surgical outcomes.

Physical activity has been shown to be a key component for successful weight loss and maintenance of weight loss in overweight and obese individuals during and following a standard behavioral weight loss program [15–17]. Recent studies suggest that success following bariatric surgery also may be associated with the individual's ability to make lifestyle changes including physical activity modifications, but these studies have relied on self-reported physical activity participation [18, 19]. There are limited studies that have objectively assessed physical activity participation in this patient population. Furthermore, physical function has been shown to improve after surgical weight loss interventions [20–22], but there are no studies to our knowledge that have examined physical function (what

the patient is physically capable of doing) in this population and how it may or may not be a barrier to physical activity participation (what the patient is doing in terms of activity level) following a weight loss surgical intervention. A better understanding of the relationship of physical activity behaviors and physical capabilities in the long term will enable the development of effective post-surgical exercise guidelines and interventions to enhance surgical outcomes.

Thus, this study defined a physical activity profile of the subjects 2–5 years post-bariatric surgery by characterizing their physical activity participation and examining the relationship between the level of physical activity and the level of weight loss. Additionally, this study examined the association between physical function and level of physical activity in subjects who have undergone bariatric surgery.

Methods

Subjects

Subjects who had undergone laparoscopic RYGB 2–5 years prior to study onset were recruited for this study. These individuals were recruited from (1) bariatric surgical practice at a local tertiary care center, (2) an ongoing NIH funded study examining the feasibility and efficacy of a weight loss behavioral intervention for individuals who have undergone bariatric surgery and who remain significantly overweight, and (3) the community. Subjects were excluded if they had undergone bariatric surgery revision, were unable to ambulate greater the 150 ft independently, or were pregnant within the last 6 months. Subjects provided written informed consent prior to beginning the study. Procedures for this study were approved by the Institutional Review Board at the University of Pittsburgh.

Measures

All subjects underwent a one-time assessment of body weight, height, BMI, and physical activity. Questionnaires were used to assess physical function and to obtain a detailed medical history, dietary intake, and demographic information.

Body Weight, Height, and BMI

Weight and height were measured using a calibrated electronic scale and a stadiometer according to standard procedures. BMI was computed from measurements of weight and height (kilogram per square meter). Weight loss was expressed as percent of excess weight lost (%EWL) = $[(\text{initial weight} - \text{current weight}) / (\text{initial weight} - \text{ideal weight})] \times 100$. The initial weight was recorded from the pre-surgery medical record. The ideal weight was based on reference tables published by Metropolitan Life Insurance Company [23].

Dietary Intake

To analyze dietary intake, subjects completed the 2005 Block Food Frequency Questionnaire, which was designed to estimate usual intake of a wide variety of nutrients and food groups over the course of a year [24].

Physical Activity

The BodyMedia SenseWear® Pro (SWPro) armband (BodyMedia Inc., Pittsburgh, PA) was used to measure physical activity. The SWPro armband is a wireless, wearable body monitor that collects and analyzes physiological and lifestyle data to determine energy expenditure and physical activity levels and duration. It has been shown to provide a valid assessment of free living energy expenditure [25]. The SWPro armband provides no feedback to the subject and, thus, does not encourage “performance behavior” [25, 26]. The algorithms within Version 6.1 of the SenseWear® Professional Software were used to compute energy expenditure per minute. Physical activity was defined as the minutes spent weekly in 1-min bouts of moderate-to-vigorous activity (MVPA), defined as activity that has a metabolic equivalent (MET) value of 3 or greater. Physical activity that was ≥ 3 METs would include activities such as brisk walking, bicycling, jogging, or other activities of similar levels of energy expenditure [27]. The weekly minutes spent performing MVPA in bouts ≥ 10 min (sustained MVPA) were also examined to determine the level of compliance with public health guidelines, which specify that 150 min/week of MVPA in bouts of ≥ 10 min is recommended to enhance health-related outcomes [28].

Subjects were instructed to wear the armband during all waking hours for seven consecutive days following their assessment and to only remove the armband when sleeping, bathing/showering, or swimming. The subjects were also provided with a physical activity diary to record wearing time of the armband and a postage-paid envelope to return the device.

Physical Function

Physical function (PF) was measured using the physical function subscale of the 36-Item Short Form Health Survey instrument (SF-36_{PF}) [29]. The SF-36 has been proven to be a useful tool in assessing patient outcomes following bariatric surgery [30, 31]. This measure assesses limitations in activities of daily living such as bathing, dressing, and mobility limitations. This domain is scored from 0 (lowest level of functioning) to 100 (highest level of functioning).

Statistical Analyses

Baseline characteristics were expressed as the mean ± standard deviation or percentages as appropriate. Due to non-normality of the distribution of the physical activity and physical function data, a Spearman's rank correlation coefficient was used to test for associations between MVPA, PF, and %EWL. To determine the association between MVPA and %EWL, a regression analysis was performed while controlling for specific variables that may impact weight loss. In particular, we included subject age, months post-bariatric surgery, daily caloric intake, and PF. To further examine the differences in weight loss among the subjects according to the amount of MVPA participation, a Mann–Whitney *U* was performed. Subjects were placed in one of two physical activity groups based on the total time spent engaged in MVPA: (1) low level <150 min/week and (2) high level ≥ 150 min/week. These groups were defined based on recent public health recommendations for physical activity [28]. All analyses were performed using SPSS software (version 17.0 for Windows; SPSS, Inc., Chicago, IL, USA), with statistical significance defined as *p* < 0.05.

Results

Subject Characteristics

Forty-two participants agreed to participate in the study, and two were excluded from data analysis because their physical activity and physical function assessments were incomplete. The participants' mean age was 50.6 ± 9.8 years, and the majority of the sample was female (90%). The sample was 88% Caucasian, 2% Hispanic, and 10% African American. The mean BMI was 32.6 ± 7.9 kg/m² (with a reported preoperative mean BMI of 48.8 ± 7.1 kg/m²) and the mean %EWL was 62.7 ± 19.7 with a range of 24.9–92.1%. Average daily caloric intake was $1,279.8 \pm 446.4$ kcal. The participants' mean years post-bariatric surgery was 3.3 ± 1.1 . The mean age, BMI, %EWL, and daily caloric intake by years post-bariatric surgery are presented in Table 1. There was no significant difference between the variables for years post surgery.

Physical Activity

Data from the SWPro armband were analyzed and divided into several categories. When activity was defined as time spent engaged in MVPA, the subjects spent an average of 212.8 ± 141.0 min/week. However, when the data were analyzed to identify the weekly accumulation of sustained MVPA (bouts of 10 or more continuous minutes), the total minutes per week decreased to 49.3 ± 68.9 min (Table 2).

Spearman's rank-order correlation indicated a significant association between the overall amount of MVPA participation and weight loss post-bariatric surgery, adjusted for months post-bariatric surgery ($r = 0.44$, $p = 0.01$) among the subjects ($n = 40$). Additionally, sustained MVPA (bouts of >10 min in duration) was also related ($r = 0.37$, $p = 0.02$).

A linear regression was conducted to examine the relation of MVPA and %EWL while accounting for age, months post-bariatric surgery, and daily dietary intake (Table 3). The overall variance explained by MVPA was 18%. MVPA was significantly associated with %EWL ($\beta = 0.38$, $t = 2.43$, $p = 0.02$), while age, months post-bariatric surgery, and daily caloric intake did not significantly contribute to the regression model. We also examined if the subjects' perception of their physical capabilities had an impact on this relationship. The addition of the SF-36_{PF} scores to the regression model did not explain anymore of the variance (Table 3).

Results of the Mann–Whitney U analysis revealed a significant difference in %EWL among the two levels of MVPA participation ($p = 0.01$). The study participants who participated in 150 min/week or greater of MVPA ($n = 26$) had a greater %EWL (68.2 ± 19.0) than the study participants ($n = 14$) who participated in less the 150 min/week of MVPA (52.5 ± 17.4).

Physical Function

The physical function score using the SF-36_{PF} subscale was 86.3 ± 22.4 . Previously published data from the general US population reported a mean of 84.2 ± 23.3 for men and women of all ages [32]. There was a significant relationship between %EWL and physical

function ($r = 0.38$, $p = 0.02$). However, there was no significant correlation between physical function and physical activity ($r = 0.24$, $p = 0.14$).

Discussion

This study addresses the paucity of information related to physical activity and physical function associated with bariatric surgery. Physical activity participation has been shown to increase following bariatric surgery, and this increase has been associated with greater weight loss success [18, 19]. However, previous studies have relied on self-reported physical activity participation, and the findings may have been influenced by the inherent limitations in the measurement method. For example, it has been shown that obese individuals over-report frequency and duration of physical activity [33, 34]. To our knowledge, few studies have been published using objective monitoring of physical activity participation post-bariatric surgery, especially when examining the association between physical activity and weight loss at 2–5 years post-bariatric surgery. The unique contribution of this study is that physical activity was objectively assessed at this time period.

On average, subjects in this study participated in 212.8 ± 141.0 min/week of MVPA in bouts ≥ 1 min at 2–5 years post-bariatric surgery. Moreover, 32% had no sustained MVPA (bouts of ≥ 10 min in duration), and only 10% of the subjects met the national physical activity recommended guidelines of ≥ 150 min/week of MVPA in bouts of ≥ 10 min. Despite the fact that participants were active throughout the day, the majority of these post-bariatric surgery patients were not participating in recommended levels of physical activity to enhance health-related benefits.

The finding that weight loss induced by bariatric surgery is moderately correlated with physical activity participation is consistent with previously reported studies [18, 19, 35, 36]. Moreover, weight loss was significantly greater in subjects participating in ≥ 150 min/week of MVPA compared to those subjects participating in <150 min/week of MVPA. These findings are similar to that of Evans et al. [36] who reported that patients who participated in a minimum of 150 min/week of moderate or higher intensity physical activity achieved the greatest postoperative weight loss at 12 months post-bariatric surgery. These results appear to support the importance of sufficient doses of MVPA to enhance long-term weight loss post-bariatric surgery.

It has well been established that physical activity plays an essential role in weight loss maintenance after a dietary intervention [37, 38]. Additionally, several weight loss studies have shown a clear dose response between physical activity and prevention of weight regain [38, 39]. Results from this study indicate that greater long-term weight loss was associated with higher levels of physical activity participation and not with daily caloric intake. Further investigation of the amount and frequency of physical activity for weight loss and prevention of weight regain is certainly warranted.

The data showed a relationship between the amount of weight loss and physical function at 2–5 years post RYGB. However, a higher level of physical function was not related to greater physical activity participation in this sample. This finding may have been influenced

by the limitations in the method used to assess physical function. Physical function was assessed using a self-report questionnaire, and although this measure queries the subjects' perception of their capabilities to complete an activity, it may not reflect their true ability. In the absence of performance-based measures, it is plausible that subjects' perceptions may not be matched by true abilities. They may incorrectly perceive a higher level of physical function as a result of the bariatric surgery rather than a legitimate improvement in function. This inaccurate perception of physical function may be a result of factors such as reduction of medical co-morbid conditions, reduction of pain in weight-bearing joints, and/or improvement in quality of life, all of which have been shown to improve after bariatric surgery [4, 11, 22]. Therefore, the use of a performance-based measure may be needed to capture true functional limitations in this population.

The disparity between physical activity and physical function would suggest that subjects feel they are capable of performing most activities associated with exercise and mobility activities, but are not necessarily participating in daily physical activities. This leads us to believe that there are other issues besides physical limitations that are interfering with a sufficiently active lifestyle in individuals who have undergone bariatric surgery. Future research should focus on exercise interventions that address behavioral barriers (e.g., musculoskeletal pain, psychosocial factors, and social stigma) in addition to taking advantage of early post-surgical physical function improvements in order to maximize post-surgical weight loss success and enhance healthful behaviors.

Although this study had several strengths including the use of an objective assessment of MVPA, it also had several limitations. First, physical activity was assessed using the SWPro armband as an objective measurement of physical activity. While this monitor has been shown to provide valid objective data on energy expenditure in healthy, relatively young, normal weight adults [25, 26], the SWPro armband has not undergone extensive validation in a bariatric surgery population. Second, due to the cross-sectional design of this study, causality cannot be established, and therefore, the results of this study need to be validated in a prospective cohort. Third, while the investigator made every attempt to recruit a diverse group of subjects, ultimately, subjects self-selected to participate in this study. This may have resulted in selection bias with regard to weight loss, physical activity, and physical function. Additionally, the sample was predominantly female; thus, these results may not generalize to a male population. Lastly, all subjects had undergone a laparoscopic RYGB procedure; these results may be different for other surgical procedures.

In conclusion, we found that the amount of physical activity participation and the level of physical function are each independently associated with weight loss in individuals 2–5 years after bariatric surgery. This study has shown that physical function (what the patient is capable of doing) is not correlated with physical activity, which may suggest that the capacity to engage in physical activity does not necessarily translate into greater levels of activity participation. Other studies of weight loss have shown that barriers to physical activity, self-efficacy, and additional behavioral and/or cognitive factors contributed to physical activity adoption and maintenance [40, 41]. Therefore, these factors warrant examination within adults who have undergone bariatric surgery to determine how these factors contribute to physical activity adoption and maintenance. A better understanding of

the relationship between what patients do versus what they are physically capable of doing in this population will assist in the development of effective post-surgical exercise guidelines and are a prerequisite for designing an effective intervention for weight management.

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Table 1

Characteristics of subjects according to years post-bariatric surgery (values are mean $\pm$ standard deviation)

Variable	Years post-bariatric surgery			
	2 (<i>n</i> = 13)	3 (<i>n</i> = 7)	4 (<i>n</i> = 15)	5 (<i>n</i> = 5)
Age, years	49.5 $\pm$ 10.7	48.9 $\pm$ 8.3	52.1 $\pm$ 11.4	51.4 $\pm$ 3.6
BMI, kg/m ²	29.0 $\pm$ 4.2	36.1 $\pm$ 5.9	34.4 $\pm$ 10.5	31.9 $\pm$ 8.2
%EWL	72.8 $\pm$ 10.8	53.0 $\pm$ 17.6	60.1 $\pm$ 21.5	58.0 $\pm$ 28.4
Daily caloric intake, kcal	1,082.9 $\pm$ 410.0	1,360.6 $\pm$ 298.3	1,292.6 $\pm$ 509.5	1,640.6 $\pm$ 309.5

BMI body mass index, *%EWL* percent of excess weight loss

Table 2

Descriptive data of physical activity when defined using different criteria

Criteria to define physical activity	Mean $\pm$ SD	Range
Total minutes/week at ≥ 3 METs and ≥ 1 -min bouts	212.8 $\pm$ 141.0	20.0–528.0
Total minutes/week at ≥ 3 METs and ≥ 10 -min bouts	49.3 $\pm$ 68.9	0.0–257.0

METs metabolic equivalents, *SD* standard deviation

Table 3

Linear regression for percent of excess weight loss (%EWL)

Variable	Model 1			Model 2		
	β	p	Adjusted R^2	β	p	Adjusted R^2
Age	-0.08	0.60		-0.08	0.60	
Months post surgery	-0.21	0.18		-0.22	0.18	
Daily caloric intake	-0.11	0.51		-0.11	0.52	
MVPA	0.38	0.02		0.38	0.03	
SF-36 _{PF}				-0.12	0.91	
Total model			0.18 [*]			0.15

Model 1 = percent of excess weight loss (%EWL) = age + months post-bariatric surgery + daily caloric intake + moderate-to-vigorous physical activity (MVPA)

Model 2 = %EWL = age + months post-bariatric surgery + daily caloric intake + MVPA + SF-36_{PF}

^{*}
 $p < 0.05$