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Baseline Psychosocial, Environmental, Health, and Behavioral Correlates of 1- and 3-Year Weight Loss After Bariatric Surgery

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Abstract

Purpose: Weight loss surgery is an effective, long-term treatment for severe obesity but individual response to surgery varies widely. The purpose of this study was to test a comprehensive theoretical model of factors that may be correlated with the greatest surgical weight loss at 1 – 3 years following surgery. Such a model would help determine what predictive factors to measure when patients are preparing for surgery that may ensure the best weight outcomes.

Materials and Methods: The Bariatric Experience Long Term (BELONG) study collected self-reported and medical record-based baseline information as correlates of 1- and 3-year % total

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

CONSENT: All participants gave verbal consent at the time of recruitment.

weight loss (TWL) in n = 1,341 patients. Multiple linear regression was used to determine the associations between 120 baseline variables and %TWL.

Results: Participants were 43.4 ± 11.3 years old, Hispanic or Black (52%; n = 699), women (86%; n = 1,149), partnered (72%; n = 965) and had annual incomes of ≥ $51,000 (60%; n = 803). A total of 1,006 (75%) had 3-year follow-up weight. Regression models accounted for 10.1% of the variance in %TWL at 1-year and 13.6% at 3-years. Only bariatric operation accounted for a clinically meaningful difference (~5%) in %TWL at 1-year. At 3-years after surgery, only bariatric operation, Black race, and BMI ≥ 50 kg/m^2 were associated with clinically meaningful differences in %TWL.

Conclusions: Our findings combined with many others support a move away from extensive screening and selection of patients at the time of surgery to a focus on improving access to this treatment.

Introduction

Metabolic and bariatric surgery is the most effective treatment for patients with severe obesity (body mass index [BMI] ≥ 35 kg/m^2); compared to conventional weight loss strategies, surgery has resulted in much higher weight loss over a period of 2 – 7 years.[1–4] Despite this clear benefit, there is large variation in weight loss outcomes even within the same bariatric operation ranging from 56% total weight loss (%TWL) to 15% gain up to 7 years after surgery.[5,6] Given this large variation, it is imperative to understand if modifiable factors predict this variability so that we can improve outcomes for all patients.

Metabolic and bariatric surgery programs invest considerable resources in the preparation of patients for surgery based on recommendations from the American Society for Metabolic and Bariatric Surgery (ASMBS).[7] Although guidelines for surgical eligibility were recently updated,[8] there are no universal criteria for who is the best candidate for weight loss surgery. This concept of the best candidate remains controversial, in part because there is not consistent evidence for what factors measured *before* surgery are related to weight loss *after* surgery.

To understand correlates of bariatric surgical outcomes, there are two general foci in the literature to date: immutable patient characteristics such as demographics and bariatric operation type that cannot generally be affected by patient, provider, or system level actions;[9–11] and modifiable factors such as health behaviors, weight before surgery, mental health, and social support that could be targeted for change.[12–21] Most of the work on modifiable factors is not grounded in psychosocial theoretical models or theories of health behavior change,[22,23] nor is it informed by the numerous studies on non-surgical weight loss that have provided extensive evidence for what leads to long-term weight loss maintenance.[24,25]

In addition, much of the work done to date on self-reported psychological and behavioral factors measured at the time of surgery has come from the Longitudinal Assessment of Bariatric Surgery (LABS) study, which focused primarily on eating behaviors and psychiatric conditions.[26,27] Patients in this cohort mostly self-identified as White race and with very few sleeve gastrectomy (SG) cases, which is now the most frequently used operation in the U.S.[28]

The Bariatric Experience Long Term (BELONG) prospective cohort study was designed to address the limitations in the literature by applying a comprehensive theoretical model of health behavior change to the collection of data from people preparing to have surgery.[29,30] This cohort of patients is racially diverse and has a large sample of both Roux-en-Y gastric bypass (RYGB) and SG. The purpose of the current study was to test a comprehensive theoretical model (see Figure 1) of factors measured before or at the time of surgery that may be correlated with 1- and 3-year %TWL to address the question of what may be important to measure when patients are preparing for surgery to affect the period when the greatest weight loss occurs (1 – 3 years following surgery).

METHODS

Participants

The BELONG cohort has been described in detail elsewhere.[29,30] Eligibility criteria for inclusion in the BELONG study were: 1) member of the healthcare system at the time of recruitment; 2) enrolled in a 12-week bariatric surgery preparation course; 3) planning to have a first bariatric surgery within 6 months of the baseline survey; 4) adult 18 years of age and older; and 5) meeting general eligibility criteria for weight loss surgery at the time of enrollment.[31] Recruitment for the survey began in February 2016 and ended in May 2017. A total of n = 1,975 patients were surveyed at baseline (42% response rate). Further exclusions were made (please see Online Supplement for details) that resulted in n = 1,338 patients available for analyses.

Procedures

All data were collected at baseline before surgery. Half of survey respondents completed the baseline survey using a self-guided study website; the remainder completed a survey by phone with a trained surveyor. The following data were also abstracted from the EHR at the time of surgery: diagnoses and pharmacy records to determine disease burden (including mental health-related), adherence to scheduled visits for routine medical care in the year before surgery, weight and height to determine both BMI and %TWL in the year before surgery, and date of birth to calculate age. Height and weight were collected by clinical staff as part of routine clinical care.

Measures

All 120 survey variables chosen to operationalize the domains of interest (demographics, behavior, health, psychosocial, and environment) in the BELONG theoretical model (see Figure 1) are summarized in Table S1 in the Online Supplement. Details for the selection of these variables and their scale reliabilities have been described previously.[29,30]

Outcome

Our weight loss outcome was %TWL calculated as [((weight [kg] at surgery - weight [kg])/weight at surgery [kg]) x100], at 1- and 3-years of follow-up. Using this formula resulted in positive values for weight loss. Weight was objectively measured by clinic staff.

Analyses

Imputation.—The linear regression analysis used to test the contributions of all 120 variables in the BELONG theoretical model to %TWL required that each participant have a value for every variable in the model. Although the rates of missingness were low for each individual variable (< 3%), when all variables were combined in linear regressions, 783 participants were excluded (leaving n = 555 with complete data). To mitigate the loss of participants' data, we chose to use the *MICE* (Multivariate Imputation by Chain Equations) R package to impute the missing values for baseline survey data.[32] MICE generated 5 imputed data sets and provided a pooled linear regression model using the imputed data sets. The pooled linear regression analysis was used for estimation and inferences for the relationships between selected correlates and %TWL at year-1 and year-3.

Regressions.—Three separate linear regressions were conducted for each of the 1- and 3-year weight loss outcomes using the imputed baseline correlates sample: a basic model using a set of factors that have been shown to affect weight loss after surgery (age, gender, race/ethnicity, socioeconomic status, type of surgery, having a BMI ≥ 50 kg/m^2, comorbidity burden, presence of diabetes and/or hypertension at surgery, and %TWL in the 12 months before surgery); a full model with all 120 variables to help us determine which variables to select for the final regression. This final parsimonious regression included all significant variables ($p < .05$) from the full model (second regression). Results are shown for the basic and final models.

Sensitivity analyses.—Table S1 in the Online Supplement provides descriptive statistics for each variable in our theoretical model for the full sample with imputation (n = 1,338) and the restricted sample without imputation (n = 555). These two samples were compared to each other for each variable in the model to determine if the sample with imputation differed significantly from those without imputation. Significance level was adjusted for multiple comparisons using a Bonferroni correction, to control Type I Error inflation ($p \leq .0004$). In addition, we conducted 1-year regressions using only the n = 555 participants who had complete responses for all survey items (see Table S2 in the Online Supplement) to determine if imputation affected the findings. Analyses were conducted in R Version 4.1.1 which was downloaded from the *R CRAN* website.[33]

RESULTS

Participants

Participant demographic characteristics for the analytic cohort (n = 1,338) are shown in Table S1 in the Online Supplement. All participants had measured weight at year-1 (100% follow-up) and n = 1,006 had a 3-year follow-up measured weight (75% follow-up rate). Participants were 43.4 ± 11.3 years old, self-identified as Hispanic or Black race (52%; n =

699), women (86%; n = 1,149), and partnered (72%; n = 965). Over half of all participants (60%; n = 803) had annual incomes of ≥ $51,000.

1-Year Weight Loss

Table 1 provides findings for variables associated with %TWL at 1-year. The basic model accounted for 7.0% of the variance in weight loss at 1-year. Adding variables increased the variance accounted for to 10.1%. In the final model, two immutable factors (having RYGB; higher annual income) and one modifiable factor (indicator of food addiction) were significantly associated with *greater* %TWL at 1-year. Conversely, three immutable (Black or Hispanic race; lower employment density for retail, entertainment, and educational uses in a neighborhood; older age) and four modifiable (BMI ≥ 50 kg/m^2; having adequate health literacy; better sleep efficiency; fewer days of strength training) factors were significantly associated with *lower* %TWL at 1-year. Detailed model effects are provided in the Online Supplement. Only having RYGB (3.63% more TWL) and identifying as Black race (3.63% less TWL) approached clinically meaningful effects (~5% TWL).

3-Year Weight Loss

Table 2 provides findings for variables associated with %TWL at 3-years. The basic model accounted for 8.1% of the variance in weight loss at 3-years, and adding variables increased the variance accounted for to 13.6%. In the final model, two immutable factors (having RYGB, perception of neighborhood having more four-way intersections – an indicator of more walkability) and four modifiable factors (indicator of food addiction, greater self-care, higher comorbidity burden, greater % TWL in 12 months before surgery) were significantly associated with *greater* %TWL at 3-years. Conversely, four immutable (Black or Hispanic race, perception that the neighborhood had less heavy traffic – an indicator of more walkability; lower employment density for retail, entertainment, and educational uses in a participant's neighborhood; older age) and five modifiable (BMI ≥ 50 kg/m^2; better sleep efficiency; more days of strength training; having hypertension and/or diabetes) factors were associated with *lower* %TWL at 3-years. Detailed model effects are provided in the Online Supplement. Only having RYGB (4.61% more TWL) and identifying as Black race (4.24% less TWL) approached clinically meaningful effects (~5% TWL).

Sensitivity Analyses

Table S2 in the Online Supplement provides the results for 1-year %TWL using only the n = 555 participants who did not have any scale items imputed. Similar to the model using imputation (Table 1), the final model accounted for 14.0% of the variance in 1-year %TWL. Like the model using imputation, the final model also found associations for operation type, race, age, strength training, health literacy, and sleep (although this was latency not efficiency). However, socioeconomic status, BMI ≥ 50 kg/m^2, adherence rate to outpatient visits in the year before surgery, and weight loss self-efficacy were also significantly associated with %TWL at 1-year.

DISCUSSION

The BELONG cohort is one of the largest, most diverse and comprehensive assessments of factors theoretically related to weight loss following metabolic and bariatric surgery. We found that 120 variables accounted for 10.1% of the variance in %TWL at 1-year and 13.6% of the variance in %TWL at 3-years. After accounting for all variables in the theoretical model, the type of bariatric operation accounted for the greatest difference in %TWL at both 1- and 3-years, with RYGB having 4.6% more TWL than SG at 3-years. In addition, at 3-years after surgery, participants who identified as Black had 4.24% less TWL than those who identified as White and participants with a BMI ≥ 50 kg/m^2 had 2.93% less TWL than those with < 50 kg/m^2. Other variables were statistically significant in multivariate models, however, the effect was small at 1%−3% TWL and likely not clinically meaningful. These findings have been reported in numerous other studies,[34–39] where demographic, physical health and behavioral factors are often the only variables related to weight loss at 2 – 5 years after surgery. A comprehensive meta-analysis found no consistent evidence for the role of any mental health condition in post-operative weight loss.[40]

Some of our findings were in the opposite direction than hypothesized if they were used in univariate analyses, such as spending more and more time obtaining food (an indicator of food addiction) resulting in 2.58% *greater* TWL 3-years following surgery. The LABS study also reported counter-intuitive findings for baseline factors affecting weight loss after RYGB surgery.[41] For example, their patients with the highest rates of disordered eating at baseline had the greatest %TWL 3-years following surgery.[42] Very few studies report variance accounted for, however, a recent study by Chang and colleagues found that age and type of operation explained 17.5% of the variance in weight loss at 3- and 14.6% of the variability at 5-years.[43]

Our study had several important limitations. We had a low survey response rate of 42% limiting our generalizability. Because of the limitations in the analytic strategy for survey item non-response, findings were based on some imputation of survey summary scores for over half the sample. We conducted two analyses to understand the impact of missing data on our findings, univariate comparisons for variables in each model between those participants with (n = 1,338) and without (n = 555) imputation and regressions with only the 555 participants for whom there was no imputation (see Table S1 and S2 in the Online Supplement). Although some of the correlates differed and their magnitude was reduced, the variance accounted for was similar to the full sample (14% for the final model) supporting the overall conclusion. Finally, even though this healthcare system included 23 bariatric surgeons across 9 practices, our findings may not apply to other bariatric practices and thus should be replicated more systematically in other settings.

Another limitation was that we did not include every possible factor that could affect weight loss after surgery. For example, a recent publication found that impulsivity was the strongest predictor of outcomes from metabolic and bariatric surgery.[44] However, we carefully considered the existing evidence for both surgical and non-surgical weight loss when building our theoretical model (see Figure 1),[29] and feel confident that our findings are some of the most comprehensive in the literature. Finally, we only looked at 3-year weight outcomes. More studies are needed to determine if baseline psychosocial, behavioral, and health factors are related to very long-term outcomes (5 – 10 years).

CONCLUSION

Our findings combined with many other studies on baseline factors related to weight loss following metabolic and bariatric surgery suggest that pre-surgical characteristics, especially those that are modifiable, may only predict small variations (1% – 3%) in weight loss. Based on this work, we feel that the field should move away from extensive screening and selection of patients at the time of surgery to a focus on improving access to this treatment, especially for people who suffer disproportionately from severe obesity such as Black and Hispanic patients. Many studies have shown a marked improvement in mortality rates for those patients who have metabolic and bariatric surgery,[45,46] clearly indicating that this is a life-saving approach to treating severe obesity. Other life-saving operations for conditions related to obesity, such as coronary artery revascularization, do not require such extensive screening and selection for patients.[47] Research and clinical care resources should be moved to the post-operative period to see if modifiable post-operative factors such as physical activity, social isolation, weight control strategies, and weight loss expectations, can help us understand why some patients may not experience the same benefits from metabolic and bariatric surgery than others.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Points

- 120 baseline variables accounted for only 13.6% of weight loss at 3-years
- Only operation type, Black race, and BMI ≥ 50 kg/m^2 were clinically meaningful
- Baseline modifiable characteristics predict small weight loss variations (1% – 3%)
- This supports less pre-selection of patients and a focus on improving access

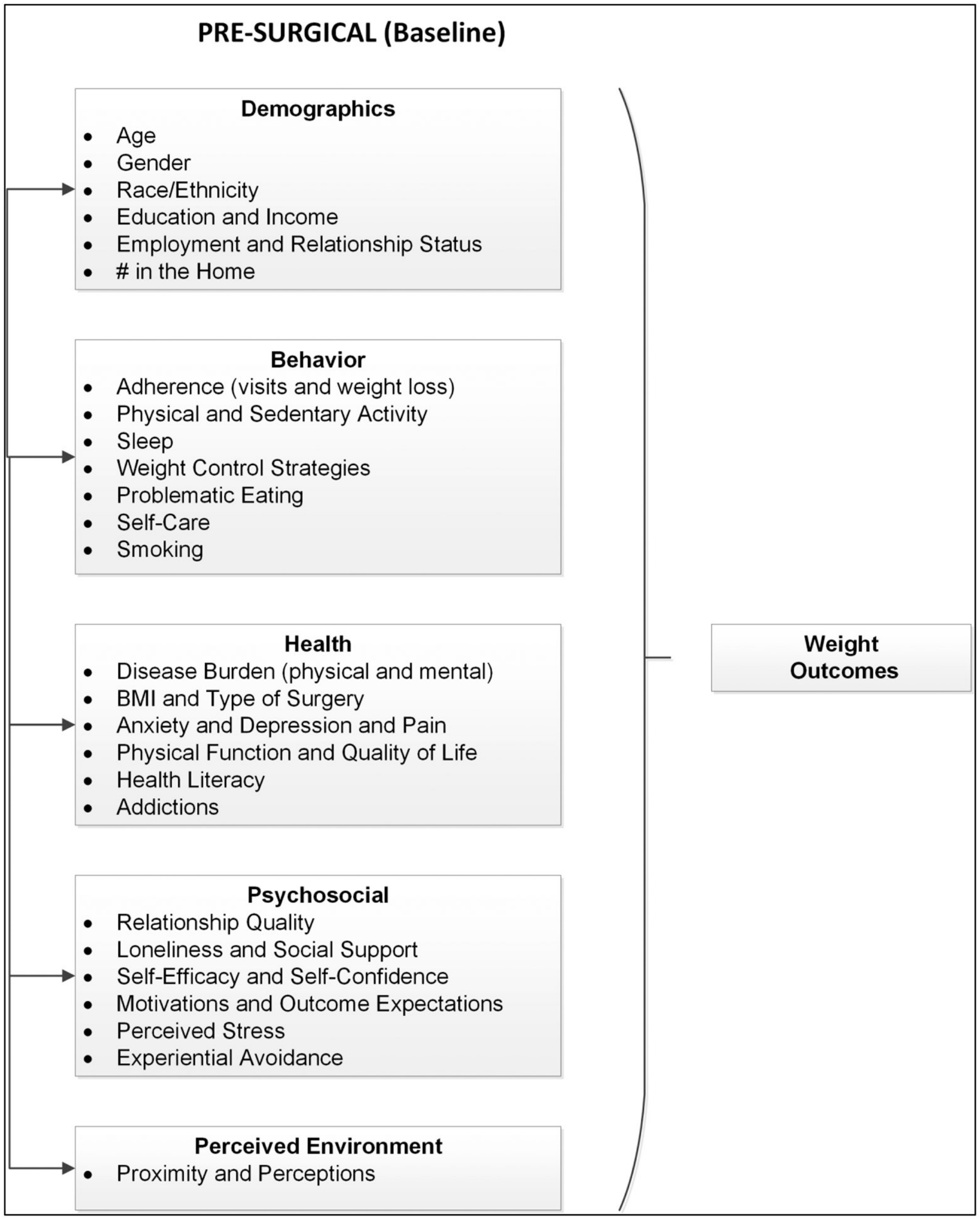

Figure 1.

Theoretical model used to test baseline factors correlated with 1- and 3-year % Total Weight Loss (%TWL). All 120 survey variables chosen to operationalize the domains of interest (demographics, behavior, health, psychosocial, and environment) are summarized in Table S1 in the Online Supplement. Details for the selection of these variables and their scale reliabilities have been described previously.[29,30]

Table 1.

Linear regression results for basic (adjusted $R^2 = 7.0\%$) and final (adjusted $R^2 = 10.1\%$) models of baseline factors that were related to 1-year % total weight loss (%TWL) in the Bariatric Experience Long Term (BELONG) study cohort. Regressions use the full analytic sample (n = 1,338) which contains some imputation of survey variables.

	Basic Model			Final Model		
Variable	**Est**	**SE**	**p**	**Est**	**SE**	**p**
Intercept	32.62	1.67	<.001	33.76	1.83	<.001
Type of Surgery (% Gastric Bypass)	3.58 *	0.53	<.001	3.63	0.53	<.001
Age (years)	−0.11 **	0.03	<.001	−0.12	0.03	<.001
Race (compared to Caucasian/White)						
Hispanic/Latino	−1.80	0.60	<.001	−1.74	0.61	<.001
African American/Black	−4.26	0.77	<.001	−3.63	0.80	<.001
Other	−2.28	1.11	.04	−1.77	1.10	.11
Mixed	−1.71	0.88	.05	−1.59	0.88	.07
Gender (% Women)	0.46	0.69	.51	0.08	0.69	.91
Socioeconomic Status (range 8 – 67)	0.01	0.02	.59	0.01	0.02	.46
Comorbidity Burden	−0.09	0.24	.71	−0.12	0.23	.60
Hypertension (% yes)	−0.10	0.59	.86	−0.25	0.58	.67
Type 2 Diabetes Mellitus (% yes)	−1.26	0.66	.06	−1.21	0.65	.07
%TWL 1 Year Before Surgery	0.06	0.05	.22	0.03	0.05	.63
BMI ≥ 50 kg/m^2 (% yes)	−1.79	0.71	.01	−1.73	0.70	.01
Food Addiction: More Time to Obtain (% yes)	---	---	---	1.67	0.54	<.001
Annual Income ≥ $51,000 (% yes)	---	---	---	1.03	0.52	.05
Neighborhood Deprivation Index	---	---	---	0.47	0.28	.09
Dog Walking (min/day)	---	---	---	0.004	0.002	.07
Outcome Expectations for %TWL: Disappointed	---	---	---	−0.01	0.01	.50
Proportion of Retail Space	---	---	---	−0.31	0.12	.01
Strength Training (days/week)	---	---	---	−0.58	0.15	<.001
Adequate Health Literacy (% yes)	---	---	---	−1.53	0.59	.01

	Basic Model			Final Model		
Variable	**Est**	**SE**	**p**	**Est**	**SE**	**p**
Sleep Efficiency Rating (% better/somewhat better)	---	---	---	−1.57	0.63	.01

*A positive estimate means that as the value of the variable in the model increased, there was more %TWL.

**A negative variable estimate means that as the value of the variable in the model increased, there was less %TWL.

Table 2.

Linear regression results for basic (adjusted $R^2 = 8.1\%$) and final (adjusted $R^2 = 13.6\%$) models of baseline factors that were related to 3-year % total weight loss (%TWL) in the Bariatric Experience Long Term (BELONG) study cohort. Regressions use those participants from the full analytic sample (n = 1,338) which contains some imputation of survey variables who also had a weight measure at year 3 (n = 1,006).

	Basic Model			Final Model		
Variable	**Est**	**SE**	**p**	**Est**	**SE**	**p**
Intercept	29.39	2.41	<.001	25.06	3.17	<.001
Type of Surgery (% Gastric Bypass)	4.48 *	0.71	<.001	4.61	0.69	<.001
Age (years)	−0.08 **	0.03	.02	−0.10	0.03	.01
Race (compared to Caucasian/White)						
Hispanic/Latino	−1.98	0.79	.01	−1.86	0.79	.02
African American/Black	−4.49	1.01	<.001	−4.24	1.01	<.001
Other	−1.66	1.49	.26	−1.22	1.46	.40
Mixed	−0.58	1.17	.62	−0.27	1.14	.82
Gender (% Women)	−0.34	0.94	.72	−0.53	0.92	.57
Socioeconomic Status (range 8 – 67)	0.04	0.05	.41	0.06	0.05	.23
Comorbidity Burden	0.69	0.31	.03	0.70	0.30	.02
Hypertension (% yes)	−1.62	0.77	.04	−1.64	0.75	.03
Type 2 Diabetes Mellitus (% yes)	−2.39	0.88	.01	−2.36	0.86	.01
%TWL 1 Year Before Surgery	0.24	0.07	<.001	0.20	0.07	<.001
BMI ≥ 50 kg/m^2 (% yes)	−3.19	0.94	<.001	−2.93	0.92	<.001
Perception that Neighborhood Has Four Way Intersections (% yes)	---	---	---	2.70	0.66	<.001
Perception that Neighborhood Does Not Have Heavy Traffic (% yes)	---	---	---	−1.79	0.68	.01
Food Addiction: More Time to Obtain (% yes)	---	---	---	2.58	0.70	<.001
Self-Care (range 4 – 20)	---	---	---	0.18	0.07	.02
Experiential Avoidance (range 15 – 75)	---	---	---	0.06	0.04	.12
Dog Walking (min/day)	---	---	---	0.01	0.00	.08
Proportion of Retail Space	---	---	---	−0.53	0.16	<.001
Strength Training (days/week)	---	---	---	−0.68	0.20	<.001

	Basic Model			Final Model		
Variable	**Est**	**SE**	**p**	**Est**	**SE**	**p**
Sleep Efficiency Rating (% better/somewhat better)	---	---	---	−1.73	0.80	.03

* A positive estimate means that as the value of the variable in the model increased, there was more %TWL.

** A negative variable estimate means that as the value of the variable in the model increased, there was less %TWL.