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Capacity for Physical Activity Predicts Weight Loss After Roux-en-Y Gastric Bypass

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Despite its overall excellent outcomes, weight loss after Roux-en-Y gastric bypass (RYGB) is highly variable. We conducted this study to identify clinical predictors of weight loss after RYGB. We reviewed charts from 300 consecutive patients who underwent RYGB from August 1999 to November 2002. Data collected included patient demographics, medical comorbidities, and diet history. Of the 20 variables selected for univariate analysis, 9 with univariate *P* values ≤ 0.15 were entered into a multivariable regression analysis. Using backward selection, covariates with *P* < 0.05 were retained. Potential confounders were added back into the model and assessed for effect on all model variables. Complete records were available for 246 of the 300 patients (82%). The patient characteristics were 75% female, 93% white, mean age of 45 years, and mean initial BMI of 52.3 kg/m². One year after surgery, patients lost an average of 64.8% of their excess weight (s.d. = 20.5%). The multivariable regression analysis revealed that limited physical activity, higher initial BMI, lower educational level, diabetes, and decreased attendance at postoperative appointments had an adverse effect on weight loss after RYGB. A model including these five factors accounts for 41% of the observed variability in weight loss (adjusted r^2 = 0.41). In this cohort, higher initial BMI and limited physical activity were the strongest predictors of decreased excess weight loss following RYGB. Limited physical activity may be particularly important because it represents an opportunity for potentially meaningful pre- and postsurgical intervention to maximize weight loss following RYGB.

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INTRODUCTION

The prevalence of obesity has been increasing steadily since 1980 and shows no signs of abating (1,2). Currently, 66% of adults in the United States are classified as being overweight (BMI between 25 kg/m² and 29.9 kg/m²) or having obesity (BMI ≥30 kg/m²). Recent studies show that 32% of the population has obesity and >5% has severe obesity (BMI ≥40 kg/m²) (3). In addition to the increased risk of mortality independently associated with being overweight and having obesity (4), excess weight can lead to many devastating comorbidities, including type 2 diabetes, coronary artery disease, hypertension, sleep apnea, osteoarthritis, and several types of cancer (5,6).

Gastrointestinal weight loss surgery, particularly Roux-en-Y gastric bypass (RYGB), has proven to be an effective long-term treatment for obesity. Studies have revealed that after this operation patients lose an average of 60–75% of their excess body weight and maintain >50% excess body weight loss for >15 years (7,8). This operation has also been shown to reduce or eliminate many of the medical comorbidities associated with obesity, including sleep apnea, type 2 diabetes, hypertension, dyslipidemia, and the metabolic syndrome (7,9–11). As a result, weight loss surgery has been shown to decrease long-term mortality risk by up to 40% (12,13). Evidence also suggests that weight loss surgery is cost effective over time (14–18). Consequently, the number of bariatric procedures performed has increased dramatically over the past several years, from 7,000 in 1996 (19) to nearly 180,000 in 2006 (20).

Despite its profound benefit on comorbidities and long-term mortality, RYGB carries significant risk, with associated perioperative mortality rates between 0.25% and 2% across different settings and populations (12,13,21,22). Observed differences in short-term mortality may be because of a variety of factors including surgeon experience, surgical technique, procedural complications, and patient behavior, as well as patient characteristics (7,23). This operation also requires patients to make substantial and long-term lifestyle changes in order to optimize outcomes after the procedure. Therefore, it would be practical and beneficial to identify patient characteristics that help predict weight loss after RYGB. This information could be utilized as part of the preoperative assessment of each patient with obesity to determine if the indications for surgery and benefits from the resulting weight loss outweigh the contraindications and inherent risks associated with this operation.

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Several clinicians and investigators have attempted to identify important preoperative predictors for weight loss after RYGB. Psychological variables such as depression (24) and anxiety (9) may lead to diminished weight loss after surgery, although the effect of these factors appears to depend on whether the patient is currently in treatment (25). Type 2 diabetes has been shown to be associated with decreased weight loss after surgery (26,27), as has a limited dieting history (28) and being married (29). Increased age is associated with blunted weight loss as well as a higher incidence of complications after surgery (30,31), but the effects of age are not so robust as to exclude older patients from consideration of surgical treatment (24,32,33). One of the most consistently reported predictors of weight loss following surgery is initial BMI; however, the nature and direction of this relationship depends on how outcome is assessed. If an absolute measure is used, such as change in BMI or body weight, then higher initial BMI is generally associated with greater weight loss (34). If a relative measure is used, such as percent excess body weight or percent excess BMI, then higher BMI has been found to be associated with reduced postoperative weight loss (27,29,35–37). Most studies of preoperative predictors have only looked at one or a few potential variables (24,27,34,38–40), often within a single category (e.g. demographics, psychosocial variables, medical comorbidities), and often in small populations (9,24,38,41–43).

In the present study, we sought to examine a broad array of potential clinical, psychological, and physical predictors in order to determine which, if any, have a significant effect on outcome after RYGB. From a prospective chart review of 300 consecutive patients who underwent this procedure, we found that among 20 variables examined, 5—limited physical activity, higher initial BMI, lower education level, diabetes, and fewer postoperative appointments attended in the year following surgery—were associated with diminished weight loss after RYGB. Of these variables, higher initial BMI and limited physical activity had the greatest adverse effect on postoperative weight loss.

METHODS AND PROCEDURES

Study design

We conducted a prospective review of the charts of 300 consecutive patients who underwent open or laparoscopic RYGB from August 1999 to November 2002 as part of a multidisciplinary treatment program within a specialized obesity center. This center is part of an academic medical institution belonging to a larger network of health care centers including other academic medical centers, community hospitals, and community-based health-care clinics. Each operation was performed by one of two surgeons at the center using the same operative approach. Data for this study were extracted by a comprehensive review of both paper records located on site and the electronic medical record available to the center and larger hospital network. Each patient's medical record contained notes from the patient's treating physician, psychologist, dietitian, and surgeon. It also included responses to questionnaires about the patient's medical, psychological, and dietary histories that were provided by the patient prior to the initial evaluation at the obesity treatment center. Full records, including weights 1 year after surgery, were available for 246 of the 300 patients (82%).

Surgical procedure

Operations were either open (65.4%) or laparoscopic (34.6%). For the open procedure, the stomach was partitioned but not divided, and for laparoscopic procedure the pouch was partitioned and divided from the remaining stomach. Otherwise, the techniques were the same, with an ~30 ml pouch and a 100–120 cm Roux limb fashioned in a retrocolic, retrogastric configuration, and the pancreaticobiliary limb extending ~75 cm from the ligament of Treitz. There was a single death in this series within 30 days after surgery; this patient was excluded from the analysis.

Measures

Demographics. *Age*: Age was defined as the difference between the date of birth and date of surgery. *Employment*: Gainful employment was defined as having a full-time or part-time occupation performed outside the home. *Marital status*. Marital status was defined as the marital status at the time of surgery. Possible categories included married, single, divorced, cohabitating, or widowed. *Race*. Self-reported race was categorized as non-Hispanic white, non-Hispanic black, Hispanic, Asian–Pacific Islander, and American Indian. *Education level*. Self-reported patient education was determined using the highest level of education achieved. Categories included elementary/grade school, high school, technical school, some college, college degree, or graduate degree.

Comorbidities. The medical comorbidities of *type 2 diabetes*, *use of insulin*, *coronary artery disease*, *osteoarthritis*, and *low-back pain* were classified as being present or absent by using diagnoses listed in the notes of either a physician at the obesity treatment center or the patient's primary care provider. *Depression* was categorized as being present or absent using diagnoses listed in the notes of the staff psychologist during the initial evaluation at the obesity treatment center. *Limited physical activity* was defined as the inability to climb two flights of stairs or walk two city blocks, as determined by dietitian assessment using the Pfaffenberger Physical Activity Scale. Limited physical activity status was excluded in patients who successfully completed an exercise tolerance test, or were currently involved in regular physical activity, as documented by notes in the medical record. A physician who was not involved in the patient's care at any time reviewed the available information and determined the status of each patient's physical activity level.

Weight history. *BMI*. Initial BMI was defined as the BMI in kg/m^2 recorded immediately prior to surgery. *Parental weights*. Mother's and father's weights were determined using the scale developed by Stunkard *et al.* (44) This scale consists of pictures of women and men at different weights. The pictures were numbered one through nine, with one being the lightest and nine the heaviest. Each patient was then asked to list the number of the picture that best reflected the current weight of his or her mother and father. These pictures correspond to specific BMIs (45), allowing categorization of the figures as normal weight (figures 1–5), overweight (figure 6), or having obesity (figures 7–9). *Weight cycling*. Weight cycling was categorized using a modified version of established weight cycling measures as described by Field *et al.* (46) Because this study was conducted as a chart review, we were limited by the open-ended format in which the questions were asked during the clinical evaluation process. The categories were adapted as follows: no weight cycling was defined as having lost 10 pounds fewer than three times; mild weight cycling was defined as having lost 20 pounds one or two times or having lost 10 pounds three or more times; moderate weight cycling was defined as having lost 50 pounds one or two times or having lost 20 pounds three or more times; and severe weight cycling was defined as having lost 50 pounds three or more times. *Total lifetime weight loss (TLWL)*. Similar to weight cycling, total lifetime weight loss was adapted from existing measures established by Venditti *et al.* (47) and coded from the patient's responses to open-ended questions. TLWL was defined as the sum of the number of times the patient had lost 10 pounds multiplied by a factor of 10, the number of times the patient had lost 20 pounds multiplied by 20, and the number of times the patient had lost 50 pounds multiplied by 50. *Age of obesity onset*. Age of obesity onset was categorized as early childhood, late childhood, adolescence, young adulthood, mid adulthood, or late adulthood.

This information was self-reported by patients in a questionnaire and obtained from the medical record.

Postoperative outcomes. Weight loss. Weight loss was calculated as percentage of excess body weight lost (%EBWL) 1 year after surgery. This value was determined by subtracting the patient's weight at 1 year from his or her presurgical weight, and then dividing this difference by the difference between the patient's initial weight and his or her weight at a BMI of 25 kg/m^2. *Percentage of appointments attended*. The percentage of appointments attended within the first year after surgery was calculated using scheduling and arrival data available in the electronic medical record. In the surgical program at this center, all patients are routinely scheduled for between 20 and 22 visits with staff physicians, psychologists, surgeons, and dieticians during this period. The number of appointments attended was divided by the number of appointments scheduled.

Analysis

We conducted a univariate regression analysis for each predictor against percent excess body weight loss at 1 year to determine eligibility for inclusion into the multivariable analysis. To maximize the inclusion of all independent predictors of excess weight loss and minimize the exclusion of potential confounders, we chose an *a priori* criterion of $P \leq 0.15$ as the standard for inclusion into the multivariable analysis. Nominal-level categorical variables were analyzed with indicator variables that compared each category to the category with the largest number of participants, which was selected as the reference group in order to maximize power.

We obtained a model using a backward selection process with a criterion P value of <0.05 for a variable to remain in the model. Potential confounders were then added back into the model one at a time in the opposite order of removal during the backward selection process, and the effect of each added variable on all model variables was assessed. Shifting of the effect estimates for any variable by 20% or greater was considered confounding, and variables that had this effect were retained in the model. After the final multivariable model was selected, we carried out diagnostics on the model's residuals to identify potential high leverage points (influential outliers) and to assess if the multiple linear regression model assumptions (linearity, normality, and homoscedasticity) held in this data set.

RESULTS

Descriptive statistics

Complete medical records, including weights at 1 year after RYGB, were available for 246 of the 300 patients (82%). Full descriptive characteristics of the patients are presented in **Table 1**. One year after surgery, patients had lost an average of 64.8 % of their excess body weight (s.d. = 20.5%; range 16.3–119.7%; **Figure 1**).

Analysis

Nine of the original 20 variables had univariate P values ≤0.15 (**Table 2**), as determined by univariate regression analysis. These variables were then included in the multivariable regression process. From this analysis, five variables were found to have P values <0.05: presence of type 2 diabetes, education level, percentage of appointments attended, limited physical activity, and initial BMI (**Table 3**). Standardized beta coefficients indicate the relative magnitude of the variability in %EBWL that can be explained by each variable, independent of the variable's units or scale. The data indicate that the two variables with the largest effect on weight loss were initial BMI and limited physical activity, followed in order by type 2 diabetes,

Table 1 Patient characteristics

Demographic	
Age (years; mean ± s.d.)	45.1 ± 11.1
Sex (% female)	74.8
Employment (% employed)	70.3
Marital status (%)	
Never married	28.9
Married	41.9
Cohabitating	6.4
Separated/divorced	18.2
Widowed	4.5
Race (%)	
White (non-Hispanic)	92.7
Black (non-Hispanic)	4.6
Hispanic	2.3
American Indian	0.5
Education level (%)	
Elementary school	3.3
High school	21.5
Technical school	6.9
Some college	30.9
Completed college	25.2
Graduate school	12.2
Medical comorbidities	
Limited physical activity (%)	16.3
Type 2 diabetes mellitus (%)	28.1
Use of insulin (%)	12.2
Osteoarthritis (%)	44.7
Coronary artery disease (%)	10.6
Low back pain (%)	41.8
Depression (%)	43.5
Weight history	
Initial BMI (kg/m^2; mean ± s.d.)	52.3 ± 8.7
Mother's weight (1 to 9 scale)[a]	6 ± 1.8
Father's weight (1 to 9 scale)[a]	6 ± 2.1
Degree of weight cycling (%)	
No weight cycling	7.0
Mild weight cycling	6.1
Severe weight cycling	54.4
Extreme weight cycling	32.5
Total lifetime weight loss (lbs; mean ± s.d.)	505.5 ± 723.1
Age of obesity onset (%)	
Early childhood	36.7
Late childhood	24.7
Adolescence	15.5
Young adulthood	15.5
Adulthood	7.5
Postoperative	
Percent excess weight loss (mean ± s.d.; (range))	64.1 ± 20.5 (16.4–119.7)
Percentage of appointments kept ((mean ± s.d.; (range))	92.3 ± 10.1 (45.3–100.0)

[a]Parental weights were determined using a scale that ranks picture silhouettes according to weight with 1 the thinnest and 9 the heaviest

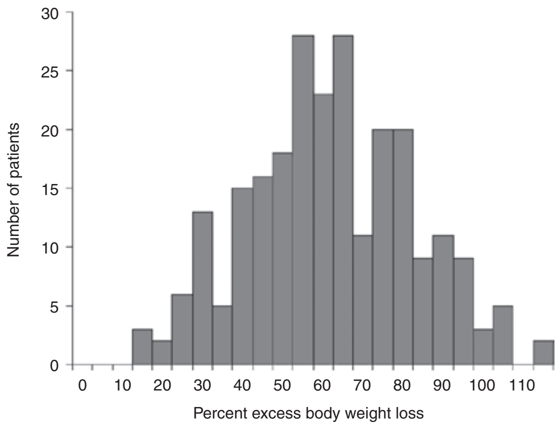

Figure 1 Distribution of weight loss 1 year after RYGB in 246 patients.

Table 2 Unadjusted *P* values

Characteristic	Unadjusted *P* value
Education level	<0.001
Initial BMI	<0.001
Limited physical activity	<0.001
Type 2 diabetes mellitus	0.002
Percentage of appointments kept	0.005
Osteoarthritis	0.022
Sex	0.039
Employment	0.039
Age	0.048
Mother's weight	0.256
Total lifetime weight loss	0.305
Coronary artery disease	0.321
Marrital status	0.395
Father's weight	0.397
Use of insulin	0.443
Low back pain	0.527
Degree of weight cycling	0.580
Depression	0.715
Age of obesity onset	0.817
Race	0.932

education level, and percentage of appointments attended. Together, these five factors account for 41% of the variability in weight loss (r^2 = .41) following RYGB in this cohort.

To assess potential confounding relationships, each covariate that had been dropped in the backwards selection process was reentered. There were no potential confounders that adjusted the beta coefficient of any of the five variables in the model by 20% or more, so no variable was added back into the model. In addition, we were concerned that use of insulin may affect the relationship between diabetes and percent excess body weight lost after surgery, so we tested insulin use as a potential confounder of this relationship. Entering insulin use into the model did not change the beta coefficient for diabetes and therefore was not considered a confounder of this relationship. Similarly, hypothesizing that the presence of osteoarthritis or low back pain might affect the relationship between limited physical activity and percent excess body weight lost after surgery, we tested each of these variables separately as potential confounders. Neither affected the beta coefficient for limited physical activity, so these variables were not considered confounders of this relationship.

Table 3 Multivariable regression model

Characteristic	Standardized β coefficient	β coefficient	*P* value
Initial BMI	−0.387	−0.910	<0.001
Limited physical activity	−0.311	−17.15	<0.001
Type 2 diabetes mellitus	−0.136	−6.17	0.008
Education level	0.125	1.56	0.043
Percentage of appointments kept	0.107	0.23	0.018

After the model was fit, we carried out diagnostics of the residuals from the fitted multiple linear regression. A *P* value of 0.39 was found for the Shapiro–Wilks test, indicating that the residuals were normally distributed. A scatterplot of the residuals against predicted values indicated equal variance across the range of our values (data not shown). We assume that %EBWL from patient to patient is independent. Therefore, a parametric linear regression model was deemed appropriate. Examination for outliers found 10 of 246 observations with studentized residuals with a magnitude greater than ±2. Therefore, we carried out influence diagnostics using the critical value of Cook's distance. At the $\alpha = 0.05$ level, the critical value for the Cook's distance test was 0.083. We found no observations to be >0.083, indicating no highly influential data points. As a result, no observations were excluded from the data set.

DISCUSSION

Although RYGB is highly effective and increasingly utilized as a treatment of severe obesity, little is known about the mechanisms by which it causes durable weight loss. As part of a larger effort to explore mechanisms of action of this procedure, the present study sought to identify patient characteristics, detectable preoperatively, that predict the magnitude of weight loss after surgery. We found that limited physical activity, higher initial BMI, lower education level, diabetes, and poor attendance at postoperative appointments all predicted more limited weight loss in the first year after RYGB.

Similar to what is has been observed previously, patients in this cohort demonstrated high variability in weight loss after surgery (27–29,35). Percent excess body weight loss followed a normal distribution with a mean of 64.8% and a standard deviation of 20.5% (**Figure 1**). Notably, only one patient (0.4%) became underweight (in association with a postoperative complication), only 3.7% achieved or exceeded 100% excess weight loss, and no patients gained weight after this operation. It is unlikely that a single variable is driving this normal distribution of postoperative weight loss; it is more likely explained by a complex interaction of multiple genetic, biological, and environmental factors.

Several recent studies have identified factors that predict weight loss after bariatric surgery. However, many have focused on only one (40,42) or a few factors (24,27,34,38,39), often with small sample sizes (9,24,38,41–43), low participation rates, and/or high loss to follow-up (9,24,28,41,48). In addition, some studies tested each factor in a different patient subgroup depending on how many participants had data for that factor (37,48). Many studies have looked at the effect of the predictor(s) without being adjusted for any other variables (28,40,48,49), such as other predictors or potential confounders, while other studies have only adjusted for a very limited number of factors (9,24,27,29,36–39,41,43). In the present study, we sought to extend our understanding of the predictors of weight loss after RYGB surgery and address many of the limitations of previous studies by securing complete data for a large number of patients, testing a wide variety of potential predictors, and testing for a number of potential confounders.

We observed that higher initial BMI was associated with lower percent excess body weight loss after surgery. The direction of this relationship is in contrast to studies that have used a measure of absolute weight rather than percent excess weight loss (34). Indeed we found that higher initial BMI was associated with greater absolute weight loss (I.J.H. and L.M.K., unpublished data); however, we and others feel that percent excess body weight loss is a more clinically meaningful outcome measure. Our findings are consistent with most previous studies that have looked at initial BMI (27,29,35–37). They are discrepant with the observations of Averbukh *et al*. (24) who found that higher initial BMI was related to a greater percent excess weight loss following RYGB. In that study, however, the sample population was small ($n = 47$) and the follow-up rate was low (32%), so these findings may not be broadly generalizable. In a study of predictors of weight loss following laparoscopic adjustable gastric banding (LAGB) that used the same outcomes as in the study reported here, Dixon *et al*. (37) found that higher initial BMI was related to diminished weight loss in the first year after the procedure; however by the second year of follow-up initial BMI was no longer predictive. This pattern may be explained by the fact that because larger patients have more absolute weight to lose, they would have to lose weight at a faster rate than their lighter counterparts in order to achieve the same percent of excess body weight lost in the first year after surgery. Diminished excess weight loss in those with higher initial BMI may also reflect the greater severity of the underlying biological causes of obesity and inability of the surgical procedure to fully overcome these drives. Although biologically interesting, we do not believe higher initial BMI as a predictor of diminished weight loss has strong clinical implications. Weight loss surgery is generally reserved for patients with severe obesity, and restricting access to these operations on the basis of higher initial BMI would exclude those who are most likely to receive the greatest health benefits from having the procedure. Although higher initial BMI may predict decreased short-term (1 year) weight loss, the long-term benefit of RYGB likely far exceeds the modest short-term limitations.

Limited physical activity (LPA) was a second strong predictor of decreased weight loss 1 year following RYGB. Relative to people who are not activity restricted, those with limited physical activity exhibited an average 17.2% less excess weight loss. This observation is similar to one made by Dixon *et al*. (37), who found that after LAGB poor physical ability, as measured by the physical component summary of the SF-36, predicted diminished postoperative weight loss.

Our findings about the predictive value of LPA are notable in light of recent studies using animal models of RYGB that demonstrated an increase in resting energy expenditure after RYGB. This observation belies conventional wisdom, which would predict that a decrease in caloric intake from food restriction or dieting would generate a counterregulatory response that decreases total energy expenditure as the body attempts to maintain stable energy stores (50,51). Patients do decrease their caloric consumption after RYGB, so it would be logical to assume that these patients might similarly compensate with lower energy expenditure. In contrast, our group has recently shown that rats that have undergone RYGB both decreased food intake and increased resting and total energy expenditure (13% increase in VO_2 by indirect calorimetry; N. Stylopoulos and L.M.K., unpublished data). This increase in total energy expenditure accounts for up to 50% of the animal's weight loss following RYGB. These observations may help explain the predictive value of limited physical activity. Patients with restricted physical activity may not be able to take full advantage of the physiological drive to adjust energy expenditure following this operation.

Because in this study we examined only presurgical patient characteristics, we do not know to what extent preoperative LPA reflects physical activity following RYGB. Predictive value might be even greater in the subset of patients who are physically unable to be active postoperatively. Due to limitations associated with the use of existing data, we also do not know if those with LPA were categorized because of an inability (e.g., from a medical condition such as osteoarthritis, diabetes complications, or severe deconditioning) or an unwillingness to engage in physical activity. Perhaps those who are unable to be active continue to be inactive following surgery, whereas those who chose not to be active before surgery tended to modify their behavior postoperatively. This distinction between an inability and unwillingness to engage in physical activity may be significant in its implications for the development of pre- and postoperative surgical protocols for patients with these two characteristics. For example, patients with an inability to move might be encouraged to complete a preoperative rehabilitation or exercise program to improve their preoperative conditioning, while patients who choose not to be active might benefit from focused education on the importance of pre- and postoperative activity.

This study confirms previous findings that patients with type 2 diabetes exhibit diminished weight loss after surgery (26,27,37). From a clinical standpoint, the magnitude of the relationship between diabetes and less weight loss is small (6.2% less excess weight loss among diabetics) relative to the substantial and direct beneficial effect of weight loss surgery on the diabetes itself (7,52,53). Several studies have documented a dramatic improvement or resolution of diabetes following RYGB (7,8,54–56). Therefore, the somewhat diminished weight loss in this population should have limited import in clinical decision making. In addition, in this study insulin dependence did not have an effect beyond the presence of diabetes. One way to interpret this finding is that although diabetes influences weight loss after surgery, the *severity* of the diabetes, as marked by the presence or absence of insulin dependence, did not affect weight loss following surgery. Biologically, because we did not sensitively measure postoperative resolution of diabetes it is possible that those patients who did not return to euglycemia and may be on weight-promoting medications to treat the diabetes are driving this apparent relationship. It is also possible that diabetes and obesity may share common genetic or other biological characteristics such that diabetes enhances the drive toward excess body fat.

Education level was directly related to weight loss with patients having a higher level of education experiencing greater weight loss after surgery. Those who had attained the highest level of education (postgraduate degree) lost 7.8% more excess weight than those with the lowest level of education (less than a high school diploma). Similar results have been found for nonsurgical methods of weight loss (57–60). The mechanism by which education levels might affect postoperative weight loss is not entirely clear. Education may serve as a proxy for socioeconomic status (SES) (61), which has been shown to be related to higher levels of stress that may then inhibit weight loss or cause weight gain (62–64) via activation of the hypothalamic–pituitary–adrenal axis (65–68). Furthermore, low SES has been shown to be associated with increased consumption of foods with high energy density but low nutritional value (69–72). Education may also be serving as an indicator of other factors such as free time, patient attitudes, comprehension of pre- and postoperative materials, or other patient characteristics.

Finally, more frequent attendance at follow-up appointments in the year after surgery was associated with greater weight loss. This effect may reflect a correlation between motivation to attend appointments and motivation to follow an optimal postoperative regimen. It may also reflect the value of postoperative patient education, with those attending more appointments receiving the most information. Together with the observation that education was predictive of weight loss following surgery, these data suggest that postoperative programs should be tailored to ensure that patients are able to fully participate in and comprehend the pre- and postoperative protocols, and patients should be educated regarding the benefits of regular follow-up.

Notably, depression, increased age, and being married, which have previously been shown to be associated with decreased weight loss following bariatric surgery (24,27,29,35,37,38), were not associated with weight loss in this cohort. These disparate observations may be due to methodological differences, the limited size of previous studies, different methods of adjustment, or inherent differences in the populations studied. Limitations in the design of the present study may also contribute to the disparate results. This study was conducted as a chart review where the source information was dependent on preexisting clinical data, which may have led to measurement error or misclassification. This limitation may be particularly relevant in the assessment of factors such as depression; we detected depression based on a diagnosis noted in the patient's medical record. While all patients at the center were evaluated both clinically and with the Beck Depression Inventory, other studies have used more comprehensive assessments (24,38). In addition, our study population was racially homogenous and thus the observations may be limited in their generalizability. To overcome these limitations, it will be necessary to determine if these findings are replicated in studies that encompass diverse populations.

In summary, this study identified higher initial BMI, limited physical activity, diabetes, lower education level, and fewer postoperative appointments attended in the year following surgery as predictors of less weight loss after RYGB. These five factors accounted for ~40% of the variability in percent excess weight loss in this cohort. Thus, although these factors help explain a large proportion of variability in outcome after surgery, other predictive factors remain to be identified. The known physiological effects of RYGB and the wide and normal distribution of weight loss after RYGB suggests an important role for biological factors in determining weight loss. Perhaps more sophisticated assessment of genetic and physiological parameters will reveal these other predictive factors.

Of the characteristics identified in this study, limited physical activity deserves particular attention both because the magnitude of the effect is clinically meaningful and this characteristic is potentially modifiable. It may prove to be beneficial for patients who have limited capacity for physical activity to engage in individualized rehabilitative efforts before and after surgery in order to maximize their ability to enhance energy expenditure. It may also be beneficial to build physical activity training and education into pre- and postoperative care guidelines. Similarly, preoperative educational programs should be tailored to the comprehension level of the patient, and patients should be encouraged to attend all postoperative appointments. Based on the observations reported here, it would be valuable to pursue prospective trials of these interventions to augment the efficacy of RYGB and other forms of weight loss surgery. We cannot suggest that these five predictors of limited weight loss after RYGB be viewed as contraindications to surgery, as patients with these characteristics nevertheless benefit from the substantial weight loss following the surgical intervention. Rather, as prospective studies identify those factors that most affect outcomes and complications of this procedure, we anticipate that by using knowledge of these predictors to optimize patient selection and provide appropriate perioperative interventions, we can enhance the efficacy and safety of weight loss surgery.

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DISCLOSURE

The authors declared no conflict of interest.

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