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CLINICAL RESEARCH

Understanding Dietary Monitoring and Self-Weighing by Gastric Bypass Patients: a Pilot Study of Self-Monitoring Behaviors and Long-Term Weight Outcomes

Amanda Lynch · Carole Bisogni

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Abstract
Background Weight and dietary monitoring have been associated with better weight loss outcomes among dieters using lifestyle modification, but they have rarely been studied among gastric bypass surgery patients. This exploratory study examined dietary and weight self-monitoring behaviors and their association with weight outcomes in a sample of gastric bypass patients who were at least 12 months post-surgery.
Methods A convenience sample of 32 female and 5 male patients living in Upstate New York was recruited through support group list-servs. The participants completed an anonymous on-line survey about their weight histories, surgical histories, current weights, dietary monitoring practices, weight monitoring practices, and demographic characteristics. Measures were developed to assess frequency of monitoring behaviors (recording food intake, mentally tracking food, weighing/measuring foods, and self-weighing). Weight loss outcomes, based on self-reported weights, were current body mass index (BMI), percent excess BMI lost, and percent weight loss maintained.
Results Mean pre-surgical BMI was 49.5±6.6. The participants were at an average of 32 months post-surgery with a BMI 31.2±6.6. They maintained 89.2±14.1 % of their weight loss and 76.3±26.0 % excess BMI was lost. Higher scores for dietary monitoring behaviors, being unmarried, and lower pre-surgery BMI were associated with lower current BMI and greater excess BMI lost when controlling for age, sex, and time since surgery.
Conclusions This study yielded constructs, measures, and relationships that warrant further examination in a larger sample of gastric bypass patients.

Keywords Gastric bypass surgery · Self-monitoring · Dietary self-monitoring · Weight monitoring

Introduction

The role of self-monitoring behaviors in long-term weight outcomes for gastric bypass patients warrants investigation because these behaviors have been linked with successful weight outcomes in adults using lifestyle modification approaches. More frequent and consistent habits of self-weighing have been associated with greater weight loss maintenance among dieters [1–3]. Dietary monitoring has also been associated with greater weight loss [4, 5], though frequency of monitoring efforts may be an important factor [6].

Self-monitoring is a key component of the self-regulation of behavior [7, 8]. It is part of a "feedback loop" in the self-regulation of behavior, allowing for adjustments in behavioral performance [9, 10] that can lead to behavior change. From this theoretical perspective, keeping food records or measuring food intake would raise patients' awareness of their dietary choices and quantity of intake, while checking weight with a scale would alert post-gastric bypass patients to changes in their weight. Both monitoring behaviors would therefore prompt patients to make salient and timely changes.

Existing data about the monitoring behaviors of gastric bypass patients are limited. In one survey examining habits of long-term gastric bypass patients, weekly self-weighing

A. Lynch (✉)
Oakland University,
2200 N. Squirrel Rd,
Rochester, MI 48309, USA
e-mail: ail7@cornell.edu

C. Bisogni
Cornell University,
183 Martha Van Rensselaer Hall,
Ithaca, NY 14853, USA
e-mail: cab20@cornell.edu

and taking personal responsibility for weight were reported by gastric bypass recipients who maintained 74 % of their weight loss [11]. However, details of questions regarding self-weighing frequency or personal responsibility were not presented. Another study found that a majority of participants weighed themselves monthly or one to two times a week [12], though this behavior was not assessed in relation to weight loss or current body mass index (BMI).

This exploratory study developed and pilot-tested an online survey to examine the relationship between dietary and weight self-monitoring practices of gastric bypass patients and their self-reported weight outcomes. The hypothesis was that the increased use of dietary and weight self-monitoring practices would be associated with better long-term weight loss outcomes in gastric bypass patients at least 12 months post-surgery.

Materials and Methods

Participant Recruitment A convenience sample of participants was recruited from five bariatric surgery support groups in Upstate New York that met in person but also had electronic list-servs. Three support groups were associated with surgical centers and two were peer-run. Groups varied in size from 12 to over 40 members. Support groups were open to both pre- and post-surgery patients and included recipients of gastric bypass, gastric banding, and other bariatric operations. The participants were recruited through e-mails sent through support group list-servs. One group leader was able to send e-mails only to gastric bypass recipients, and the response rate from these patients was 33 %. The other four group leaders did not have access to the participants' bariatric surgical status. Therefore, the number of potential respondents who met inclusion criteria was unknown and a total survey response rate could not be determined.

Following a modified tailored design method [13], the researcher contacted group members three times, with each contact being through the group leader or list-serv manager to ensure anonymity. The researcher received confirmation from the group leader after he or she forwarded each e-mail to the group. The first contact informed participants of the study and alerted them to a future e-mail containing a link to the survey. The second contact again described the study and contained an active link to the survey. The final contact was sent a week after the first to thank individuals who participated and remind those who had not that they could still participate. The study was described again and a link to the survey was provided. An electronic consent form was presented as the first page of the survey. Only participants who chose "continue" were permitted to fill out the survey. The institutional review board of the researchers' sponsoring university as well as hospital review boards approved all aspects of the study, including the questionnaire, recruitment method, and consent process.

Survey Questions and Constructs The survey consisted of 58 questions and took an average of 16 minutes and 45 second to complete, as indicated by timestamps on the surveys. This study reports on the questions related to weight history, dietary monitoring practices, weight monitoring practices, and demographic characteristics.

Information about weight outcomes was gathered through questions asking participants to report (in pounds) pre-surgery weight, lowest post-surgery weight, current weight, and highest adulthood weight. Participants were also asked to report the number of months after surgery at which they reached their lowest weights and how many months they had been at their current weight. Finally, they were asked to report their height (in feet and inches).

Dietary self-monitoring was defined as the behavioral and mental efforts of keeping track of what and how much one ate. Behaviors assessed were keeping food records, mentally tracking food and drink consumed, and weighing or measuring food. Weight self-monitoring was defined as any effort to keep track of weight. Items were developed to assess the frequency with which individuals checked their weight with a scale.

Each dietary and weight self-monitoring behavior of interest was assessed in two different ways. One question asked how many days in the past week participants had performed a self-monitoring behavior. A second question asked participants how frequently they performed self-monitoring behaviors (never, once a year, several times a year, once a month, several times a month, once a week, several times a week, once a day, several times a day). Questions were developed by the researcher with input from weight self-monitoring surveys [14].

Demographic questions included sex, age, education level, income, marital status, race/ethnicity, and employment. Participants were asked to indicate the type of surgery they had most recently and the date of their surgery.

An expert panel was used during the process of drafting, revising, and finalizing the questionnaire to ensure content validity [15]. The expert panel consisted of nutrition professionals familiar with survey development, self-monitoring, obesity, and weight loss. One member had experience counseling pre-gastric bypass surgery patients. Also on the panel was a gastric bypass recipient and former bariatric surgery support group leader. The expert review ensured that items were relevant to the constructs, that other salient constructs or topics had not been overlooked, and that items were clear and concise [15].

On-line Survey The final questionnaire was transferred to an on-line format following the guidelines of Dillman [13]. This method uses social exchange theory as the basis for understanding influences and motivations for participant compliance in answering surveys. The guidelines address the design of the survey, the messages attached to the survey, and the procedure for soliciting and following up with potential participants to increase participation [13].

Checkbox ® 4.4.0.5 (Prezza Technologies, Inc.) was used to host the on-line survey and was approved by the researchers' university insitutional review board as a secure on-line survey program. Prior to sending the survey to the group leaders, the researcher enlisted volunteers to evaluate the on-line survey for readability and accessibilty. These pre-pilot testers took the survey on several different computers and operating systems to ensure consistency in appearance and usability. Through this process, the researcher identified and fixed issues that had the potential to hinder survey responses.

Weight Outcome Variables To compute the weight outcome variables, weight data provided by participants were converted to kilograms and height data were converted to meters. The calculations for weight outcome variables are shown in Table 1. Current BMI, percent excess BMI lost, and percent weight loss maintained were examined due to their relationship with different indicators of success after gastric bypass surgery. Current BMI can also be compared to the reference standards of healthy weight (BMI 18.5–24.9), overweight (BMI 25–29.9), and obese (BMI >30) [16].

Self-Monitoring Measures To develop the scales for self-monitoring behaviors, item frequencies for dietary recording, mental tracking, weighing and measuring food, and checking weight with a scale were assigned values 0 (never) to 8 (several times a week). The number of days in the past week that these same behaviors were performed was coded as the actual number of days, with a possible range of 0 to 7.

A scale was developed for dietary self-monitoring by summing the item responses [15]. Intially, six dietary self-monitoring variables were included, but the mental tracking items were negatively correlated with the other dietary self-monitoring variables. Therefore, a four-item scale (two record-keeping items, two weighing/measuring items) was created.

Demographic Characteristics The analysis considered the sex (male vs female), age (years), and time since surgery (months). Marital status was transformed into a dichotomous variable (married vs unmarried) by combining the "single, never married" and "single divorced" because there was no significant difference (using LSD comparison) in the weight outcomes of these two groups. Income was treated as a categorical variable with eight categories, with each category representing the annual household income in increments of $10,000 starting from $10,000–19,000. Education was also treated as a categorical variable, with four categories: high school diploma, some college, college graduate, and graduate degree.

Statistical Analysis SPSS 18 (IBM, 2010) for Windows was used for all analyses. Means and standard deviations were calculated for quantitative descriptive variables and frequencies for categorical variables. General linear models were used to assess relationships between weight outcomes and the independent variables at the level of significance of $p \leq 0.05$, with co-variates or co-factors added in as noted. Interactions were tested for dietary self-monitoring, weight self-monitoring, and marriage and were not found to be significant.

ANOVAs were used to examine associations between the three weight outcome variables and each of the following variables: four-item dietary self-monitoring scale, two-item weight self-monitoring scale, pre-surgery BMI, marital status, sex, income, and education. Then, simultaneous regressions were run to examine the relationship of the two self-monitoring scales with the other variables that had significant associations with weight outcome variables. Next, these models were examined, controlling for time since surgery, age, and sex. Finally, all of the models were examined with the data only from the 30 participants who were over 18 months post-surgery as the group differed in weight regain

Table 1 Calculations for weight outcome variables

Variable	Calculation
BMI	Weight (kg)/height $(m)^2$
Total weight lost (kg)	Pre-surgery weight − lowest post-surgery weight
Net weight lost (kg)	Pre-surgery weight − current weight
% weight loss maintained	Net weight lost/total weight lost
Excess BMI	BMI − 25
% excess BMI lost	[(Pre-surgery BMI − current BMI)/Pre-surgery excess BMI]×100

compared to participants between 12 and 17 months post-surgery.

Results

Participant Characteristics The 32 female and 5 male participants had a mean age of 48.6 ±7.6 years. Sixty-eight percent were married, 84 % lived with a spouse or significant other, and 75 % were employed full time. Table 2 shows the demographic characteristics of the participants. At the time of the survey, the participants were at an average of 32.6±22.1 months post-surgery, with a range of 12–129 months. Two participants had surgery times beyond two standard deviations: one was 86 months post-surgery and the other 129. When the outliers were removed from calculations, the average time since surgery dropped to 28.3 ±11 months. These two outliers were kept in the data analysis as this was the only value in which they were extreme. The participants originated from five different support groups, but only 22 % (n=8) of participants attended support group meetings once a month or more, while the remainder attended meetings six times a year or fewer (n=22) or never (n=6). Thus, not all participants who were members of the support group e-mail list-serv attended support group meetings in person.

Table 2 Demographic characteristics of gastric bypass patients participating in survey (n=37)

	Frequency
Age, mean (± SD) 48.6 years ±7.6, range 30–62	
Sex	
Female	32
Male	5
Race/ethnicity	
White/Caucasian	37
Marital status	
Married	25
Single/divorced	7
Single/never married	5
Education	
High school diploma/GED	8
Some college (1–3 years)	11
College degree	13
Post-graduate degree	5
Employment	
Full-time	28
Part-time	3
Unemployed	3
Household income	
$10,000–19,000	1
$20,000–29,000	2
$30,000–39,000	2
$40,000–49,000	3
$50,000–59,000	3
$60,000–69,000	6
$70,000–79,000	9
Over $80,000	10

Weight Outcomes Mean pre-surgery BMI was 49.5±6.6, and mean weight was 136.1±24.2 kg. Mean maximum reported weight loss was 55.8 ±20.0 kg, with the participants reporting reaching their lowest weight at approximately 15.7 ±7.3 months. Mean lowest post-surgery BMI was 29.0 ±0.9. At this time, the participants had achieved a mean decrease of 20.4±7.0 BMI units. Table 3 summarizes the participants' weight loss outcomes.

Mean current BMI was 31.2±6.6 with a range from 17.1 to 45.8. Figure 1 presents each participant's weight loss pattern in BMI units at three time points: pre-surgery, lowest post-surgery weight, and current weight. At the time of the study, four (10.8 %) participants reported current weight and height data that placed them in the healthy BMI range, 14 (38 %) were overweight, and 18 (49 %) were obese. One participant was underweight with a BMI of 17.4.

At the time of the survey, mean percent excess BMI lost was 76.3±26.0 % with a range of 23 to 145 %. This was based on a net change in BMI of 18.2±7.1 units and a current mean excess BMI of 6.2±6.6 units. The mean percent of weight loss maintained was 89.2 ±14.1 % at the time of the survey.

Self-Monitoring Behaviors

Self-Monitoring Scales The four-item dietary self-monitoring scale had a Cronbach's alpha internal consistency reliablity of 0.85, a mean of 8.35±10.14, and a range of 2 to 32. The weight self-monitoring scale included the two weight self-monitoring items and had Cronbach's alpha of 0.87, a mean of 7.83±4.06, and a range of 3 to 16. The dietary and weight self-monitoring scales were not significantly correlated with one another (r=0.24, p=0.17).

Dietary Self-Monitoring The participants varied in their dietary self-monitoring behaviors. Twenty-five (68 %) participants said they never wrote down what they ate or drank, while only seven (19 %) said they did this several times a week or more. In contrast, 28 (76 %) said that they mentally kept track of what they ate and drank at least several times a week. The popularity of mentally tracking intake versus keeping food records was also shown in the participants' reports of the

Table 3 Summary of gastric bypass patients' weight loss outcomes based on participants' self-reported data in an on-line survey (n=37)

Variable	Mean ± standard deviation (range)
Current BMI Weight (kg)/height (m)^2	31.2 ±6.6 (17.1−45.8)
Total weight lost (kg) Pre-surgery weight − lowest post-surgery weight	55.9±20.1 (25.0−101.4)
Net weight lost (kg) Pre-surgery weight − current weight	50.1±19.9 (25−101.4)
Weight regained (kg) Current weight − lowest pre-surgery weight	5.8±7.5 (00−26.82)
Total weight loss, % Total weight lost/pre-surgery weight	40.6 ±11.1 (18−65)
Weight loss maintained, % Net weight lost/total weight loss	89.2 ±14.1 (45−100)
Total change BMI Pre-surgery BMI − lowest post-surgery BMI	20.4±7.0 (8.38−37.94)
Net change BMI Pre-surgery BMI − current BMI	18.2 ±7.1 (5.5−36.7)
Current excess BMI Current BMI − 25	6.2±6.6 (−7.59−20.83)
Excess BMI lost, % [(Pre-surgery BMI − current BMI)/Pre-surgery excess BMI]×100	76.3±26.0 (23.0−145.0)

number of days per week on which they used these ways of keeping track of their intake. Sixteen (43 %) participants reported measuring or weighing their food several times a week or more. Twenty (54 %) never weighed or measured their food.

Weight Self-Monitoring Twenty-seven (73 %) participants reported weighing themselves once a week or more, and only ten (27 %) participants stated they had not weighed themselves in the past week. The mean number of days per week that the participants weighed themselves was 2.6 ±2.6,

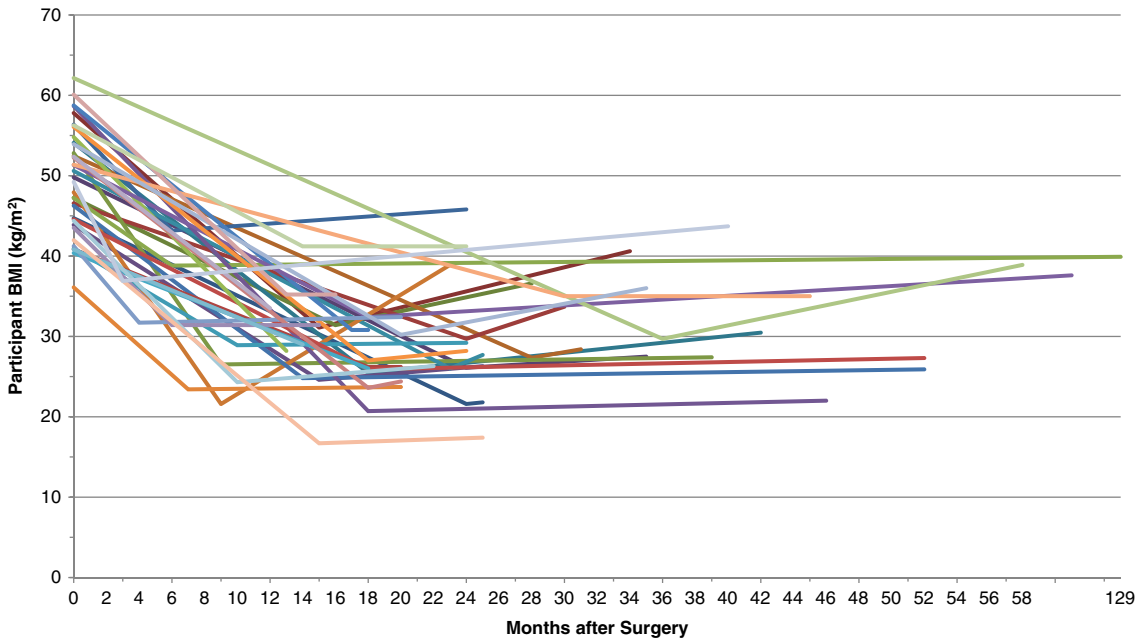

Fig. 1 Weight loss outcomes among gastric bypass patients presented as BMI before surgery, at lowest weight post-surgery, and at time of survey (n=37)

with a range of 0 to 7 days a week. One participant did not report the number of days in the past week he/she weighed himself/herself, and this was excluded from the analyses of weight outcomes.

Table 4 offers a more detailed description of participants' frequencies of self-reported dietary and weight self-monitoring frequencies. Response categories have been collapsed to indicate partcipants who performed a self-monitoring behavior at least one time per week/month/year or never, providing a contrast between those who very frequently monitor (weekly or daily) and those who never or very infrequently monitor their weight or diet.

Self-Monitoring Behaviors and Weight Outcomes The four-item dietary self-monitoring scale was negatively related to current BMI (p=0.019) and positively related to both percent excess BMI lost (p=0.007) and percent weight loss maintained (p=0.015). The weight self-monitoring scale was not significantly related to current BMI nor percent excess BMI lost; however, it was positively related to percent weight loss maintained (p=0.025).

When dietary and weight self-monitoring scales were entered into the model together (as main effects), only dietary self-monitoring was significantly related to current BMI (p=0.034) and excess BMI lost (p=0.012). Neither was significantly related to percent weight loss maintained.

Demographic Characteristics and Weight Outcomes Being married was positively associated with current BMI (F(1,35)=8.974, p=0.005, B=6.292) and negatively associated with percent excess BMI lost (F(1, 35)=12.751, p=0.001, B=−0.283). Marital status was not associated with percent weight loss maintained. Pre-surgery BMI was positively associated with current BMI (F(1,35)=7.597, p=0.009, B=0.426), but it was not significantly related to excess BMI lost or percent weight loss maintained. Time since surgery, sex, age, frequency of support group attendance, income, and education were all unrelated to current BMI, percent excess BMI lost, and percent weight loss maintained.

Regression Models for Weight Outcomes Simultaneous regressions were run to first examine how the three weight outcomes were explained when the dietary self-monitoring scale, weight self-monitoring scale, marital status, and pre-surgery BMI were considered together. These models were examined while controlling for time since surgery, followed by models that also controlled for age and sex. Therefore, three models were examined for each of the three weight outcome variables.

Dietary self-monitoring, pre-surgery BMI, and marital status were significantly related to current BMI (F(4, 31)=7.277, p<0.001, r^2=0.418) and remained significant when controlling for time since surgery, age, and sex (F(7,28)=3.821, p=0.008). In the final model, higher current BMI was associated with lower dietary self-monitoring scores (B=−0.221, p=0.022), being married, (B=5.062, p=0.013), and having a higher pre-surgery BMI (B=0.427, p=0.003). The adjusted r^2 for the final model was 0.418, indicating that 41.8 % of the variance in current BMI was explained by pre-surgery BMI, marital status, and dietary self-monitoring when controlling for time, age, and sex. Weight self-monitoring was not related to current BMI in any of the models.

Dietary self-monitoring (B=0.962, p=0.011), pre-surgery BMI (B=−1.181, p=0.032), and being married (B=-22.60) were significantly related to percent excess BMI lost (F(4,31)=6.051, p=0.001, r^2=0.366). The relationship remained significant when controlling for time since surgery, age, and sex only for dietary self-monitoring (B=0.917, p=0.018) and marital status (B=−22.8, p=0.006, F(7,28)=4.12, p=0.003, r^2=0.384). Higher scores on dietary self-monitoring were associated with greater percent

Table 4 Self-reported frequencies of dietary and weight self-monitoring behaviors by gastric bypass patients participating in an on-line survey (n=37)

	Frequency of keeping food records	Frequency of mentally tracking food and drink	Frequency of weighing or measuring food	Frequency of checking weight with a scale
Once a day or several times a day	16.2 % (6)	81.1 % (30)	27.0 % (10)	27.0 % (10)
Once a week or several times a week	2.7 % (1)	10.8 % (4)	16.2 % (6)	45.9 % (17)
Once a month or several times a month	2.7 % (1)	5.4 % (2)	0	21.6 % (8)
Once a year or several times a year	10.8 % (4)	0	2.7 % (1)	5.4 % (2)
Never	67.6 % (25)	2.7 % (1)	54.1 % (20)	0
Total	100.0 % (37)	100.0 % (37)	100.0 % (37)	100.0 % (37)

excess BMI lost, while being married was associated with less percent excess BMI lost. Pre-surgery BMI was significantly and negatively related to percent excess BMI lost when controlling for time but was no longer significant when controlling for age and sex. Weight self-monitoring was not significantly related to percent excess BMI lost in any of the models.

None of the variables was significantly associated with percent weight loss maintained in any of the models, though dietary self-monitoring approached significance when controlling for time since surgery ($p=0.056$).

Patients Beyond 18 Months These sequences of regressions were repeated with only the 30 participants who were more than 18 months post-surgery. ANOVAs comparing percent weight loss maintained of participants between 12 and 18 months post-surgery and those beyond 18 months indicated that there was a significant difference between the groups ($F(1,35)=5.618$, $p=0.023$). Mean percent weight loss maintained of the 12–18-month group was 99.9±0.05 % (mean regain, 0.1 %), and mean percent weight loss maintained of the other group was 86.7.±0.02 % (mean regain, 13.3 %). The two groups did not differ in excess BMI lost, pre-surgery BMI, or self-monitoring scores. Nineteen months was the earliest time from surgery that any participant reported experiencing weight regain in the group beyond 18 months post-surgery.

Excluding participants less than 18 months post-surgery in the regression models yielded results similar to the models with these participants included. When controlling for time, age, and sex, dietary self-monitoring ($B=-0.243$, $p=0.047$) and pre-surgery BMI ($B=0.497$, $p=0.015$) were significantly related to current BMI ($F(7, 21)=3.821$, $p=0.008$, $r^2=0.414$), though marital status was not related ($p=0.104$). In the model examining excess BMI lost, dietary self-monitoring ($B=1.01$, $p=0.034$), pre-surgery BMI ($B=-1.48$, $p=0.041$), and marital status ($B=-22.03$, $p=0.039$) were significantly related to excess BMI lost ($F(4,24)=5.266$, $p=0.003$, $r^2=0.379$). When controlling for time since surgery, only dietary self-monitoring ($B=1.06$, $p=0.023$) remained significantly related to excess BMI lost ($F(4,24)=3.432$, $p=0.013$, $r^2=0.378$). This relationship was no longer significant when controlling for age and sex ($p=0.053$).

Only dietary self-monitoring ($B=0.537$, $p=0.049$) was significantly related to percent weight loss maintained for patients beyond 18 months post-surgery ($F(4, 24)=3.111$, $p=0.034$, $r^2=0.232$). When time, age, and sex were added to the model, the relationship between dietary self-monitoring and percent weight loss maintained was no longer significant ($p=0.081$).

Discussion

This study explored the relationships between self-monitoring behaviors and weight loss outcomes following gastric bypass surgery in patients who were 1 year or more post-surgery. Results support the hypothesis that dietary self-monitoring, but not weight self-monitoring, behaviors were related to positive weight outcomes. However, the relationships were complex in that marital status and pre-surgery BMI played important roles in explaining weight outcomes. Participants who more frequently monitored their diet had lower pre-surgery BMIs, and those who were unmarried, had lower BMIs and lost a greater percent excess BMI compared to those who less frequently monitored their diet, were married, and had higher pre-surgery BMIs. When only including participants who were more than 18 months post-surgery in the analysis, relationships were maintained. None of the independent variables was significantly related to percent weight loss maintained when all participants were included in the analysis; however, among those beyond 18 months, dietary self-monitoring was significantly and positively related to percent weight loss maintained.

The finding that pre-surgery BMI is positively related to current BMI and negatively related to excess BMI lost is consistent with prior bariatric surgical reports [12, 17–19]. Individuals with higher BMIs have a greater amount of excess BMI to lose. Thus, even if they experience the average reduction in BMI, this still places them at a higher BMI with less excess weight loss [20, 21].

In this study, marital status had the largest impact on current BMI and percent excess BMI lost. Being married was associated with an increase of five BMI units and a 22-% decrease in excess BMI lost. The finding that marital status is positively related to current BMI is consistent with findings that married persons are heavier than single (unmarried) persons in general [22, 23]. In addition, at least one other study has found greater weight loss among single gastric bypass patients compared to their married counterparts [24].

It is unclear why married persons might be heavier or lose less weight compared to non-married individuals. The "marriage market hypothesis" contends that single persons have lower BMIs which are desirable to potential mates, and once married, the drive to maintain this weight lessens [23]. However, the marriage market hypothesis may not fully explain the weight differences between married and unmarried gastric bypass recipients. One study identified marriage satisfaction as positively influencing successful weight loss outcomes among female gastric bypass recipients [25], suggesting the importance of supportive spouses. Lack of support from spouses could negatively impact weight loss by limiting the patients' ability to make changes in the shared food environment. Conversely, it may be difficult to change

shared habits and behaviors within the context of marriage. Reasons for differential weight loss in married versus unmarried persons is an area for future inquiry; however, including spouses in pre- and post-surgery counseling may be an important aspect of setting patients up for long-term success.

Dietary self-monitoring was negatively associated with current BMI and positively associated with excess weight loss, consistent with findings among non-surgical dieters [4, 6]. The act of recording intake or controlling portions may raise awareness of food choices and quantity of food consumed, which in turn can directly impact calorie consumption. Increases in dietary self-monitoring frequency could have small but meaningful changes in weight outcomes. Interpreting the dietary self-monitoring regression model coefficients, the following theoretical impact emerges: Moving from never recording intake to recording once a week (an increase of five points in the dietary monitoring scale) would be associated with a decrease in BMI of one unit and an increase of 4.8 % excess BMI lost.

In addition, dietary self-monitoring was the only independent variable associated with percent weight loss maintenance, but only once those less than 18 months post-surgery were excluded. Vigilance in dietary intake may become more important as time goes on. Weight regain begins between 2 and 3 years post-surgery [4, 6], possibly due to the return of previous eating habits or hunger [26]. Dietary monitoring may prevent the recurrence of these behaviors by promoting the newly established eating behaviors.

Weight self-monitoring was not related to current BMI or excess BMI lost. It was related to percent weight loss maintained only when other independent variables were not included in the models. This is in contrast to consistent reports of the positive relationship between self-weighing and weight loss outcomes among non-surgical dieters using lifestyle modification [27]. The lack of relationship of weight self-monitoring may be due to the lack of statistical power, the lack of variablity in participants' self-weighing habits, and lack of variability in percent weight loss maintenance.

Only one other study has examined the role of dietary self-monitoring after gastric bypass surgery. Odom and colleagues [28] found that keeping records and regular self-weighing were associated with weight loss maintenance among gastric bypass patients 2 years post-surgery. As the two self-monitoring methods were combined in their analysis, it is unclear if there were separate effects of the two methods as were found in this study.

The three outcome measures chosen (current BMI, percent excess BMI lost, and percent weight loss maintained) represent different types of long-term outcomes. Although a controversial measure of health and body fat [29, 30], BMI was chosen as an outcome measure due to its prominence as a reference to health and its frequent use as both a descriptive and outcome variable in obesity surgery research. Percent excess BMI lost has been identified as an ideal standard for comparing weight loss across studies of bariatric surgery [31] as change in BMI is a better indicator of loss of body fat than change in weight in kilograms. Percent excess BMI provides a measure of how much weight patients lost compared to how much they needed to lose to reach a BMI of 25, the upper limit of a healthy BMI and would ideally be 100 % or more. Both current BMI and excess BMI lost are related to the amount of weight an individual lost as a result of the surgery and are direct outcomes of the surgery itself and the dietary restrictions imposed by the surgery. They are also influenced by other factors which might promote a heavier weight, such as marriage. On the other hand, percent weight loss maintained captures how successful individuals have been at maintaining weight loss, irrespective of total weight lost or current BMI. Percent weight loss maintained would be due to the ability to persist in dietary and lifestyle changes, which may explain why dietary self-monitoring was the only variable related to percent weight loss maintenance.

A limitation of this study was the use of self-reported heights and weights, which participants were asked to recall from past time periods. Another limitation was the small, convenience, non-random sample from a select set of support groups in one location which limits the applicability of the results to the gastric bypass population in general. Although study participants were from both peer-run and practitioner-run groups and had diverse educational and economic backgrounds, the sample was predominantly White females and, therefore, not representative of the experiences of minorities or men. However, the mean age (48.6 years) and percentage of women (86 %) is similar to patient characteristics in larger studies [32]. The participants in this study may also be more motivated and engaged in their weight management efforts than the average post-surgical patient. However, only 22 % of participants reported attending support group meetings once a month or more, suggesting that their level of engagement does not extend to support group attendance. Motivation and engagement may be a necessary component to successful weight loss in this population as has been suggested based on studies of successful dieters using lifestyle approaches [27, 33].

The relationships uncovered in the analysis do not provide evidence for a causal effect. It cannot be ascertained if dietary self-monitoring is a newly developed behavior, only recently begun as weight stabilized, or if participants had been monitoring their intake from the beginning. In addition, this study did not take into account other influencing factors, such as physical activity, food selection, other eating

behaviors such as grazing and meal patterns, support group attendance, or social support, all of which could impact weight loss and self-monitoring behaviors.

Conclusion

Dietary and weight self-monitoring behaviors warrant further investigation toward understanding patients' different weight loss outcomes after gastric bypass surgery. Studies to understand the factors that contibute to successful weight loss outcomes must consider the complexity of patients' experiences, the individual patterns of weight loss, individual dietary behaviors, and social factors such as marital status. Future studies should include a larger, more diverse group of participants, followed over time with accurately reported weight and dietary behaviors. Once these relationships are uncovered more clearly, dietary and weight self-monitoring behaviors could be recommended as long-term strategies to promote successful weight loss outcomes among gastric bypass recipients.

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Conflict of Interest All contributing authors declare that they have no conflicts of interest.

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