October 2018

Predicting Weight Loss Following Bariatric Surgery: The Impact of Stress, Depression, Social Support and Patient Gender

Erica Ahlich
University of South Florida, eahlich@gmail.com

Predicting Weight Loss following Bariatric Surgery: The Impact of Stress, Depression, Social Support and Patient Gender

by

Erica Ahlich

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts
Department of Psychology
College of Arts and Sciences
University of South Florida

Major Professor: Diana Rancourt, Ph.D.
Jonathan Rottenberg, Ph.D.
Kristen Salomon, Ph.D.

Date of Approval:
September 28, 2018

Keywords: psychosocial, obesity, preoperative, outcomes, mental health

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to those individuals who supported me throughout the process of writing my master's thesis. First, I am very appreciative for the helpful feedback from my committee members. The project greatly benefited from their expertise. Special thanks to my mentor, Dr. Diana Rancourt, for her support and guidance throughout this process. I would also like to express my gratitude to all of my family, friends, and peers for their words of encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The buffering effect of social support against a range of stress-related health outcomes has been well-documented in a variety of research areas; however, no previous work has examined the applicability of this model to bariatric surgery outcomes. Additionally, based on previous evidence and relevant theoretical work, the stress-buffering effect of social support may show important gender differences. The current study examined stress, depression, social support, and patient gender as predictors of curvilinear weight loss trajectories during the first year following surgery. Data were collected using retrospective chart review. The buffering effects of three types of support were explored using growth curve modeling: structural, emotional, and functional support. On average, patients lost 27% of their total body weight between baseline and the 12 month follow up. Additionally, the current study found partial support for the stress-buffering model of social support among bariatric surgery patients. Overall, emotional and functional support appear be most relevant to weight loss/maintenance in this population; structural support did not predict weight loss or show any significant interactions with stress or depression. However, results varied depending on patient gender and whether patients reported experiencing high levels of stress (significant interaction with emotional support) or depression (significant interaction with functional support). Such findings have important implications for assessment and follow-up care after bariatric surgery, as well as for future research in this area.

INTRODUCTION

Obesity is a serious and pervasive problem in the United States. With more than one-third of adults classified as obese (Ogden, Carroll, Kit, & Flegal, 2014), and the significant personal and societal costs associated with obesity (Carr & Friedman, 2005; Finkelstein, Trogdon, Cohen, & Dietz, 2009; Peeters et al., 2003; Wyatt, Winters, & Dubbert, 2006), improving the efficacy of current weight loss treatments is of great public health concern. Though several non-surgical interventions exist, for those who have Class III obesity conventional treatments are often unsuccessful. Compared to patients in conventional, non-surgical interventions, bariatric surgery patients show more weight loss, better weight loss maintenance, and a greater reduction in diabetes and cardiovascular risk factors (Sjöström et al., 2004).

The incidence of bariatric surgery in the United States grew steadily from the early 1990s– in 1993 8,597 procedures were performed– to its peak in 2003 when 115,194 procedures were performed (Livingston, 2010). According to a recent meta-analysis, patients' mean excess weight loss following bariatric surgery was 61.2% and significant improvements in other health-related outcomes were found, including hyperlipidemia, diabetes, hypertension, and obstructive sleep apnea (Buchwald et al., 2004). However, not all patients lose a significant amount of weight, and studies that include longer follow-up assessments show that many patients have difficulty maintaining weight loss several years post-surgery (Christou, Look, & Maclean, 2006; Clark et al., 2003; Shah, Simha, & Garg, 2006). Thus, additional research is needed to improve our understanding of the correlates of successful weight loss, weight maintenance, and improved outcomes. Given the complex nature of health behaviors, a multidisciplinary approach is likely to benefit this effort.

Bariatric Surgery

Bariatric surgery is a medical procedure which seeks to cause weight loss in severely obese patients. Depending on the specific technique used, this is achieved by restricting the volume of food that the stomach can hold and/or by decreasing the amount of nutrients absorbed by the body after eating. Roux-en-Y gastric bypass (RYGB) is the most commonly performed procedure worldwide (Angrisani et al., 2015). RYGB causes weight loss by bypassing a large section of the stomach, thereby both restricting the size of the stomach and causing malabsorption. The latter is achieved because a section of the intestine is also bypassed and this decreases the amount of calories the body can absorb.

Sleeve gastrectomy and gastric banding are two other types of bariatric surgery. According to a 2013 survey, sleeve gastrectomy surpassed RYGB to become the most commonly performed procedure in the United States/Canada (RYGB was still the most common procedure worldwide; Angrisani et al., 2015). Sleeve gastrectomy causes weight loss by removing a section of the stomach. The section that remains connected to the esophagus and the intestines is shaped like a tube and restricts the amount of food that can be consumed. Additionally, the fundus is removed, causing a decrease in the sensation of hunger. Laparoscopic adjustable gastric banding (LAGB) is a procedure involving an inflatable band that is placed around the top portion of the stomach. This causes the formation of a small pouch above the rest of the stomach, which holds a smaller amount of food. This is a reversible procedure, and additionally, the amount of restriction can be adjusted by inflating or deflating the band. Given the minimally invasive nature of gastric banding, and successful weight loss outcomes, it was very popular after first being introduced in the 1990's. However, long-term follow up studies have suggested high rates of complications (Suter, Calmes, Paroz, & Giusti, 2006), leading to a significant reduction in number of gastric band procedures being performed today.

Averaging across type of procedure, the most significant weight loss typically occurs during the first year following surgery (Chang et al., 2014; Courcoulas et al., 2013). Several reviews and meta-analyses have reported that those who undergo laparoscopic gastric bypass procedures show more weight loss than those who undergo laparoscopic adjustable banding procedures (Buchwald et al., 2004; Franco, Ruiz, Palermo, & Gagner, 2011; Tice, Karliner, Walsh, Petersen, & Feldman, 2008). However, an analysis which focused on studies with a longer follow-up reached a different conclusion. O'Brien and colleagues conducted a systematic review of studies examining weight loss trajectories up to 10 years post-surgery (O'Brien, McPhail, Chaston, & Dixon, 2006). The pooled results indicated that RYGB patients show significant weight loss during the first 2 years; thereafter the rate slows and many patients begin to slowly regain weight throughout the next 8 years. Pooled results for LAGB patients revealed a less dramatic weight loss during the first two years following surgery, but relatively stable maintenance as long as 10 years post-surgery. In fact, the findings of this review suggest that by year 3, RYGB and LAGB patients are not significantly different in terms of percentage of weight lost. Sleeve gastrectomy is a newer procedure and studies to date have not included a long enough follow-up period to determine the average long-term weight loss trajectory. Studies examining weight loss in the short-term suggest that it is at least as effective as gastric banding (Dogan et al., 2015; Hutter et al., 2011), but additional research investigating weight loss maintenance following sleeve gastrectomy is needed.

On average, and particularly compared to other weight loss interventions, bariatric surgery has a relatively high success rate; even so, a subset of patients do not lose 50% excess weight within the 1st year (Sanchis et al., 2015)– one criterion for a successful surgery– and a subset show significant weight regain during follow-up. Reported amounts of weight regain vary, with some studies stating that as many as 37% of patients regain 25% or more of their lowest post-surgical weight (Cooper, Simmons, Webb, Burns, & Kushner, 2015). Christou, Look, and MacClean (2006) followed a group of bariatric surgery patients for over ten years and found that 20% of patients with an initial BMI 35 - 50 kg/m^2 returned to a BMI ≥35 kg/m^2 by the last follow-up appointment. Thus, it is important to identify factors that influence initial weight loss as well as weight maintenance.

Measurement of Weight Loss Outcomes

One barrier to being able to identify reliable predictors of successful weight loss has been inconsistency in results reporting. Defining and measuring obesity and weight loss has proven to be a challenge for the medical field, both logistically and ethically. Broadly speaking, obesity is a medical condition in which there is an excess amount of fat in the body. Body mass index (BMI) is the most common metric used to estimate body fat, primarily because it is easy to measure and compute. BMI is calculated by dividing weight (in kilograms) by height squared (in meters). The World Health Organization, the Centers for Disease Control and Prevention, and the National Institutes of Health all define obesity as a BMI of 30 or higher (CDC, 2010; WHO, 2000a; NHLBI, 1998). Obesity can be further categorized as Class I (30-34.9), Class II (35-39.9), or Class III (≥ 40).

Although some have reported that on average BMI performs similarly to other measures in predicting health outcomes (Flegal & Graubard, 2009; Flegal et al., 2009; Mills, 2005;

Steinberger et al., 2005; Sun et al., 2010; Willett, Jiang, Lenart, Spiegelman, & Willett, 2006), it is a relatively crude measure of body fat which has several weaknesses. Okorodudu and colleagues (2010) conducted a meta-analysis to assess the sensitivity and specificity of BMI compared to gold standard measures used to identify excess body fat (e.g., dual energy x-ray absorptiometry, hydrodensitometry, etc.). The authors found that while the specificity of BMI was relatively high (pooled .90; 95% confidence interval [CI]: 0.86–0.94), the sensitivity was quite low (pooled .50; 95% CI: 0.43–0.57). This indicates that many people who would be classified as obese according to measures that are more accurate are not being classified as obese based on BMI. Others have pointed out that certain groups, such as athletes and very tall or short individuals tend to be misclassified due to the nature of how BMI is calculated (Jonnalagadda, Skinner, & Moore, 2004; Ode, Pivarnik, Reeves, & Knous, 2007; NHLBI, 1998). Moreover, research indicates that the association between BMI and body fat may vary by sex and ethnicity (Carroll et al., 2008; Daniels, Khoury, & Morrison, 1997; Gallagher et al., 1996). For example, some work suggests that Hispanic and white men and women have more abdominal fat compared to African American men and women with a similar BMI and waist circumference (Carroll et al., 2008). Others have reported a significant difference by sex, such that among those with a similar BMI, women have significantly more body fat than men (Gallagher et al., 1996). More precise measures do exist, such as hydrodensitometry, computed tomography, or dual-energy X-ray absorptiometry, but these options are more expensive and more time-consuming. Therefore, work is being done to establish more accurate guidelines for using BMI to diagnose obesity (e.g., WHO guidelines for some Asian ethnic groups; Organization, 2000b).

The best approach to reporting weight loss following bariatric surgery has also been the topic of much debate. Historically, the most commonly reported outcome measure has been percent excess weight loss (%EWL), which is calculated by dividing weight loss by excess weight (weight compared to ideal weight) and multiplying by 100. Recently, however, it has been argued that this measure's reliance on an "ideal weight," is arbitrary and problematic (Dixon, McPhail, & O'brien, 2005; Hatoum & Kaplan, 2013; Karmali, Birch, & Sharma, 2009; van de Laar, 2012). Instead, some have advocated for the use of percent total weight loss (%TWL) or change in BMI, asserting that both are more accurate metrics of weight loss following bariatric surgery (van de Laar, 2016). Likewise, several journal guidelines have recently been revised to require change in BMI or %TWL as the method of describing weight loss in bariatric patient samples.

In addition to the complexities involved in establishing an accurate definition for medical purposes, discussions around the ethics of how obesity is defined have also emerged. Some have argued that the current emphasis on weight loss by the media, government agencies, academia, and healthcare settings is an issue of weight bias, not necessarily resulting from a true "epidemic" (e.g., Oliver, 2006). Having a higher BMI in and of itself does not guarantee the presence of medical issues. A systematic review of studies investigating the association between BMI and mortality found that having a BMI in the overweight range was associated with lower risk of mortality, whereas having a BMI below 20 was associated with an increased risk of mortality (Romero-Corral et al., 2006). The authors point out that findings such as these may be due to BMI's inability to differentiate between body fat and lean mass; thus, even the label of "overweight" based on BMI may be misleading. Likewise, by some standards obesity does not qualify as a "disease" at all. The way in which we define obesity has important ethical and clinical implications.

A discussion of the outcomes associated with obesity cannot be separated from the conceptual and ethical issues discussed above. Nonetheless, at some point, likely dependent on a number of individually and environmentally determined factors, excess fat is problematic for health and quality of life. Meta-analyses support associations between abdominal adiposity and risk of cardiovascular disease and type 2 diabetes among men and women (De Koning, Merchant, Pogue, & Anand, 2007; Freemantle, Holmes, Hockey, & Kumar, 2008). Moreover, visceral fat is positively associated with risk of sleep apnea (Vgontzas et al., 2000) and obesity, as defined based on BMI, is associated with a reduced health-related quality of life (Jia & Lubetkin, 2005). Some researchers have suggested those with Class III obesity also show a reduced overall quality of life (Jagielski, Brown, Hosseini-Araghi, Thomas, & Taheri, 2014), but as this was a treatment-seeking sample, it is not clear whether those with Class III obesity who are not seeking treatment might also report reduced overall quality of life.

The consequences discussed here, and others, likely contribute to the decision of many individuals classified as obese to consider undergoing bariatric surgery. However, even after the decision to have surgery is made, maintaining the weight loss and improving current and future mental and physical health are not a guarantee. As previously discussed, there is much room for improvement in understanding why some patients initially lose more weight than others as well as what factors influence maintenance.

Predictors of Weight Loss Outcomes

Many researchers have begun investigating the role of individual, medical, environmental, and social factors in predicting bariatric surgery outcomes. Several factors have shown a relatively consistent association with post-operative weight loss. For example, the type of procedure a patient undergoes is significantly related to how much weight loss is achieved

(Benoit, Hunter, Francis, & De La Cruz-Munoz, 2014). Some research suggests that requiring patients to lose weight immediately prior to surgery can lead to more post-surgical weight loss. According to a systematic review by Livhits and colleagues (2012), patients who were required to lose a set percentage of their weight (e.g., 5-10% EWL) before surgery lost more weight following surgery. Research also suggests that pre-surgical weight is a relatively consistent predictor of weight loss following surgery, with a higher weight before surgery associated with less weight loss (Agüera et al., 2015; Benoit et al., 2014; Livhits et al., 2012; Wimmelmann, Dela, & Mortensen, 2014).

However, the majority of investigated variables (particularly psychosocial factors) have received mixed support. Research indicates that stress, for example, is associated with unhealthy eating behaviors among adult men and women, including disrupted eating patterns and increased consumption of snacks and fast food (Barrington, Beresford, McGregor, & White, 2014; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Oliver & Wardle, 1999; Torres & Nowson, 2007) and is associated with less physical activity and more sedentary behavior (Stults-Kolehmainen & Sinha, 2014). Yet, in the few studies that have examined the association between stress and post-operative outcomes, findings have been inconsistent (Buddeberg-Fischer, Klaghofer, Sigrist, & Buddeberg, 2004; Figura et al., 2015). Likewise, depressive symptoms are associated with poor diet quality as well as a preference for sweet foods, and have been shown to increase risk for obesity (Appelhans et al., 2012; Jeffery et al., 2009). However, the reported association between depression and weight change following surgery has been inconsistent in the literature; some studies have found that depression is associated with less weight loss (Kalarchian et al., 2008; Rydén, Hedenbro, & Frederiksen, 1996), whereas others have reported no association or an association with *greater* weight loss (Averbukh et al., 2003;

Bergh, Lundin Kvalem, Risstad, & Sniehotta, 2016; Busetto et al., 2002; Sarwer et al., 2008; Scholtz et al., 2007; White et al., 2015). Other demographic and psychosocial variables, including age, gender, and social support have also shown variability in findings across studies (Averbukh et al., 2003; Bergh et al., 2016; Busetto et al., 2002; Delin, Watts, & Bassett, 1995; Dixon, Dixon, & O'Brien, 2001; Hafner, Rogers, & Watts, 1990; Larsen et al., 2004; Livhits et al., 2011; Ortega et al., 2012; Sarwer et al., 2008; Song, Reinhardt, Buzdon, & Liao, 2008; Sysko et al., 2012).

Several examples of why results have been inconsistent with regard to psychosocial predictors of weight loss include differences in time of measurement (e.g., pre- vs post-surgery), length of follow up, measurement of predictors, or specific outcomes of interest. For example, some have investigated predictors of surgery non-completion (e.g., Sockalingam et al., 2013), while others have focused on predictors of post-surgical weight loss and quality of life (e.g., Herpertz, Kielmann, Wolf, Hebebrand, & Senf, 2004). With regard to predictors, a recent systematic review of social support for bariatric surgery patients highlights the diversity that exists in how constructs can be defined and measured (Livhits et al., 2011). In some studies, social support was defined as support group attendance. In other studies, social support was defined as perceived family support. Still others operationalized this construct by measuring self-reported number of confidants. Additionally, the possibility of interactions between predictors is unexplored in many studies and over-reliance on main effect designs may contribute to inconsistent findings. A primary goal of this study is to investigate two predictors of weight loss– stress and depression– from the perspective that these associations are likely influenced by several, yet unaccounted for, third variables. Specifically, the focus of the current study will be on social support and gender as potential moderators. In other areas of research, stress and depression are associated with many negative outcomes, but much previous work also suggests that high levels of social support act as a buffer against those negative outcomes (e.g., Kilpatrick et al., 2007; Uchino, Cacioppo, & Kiecolt-Glaser, 1996; Wareham, Fowler, & Pike, 2007).

Social Support as a Potential Moderator

For many predictors of surgical outcomes, investigating only main effects is unlikely to be a good match for how these variables interact in the real world. In the case of depression or stress as predictors of post-surgical outcomes, it might be the case that for those who report depressive symptoms or high stress levels, but who also have high levels of social support, the associations with subsequent weight loss are weaker than for those who report depressive symptoms or high stress levels and do not have access to strong support systems. No previous examinations of this interaction were found in a review of the literature, but research in other areas would support this hypothesis.

The buffering effect of social support against the risk of negative mental and physical health outcomes associated with stress has been well documented in a broad range of areas, such as research on intimate partner violence (Beeble, Bybee, Sullivan, & Adams, 2009), cardiovascular health (Bowen et al., 2014), breast cancer (Koopman, Hermanson, Diamond, Angell, & Spiegel, 1998), and alcohol use (Peirce, Frone, Russell, & Cooper, 1996). This has been termed the "stress- buffering hypothesis" of social support (Cohen & Wills, 1985). Social support is a broad construct thought to encompass the various kinds of assistance that are available to people through their connections with others, which help them to cope with life's demands. In the stress-buffering model, social support is often described as being either functional or structural. The distinction is between whether support is measured as the extent to which someone has existing relationships in place that can be relied upon (i.e., social support structures; often a count measure of friends, relatives, etc. or a dichotomous measure such as married or not) or measured as the extent to which the relationships offer some functional support. Functional support can be further divided by type, such as informational, emotional, or instrumental/tangible (House, Kahn, McLeod, & Williams, 1985; Schaefer, Coyne, & Lazarus, 1981).

Social support researchers have theorized that the ability of social support to buffer against negative outcomes will depend upon the extent to which the kind of social support available matches the specific needs of a person undergoing a stressful life event (Cohen & Wills, 1985). The current study focused on three sources of support most likely to match the needs of patients undergoing bariatric surgery: attendance at support group meetings following surgery, current dating/marital status, and number of people perceived to be helpful when patients feel upset about their weight. Attendance at support group meetings following surgery represented functional support. These meetings provide patients with information to better understand and cope with surgery-specific challenges, as well as providing a space in which patients can share their struggles and successes. Therefore, because these meetings serve many support functions, no sub-categorization was specified. Structural social support was investigated using patients' reported marital/dating status, specifically whether patients are cohabitating with a spouse or partner. This type of structural support is thought to provide patients with a sense of embeddedness and regular social contact (Cohen & Wills, 1985). Moreover, living with a significant other is thought to offer patients a wide variety of support functions that have the potential to buffer against the effects of stress and depression both before and after surgery, an idea consistent with Cohen & Wills' statement that "an enduring and intimate relationship such as marriage is likely to provide several kinds of functional support" (1985, p. 321) Lastly, we assessed the extent to which patients had people available who were helpful to them when they were feeling upset by their weight; this is thought to represent functional, emotional support. It was theorized that for patients with high levels of stress or depression, each of these support variables targeted difficulties in a distinctive way to help patients cope.

Social Support among Men and Women

Patient gender is not often accounted for in studies examining psychosocial predictors of bariatric surgery outcomes. Likewise, research on how gender may influence the stress-buffering effects of social support is limited. However, there are theoretical reasons and empirical support for considering gender in the current analysis.

Historically, research on stress responses was primarily conducted on non-human mammals, and was characterized by descriptions of a "fight or flight" response. More recently, social psychologists described a different response to stress observed among humans, termed the "tend-and-befriend" response (Taylor, 2006; Taylor et al., 2000). Specifically, and consistent with the discussions of the buffering effect of social support described previously, researchers observed that in times of stress, humans have a tendency both to seek out support and to provide support to others. That humans show an affiliative nature after experiencing stress has been well documented and has received neurobiological support (Taylor et al., 2000). For example, oxytocin is thought to play a role in the buffering effect of social support, such that subsequent to experiencing a stressor, oxytocin is released. Oxytocin appears to prompt affiliative behavior (Cardoso, Ellenbogen, Serravalle, & Linnen, 2013), and furthermore, assuming positive support from others is received, decrease the physiological stress response (Ditzen et al., 2009; Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003). However, there appears to be some differentiation in how this process unfolds depending on gender.

From an evolutionary perspective, social support may have been particularly important for women. Among early humans, while men were the primary hunters in a group, women were largely responsible for child rearing and foraging. Thus, in times of stress (e.g., faced with a threat), women would have been more likely to both protect themselves *and* their offspring (for gene and species survival benefits). Likewise, women were thought to form close ties with one another in order to share child care responsibilities and forage for food cooperatively. Therefore, biological processes that encourage such an affiliative response, such as oxytocin release, are thought to be particularly relevant to women in times of stress. Research on coping behaviors supports that, in comparison to men, women do tend to rely more on social support in times of stress, in order to effectively down regulate the stress response (Tamres, Janicki, & Helgeson, 2002).

Researchers working in the area of behavioral treatment of obesity have presented findings that the effects of social support on outcomes may indeed depend upon the gender of the patient. Wing and colleagues randomized patients to a behavioral weight control program in which they either participated alone or participated with their spouses. The main effect of condition (alone vs. with spouse) on weight loss, measured both at post-treatment and at follow-up, was not significant. However, there was a significant interaction effect between patient gender and condition on weight loss at post-treatment. Results showed that for women, participating with one's spouse was associated with greater weight loss, whereas for men, those who participated alone had better outcomes (Wing, Marcus, Epstein, & Jawad, 1991).

Similar results have been demonstrated by those working in other areas of health research. Heitzman and Kaplan (1984) found that women who were more satisfied with their level of social support had better control of their diabetes, whereas, for men, high satisfaction with social support was associated with poorer control of diabetes. Additionally, researchers have found that in a group of individuals experiencing a highly stressful life event (longitudinal study of East German migrants in beginning in 1989) women with low social support reported more health complaints and symptoms of depression, whereas for men, social support was unrelated to these outcomes (Knoll & Schwarzer, 2002). However, this finding has not been consistently replicated in studies examining social support as a buffer between stress and health outcomes, with more recent work suggesting no gender differences (Bowen et al., 2014). More work is needed to understand the extent to which gender may moderate outcomes, particularly related to bariatric surgery.

Current Study

Whether social support interacts with stress or depression in predicting post-surgical outcomes remains a gap in the literature, and is one which the current study sought to address as its primary aim. In qualitative explorations, researchers have noted this type of interaction described by patients. For example, Hafner, Watts, and Rogers (1991) found that bariatric patients stressed the value of support group participation in helping them to face the challenge of adjusting to a new eating regimen after surgery. However, no previous studies have investigated the interaction quantitatively, using statistical modeling. Secondarily, the study examined how social support may interact with stress or depression differently depending on patient gender. It was hypothesized that high levels of stress and depression would be associated with worse outcomes (i.e., less initial weight loss or more subsequent weight regain) when social support was low compared to when social support was high for women. Among men, it was anticipated that the associations between the stress and depression and post-surgical outcomes would not differ by level of social support. The study explored these hypotheses by modeling curvilinear weight loss trajectories during the first year following surgery.

METHOD

Participants

Data were collected using retrospective chart review at a large teaching hospital in the southeastern United States. Only patients who had surgery from the time the bariatric center began using electronic medical records (2012) through 2015 were included in this analysis. Only patients undergoing bariatric surgery for the first time were included; revision surgeries were not included. The bariatric center provides three types of bariatric surgery: Roux-en-Y gastric bypass, sleeve gastrectomy, and laparoscopic adjustable gastric banding. A multi-disciplinary team assists patients from pre-surgery through post-surgery; patient medical records include information gathered by physicians, psychologists, dieticians, nurse practitioners, physician assistants, and nurses. Eligibility criteria for surgery during this period of time included being at least 18 years old, having previously and unsuccessfully undergone medically-supervised weight loss, having a BMI of at least 40kg/m^2 *or* having a BMI of at least 35 kg/m^2 *and* one or more obesity-related medical conditions (e.g., diabetes, high blood pressure, heart disease, or sleep apnea).[1] Patients were also required to demonstrate an understanding of what the surgery involved and the lifestyle changes that would be necessary following surgery. To assist patients with this requirement, all were required to attend an informational session prior to surgery. Exclusion criteria for surgery included being a current smoker or pregnant.

[1] Despite the stated requirements, eight patients had a BMI less than 35 at the time of surgery. Either these patients lost weight prior to the date of surgery or an exception was made due to the presence of significant medical comorbidities. As such, these cases were retained.

Based on a search query conducted by hospital staff, 799 patients were identified as having had bariatric surgery during the aforementioned time period. Out of the 799 eligible patients, 128 patients were dropped due to having had weight loss surgery performed in the past. Additionally, 100 patients were not able to be located in EPIC, suggesting they had surgery prior to the transition to electronic medical records. An additional 7 patients had restricted charts that prevented access to both the bariatric intake packet and the weight/height measurements. Likewise, 16 patients were located in EPIC, but either had no record of bariatric surgery (n = 15) or the intake packet was in Spanish (n = 1). The final sample included 548 patients (see Table 1).

Patient attendance at follow-up appointments was variable; therefore, demographics and responses to primary study variables were compared between those who did and did not attend the 6 month and 12 month follow up appointments. Patients missing the 6 month follow up appointment were not significantly different in gender (p = .998, φ_c = .00), race (p = .758, φ_c= .01), education (p = .507, d = .06) initial BMI (p = .479, d = .06), or age (p = .116, d = .13). Likewise, no associations were found between these variables and having missed the 12-month appointment. With regard to primary study variables, patients missing the 6 month appointment were not significantly different in stress (p = .640, d = .04), current depression (p = .095, φ_c = .08), emotional support (p = .752, d = .03), or functional support (p = .495, d = .05). Again, no associations were found between these variables and missing the 12 month follow-up appointment. Structural support was significantly associated with missing the 6 month follow up (p = .039), but the effect size was small (φ_c = .10). No association was found for missing the 12 month follow up (p = .465, φ_c = .03).

The sample was majority female (81.2%) and non-Hispanic (81.1%). Patients self-identified as 67.6% White, 17.9% Black or African American, .2% Asian, .4% Arab or Middle

Eastern, and 13.1% other or multi-racial. Five patient records (.9%) did not include information on race. The average age at time of intake was 43.86 years old (*SD* = 11.86) and the average BMI was 47.75 (*SD* = 8.69). Patients reported an average of 13.75 years of education, 65.6% were employed, 23.4% were unemployed, and 11.0% were retired.

Materials

All data were abstracted from patient medical records. Demographic variables included age, race, ethnicity, gender, education, and employment status. Height, weight, and procedure type were also collected from patient records. Other key study variables included depression, stress, and social support, which were all measured at the time of intake as part of the standard medical and psychosocial health assessment forms that all patients completed at this center.

Depression. All patients were asked to complete a psychiatric history form. For the purposes of the current study, two intake questions were used to assess depression, one of which asked patients to report current depression whereas the other asked patients to report any history of depression. Responses to each were coded dichotomously. Current depression was the primary variable of interest, but exploratory analyses were conducted with history of depression.

Stress. As part of a modified version of the Weight and Lifestyle Inventory (WALI; Wadden & Foster, 2006; Appendix B), patients were asked to "Please indicate if you are currently experiencing any stress in your life related to the following. Check all that apply." The following eight areas were included: work, health, relationship with spouse or significant other, activities related to children, activities related to parents, legal or financial trouble, school, and moving. Stress was operationalized as a count of the items that patients endorsed as current stressors. Therefore, the total possible range was from 0 to 8. Others have reported that these items show good test-retest reliability, ranging from 76.4% to 96.3% (Wadden et al., 2006). An additional measure of perceived stress was included in secondary analyses, which asked patients "How stressful has your life been during the past 6 months?" Patients responded on a 1-5 Likert scale, with 1 indicating "much less stressful than usual" and 5 indicating "much more stressful than usual."

Social Support. Social support was measured using three methods, each representing a unique aspect of social support as described by House et al. (1985) and as discussed in previous sections. First, attendance at support group meetings following surgery represented general functional support. In compliance with HIPPA regulations regarding protected health information, only number of support group meetings attended and the length of time between each meeting and the date of surgery were collected (as opposed to specific visit dates). The topic of support group meetings varied by week according to patient needs and typically, each meeting lasted approximately 60 to 120 minutes. Attendance at these meetings was recorded in patient medical records. A greater number of support group meetings represented greater *functional support*. Because these meetings served many functions, including providing information as well as emotional support, no sub-categorization was specified.

For the second and third measures of social support, responses were extracted from the Weight and Lifestyle Inventory (Wadden & Foster, 2006; Appendix C), which patients completed during intake. To assess *structural social support*, responses to an item which asked about living arrangements/marital status were extracted ("Currently, I am [check all that apply]: Living alone; Living with a spouse/partner; Living with a significant other; Living with children; Living with parents/step-parents; Living with other relatives; Living with roommates"). Structural social support was captured by dichotomous coding of patients' marital/dating status, specifically whether they were in a committed relationship and cohabitating (living with a spouse/partner; living with a significant other) or not (all other responses). Lastly, patients were asked the open-ended question "How many people do you talk to about your weight when you are upset by it?" followed by "How many of these people are helpful to you?" For the third measure of social support, a count measure was extracted from responses to the latter question, with higher counts indicating greater *functional, emotional support.*

Weight Loss. The outcome of interest in this study was post-operative weight loss. BMI was selected as the primary outcome for modeling, to allow for comparisons with previous research, much of which has reported BMI. However, %TWL was also used to describe weight loss in the sample, in accordance with recent recommendations. Weight (kg) and height (cm) were measured at each post-operative visit to the Bariatric Center. BMI (kg/m^2) and %TWL ([operative weight - follow-up weight/operative weight]*100) were computed for each visit.

During data abstraction, time was originally coded as months and days from time of surgery. Time was subsequently recoded such that baseline weight (at time of surgery) was coded as Time 0. Four additional time points were established, corresponding to every 3 months from surgery (e.g., Time 1 = 3 months, Time 2 = 6 months, etc.) until one year follow-up. Because patient follow up visits varied in exact time from surgery, weight measurements were coded as corresponding to a specific time point if they occurred during that month (e.g., month 3) or +/1 one month from that time point (e.g., 2-4 months were included as Time 1 data; 5-7 months were included as Time 2 data).

Procedure

After IRB approval (see Appendix D), data collection was performed through access to the hospital's EPIC system. Collection procedures were in accordance with HIPPA guidelines. All abstractors were graduate students trained in medical record data abstraction. A subset of records (n = 25) were used to test the abstraction process before official data collection began. The data set was deidentified such that participant names were replaced with a random ID. Months between baseline and each follow-up visit were used instead of visit dates. This method obviated the need to collect protected health information while maintaining relative time between measurements.

Data Analysis

Following initial data collection, 20% of files were re-entered by a second abstractor. This subset of files was used to examine reliability. The criterion for reliability was 80% agreement between abstractors. All variables in the current study surpassed this threshold, ranging from 89% to 100% agreement.

Missing data were present for all level 1 and level 2 predictors, as well as the outcome variable. The average number of collected weight measurements within the first year following surgery was 2.87 (SD = 1.10) out of 5 possible. Degree of missingness varied by time point, with nearly every patient having a weight measurement at time of surgery (Time 0; 96%), but a smaller number of patients having data by 12 months post-surgery (Time 4; 35% follow up visit information available). With regard to predictors, all of which were collected pre-surgery, 81% and 82% of patients provided information on number of current stressors and on current/past depression, respectively. Nearly every patient had data available for the measure of functional support (99.5%). In contrast, 84.3% of patients had data on the measure of structural support and 69.5% on emotional support.

Missing data were handled using Blimp (Enders, Keller, & Levy, 2017), which generated 20 imputed data sets. Blimp is a flexible imputation program that allows for imputation of continuous and categorical variables. For this study, 1,000 burn-in iterations and 1,000 thinned iterations were specified. The model was structured such that BMI was the outcome, and random slopes for time and time^2 were specified. Study ID was used as the level 2 identifier. The gibbs option was utilized to avoid computational problems.

All analyses were conducted using SAS 9.4. Correlation coefficients were computed for all study variables (see Table 2). The PROC MIXED procedure with Restricted Maximum Likelihood (REML) was used to estimate all models; however, Maximum Likelihood estimation was used for the purpose of model comparisons. Linear and quadratic changes in weight were modeled, given previous research showing deceleration or gain following initial weight loss. Errors were modeled as unstructured. Parameters were estimated for each imputed data set and results were pooled using the PROC MIANALYZE procedure.

All predictors were Level 2 (i.e., covariates, stress, depression, and all types of social support) time-invariant predictors. Gender, employment status, depression, and structural social support were included as binary variables (0 = male; 0 = unemployed; 0 = did not endorse depression; 0= not living with a spouse, partner, or significant other). Race was dichotomized, such that those not identifying as a racial minority were coded 0. Age was entered as a continuous variable and was centered at the mean for all hypothesis testing. Stress, emotional support, and functional support were treated as continuous variables given the extended scale for these items (0-8, 0-20, and 0-21, respectively). Based on the presence of a meaningful zero (0 = no identified stressors, 0 support group meetings attended, 0 people talked to when upset about weight), none of these variables were centered. The outcome variable, BMI, was continuous. Time was coded 0-5 and was the only level 1, repeated measures variable.

To increase interpretability and reduce the number of parameters estimated in each model, six sets of hierarchical models were built (i.e., three sets for stress, with each of the social support variables; three sets for depression, with each of the social support variables). First unconditional linear versus quadratic models were tested for fit. The best-fitting model was selected and a model with covariates was estimated. Following inclusion of the covariates, primary predictors were entered. Subsequently, two-way (e.g., time*depression, time*gender, time*structural support, depression*structural support, $time^2$*depression, $time^2$*gender, etc.), then three-way (e.g., time*depression*structural support, time*gender*structural support, depression*gender*structural support, $time^2$*depression* structural support, etc.), and finally four-way (e.g., time*depression*structural support*gender, $time^2$*depression*structural support*gender) interaction terms were added to test change in model fit (Δ-2 LL) and statistical significance of relevant parameter estimates. Significant interactions were probed using Jeremy Dawson's online interaction utilities (Dawson, , n.d.).

Secondary analyses followed the same data analytic plan, with the exception that a predictor variable of interest was substituted (e.g., history of depression vs current depression). History of depression was coded such that 0 = no history of depression. Perceived stress during the past 6 months was treated as a continuous variable.

Data were screened for violations of relevant assumptions. Normality of the outcome variable (BMI) was evaluated using descriptive statistics and histograms. No severe departures from normality were detected. BMI showed slight positive skew (1.21) and moderate kurtosis (3.24), both of which are within the range of acceptable values (Curran, West, & Finch, 1996). All predictor variables showed adequate variability in the distribution. Additionally, multicollinearity was not an issue in the present sample; all correlations between predictors were small and non-significant (ranging from -.17 to .21; see Table 2).

RESULTS

Preliminary Analyses

Weight loss. Overall, the sample lost a significant amount of weight on average between time of surgery and the 12 month follow up (*M* = 37.11 kg, *SD* = 17.46). This corresponds to 27.05% total weight loss and 13.19 BMI points on average. When separated by initial BMI group, those with an initial BMI of ≥ 60 had the greatest change in weight (ΔBMI = 20.81; %TWL = 29.88), whereas those with an initial BMI between 30-39.9 had the smallest change in weight (ΔBMI = 8.08; %TWL = 21.10%). Importantly, there was significant variation in weight loss in the sample. Based on a recommended 25% TWL criterion (van de Laar, van Rijswijk, Kakar, & Bruin, 2018), 38.5% of the current sample would be classified as sub-optimal responders. However, due to the significant number of patients lost to follow up, this percentage is based only on the subsample of patients (n = 187) who had a 12 month follow up visit. See Table 3.

Preliminary Models. An unconditional model (Model 1) was analyzed with no predictors and the intercept modeled as a random effect. Based on this model, the intercept ($\gamma 00$) was shown to be 38.89, indicating that the average BMI across all patients and all time points was 38.89. Substantial variability was found within patients across time ($\sigma^2 = 35.36$, $p < .001$), as well as between patients ($\tau 00 = 45.15$, $p < .001$). Between-individual variance accounted for a large proportion of the variability in weight in this sample (ICC = .56), suggesting that evaluating between-person characteristics as predictors of weight change is likely to be useful.

Subsequently, time was entered as a linear random effect (Model 2). Model comparison between Model 1 and Model 2 suggested a significant decrease in model deviance Δ-2LL = 2353.37, $p < .05$. Additionally, adding time as a random effect accounted for 70% of the within-subject variance. With no predictors of change entered, Model 2 suggested that BMI at Time 0 (time of surgery) was estimated to be 44.91; however significant variability remained around the intercept ($\tau00 = 62.59$, $p < .001$). On average, patients lost a significant amount of weight during each 3 month period (linear change = -3.01 BMI points; $p < .001$). Significant between-person variability in slope was observed, suggesting that people differed in their rate of change in weight over time ($\tau11 = .80$, $p < .001$). Likewise, weight loss varied significantly within-persons over the course of the study ($\sigma^2 = 10.68$, $p < .001$). A significant, negative covariance was found, indicating that patients who had a higher BMI at the time of surgery had a more negative slope (i.e., lost more weight over time, $\tau01 = -3.92$, $p < .001$).

Next, time was modeled as a quadratic effect. Model 3 suggested that adding time as a quadratic random effect did result in significantly improved model fit over Model 2, in which time was entered as a linear effect only (Δ -2LL = 1794.06, $p < .05$). Likewise, the addition of time as a quadratic effect explained 68% of the within-subject variance in Model 2. Evaluation of model parameters suggested that while weight initially decreased following surgery ($b = -7.90$, $p < .001$), on average, patients began to show a modest amount of weight regain over time, as indicated by a positive quadratic term ($b = 1.22$, $p < .001$).

Covariates were entered into the model as fixed effects in Model 4, including age, years of education, minority racial group status, employment status, and procedure type. Overall, model fit significantly improved, Δ-2LL = 36.79, $p < .05$, and the addition of this group of covariates explained 6% of the between-subject variance in intercept. Additionally, age (b = -

.06, p =.047), employment status (b = -2.79, p =.001), and race (b = 1.98, p =.003) emerged as significant predictors of the intercept. Specifically, being younger, unemployed, and identifying as a racial minority were associated with a higher BMI at the time of surgery. See Table 4 for results of Models 1-4.

Stress

Functional Support. Next, fixed effects of stress, patient gender, and functional support (i.e., attendance at post-operative support group meetings) were entered into the model as predictors of the intercept. Results suggested that individually, neither stress (b = .11, p = .634) nor functional support (b = -.05, p = .800) significantly predicted starting BMI. Patient gender was significant (b = -1.57, p = .049), suggesting that women had a lower baseline BMI than men. However, these predictors accounted for only a small amount of the between-subject variance around the intercept (<1%). Additionally, model comparisons suggested that Model 5 was not associated with a significant improvement in fit, Δ-2LL = 5.30, $p > .05$.

In Model 6, two-way interactions between study predictors and time were entered to explore whether stress, depression, or functional support predicted linear or quadratic change in BMI over time. First, for the sake of parsimony, covariates that showed no significant fixed effects in Model 5 were removed. These included education and procedure type. In Model 6, no significant interactions emerged and there was no significant improvement in model fit from Model 4 (the last significant change in model fit), Δ-2LL = 15.02, $p > .05$,

In Models 7 and 8, three- and four-way (1: time*stress*functional support*gender; 2: time^2*stress* functional support*gender) interactions were entered in the model, to examine moderation effects. No significant higher order interactions emerged (one two-way and one three-way interaction term emerged in Model 8, but these were not significant in prior steps). Likewise, inclusion of these interaction terms did not improve model fit, $\Delta\text{-2LL}_{(\text{model 4- model 7})} = 23.91$, $p > .05$.

Results of these analyses did not support the hypothesis that the association between stress and weight loss would be moderated by functional support and patient gender. With the inclusion of all fixed and random effects, significant between-subjects variability remained around the intercept ($\tau_{00} = 65.77$) and slope ($\tau_{11} = 3.99$), as well as within-subjects ($\sigma^2 = 3.41$), indicating significant variability in the model that is not being accounted for by the current set of predictors. See Table 5 for results of Models 5-8.

Structural Support. The same procedure described above was utilized for the remaining analyses. Model 9 was built from Model 4, including all covariates. Patient gender, structural support (i.e., living with a spouse, partner, or significant other), and stress were then entered. Model fit was significantly improved compared to Model 4, $\Delta\text{-2LL} = 49.39$, $p < .05$. Results of Model 9 suggested that in addition to employment status ($b = -2.49$, $p = .002$) and race ($b = 1.85$, $p = .005$), patient gender ($b = -1.86$, $p = .022$) and structural support also predicted the intercept ($b = -1.69$, $p = .021$). As was described in Model 5, women had a lower baseline BMI than men. Additionally, those with greater structural support had lower starting BMI values. Although the interactions added in Model 10 did significantly improve model fit, $\Delta\text{-2LL}_{(\text{model 9- model 10})} = 23.76$, $p < .05$, results of Models 10-12 suggested that structural support did not predict weight change over time (linear $p = .792$; quadratic $p = .181$), or show any significant three-way interactions with time and stress (linear $p = .707$; quadratic $p = .290$). Likewise, patient gender did not moderate these associations, with no significant four-way interactions (linear $p = .377$; quadratic $p = .343$).

Results of these analyses did not support the hypothesis that the association between stress and weight loss would be moderated by structural support and patient gender. With the inclusion of all fixed and random effects, significant between-subjects variability remained around the intercept (τ_{00} = 67.47) and slope (τ_{11} = 4.03), as well as within-subjects (σ^2 = 3.41), indicating significant variability in the model that is not being accounted for by the current set of predictors. See Table 6 for results of Models 9-12.

Emotional Support. In Model 13, emotional support (i.e., helpful confidants when feeling upset about weight) was included as the measure of social support. Model 13 suggested that again, age (b = -.06, p = .042), employment status (b = -2.66, p =.001), and race (b = 2.13, p =.001) predicted starting BMI values. Also consistent with previous models, women showed a lower initial BMI than men (b = -1.62, p = .043). However, when Model 13 was compared to Model 4, the baseline model, fit was not significantly improved, Δ-2LL = 6.18, $p > .05$.

When the two-way interactions were added, Model 14 suggested that emotional support was a significant predictor of linear weight change over time (b = -.22, p = .042). Model 14 *did* show significantly better fit than Model 4, Δ-2LL = 34.56, $p < .05$. In Model 15, a significant three way interaction emerged, between time^2, stress, and emotional support (b = -.03, p = .030). Again, model fit significantly improved, Δ-2LL = 30.17, $p < .05$. No other significant two- or three-way interactions emerged. In Model 16, no significant four-way interactions emerged between time/time^2, stress, emotional support, and patient gender (linear p = .694; quadratic p = .782). Additionally, the model fit statistics suggested that compared to Model 15, Model 16 did not significantly improve fit, Δ-2LL = 3.96, $p > .05$.

Model 15 was retained as the final model. The significant interaction was plotted (see Figure 1), revealing that among those with high stress, there was little difference in linear slope between those with high and low levels of emotional support. However, those with low emotional support showed greater weight regain toward the end of the 12-month follow up period, compared to those with high levels of emotional support. Among those with low levels of stress, differences in weight regain/stabilization (i.e., quadratic trajectories) were in the opposite direction; in the low stress group, higher emotional support was associated with greater weight regain. Therefore, results of these analyses only partially supported hypotheses. Moreover, inconsistent with hypotheses, this pattern of associations did not differ by patient gender. See Table 7, Models 13-16 for results of these analyses.

Depression

Functional Support. In Model 17, fixed effects of patient gender, depression, and functional support were entered into the model. Results suggested that individually, neither depression (b = .94, p =.301) nor functional support (b = -.06, p = .777) were significant predictors of the intercept. Consistent with previous models, patient gender was a significant predictor of the intercept; women had a lower initial BMI than men (b = -1.69, p = .034). However, these predictors accounted for a small amount of the between-subject variance around the intercept (1%). Likewise, Model 17 was not associated with a significant improvement in fit over Model 4, Δ-2LL = 6.95, $p > .05$.

In Model 18, two-way interactions were entered, but no significant interactions emerged. Despite this, Model 18 was associated with a significant improvement in fit, Δ-2LL = 28.76, $p <$ .05. In Model 19, a significant three-way interaction emerged between time, depression, and functional support (b = -.54, p = .046), but model fit did not significantly improved Δ-2LL = 11.82, $p > .05$. In Model 20, two four-way interactions (1: time*depression*functional support*gender; 2: time^2*depression* functional support*gender) were both entered to test the study hypotheses. The interaction between time, depression, functional support, and gender was significant (*b* = 1.46, *p* = .004). Moreover, the interaction between time^2, depression, functional support, and stress was significant (*b* =-.25, *p* = .019). Likewise, model fit significantly improved compared to Model 18, Δ-2LL = 21.88, $p < .05$. See Table 8 (Models 17-20) for results of these analyses.

Model 20 was retained as the final model. Due to the complexity of interpreting a four-way interaction, the sample was split by patient gender. Subsequently, the three-way interaction between time^2, depression, and functional support was re-examined within each subsample. In contrast to the hypothesis that social support would act as a buffer among women, but not men, these analyses indicated that both the linear and quadratic three-way interactions were significant among men (linear *b* =-1.65, *p* = .002; quadratic *b* = .29, *p* = .009), but not among women (linear *b* = -.17, *p* = .550; quadratic *b* = .04, *p* = .560). Plots suggested that among men, those with depression and greater functional support started at a higher weight, but lost weight at a steeper rate than those with depression and lower functional support. Among those without depression, those with greater functional support also started at a lower weight, but lost weight at a *slower* rate than those with lower functional support. However, results of quadratic analyses were not consistent with the hypotheses. Instead, results suggested that among men with *no current depression*, those with low levels of functional support had greater weight regain compared to those with high levels of functional support. The quadratic effect appeared similar for men with depression, regardless of functional support. See Figure 2.

Structural Support. In Model 21, fixed effects of patient gender, structural support, and depression were examined, in addition to the covariates previously described. Model fit significantly improved compared to Model 4, Δ-2LL = 13.77, p < .05. Results of Model 21 suggested that in addition to age ($b = -.06$, $p = .049$), employment status ($b = -2.39$, $p = .004$) and race ($b = 1.87$, $p = .004$), gender ($b = -1.96$, $p = .015$) and structural support ($b = -1.63$, $p = .024$) predicted initial BMI. Consistent with Model 9, women and those with greater structural support had lower starting BMI values. Despite significantly improved model fit (Δ-2LL $_{model\ 21-22}$ = 38.07, $p < .05$), results of Models 22-24 suggested that structural support did not predict weight change over time, or show any significant interactions with depression. Likewise, patient gender did not moderate these associations, with no significant four-way interactions (1: time*depression*structural support*gender; 2: $time^2$*depression* structural support*gender).

Results of these analyses did not support the hypothesis that the association between depression and weight loss would be moderated by structural support and patient gender. With the inclusion of all fixed and random effects, significant between-subjects variability remained around the intercept ($\tau_{00} = 65.37$) and slope ($\tau_{11} = 4.14$), as well as within-subjects ($\sigma^2 = 3.41$), indicating significant variability in the model that is not being accounted for by the current set of predictors. See Table 9 for results of Models 21-24.

Emotional Support. In Model 25, depression and emotional support were included as fixed effects. Model fit was significantly improved compared to Model 4, Δ-2LL = 110.39, $p < .05$. Consistent with previous models, age, employment, minority race, and gender predicted initial BMI. However, depression ($b = .96$, $p = .284$) and emotional support ($b = .08$, $p = .634$) did not. Likewise, Model 26 suggested that neither depression ($b = 3.28$, $p = .194$) nor emotional support ($b = .30$, $p = .629$) predicted linear change in BMI or the quadratic effect ($b = -.11$, $p = .218$; $b = .04$, $p = .118$) when controlling for the other variables in the model. Likewise, model fit statistics suggested that compared to Model 25, Model 26 did not significantly improve fit, Δ-2LL = -23.75, $p > .05$. Models 27 and 28 suggested no significant three- or four- way interactions (1: time*depression*emotional support*gender; 2: $time^2$*depression* emotional support*gender).

Results of these analyses did not support the hypothesis that the association between depression and weight loss would be moderated by emotional support and patient gender. With the inclusion of all fixed and random effects, significant between-subjects variability remained around the intercept ($\tau_{00} = 65.27$) and slope ($\tau_{11} = 3.85$), as well as within-subjects ($\sigma^2 = 3.41$), indicating significant variability in the model that is not being accounted for by the current set of predictors. See Table 10 for results of Models 25-28.

Secondary Analyses

An alternative measure of stress– perceived stress during the past 6 months– was used in secondary analyses. This measure of stress and the count measure used in primary analyses were moderately correlated ($r = .44$). Results of these secondary analyses are presented in Appendix A. Findings were consistent across both measures of stress for models including functional and structural support. Specifically, no significant interactions emerged between stress, time, and social support.[2] Likewise, no moderation by patient gender was detected. However, whereas models including the current measure of stress showed a significant three-way interaction between $time^2$, stress, and emotional support, that interaction was not replicated when stress was measured as perceived stress in the past 6 months (see Model 15 vs Model S11).

Additionally, history of depression was examined in place of current depression in secondary analyses. Results were largely consistent with those found for current depression (see Appendix A). The interaction between time, history of depression, functional support, and gender was significant (linear $b = 1.05$, $p = .040$); however, no significant four-way interaction

[2] Although the two-way interaction between time and emotional support was significant in Model S10, a conservative approach was taken and this was not interpreted. The explained variance for linear trajectories was not deemed meaningful (<1%).

was found for time^2, depression, functional support, and gender (b = -.14, p = .230). Moreover, none of the models (S13-S16) with history of depression and functional support as predictors were significantly better in terms of model fit, when using Model 4 (covariates only) as the baseline model. Therefore, this interaction was not probed or interpreted. An additional difference between results for current and past depression emerged in analyses utilizing structural support as the measure of social support. The interaction between time, gender, and history of depression was significant in Model S19 (b = 1.63, p = .045). This interaction was not significant for current depression (see results for Model 23). However, Model S19 did not show a significant improvement in fit over Model 4 (the last significant model), Δ-2LL = 19.38, $p > .05$. Additionally, examination of the plotted slopes suggested very small differences in change in BMI over time between groups. In addition to concerns due to the large number of analyses conducted in this study, this suggests the difference may not have been highly meaningful; therefore, this interaction was not interpreted.

Residual Analysis

Residual analyses were conducted for each of the final models described above. The aims of these analyses included detecting outliers and ensuring that all assumptions were met, including normality of residuals. Based on Q-Q plots, histograms, and scatter plots of residuals, the assumptions were met. Residuals were greater at very high and very low BMI values, but the degree of difference in residuals was not deemed problematic. Likewise, influence statistics did not indicate any problematic cases.

DISCUSSION

The primary aim of this study was to test an application of the stress buffering hypothesis of social support to weight outcomes following bariatric surgery. Secondarily, the study examined how the buffering effect of social support may differ depending on patient gender. It was hypothesized that high levels of stress and depression would be associated with worse outcomes when social support was low for women compared to when social support was high; whereas for men, it was anticipated that the associations between the stress and depression and post-surgical outcomes would not differ by level of social support. Multilevel modeling was used to estimate weight loss during the first year following surgery.

Overall Weight Loss

Consistent with previous research, patients undergoing bariatric surgery lost a significant amount of weight over time. Results of linear modeling suggested that patients lost ~ 7 BMI points between each follow up visit. On average, patients lost 27% of their total body weight between baseline and the 12 month follow up. However, results also suggested that the average trajectory of weight loss was not a continuous, linear decline in weight. This finding is consistent with prior work (Karlsson, Taft, Ryden, Sjöström, & Sullivan, 2007; Sysko et al., 2012). Instead, weight stabilized or showed a modest amount of regain toward the latter half of the first year, as indicated by a positive quadratic term.

However, results of modeling also suggested that there was significant variability in weight loss over time. A significant, negative covariance between intercept and linear slope emerged in every model tested, suggesting that initial weight loss was greater for those with a higher baseline BMI. However, a positive covariance between the intercept and the quadratic term was also found, suggesting that greater weight stabilization was also associated with a higher baseline BMI. Variability in weight loss was also found depending on baseline BMI. Those with a BMI of 60 or greater at baseline lost the most weight by 12 months, with ~30% TWL and 21 BMI points. In contrast, patients with a BMI of 30-39 at baseline lost ~21% TWL and 8 BMI points.

Additionally, a negative covariance was found between the linear and quadratic terms, suggesting that the more weight patients lost initially, the less likely they were to regain weight. This is consistent with previous research on bariatric surgery outcomes (Ritz et al., 2013), and with research on non-surgical weight loss interventions suggesting an association between short-term loss and long-term maintenance (Neiberg et al., 2012; Unick et al., 2014). Over a third of the patients in this study had sub-optimal weight loss (< 25% TWL; van de Laar et al., 2018). Notably, %TWL by 6 months and by 1 year were not meaningfully different on average. For example, among those with a baseline BMI of 40-49, weight at 6 months was 27.12% less than initial weight on average, and at 12 months was 27.39% less. This suggests that for the average patient in this study, nadir was likely reached well before the 12 month follow-up.

These findings are consistent with previous work exploring 12 month trends in weight loss (Ritz et al., 2013) and have important implications. Specifically, the findings highlight the importance of getting patients to attend the early follow up appointments, in order to facilitate early detection of suboptimal weight loss. With regard to intervention in such cases, several pilot projects have attempted to investigate potential targets for improving weight loss among those with early suboptimal weight loss (e.g., Robinson, Adler, Darcy, Osipov, & Safer, 2016; Sarwer et al., 2012). However, most have had limited efficacy, which may be the result of still poorly understood mechanisms of early weight loss and subsequent weight stabilization or regain. For example, common characteristics across these projects include a focus on skills deficits related to dietary adherence. However, it is becoming clear that weight loss is also influenced by early changes in gut hormones (e.g., GLP-1 and PYY), microbiota, food preferences, and reward value of energy dense foods (Miras & Le Roux, 2013). Likewise, changes in exercise behaviors are associated with weight loss (Egberts, Brown, Brennan, & O'Brien, 2012).

Attrition is a major barrier for most intervention efforts, and was significant among patients in this study. A high priority for research in this area is finding ways to increase patient motivation not only to attend follow up appointments but also, in the case of suboptimal weight loss, to participate in additional treatment efforts. Moreover, multiple measures of acceptability (e.g., burden, affordability, perceived efficacy, etc.) should be taken into consideration when developing post-surgical interventions for those struggling with initial weight loss and maintenance.

Procedure Type and Demographic Differences

Previous reports have suggested differences in initial BMI depending on type of surgery performed. For example, RYGB is more likely to be performed in cases where BMI is greater than 50. Additionally, patient preferences for type of surgery vary by patients' comorbid medical complications (Fridman et al., 2013). However, in this study, procedure type was not associated with differences in initial BMI. It may be the case that provider factors (e.g., preference for a specific surgery type) and not patient factors, were more influential in decision making in this clinic. Though the association between procedure type and weight loss was not tested in this study, to reduce the number of parameters estimated, previous research would suggest that some of the variance in weight loss might have been attributable to procedure type (Franco et al., 2011). Better guidelines are needed to support physician and patient decision making in choosing the best course of treatment. Each technique has advantages and disadvantages, as well as different mechanisms of inducing weight loss. It is likely that certain patients (e.g., presence of comorbid conditions, risk of complications, adherence to diet requirements, etc.) would benefit more from specific procedures/devices, but little research has been dedicated to improving decision making in this area.

Also consistent with prior research, several demographic factors were associated with baseline BMI in this patient sample. Patients who reported being unemployed had a higher initial BMI. Additionally, consistent with previous research (Elli et al., 2016; Sudan, Winegar, Thomas, & Morton, 2014), patients who identified as a member of a racial minority started with a higher BMI on average. It is important to understand the reasons for these differences in BMI at time of surgery, as the risk of obesity-related medical conditions increases as BMI increases. For example, differences may be the result of patient-driven choices (e.g., opting not to undergo surgery sooner due to lack of trust, cultural considerations with regard to surgical vs non-surgical interventions, etc.), provider communication (e.g., lack of contact with primary care provider, lack of communication about weight loss options), or barriers to access (e.g., cost). Others have noted disparities in who is being provided access to bariatric surgery depending on race/ethnicity, controlling for eligibility based on medical comorbidities and risk of complications (Martin, Beekley, Kjorstad, & Sebesta, 2010; Wallace, Young-Xu, Hartley, & Weeks, 2010). Likewise, patients with lower socioeconomic status are less likely to be approved for surgery (Halloran, Padwal, Johnson-Stoklossa, Sharma, & Birch, 2011; Martin et al., 2010). It may be the case that our findings reflect this disparity, with those who are non-White or who are not employed having to wait longer to get surgery, and ultimately, starting with a higher

BMI. However, directly examining underlying factors in the association between these demographic variables and BMI at time of surgery was beyond the scope of the current study.

Stress Buffering Theory of Social Support

With regard to the primary hypothesis, results of the current study suggest that different types of social support do show important interactions with stress and depression in predicting weight loss during the first year following surgery. However, the results were not consistent across all types of social support, and moreover, appear to differ depending on whether stress or depression was used as the primary predictor.

In the case of depression, only functional support (i.e., attendance at post-operative support group meetings) emerged as a moderator of the association between depression and initial weight loss (linear interaction) and weight maintenance (quadratic interaction). Additionally, this pattern of findings differed by gender. However, inconsistent with predictions, the buffering effect of functional support was supported among *men*, but not among women. Men who reported depression at intake, but also attended more post-operative support group meetings, lost weight at a steeper rate than those with depression who attended fewer support group meetings. Among those without depression, the pattern was opposite; those who attended more post-operative support group meetings lost weight at a slower rate than those who attended fewer meetings. In terms of weight maintenance, results suggested that weight regain only differed among those who did *not report depression* at intake, not those who did. Specifically, among men without depression, those who attended fewer post-operative support group meetings had greater weight regain compared to those with high levels of functional support.

For initial weight loss, findings might suggest that it may be more important that support match the needs of the patient than that support be high for all patients, at least when it comes to the type of support provided in post-operative group meetings. This is only partially consistent with the buffering hypothesis of social support, which would suggest that social support acts as a buffer for those who need support (i.e., times of stress), but is not as influential for those who do not. Nor is it entirely consistent with a main effect model of social support, which suggests that social support benefits everyone, regardless of need. Instead, findings indicate that if a higher level of support is needed, such as might be expected in the case of pre-operative psychopathology, support is associated with better outcomes. However, if a high level of support is not needed, as might be the case for those without pre-operative psychopathology, it may actually be associated with worse initial weight outcomes. Importantly, the current study did not include all possible stressors/psychiatric conditions; therefore, the extent to which other variables (e.g., disordered eating) added to the variability in findings is unknown.

Notably, this "level of need" matching was not found when it came to weight maintenance during the 12 month follow up period. Instead, greater support was associated with better maintenance for those without depression, but no difference by support was found for those with depression. One possibility is that patients with a history of depression may be receiving greater support outside of attending support group meetings (e.g., psychiatric services, more frequent meetings with behavioral health specialists, etc.). Sarwer et al. (2004) examined prevalence of psychiatric diagnoses and use of services among bariatric patients, finding that a little over half of those with a known diagnosis were also receiving some form of psychiatric treatment. For those without an existing psychiatric diagnosis, who are not attending support group appointments, there may be limited recognition of difficulties maintaining weight and feelings of disappointment associated with weight regain. Likewise, there may be inadequate provision of services for coping with changes following surgery (e.g., diet changes, body image changes, etc.). All of these factors may be related to subsequent weight regain among those without an existing diagnoses who are not attending support group meetings.

These findings could have implications for identifying which patients may benefit from attending support group meetings and when attendance may be most helpful. Currently, all patients are advised to attend support meetings, but based on these findings, it may not be the case that all patients are benefiting equally from attending, at least with regard to weight loss and weight maintenance (that said, causation cannot be determined; patients were not randomized to support group vs no support group conditions). Support groups did not interact with stress or depression, or show any main effect among women, who comprised 80% of the sample. One issue may be that support group meetings are not always highly structured in terms of what is being discussed each month. Though some flexibility is thought to allow for a discussion around needs brought up by the group, some topics may be more or less relevant to particular patients. It may be the case that patients attended 1-2 groups (average attendance was low), but stopped attending if the material did not feel highly relevant to them. It will be important to examine whether this pattern of findings is maintained if other outcomes are included, such as quality of life and emergence or re-emergence of psychopathology. Also, it will be important to better understand how social support may be associated with different mechanisms, both behavioral (e.g., dietary adherence) and physiological (e.g., regulation of stress), during the weight loss and maintenance phases. This could help bariatric centers tailor meetings to certain patient groups, for example, depending on what stage of weight loss/weight maintenance they are in.

In the case of stress, only emotional support emerged as a significant predictor of weight loss trajectory. Results were in the predicted direction for those in the high stress group. For those with high levels of stress and poor emotional support, weight regain during the 12-month follow up period was greater than for those with high stress and greater emotional support. In other words, patients in this sample who reported more stressors, but perceived there to be a larger number of people who could be relied upon for emotional support had better weight maintenance. This is consistent with the stress buffering hypothesis of social support, in that social support may have "protected" against the negative effects of stress. This buffering effect may work through several potential pathways. For example, support might mitigate the effects of negative emotions on eating behaviors, enhance motivation, or dampen the harmful physiological changes associated with stress (e.g., gut microbiota and hormones; Cryan & Dinan, 2012).

For those with low stress, it was predicted that weight loss would not differ by emotional support. However, results suggested that those with low stress and *high* levels of emotional support had greater weight regain. Such findings are not consistent with the stress-buffering hypothesis of social support. One possibility was mentioned previously when discussing findings for depression, which is a "level of need" mismatch. When stress is high, but emotional support is low, support does not match need. When stress is low, but emotional support is high, again level of support does not match patient needs. In this case, perhaps having more emotional support in the form of close confidants is also associated with more people perceived as "nagging," or similarly, is associated with too much pressure from others to maintain weight. One other possibility might be that perhaps in the low stress group, having a larger number of close friends and confidants was associated with more opportunities for social influences on eating, making habit maintenance following surgery challenging (e.g., more frequent eating outside of the home due to social occasions, more celebratory eating, grazing, etc.).

That structural support did not interact with stress or depression in predicting weight loss was surprising. This was not due to lack of variability (65% endorsed living with a significant other, spouse, or partner). Unlike functional support and emotional support, the current measure of structural support did not capture *behaviors* that may be helpful to those experiencing stress or depression. In other words, patients' attendance at support group meetings and their perceptions of having more confidants to turn to for emotional support both represent important *functions* of social support that are well matched to the needs of those undergoing surgery for the first time. The buffering effect of social support is most powerful when the type of support matches the needs of those experiencing a stressor (Cohen & Wills, 1985). While it was hypothesized that having a significant other at home would translate to having more active social support, this may not have been the case. This finding is particularly relevant to patient eligibility for surgery. Physicians are often weary of providing surgery to those who lack sufficient support at home (Santry et al., 2007). However, social support is often assessed by asking patients whether they live alone, who their caretaker will be, or how many people will be providing support to them. These are measures of structural support and, in the current study, structural support showed no association with weight loss or weight maintenance. Therefore, deciding whether or not a patient is eligible for surgery based on structural support alone may not be warranted at this time.

Gender Differences

Based on the tend-and-befriend theory of stress responses, as well as previous research, it was anticipated that the interactions between stress/depression, social support, and weight loss would depend upon patient gender; however, the hypothesis was that social support would act as a buffer for women, but not men. The tend-and-befriend theory suggests that social support may be particularly important for women, and previous evidence supports a greater affiliative response to stress among women (Tamres et al., 2002). Moreover, studies of behavioral weight loss treatments suggest that for women, participating in treatment with one's spouse is associated with greater weight loss, whereas for men, participating alone is associated with better outcomes.

However, findings were not consistent with hypotheses based on the tend-and-befriend theory, or with previous work. For depression, the interaction between functional support and depression predicting weight change was only significant among men. For stress, the interaction between stress and emotional support in predicting weight loss showed the same pattern, regardless of gender. One possible explanation for these results is that the tend-and-befriend theory may be more applicable to instances of acute stressors. The development of this model arouse from an evolutionary perspective, and has primarily been applied to responses to acute threats. The types of stressors measured in the current study were chronic stressors, such as work, children, finances, etc. Gender differences in the effectiveness of social support for these types of stressors may be less pronounced.

Assuming the tend-and-befriend theory can be applied to these types of stressors, why else might functional support have shown interactions with depression in predicting weight outcomes for men, but not women? One explanation may be related to gender differences in health care utilization. Given that men in general are not as likely to seek services, it may be the case that for men, attendance at support group meetings was more impactful. Male patients who chose to attend support group meetings may have been a subgroup who were highly motivated to begin with, and more "prepared" to benefit from these groups; this could be especially true for those with a history of depression, which is associated with reduced motivation.

With regard to the lack of gender differences for stress and emotional support, one possible explanation might be that emotional support is highly relevant to men undergoing bariatric surgery who experience a high level of stress. Previous research supporting gender differences in social support and behavioral weight loss outcomes has measured *structural* support (e.g., having a spouse present for treatment), not emotional support. Having a confidant to talk to about the difficulties, for example, of adjusting to the post-bariatric regimen, or other stressors happening in one's life, may be highly relevant to men and women undergoing surgery.

Methodological factors might also have influenced the results. First, the measures of stress, depression, and social support used in this study were single item measures. It may be the case that with more sensitive measures, gender differences would have emerged. Second, the study included many more women than men. This pattern is common in bariatric surgery outcome studies (i.e., 80% female on average; Buchwald et al., 2009). Why more women than men seek bariatric surgery is not well understood, however, one possibility relates to differences in social consequences for having obesity in the United States. Women with obesity suffer worse consequences in terms of teasing, marginalization, social status, body image, depressive symptoms, and education (Fikkan & Rothblum, 2012; Merten, Wickrama, & Williams, 2008; Schwartz & Brownell, 2004; Tang-Péronard & Heitmann, 2008). Additionally, women also seek out health care services more than men in general (Mackenzie, Gekoski, & Knox, 2006; Owens, 2008). Lastly, men and women in this sample were significantly different in age, race, marital status, and employment status. Though these variables were controlled for in terms of the effects they had on baseline BMI, the influence of these demographic variables on weight loss trajectories was not investigated. Therefore, it cannot be determined whether the absence of support for the stress buffering hypothesis among women was related, for example, to being more likely to be a racial minority, younger on average, more likely to be employed, and having fewer years of education.

Limitations, Strengths, and Future Directions

This study demonstrated a number of strengths. First, although previous research has suggested the importance of social support to bariatric surgery patients, this is the first quantitative investigation of the stress buffering hypothesis in a bariatric surgery sample. Others have either tested main effects only (e.g., support group attendance and weight loss), or described the relationship qualitatively. Additionally, most examinations of pre-operative predictors of bariatric surgery outcomes have been largely atheoretical. The current study was able to draw from two well established models in the field of social psychology- the stress buffering model of social support and the tend-and-befriend model of human stress responses. Other notable strengths included the large sample size, ability to explore multiple sources of support relevant to bariatric patients, and diversity of the sample (e.g., 30% racial minority and broad age range).

However, a number of limitations may have impacted the results. First, the study had a number of challenges to measurement. Specifically, though common in medical intake packets, the study was limited to using single item measures for multiple predictors. Several of the reported effects were relatively small and could be interpreted as being limited in clinical meaningfulness. However, low reliability of single item measures, captured at a single time point, is likely to contribute to attenuation of effect sizes. Future research should explore the associations between stress, depression, social support, and weight loss using well-validated instruments, ideally measured at multiple time points and included as time varying predictors. Second, the use of BMI as the only outcome measure is a limitation. Social support may have the largest stress-buffering effect for outcomes such as quality of life, an important outcome that was not included in this study and is worthy of investigation in future research. Likewise, improvement in symptoms of obesity-related medical diagnoses (e.g., diabetes, sleep apnea, and hypertension) is one of the most important changes following bariatric surgery and should be included in future work. Third, a large number of analyses were conducted in the current study. This was both a strength and a weakness, as it allowed for the exploration of multiple indicators of social support (structural, emotional, and functional) and conditions that may be influenced by social support (e.g., stress and depression). However, it also may have contributed to inflated Type I error. Moreover, given that several results were not consistent with hypotheses, findings should be treated as preliminary and should be replicated.

Lastly, attrition across follow-up appointments was extensive, with only 35% of patients attending the 12 month follow-up appointment. The missing data techniques employed in this study are most appropriate when data are missing at random. However, this was not a testable assumption. Comparison testing did not reveal any identifiable patterns in wave nonresponse (i.e., missing specific follow up appointments) related to demographics or primary predictors, supporting the decision to use multiple imputation to handle missing data without significant bias. However it is possible that missingness was related to patient factors not included in the current study, or to weight loss trajectories. For example, being lost to follow is associated with suboptimal weight loss (te Riele, Boerma, Wiezer, Borel Rinkes, & van Ramshorst, 2010). It is also likely that cost is a consideration for many patients, and situations such as loss of insurance or other financial hardships were not tracked in this study.

Conclusions

The current study found partial support for the stress buffering model of social support among bariatric surgery patients. Overall, emotional support and functional support may be more relevant to patients than structural support. However, results varied depending on gender and whether patients reported experiencing significant stress (in which case emotional support was more relevant) or depression (in which case functional support was more relevant) at intake. Future research should focus on recording post-surgical indicators of such variables to examine a) whether there are changes in levels of perceived social support following surgery, b) whether these changes are associated with weight change over time, c) what the relevant mechanisms are and d) whether certain types of social support influence different mechanisms involved in weight loss (e.g., diet changes, physiological changes, exercise).

REFERENCES

Agüera, Z., García-Ruiz-de-Gordejuela, A., Vilarrasa, N., Sanchez, I., Baño, M., Camacho, L., . . . Lopez-Urdiales, R. (2015). Psychological and personality predictors of weight loss and comorbid metabolic changes after bariatric surgery. *European Eating Disorders Review, 23*(6), 509-516.

Angrisani, L., Santonicola, A., Iovino, P., Formisano, G., Buchwald, H., & Scopinaro, N. (2015). Bariatric Surgery Worldwide 2013. *Obesity Surgery, 25*(10), 1822-1832.

Appelhans, B. M., Whited, M. C., Schneider, K. L., Ma, Y., Oleski, J. L., Merriam, P. A., . . . Ockene, I. S. (2012). Depression severity, diet quality, and physical activity in women with obesity and depression. *Journal of the Academy of Nutrition and Dietetics, 112*(5), 693-698.

Averbukh, Y., Heshka, S., El-Shoreya, H., Flancbaum, L., Geliebter, A., Kamel, S., . . . Laferrère, B. (2003). Depression score predicts weight loss following Roux-en-Y gastric bypass. *Obesity Surgery, 13*(6), 833-836.

Barrington, W. E., Beresford, S. A., McGregor, B. A., & White, E. (2014). Perceived stress and eating behaviors by sex, obesity status, and stress vulnerability: findings from the vitamins and lifestyle (VITAL) study. *Journal of the Academy of Nutrition and Dietetics, 114*(11), 1791-1799.

Beeble, M. L., Bybee, D., Sullivan, C. M., & Adams, A. E. (2009). Main, mediating, and moderating effects of social support on the well-being of survivors of intimate partner violence across 2 years. *Journal of Consulting and Clinical Psychology, 77*(4), 718-729.

Benoit, S. C., Hunter, T. D., Francis, D. M., & De La Cruz-Munoz, N. (2014). Use of bariatric outcomes longitudinal database (BOLD) to study variability in patient success after bariatric surgery. *Obesity Surgery, 24*(6), 936-943.

Bergh, I., Lundin Kvalem, I., Risstad, H., & Sniehotta, F. F. (2016). Preoperative predictors of adherence to dietary and physical activity recommendations and weight loss one year after surgery. *Surgery for Obesity and Related Diseases, 12*(4), 910-918.

Bowen, K. S., Uchino, B. N., Birmingham, W., Carlisle, M., Smith, T. W., & Light, K. C. (2014). The stress-buffering effects of functional social support on ambulatory blood pressure. *Health Psychology, 33*(11), 1440-1443.

Buchwald, H., Avidor, Y., Braunwald, E., Jensen, M. D., Pories, W., Fahrbach, K., & Schoelles, K. (2004). Bariatric surgery: A systematic review and meta-analysis. *JAMA, 292*(14), 1724-1737.

Buchwald, H., Estok, R., Fahrbach, K., Banel, D., Jensen, M. D., Pories, W. J., . . . Sledge, I. (2009). Weight and type 2 diabetes after bariatric surgery: Systematic review and meta-analysis. *The American Journal of Medicine, 122*(3), 248-256.

Buddeberg-Fischer, B., Klaghofer, R., Sigrist, S., & Buddeberg, C. (2004). Impact of psychosocial stress and symptoms on indication for bariatric surgery and outcome in morbidly obese patients. *Obesity Surgery, 14*(3), 361-369.

Busetto, L., Segato, G., De Marchi, F., Foletto, M., De Luca, M., Caniato, D., . . . Enzi, G. (2002). Outcome predictors in morbidly obese recipients of an adjustable gastric band. *Obesity Surgery, 12*(1), 83-92.

Cardoso, C., Ellenbogen, M. A., Serravalle, L., & Linnen, A.-M. (2013). Stress-induced negative mood moderates the relation between oxytocin administration and trust: Evidence for the tend-and-befriend response to stress? *Psychoneuroendocrinology, 38*(11), 2800-2804.

Carr, D., & Friedman, M. A. (2005). Is obesity stigmatizing? Body weight, perceived discrimination, and psychological well-being in the United States. *Journal of Health and Social Behavior, 46*(3), 244-259.

Carroll, J. F., Chiapa, A. L., Rodriquez, M., Phelps, D. R., Cardarelli, K. M., Vishwanatha, J. K., . . . Cardarelli, R. (2008). Visceral fat, waist circumference, and BMI: Impact of race/ethnicity. *Obesity, 16*(3), 600-607.

CDC. (2010). Adult Obesity. Retrieved from http://www.cdc.gov/vitalsigns/adultobesity/

Chang, S.-H., Stoll, C. R., Song, J., Varela, J. E., Eagon, C. J., & Colditz, G. A. (2014). The effectiveness and risks of bariatric surgery: An updated systematic review and meta-analysis, 2003-2012. *JAMA surgery, 149*(3), 275-287.

Christou, N. V., Look, D., & Maclean, L. D. (2006). Weight gain after short- and long-limb gastric bypass in patients followed for longer than 10 years. *Annals of Surgery, 244*(5), 734-740.

Clark, M. M., Balsiger, B. M., Sletten, C. D., Dahlman, K. L., Ames, G., Williams, D. E., . . . Sarr, M. G. (2003). Psychosocial factors and 2-year outcome following bariatric surgery for weight loss. *Obesity Surgery, 13*(5), 739-745.

Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin, 98*(2), 310-357.

Cooper, T. C., Simmons, E. B., Webb, K., Burns, J. L., & Kushner, R. F. (2015). Trends in Weight Regain Following Roux-en-Y Gastric Bypass (RYGB) Bariatric Surgery. *Obesity Surgery*, *25*(8), 1474-1481.

Courcoulas, A. P., Christian, N. J., Belle, S. H., Berk, P. D., Flum, D. R., Garcia, L., . . . Mitchell, J. E. (2013). Weight change and health outcomes at 3 years after bariatric surgery among individuals with severe obesity. *JAMA*, *310*(22), 2416-2425.

Cryan, J. F., & Dinan, T. G. (2012). Mind-altering microorganisms: The impact of the gut microbiota on brain and behaviour. *Nature Reviews Neuroscience*, *13*(10), 701.

Daniels, S. R., Khoury, P. R., & Morrison, J. A. (1997). The utility of body mass index as a measure of body fatness in children and adolescents: Differences by race and gender. *Pediatrics*, *99*(6), 804-807.

Dawson, J. (n.d.). Interpreting interaction effects. Retrieved from http://www.jeremydawson.co.uk/slopes.htm

De Koning, L., Merchant, A. T., Pogue, J., & Anand, S. S. (2007). Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: Meta-regression analysis of prospective studies. *European Heart Journal*, *28*(7), 850-856.

Delin, C. R., Watts, J. M., & Bassett, D. L. (1995). An exploration of the outcomes of gastric bypass surgery for morbid obesity: Patient characteristics and indices of success. *Obesity Surgery*, *5*(2), 159-170.

Ditzen, B., Schaer, M., Gabriel, B., Bodenmann, G., Ehlert, U., & Heinrichs, M. (2009). Intranasal oxytocin increases positive communication and reduces cortisol levels during couple conflict. *Biological Psychiatry*, *65*(9), 728-731.

Dixon, J. B., Dixon, M. E., & O'Brien, P. E. (2001). Pre-operative predictors of weight loss at 1-year after Lap-Band® surgery. *Obesity Surgery, 11*(2), 200-207.

Dixon, J. B., McPhail, T., & O'brien, P. E. (2005). Minimal reporting requirements for weight loss: Current methods not ideal. *Obesity Surgery, 15*(7), 1034-1039.

Dogan, K., Gadiot, R. P., Aarts, E. O., Betzel, B., van Laarhoven, C. J., Biter, L. U., . . . Berends, F. J. (2015). Effectiveness and safety of sleeve gastrectomy, gastric bypass, and adjustable gastric banding in morbidly obese patients: A multicenter, retrospective, matched cohort study. *Obesity Surgery, 25*(7), 1110-1118.

Egberts, K., Brown, W. A., Brennan, L., & O'Brien, P. E. (2012). Does exercise improve weight loss after bariatric surgery? A systematic review. *Obesity Surgery, 22*(2), 335-341.

Elli, E. F., Gonzalez-Heredia, R., Patel, N., Masrur, M., Murphey, M., Chen, J., & Sanchez-Johnsen, L. (2016). Bariatric surgery outcomes in ethnic minorities. *Surgery, 160*(3), 805-812.

Enders, C. K., Keller, B. T., & Levy, R. (2017). A fully conditional specification approach to multilevel imputation of categorical and continuous variables. *Psychological Methods, 23*(2), 298-317.

Figura, A., Ahnis, A., Stengel, A., Hofmann, T., Elbelt, U., Ordemann, J., & Rose, M. (2015). Determinants of weight loss following laparoscopic sleeve gastrectomy: The role of psychological burden, Coping Style, and Motivation to Undergo Surgery. *Journal of Obesity, 2015, 1-10*.

Fikkan, J. L., & Rothblum, E. D. (2012). Is fat a feminist issue? Exploring the gendered nature of weight bias. *Sex Roles, 66*(9-10), 575-592.

Finkelstein, E. A., Trogdon, J. G., Cohen, J. W., & Dietz, W. (2009). Annual medical spending attributable to obesity: Payer-and service-specific estimates. *Health Affairs*, *28*(5), w822-831.

Flegal, K. M., & Graubard, B. I. (2009). Estimates of excess deaths associated with body mass index and other anthropometric variables. *The American Journal of Clinical Nutrition, 89*(4), 1213-1219.

Flegal, K. M., Shepherd, J. A., Looker, A. C., Graubard, B. I., Borrud, L. G., Ogden, C. L., . . . Schenker, N. (2009). Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults. *The American Journal of Clinical Nutrition*, *89*(2), 500-508.

Franco, J. V. A., Ruiz, P. A., Palermo, M., & Gagner, M. (2011). A review of studies comparing three laparoscopic procedures in bariatric surgery: Sleeve gastrectomy, Roux-en-Y gastric bypass and adjustable gastric banding. *Obesity Surgery, 21*(9), 1458-1468.

Freemantle, N., Holmes, J., Hockey, A., & Kumar, S. (2008). How strong is the association between abdominal obesity and the incidence of type 2 diabetes? *International Journal of Clinical Practice, 62*(9), 1391-1396.

Fridman, A., Moon, R., Cozacov, Y., Ampudia, C., Menzo, E. L., Szomstein, S., & Rosenthal, R. J. (2013). Procedure-related morbidity in bariatric surgery: A retrospective short-and mid-term follow-up of a single institution of the American College of Surgeons Bariatric Surgery Centers of Excellence. *Journal of the American College of Surgeons, 217*(4), 614-620.

Gallagher, D., Visser, M., Sepulveda, D., Pierson, R. N., Harris, T., & Heymsfield, S. B. (1996). How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? *American Journal of Epidemiology, 143*(3), 228-239.

Hafner, R., Watts, J., & Rogers, J. (1991). Quality of life after gastric bypass for morbid obesity. *International Journal of Obesity, 15*(8), 555-560.

Hafner, R. J., Rogers, J., & Watts, J. M. (1990). Psychological status before and after gastric restriction as predictors of weight loss in the morbidly obese. *Journal of Psychosomatic Research, 34*(3), 295-302.

Halloran, K., Padwal, R. S., Johnson-Stoklossa, C., Sharma, A. M., & Birch, D. W. (2011). Income status and approval for bariatric surgery in a publicly funded regional obesity program. *Obesity Surgery, 21*(3), 373-378.

Hatoum, I. J., & Kaplan, L. M. (2013). Advantages of percent weight loss as a method of reporting weight loss after Roux-en-Y gastric bypass. *Obesity, 21*(8), 1519-1525.

Heinrichs, M., Baumgartner, T., Kirschbaum, C., & Ehlert, U. (2003). Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Biological Psychiatry, 54*(12), 1389-1398.

Heitzmann, C. A., & Kaplan, R. M. (1984). Interaction between sex and social support in the control of type II diabetes mellitus. *Journal of Consulting and Clinical Psychology, 52*(6), 1087-1089.

Herpertz, S., Kielmann, R., Wolf, A., Hebebrand, J., & Senf, W. (2004). Do psychosocial variables predict weight loss or mental health after obesity surgery? A systematic review. *Obesity Research, 12*(10), 1554-1569.

House, J. S., Kahn, R. L., McLeod, J. D., & Williams, D. (1985). Measures and concepts of social support. In S. Cohen & S.L. Syme (Eds.), *Social support and health* (pp. 83-108). San Diego, CA: Academic Press.

Hutter, M. M., Schirmer, B. D., Jones, D. B., Ko, C. Y., Cohen, M. E., Merkow, R. P., . . . Committee, A.-B. A. (2011). Laparoscopic sleeve gastrectomy has morbidity and effectiveness positioned between the band and the bypass. *Annals of Surgery, 254*(3), 410-420.

Jagielski, A. C., Brown, A., Hosseini-Araghi, M., Thomas, G. N., & Taheri, S. (2014). The association between adiposity, mental well-being, and quality of life in extreme obesity. *PloS One, 9*(3), e92859.

Jeffery, R. W., Linde, J. A., Simon, G. E., Ludman, E. J., Rohde, P., Ichikawa, L. E., & Finch, E. A. (2009). Reported food choices in older women in relation to body mass index and depressive symptoms. *Appetite, 52*(1), 238-240.

Jia, H., & Lubetkin, E. I. (2005). The impact of obesity on health-related quality-of-life in the general adult US population. *Journal of Public Health, 27*(2), 156-164.

Jonnalagadda, S. S., Skinner, R., & Moore, L. (2004). Overweight athlete: Fact or fiction? *Current Sports Medicine Reports, 3*(4), 198-205.

Kalarchian, M. A., Marcus, M. D., Levine, M. D., Soulakova, J. N., Courcoulas, A. P., & Wisinski, M. S. (2008). Relationship of psychiatric disorders to 6-month outcomes after gastric bypass. *Surgery for Obesity and Related Diseases, 4*(4), 544-549.

Karlsson, J., Taft, C., Ryden, A., Sjöström, L., & Sullivan, M. (2007). Ten-year trends in health-related quality of life after surgical and conventional treatment for severe obesity: The SOS intervention study. *International Journal of Obesity, 31*(8), 1248-1261.

Karmali, S., Birch, D. W., & Sharma, A. M. (2009). Is it time to abandon excess weight loss in reporting surgical weight loss? *Surgery for Obesity and Related Diseases, 5*(4), 503-506.

Kilpatrick, D. G., Koenen, K. C., Ruggiero, K. J., Acierno, R., Galea, S., Resnick, H. S., . . . Gelernter, J. (2007). The serotonin transporter genotype and social support and moderation of posttraumatic stress disorder and depression in hurricane-exposed adults. *American Journal of Psychiatry, 164*(11), 1693-1699.

Knoll, N., & Schwarzer, R. (2002). Gender and age differences in social support: A study of East German migrants. In G. Weidner, M. Kopp, & M. Kristenson (Eds.), *Heart Disease: Environment, Stress and Gender (*pp. 198-210), Amsterdam: IOS Press.

Koopman, C., Hermanson, K., Diamond, S., Angell, K., & Spiegel, D. (1998). Social support, life stress, pain and emotional adjustment to advanced breast cancer. *Psycho-Oncology, 7*(2), 101-111.

Larsen, J. K., Geenen, R., Maas, C., Wit, P., Antwerpen, T., Brand, N., & Ramshorst, B. (2004). Personality as a predictor of weight loss maintenance after surgery for morbid obesity. *Obesity Research, 12*(11), 1828-1834.

Livhits, M., Mercado, C., Yermilov, I., Parikh, J., Dutson, E., Mehran, A., . . . Gibbons, M. (2011). Is social support associated with greater weight loss after bariatric surgery?: A systematic review. *Obesity Reviews, 12*(2), 142-148.

Livhits, M., Mercado, C., Yermilov, I., Parikh, J. A., Dutson, E., Mehran, A., . . . Gibbons, M. M. (2012). Preoperative predictors of weight loss following bariatric surgery: Systematic review. *Obesity Surgery, 22*(1), 70-89.

Livingston, E. H. (2010). The incidence of bariatric surgery has plateaued in the U.S. *American Journal of Surgery, 200*(3), 378-385.

Mackenzie, C., Gekoski, W., & Knox, V. (2006). Age, gender, and the underutilization of mental health services: The influence of help-seeking attitudes. *Aging and Mental Health, 10*(6), 574-582.

Martin, M., Beekley, A., Kjorstad, R., & Sebesta, J. (2010). Socioeconomic disparities in eligibility and access to bariatric surgery: A national population-based analysis. *Surgery for Obesity and Related Diseases, 6*(1), 8-15.

Merten, M. J., Wickrama, K., & Williams, A. L. (2008). Adolescent obesity and young adult psychosocial outcomes: Gender and racial differences. *Journal of Youth and Adolescence, 37*(9), 1111-1122.

Mills, T. C. (2005). Predicting body fat using data on the BMI. *Journal of Statistics Education, 13*(2), 1-3.

Miras, A. D., & Le Roux, C. W. (2013). Mechanisms underlying weight loss after bariatric surgery. *Nature Reviews Gastroenterology & Hepatology, 10*(10), 575-584.

Neiberg, R. H., Wing, R. R., Bray, G. A., Reboussin, D. M., Rickman, A. D., Johnson, K. C., . . . Espeland, M. A. (2012). Patterns of weight change associated with long-term weight change and cardiovascular disease risk factors in the Look AHEAD Study. *Obesity, 20*(10), 2048-2056.

O'Brien, P. E., McPhail, T., Chaston, T. B., & Dixon, J. B. (2006). Systematic review of medium-term weight loss after bariatric operations. *Obesity Surgery, 16*(8), 1032-1040.

O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology, 27*(1S), S20-31.

Ode, J. J., Pivarnik, J. M., Reeves, M. J., & Knous, J. L. (2007). Body mass index as a predictor of percent fat in college athletes and nonathletes. *Medicine and Science in Sports and Exercise, 39*(3), 403-409.

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014). Prevalence of childhood and adult obesity in the United States, 2011-2012. *JAMA, 311*(8), 806-814.

Okorodudu, D. O., Jumean, M. F., Montori, V. M., Romero-Corral, A., Somers, V. K., Erwin, P. J., & Lopez-Jimenez, F. (2010). Diagnostic performance of body mass index to identify obesity as defined by body adiposity: A systematic review and meta-analysis. *Interntational Journal of Obesity*, *34*(5), 791-799.

Oliver, G., & Wardle, J. (1999). Perceived effects of stress on food choice. *Physiology & Behavior*, *66*(3), 511-515.

Oliver, J. E. (2006). The politics of pathology: How obesity became an epidemic disease. *Perspectives in Biology and Medicine, 49*(4), 611-627.

World Health Organization. (2000a). Obesity: preventing and managing the global epidemic. Retrieved from http://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/

World Health Organization. (2000b). The Asia-Pacific perspective: Redefining obesity and its treatment. Retrieved from http://www.wpro.who.int/nutrition/documents/docs/Redefiningobesity.pdf

Ortega, E., Morínigo, R., Flores, L., Moize, V., Rios, M., Lacy, A. M., & Vidal, J. (2012). Predictive factors of excess body weight loss 1 year after laparoscopic bariatric surgery. *Surgical Endoscopy*, *26*(6), 1744-1750.

Owens, G. (2008). Gender differences in health care expenditures, resource utilization, and quality of care. *Journal of Managed Care Pharmacy, 14*(3), 2-6.

NHLBI Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. (1998). Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report. Bethesda, MD: National Heart, Lung, and Blood Institute.

Peeters, A., Barendregt, J. J., Willekens, F., Mackenbach, J. P., Al Mamun, A., Bonneux, L., & NEDCOM, t. N. E. a. D. C. o. M. R. G. (2003). Obesity in adulthood and its consequences for life expectancy: A life-table analysis. *Annals of Internal Medicine, 138*(1), 24-32.

Peirce, R. S., Frone, M. R., Russell, M., & Cooper, M. L. (1996). Financial stress, social support, and alcohol involvement: A longitudinal test of the buffering hypothesis in a general population survey. *Health Psychology, 15*(1), 38-47.

Ritz, P., Caiazzo, R., Becouarn, G., Arnalsteen, L., Andrieu, S., Topart, P., & Pattou, F. (2013). Early prediction of failure to lose weight after obesity surgery. *Surgery for Obesity and Related Diseases, 9*(1), 118-121.

Robinson, A. H., Adler, S., Darcy, A. M., Osipov, L., & Safer, D. L. (2016). Early Adherence Targeted Therapy (EATT) for postbariatric maladaptive eating behaviors. *Cognitive and Behavioral Practice, 23*(4), 548-560.

Romero-Corral, A., Montori, V. M., Somers, V. K., Korinek, J., Thomas, R. J., Allison, T. G., . . . Lopez-Jimenez, F. (2006). Association of bodyweight with total mortality and with cardiovascular events in coronary artery disease: A systematic review of cohort studies. *The Lancet, 368*(9536), 666-678.

Rydén, O., Hedenbro, J., & Frederiksen, S. (1996). Weight loss after vertical banded gastroplasty can be predicted: A prospective psychological study. *Obesity Surgery, 6*(3), 237-243.

Sanchis, P., Frances, C., Nicolau, J., Rivera, R., Fortuny, R., Julian, X., . . . Olivares, J. (2015). Cardiovascular risk profile in Mediterranean patients submitted to bariatric surgery and intensive lifestyle intervention: Impact of both interventions after 1 year of follow-up. *Obesity Surgery, 25*(1), 97-108.

Santry, H. P., Lauderdale, D. S., Cagney, K. A., Rathouz, P. J., Alverdy, J. C., & Chin, M. H. (2007). Predictors of patient selection in bariatric surgery. *Annals of Surgery, 245*(1), 59.

Sarwer, D. B., Cohn, N. I., Gibbons, L. M., Magee, L., Crerand, C. E., Raper, S. E., . . . Wadden, T. A. (2004). Psychiatric diagnoses and psychiatric treatment among bariatric surgery candidates. *Obesity Surgery, 14*(9), 1148-1156.

Sarwer, D. B., Moore, R. H., Spitzer, J. C., Wadden, T. A., Raper, S. E., & Williams, N. N. (2012). A pilot study investigating the efficacy of postoperative dietary counseling to improve outcomes after bariatric surgery. *Surgery for Obesity and Related Diseases, 8*(5), 561-568.

Sarwer, D. B., Wadden, T. A., Moore, R. H., Baker, A. W., Gibbons, L. M., Raper, S. E., & Williams, N. N. (2008). Preoperative eating behavior, postoperative dietary adherence, and weight loss after gastric bypass surgery. *Surgery for Obesity and Related Diseases, 4*(5), 640-646.

Schaefer, C., Coyne, J. C., & Lazarus, R. S. (1981). The health-related functions of social support. *Journal of Behavioral Medicine, 4*(4), 381-406.

Scholtz, S., Bidlake, L., Morgan, J., Fiennes, A., El-Etar, A., Lacey, J. H., & McCluskey, S. (2007). Long-term outcomes following laparoscopic adjustable gastric banding: Postoperative psychological sequelae predict outcome at 5-year follow-up. *Obesity Surgery, 17*(9), 1220-1225.

Schwartz, M. B., & Brownell, K. D. (2004). Obesity and body image. *Body Image, 1*(1), 43-56.

Shah, M., Simha, V., & Garg, A. (2006). Review: Long-term impact of bariatric surgery on body weight, comorbidities, and nutritional status. *Journal of Clinical Endocrinology and Metabolism, 91*(11), 4223-4231.

Sjöström, L., Lindroos, A. K., Peltonen, M., Torgerson, J., Bouchard, C., Carlsson, B., . . . Group, S. O. S. S. S. (2004). Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *New England Journal of Medicine, 351*(26), 2683-2693.

Sockalingam, S., Cassin, S., Crawford, S., Pitzul, K., Khan, A., Hawa, R., . . . Okrainec, A. (2013). Psychiatric predictors of surgery non-completion following suitability assessment for bariatric surgery. *Obesity Surgery, 23*(2), 205-211.

Song, Z., Reinhardt, K., Buzdon, M., & Liao, P. (2008). Association between support group attendance and weight loss after Roux-en-Y gastric bypass. *Surgery for Obesity and Related Diseases, 4*(2), 100-103.

Steinberger, J., Jacobs, D., Raatz, S., Moran, A., Hong, C., & Sinaiko, A. (2005). Comparison of body fatness measurements by BMI and skinfolds vs dual energy X-ray absorptiometry and their relation to cardiovascular risk factors in adolescents. *International Journal of Obesity, 29*(11), 1346-1352.

Stults-Kolehmainen, M. A., & Sinha, R. (2014). The effects of stress on physical activity and exercise. *Sports Medicine, 44*(1), 81-121.

Sudan, R., Winegar, D., Thomas, S., & Morton, J. (2014). Influence of ethnicity on the efficacy and utilization of bariatric surgery in the USA. *Journal of Gastrointestinal Surgery, 18*(1), 130-136.

Sun, Q., Van Dam, R. M., Spiegelman, D., Heymsfield, S. B., Willett, W. C., & Hu, F. B. (2010). Comparison of dual-energy x-ray absorptiometric and anthropometric measures of adiposity in relation to adiposity-related biologic factors. *American Journal of Epidemiology, 172*(12), 1442-1454.

Suter, M., Calmes, J., Paroz, A., & Giusti, V. (2006). A 10-year experience with laparoscopic gastric banding for morbid obesity: High long-term complication and failure rates. *Obesity Surgery, 16*(7), 829-835.

Sysko, R., Devlin, M. J., Hildebrandt, T. B., Brewer, S. K., Zitsman, J. L., & Walsh, B. T. (2012). Psychological outcomes and predictors of initial weight loss outcomes among severely obese adolescents receiving laparoscopic adjustable gastric banding. *The Journal of Clinical Psychiatry, 73*(10), 1351-1357.

Tamres, L. K., Janicki, D., & Helgeson, V. S. (2002). Sex differences in coping behavior: A meta-analytic review and an examination of relative coping. *Personality and Social Psychology Review, 6*(1), 2-30.

Tang-Péronard, J., & Heitmann, B. (2008). Stigmatization of obese children and adolescents, the importance of gender. *Obesity Reviews, 9*(6), 522-534.

Taylor, S. E. (2006). Tend and befriend: Biobehavioral bases of affiliation under stress. *Current Directions in Psychological Science, 15*(6), 273-277.

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A., & Updegraff, J. A. (2000). Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *Psychological Review, 107*(3), 411-429.

Te Riele, W., Boerma, D., Wiezer, M., Borel Rinkes, I., & van Ramshorst, B. (2010). Long-term results of laparoscopic adjustable gastric banding in patients lost to follow-up. *British Journal of Surgery, 97*(10), 1535-1540.

Tice, J. A., Karliner, L., Walsh, J., Petersen, A. J., & Feldman, M. D. (2008). Gastric banding or bypass? A systematic review comparing the two most popular bariatric procedures. *The American Journal of Medicine, 121*(10), 885-893.

Torres, S. J., & Nowson, C. A. (2007). Relationship between stress, eating behavior, and obesity. *Nutrition, 23*(11), 887-894.

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and physiological processes: A review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin, 119*(3), 488-531.

Unick, J. L., Hogan, P. E., Neiberg, R. H., Cheskin, L. J., Dutton, G. R., Evans-Hudnall, G., . . . Pi-Sunyer, F. X. (2014). Evaluation of early weight loss thresholds for identifying nonresponders to an intensive lifestyle intervention. *Obesity, 22*(7), 1608-1616.

van de Laar, A. (2012). Bariatric Outcomes Longitudinal Database (BOLD) suggests excess weight loss and excess BMI loss to be inappropriate outcome measures, demonstrating better alternatives. *Obesity Surgery, 22*(12), 1843-1847.

van de Laar, A. (2016). The% EBMIL/% EWL double booby-trap. A comment on studies that compare the effect of bariatric surgery between heavier and lighter patients. *Obesity Surgery, 26*(3), 612-613.

van de Laar, A. W., van Rijswijk, A., Kakar, H., & Bruin, S. (2018). Sensitivity and specificity of 50% excess weight loss (50% EWL) and twelve other bariatric criteria for weight loss success. *Obesity Surgery*, 1-8.

Vgontzas, A. N., Papanicolaou, D. A., Bixler, E. O., Hopper, K., Lotsikas, A., Lin, H.-M., . . . Chrousos, G. P. (2000). Sleep apnea and daytime sleepiness and fatigue: Relation to visceral obesity, insulin resistance, and hypercytokinemia. *The Journal of Clinical Endocrinology & Metabolism, 85*(3), 1151-1158.

Wadden, T. A., Butryn, M. L., Sarwer, D. B., Fabricatore, A. N., Crerand, C. E., Lipschutz, P. E., . . . Williams, N. N. (2006). Comparison of psychosocial status in treatment-seeking women with class III vs. class I–II obesity. *Obesity, 14*(S3), 90S-98S.

Wadden, T. A., & Foster, G. D. (2006). Weight and lifestyle inventory (WALI). *Obesity, 14*(S3), 99S-118S.

Wallace, A. E., Young-Xu, Y., Hartley, D., & Weeks, W. B. (2010). Racial, socioeconomic, and rural–urban disparities in obesity-related bariatric surgery. *Obesity Surgery, 20*(10), 1354-1360.

Wareham, S., Fowler, K., & Pike, A. (2007). Determinants of depression severity and duration in Canadian adults: The moderating effects of gender and social support. *Journal of Applied Social Psychology, 37*(12), 2951-2979.

White, M. A., Kalarchian, M. A., Levine, M. D., Masheb, R. M., Marcus, M. D., & Grilo, C. M. (2015). Prognostic significance of depressive symptoms on weight loss and psychosocial outcomes following gastric bypass surgery: A prospective 24-month follow-up study. *Obesity Surgery, 25*(10), 1909-1916.

Willett, K., Jiang, R., Lenart, E., Spiegelman, D., & Willett, W. (2006). Comparison of bioelectrical impedance and BMI in predicting obesity-related medical conditions. *Obesity, 14*(3), 480-490.

Wimmelmann, C. L., Dela, F., & Mortensen, E. L. (2014). Psychological predictors of weight loss after bariatric surgery: A review of the recent research. *Obesity Research & Clinical Practice, 8*(4), e299-e313.

Wing, R. R., Marcus, M. D., Epstein, L. H., & Jawad, A. (1991). A" family-based" approach to the treatment of obese type II diabetic patients. *Journal of Consulting and Clinical Psychology, 59*(1), 156-162.

Wyatt, S. B., Winters, K. P., & Dubbert, P. M. (2006). Overweight and obesity: Prevalence, consequences, and causes of a growing public health problem. *American Journal of Medical Sciences, 331*(4), 166-174.

TABLES

Table 1

Patient Characteristics at Time of Surgery

	Total (n = 548)	Men (n = 103)	Women (n = 445)	Effect Size (d/φ_c)	p value
Procedure				.09	.129
Roux-en-Y Gastric Bypass	40.6%	46.6%	39.2%		
Laparoscopic Adjustable Band	2.2%	3.9%	1.8%		
Sleeve Gastrectomy	57.2%	49.5%	59.0%		
Age at Time of Surgery				.29	.011*
Mean	43.87	46.55	43.24		
Range	17 – 74	24 – 71	17 – 74		
Race/Ethnicity					
% Hispanic	18.6%	13.6%	19.8%	.06	.154
% Minority Race	31.6%	19.6%	34.7%	.13	.003**
Marital Status				.22	< .001***
Married or Domestic Partner	59.8%	81.9%	54.7%		
Single	20.4%	9.1%	23.0%		
Divorced/Separated	17.9%	9.1%	19.9%		
Widowed	1.9%	0.0%	2.4%		
Employed	65.6%	62.3%	66.3%	.13	.025*
Years of education				.40	.001**
Mean	13.75	14.60	13.57		
Range	1 – 20	8 – 20	1 – 20		
BMI at Time of Surgery[a]				.18	.119
Mean	47.75	49.08	47.43		
Range	33 – 95	34 – 78	33 – 95		
Depression				.09	.071
Frequency	21.4%	14.1%	23.0%		
SD	.41	.35	.42		
Stress				.12	.319
Mean	1.95	2.10	1.91		
SD	1.52	1.71	1.48		
Structural Support					
Frequency	64.9%	83.3%	60.8%	.18	< .001***
SD	.48	.37	.49		
Emotional Support				.32	.033*
Mean	2.14	1.69	2.24		
SD	1.93	1.34	2.02		
Functional Support				.04	.735
Mean	.30	.35	.29		
SD	1.49	1.67	1.45		

Note. [a] Equal variances not assumed. $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 2

Means, Standard Deviations, and Correlations among Study Variables

	1	2	3	4	5	6	7	8	9
1. Age	-------	-.07	.17	-.12	-.12	.06	-.15	.01	-.40**
2. Race[a]	-.15**	-------	.04	-.09	-.05	-.14	.19	.00	.08
3. Years of Education	.05	-.09	-------	.00	.01	.05	-.08	.11	-.17
4. Depression[b]	.06	-.05	-.09	-------	.21	-.18	-.03	.06	.20
5. Stress	-.14**	-.05	-.03	.21**	-------	-.05	-.02	.10	.16
6.Structural Support	.07	-.17**	.03	-.07	.03	-------	-.19	.10	-.19
7. Emotional Support	-.06	-.07	-.05	-.07	-.07	-.01	-------	.02	.19
8. Functional Support	.06	-.08	.02	.01	-.08	-.03	-.06	-------	.09
9. BMI at Surgery	-.22**	.14**	-.06	.07	.07	-.12*	.00	-.05	-------

Note. Correlations for males are presented above the diagonal, while correlations for females are presented below the diagonal.
[a]1= identified as belonging to minority racial group. [b]1 = reported current depression. $^{*}p < .05$ $^{**}p < .01$

Table 3.

Weight Loss during Short-Term Follow Up by BMI Group

Initial BMI Group	Initial BMI	Initial Weight (kg)	BMI at 6 mo (BMIΔ)	Weight at 6 mo (%TWL)	BMI at 12 mo (BMIΔ)[a]	Weight at 12 mo (%TWL)[a]
30-39.9	37.79	104.70	31.35 (6.25)	82.26 (22.84%)	30.08 (8.08)	83.81 (21.10%)
40-49.9	44.59	124.04	34.97 (9.98)	92.64 (27.12%)	32.48 (12.32)	90.39 (27.39%)
50-59.9	53.99	151.94	41.69 (12.16)	111.35 (27.65%)	38.74 (15.25)	111.21 (28.24%)
≥60	68.01	197.20	52.99 (15.98)	153.84 (30.13%)	49.42 (20.81)	137.43 (29.88%)

Note. [a]Change from initial weight/BMI. mo = months. BMI = body mass index. TWL = total weight loss.

Table 4

Preliminary Models

	Model 1	Model 2	Model 3	Model 4
Fixed effects				
Intercept	38.89***	44.91***	47.36***	47.36***
Time		-3.01***	-7.90***	-7.90***
$Time^2$			1.22***	1.22***
Age				-.06*
EMP				-2.79**
Procedure Type				
AGB				3.69
SG				-.51
EDU				.10
Race				1.98**
Random effects				
σ^2	35.36	10.68	3.41	3.41
τ_{00}	45.15	62.59	71.87	67.72
τ_{11}		.80	4.09	4.09
τ_{22}			.07	.07
τ_{10}		-3.92	-10.93	-10.78
τ_{20}			1.30	1.34
τ_{12}			-.46	-.46
Deviance (-2LL)	18639.78	16286.41*	14492.35*	14455.57*
Explained variance		[a].70	[a].68	[b].06

Note. EMP= Employment Status. SG = Sleeve gastrectomy. AGB =Adjustable gastric banding. EDU = Years of Education. [a]Baseline model is previous model, explained variance for individual variance (σ^2). [b]Baseline model is previous model, explained variance for between subject variance around the intercept (τ_{00}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 5

Stress Predicting BMI Change over 12 Months following Bariatric Surgery including Functional Support and Patient Gender as Moderators

	Model 5	**Model 6**	**Model 7**	**Model 8**
Fixed effects				
Intercept	48.82***	48.38***	48.23***	48.22***
Time	-7.90***	-7.57***	-7.54***	-7.53***
$Time^2$	1.22***	1.19***	1.18***	1.18***
Age	-.06*	-.06*	-.07*	-.07*
EMP	-2.69**	-2.71**	-2.73**	-2.73**
Procedure Type				
AGB	3.44			
SG	-.46			
EDU	.06			
Race	2.12**	2.04**	2.03**	2.03**
Gender	-1.57*	-.87	-0.70	-0.70
Stress	.11	.70	0.85	0.87
FS	-.05	.13	1.24	1.74
2-Way Interactions				
Time *STR		-.17	-.26	-.27
Time*FS		.02	-.38	-.67
Time*Gender		.06	-.43	-.55
STR*FS		.05	-.23	-.38
STR*GEN		-.35	-.54	-.56
FS*GEN		-.37	-1.53	-2.13*
$Time^2$ *STR		.02	.04	.04
$Time^2$*FS		-.01	.06	.11
$Time^2$*Gender		-.01	.07	.09
3-Way Interactions				
Time*STR*FS			.11	.20*
Time*GEN*STR			.08	.10
Time*GEN*FS			.32	.68
STR*GEN*FS			.28	.57
$Time^2$*STR*FS			-.02	-.04
$Time^2$*GEN* STR			-.02	-.02
$Time^2$*GEN*FS			-.05	-.10
4- Way Interaction				
Time*STR *FS*GEN				-.17
$Time^2$*STR*FS*GEN				.03
Random effects				
σ^2	3.41	3.41	3.41	3.41
τ_{00}	67.11	66.09	65.84	65.77
τ_{11}	4.09	4.04	4.01	3.99
τ_{22}	.07	.07	.07	.07
τ_{10}	-10.66	-10.22	-10.12	-10.08
τ_{20}	1.32	1.25	1.23	1.22
τ_{12}	-.46	-.45	-.45	-.44
Deviance (-2LL)	14450.26	14440.55	14431.65	14428.62
Explained variance [a]		.01	.01	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. FS =Functional support. STR= Stress. GEN = Gender. [a] Baseline model is previous model and explained variance is for the linear slope (τ_{11}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 6

Stress Predicting BMI Change over 12 Months following Bariatric Surgery including Structural Support and Patient Gender as Moderators

	Model 9	Model 10	Model 11	Model 12
Fixed effects				
Intercept	50.15***	51.24***	52.30***	52.28***
Time	-7.90***	-7.50***	-7.66***	-7.63***
Time^2	1.22***	1.12***	1.21***	1.20***
Age	-.05			
EMP	-2.49**	-2.14**	-2.16**	-2.16**
Procedure Type				
AGB	3.80			
SG	-.51			
EDU	.06			
Race	1.85**	1.96**	1.96**	1.96**
Gender	-1.86*	-3.48	-4.91	-4.91
Stress	.13	.90	.71	.57
SS	-1.69*	-4.10	-5.79	-6.00
2-Way Interactions				
Time *STR		-.17	-.21	-.07
Time*SS		-.09	.33	.55
Time*Gender		.04	-.27	.45
STR*SS		-.25	.28	.53
STR*GEN		-.28	.09	.26
SS*GEN		2.75	5.20	5.51
Time^2 *STR		.02	-.02	-.05
Time^2*SS		.11	-.05	-.11
Time^2*Gender		.01	.10	-.07
3-Way Interactions				
Time*STR*SS			-.10	-.36
Time*GEN*STR			.14	-.04
Time*GEN*SS			-.24	-.57
STR*GEN*SS			-.90	-1.23
Time^2*STR*SS			.07	.14
Time^2*GEN* STR			-.01	.03
Time^2*GEN*SS			.02	.11
4- Way Interaction				
Time*STR *SS*GEN				.34
Time^2*STR*SS*GEN				-.09
Random effects				
σ^2	3.41	3.41	3.41	3.41
τ_{00}	66.43	67.53	67.46	67.47
τ_{11}	4.09	4.04	4.04	4.03
τ_{22}	.07	.07	.06	.06
τ_{10}	-10.78	-10.89	-10.89	-10.89
τ_{20}	1.37	1.39	1.39	1.39
τ_{12}	-.46	-.45	-.45	-.44
Deviance (-2LL)	14442.96*	14419.21*	14397.36*	14394.14
Explained variance^{a}		.01	.00	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. SS =Structural support. STR= Stress. GEN = Gender. ^{a} Baseline model is previous model and explained variance is for the linear slope (τ_{11}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 7

Stress Predicting BMI Change over 12 Months following Bariatric Surgery including Emotional Support and Patient Gender as Moderators

	Model 13	**Model 14**	**Model 15**	**Model 16**
Fixed effects				
Intercept	48.67***	47.05***	46.08***	46.10***
Time	-7.90***	-7.04***	-6.58***	-6.59***
$Time^2$	1.22***	1.09***	.97***	.98***
Age	-.06*	-.06*	-.06*	-.06*
EMP	-2.66**	-2.62**	-2.63**	-2.63**
Procedure Type				
AGB	3.45			
SG	-.47			
EDU	.06			
Race	2.13**	2.03**	2.03**	2.03**
Gender	-1.62*	-.89	-.23	-.23
Stress	.12	.91	1.35	1.16
ES	.08	.60	1.32	1.07
2-Way Interactions				
Time *STR		-.20	-.48*	-.40
Time*ES		-.22*	-.52	-.42
Time*Gender		-.20	-.45	-.09
STR*ES		-.06	-.28	-.10
STR*GEN		-.36	-.65	-.40
ES*GEN		-.10	-.73	-.43
$Time^2$ *STR		.02	.10	.10
$Time^2$*ES		.04	.10	.09
$Time^2$*Gender		-.04	.03	.01
3-Way Interactions				
Time*STR*ES			.11	.04
Time*GEN*STR			.03	-.06
Time*GEN*ES			.13	.01
STR*GEN*ES			.14	-.07
$Time^2$*STR*ES			-.03*	-.03
$Time^2$*GEN* STR			-.01	-.01
$Time^2$*GEN*ES			-.01	.00
4- Way Interaction				
Time*STR *ES*GEN				.09
$Time^2$*STR*ES*GEN				.00
Random effects				
σ^2	3.41	3.41	3.41	3.41
τ_{00}	66.79	65.20	65.11	65.09
τ_{11}	4.09	3.80	3.65	3.65
τ_{22}	.07	.06	.05	.05
τ_{10}	-10.58	-9.71	-9.58	-9.57
τ_{20}	1.31	1.14	1.11	1.11
τ_{12}	-.46	-.41	-.37	-.37
Deviance (-2LL)	14449.39	14421.01^{*c}	14390.84*	14386.88
Explained variance [a]		.07	.04 | .17[b]	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. ES =Emotional support. STR= Stress. GEN = Gender. [a] Baseline model is previous model and explained variance is for the linear slope (τ_{11}). [b]Explained variance for the quadratic function (τ_{22}). [c] Baseline model is Model 4. $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 8

Depression Predicting BMI Change over 12 Months following Bariatric Surgery including Functional Support and Patient Gender as Moderators

	Model 17	Model 18	Model 19	Model 20
Fixed effects				
Intercept	48.76***	49.01***	49.06***	49.06***
Time	-7.90***	-7.93***	-7.96***	-7.96***
Time^2	1.22***	1.25***	1.26***	1.26***
Age	-.06*	-.06*	-.06*	-.06*
EMP	-2.57**	-2.55**	-2.53**	-2.53**
Procedure Type				
AGB	3.33**			
SG	-.45			
EDU	.07			
Race	2.14**	2.09**	2.09**	2.09**
Gender	-1.69*	-1.17	-1.19	-1.19
DEP	.94	4.20	3.56	2.84
FS	-.06	.26	.24	-.11
2-Way Interactions				
Time *DEP		.12	.30	.75
Time*FS		.03	.09	.31
Time*Gender		.08	.06	.15
DEP*FS		.15	1.29	2.98*
DEP*GEN		-3.21	-2.77	-1.91
FS*GEN		-.51	-.68	-.23
Time^2 *DEP		-.12	-.12	-.20
Time^2*FS		-.01	-.04	-.07
Time^2*Gender		-.01	-.00	-.02
3-Way Interactions				
Time*DEP*FS			-.54*	-1.63**
Time*GEN*DEP			.01	-.55
Time*GEN*FS			.07	-.22
DEP*GEN*FS			-.42	-2.68
Time^2*DEP*FS			.10	.28**
Time^2*GEN* DEP			-.04	.05
Time^2*GEN*FS			.01	.06
4- Way Interaction				
Time*DEP *FS*GEN				1.46**
Time^2*DEP*FS*GEN				-.25*
Random effects				
σ^2	3.41	3.41	3.41	3.41
τ_{00}	66.84	65.99	65.78	65.47
τ_{11}	4.09	4.12	4.04	3.91
τ_{22}	.07	.07	.06	.06
τ_{10}	-10.68	-10.42	-10.27	-10.07
τ_{20}	1.34	1.29	1.26	1.23
τ_{12}	-.46	-.46	-.46	-.42
Deviance (-2LL)	14448.62	14426.81*c	14414.99	14404.93*d
Explained variance[a]		.00	.02|.14[b]	.03

Note. EMP= Employment. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Education. FS = Functional support. DEP = Depression. GEN = Gender. [a] Baseline model is previous model and explained variance is for the linear slope (τ_{11}). [b]Explained variance for the quadratic function (τ_{22}). [c] Baseline model is model 4. [d] Baseline model is model 18. $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 9

Depression Predicting BMI Change over 12 Months following Bariatric Surgery including Structural Support and Patient Gender as Moderators

	Model 21	Model 22	Model 23	Model 24
Fixed effects				
Intercept	50.12***	52.17***	51.94***	51.94***
Time	-7.90***	-7.86***	-7.91***	-7.91***
$Time^2$	1.22***	1.18***	1.22***	1.22***
Age	-.06*	-.06	-.06	-.06
EMP	-2.39**	-2.31**	-2.31**	-2.31**
Procedure Type				
AGB	3.69			
SG	-0.49			
EDU	.06			
Race	1.87**	1.86**	1.86**	1.86**
Gender	-1.96	-3.58	-3.44	-3.44
DEP	.84	4.28	5.02	5.99
SS	-1.63*	-3.88	-3.50	-3.43
2-Way Interactions				
Time *DEP		.11	.28	.34
Time*SS		-.10	-.06	-.06
Time*Gender		.06	.16	.20
DEP*SS		-.81	-1.92	-3.46
DEP*GEN		-2.89	-3.28	-4.37
SS*GEN		2.47	2.20	2.11
$Time^2$ *DEP		-.11	-.24	-.41
$Time^2$*SS		.10	.05	.04
$Time^2$*Gender		.01	.06	.01
3-Way Interactions				
Time*DEP*SS			-.35	-.43
Time*GEN*DEP			.05	-.02
Time*GEN*SS			.05	.05
DEP*GEN*SS			.52	2.28
$Time^2$*DEP*SS			.24	.49
$Time^2$*GEN* DEP			-.01	.17
$Time^2$*GEN*SS			-.01	.01
4- Way Interaction				
Time*DEP *SS*GEN				.09
$Time^2$*DEP*SS*GEN				-.29
Random effects				
σ^2	3.41	3.41	3.41	3.41
τ_{00}	66.27	65.33	65.35	65.37
τ_{11}	4.09	4.11	4.13	4.14
τ_{22}	.07	.06	.06	.06
τ_{10}	-10.80	-10.55	-10.60	-10.62
τ_{20}	1.39	1.35	1.37	1.37
τ_{12}	-.46	-.46	-.46	-.46
Deviance (-2LL)	14441.80*	14403.74*	14385.01*	14381.96
Explained variance[a]		.00	.00	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. DEP = Depression. SS =Structural support. GEN = Gender. [a]Baseline model is previous model, and computed explained variance for the linear slope (τ_{11}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 10

Depression Predicting BMI Change over 12 Months following Bariatric Surgery including Emotional Support and Patient Gender as Moderators

	Model 25	Model 26	Model 27	Model 28
Fixed effects				
Intercept	48.63***	48.36***	48.23***	48.25***
Time	-7.90***	-7.46***	-7.37***	-7.38***
$Time^2$	1.22***	1.17***	1.15***	1.15***
Age	-.06*	-.06*	-.06*	-.06*
EMP	-2.54**	-2.49**	-2.49**	-2.49**
Procedure Type				
AGB	3.34			
SG	-.45			
EDU	.06			
Race	2.15**	2.10**	2.10**	2.10**
Gender	-1.74*	-1.27	-1.28	-1.28
DEP	.96	3.28	3.45	1.38
ES	.08	.30	.63	.54
2-Way Interactions				
Time *DEP		.08	-.30	.64
Time*ES		-.21	-.36	-.32
Time*Gender		.21	.02	.19
DEP*ES		.66	.32	1.69
DEP*Gender		-3.50	-3.22	-.94
ES*Gender		-.01	-.33	-.24
$Time^2$ *DEP		-.12	.04	-.04
$Time^2$*ES		.04	.05	.05
$Time^2$*Gender		-.03	-04	-.06
3-Way Interactions				
Time*DEP*ES			.22	-.42
Time*GEN*DEP			-.09	-1.13
Time*GEN*ES			.13	.09
DEP*GEN*ES			.17	-1.33
$Time^2$*DEP*ES			-.06	.00
$Time^2$*GEN* DEP			-.04	.04
$Time^2$*GEN*ES			-.01	.00
4- Way Interaction				
Time*DEP *ES*GEN				.70
$Time^2$*DEP*ES*GEN				-.06
Random effects				
σ^2	3.41	3.41	3.41	3.41
τ_{00}	66.53	65.37	65.35	65.27
τ_{11}	4.09	3.89	3.86	3.85
τ_{22}	.07	.06	.06	.06
τ_{10}	-10.60	-10.16	-10.15	-10.11
τ_{20}	1.32	1.25	1.25	1.24
τ_{12}	-.46	-.42	-.41	-.41
Deviance (-2LL)	14381.96*	14405.71	14385.52	14381.16
Explained variance[a]		.05	.01	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. DEP = Depression. ES =Emotional support. GEN = Gender. [a]Baseline model is previous model, and computed explained variance for the linear slope (τ_{11}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

FIGURES

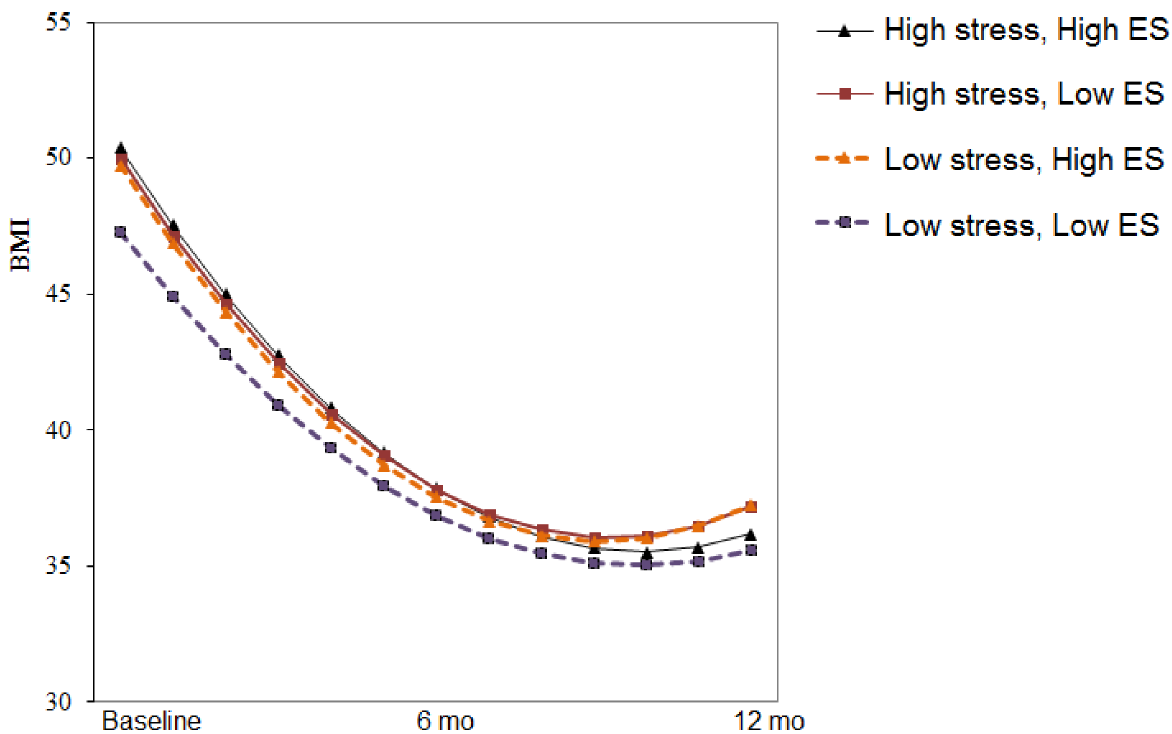

Figure 1. Curvilinear trajectory of BMI over the first 12 months following surgery, as a function of stress and emotional support (ES; Model 15).

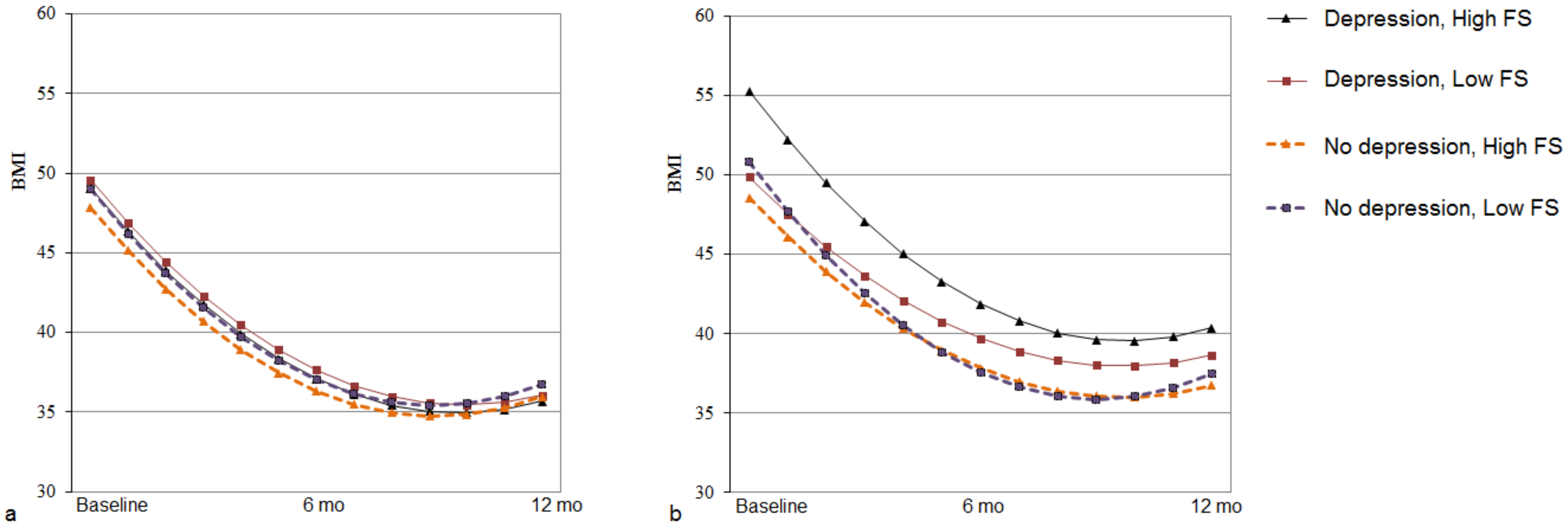

Figure 2. Curvilinear trajectory of BMI over the first 12 months following surgery, as a function of depression and functional support (FS; Model 20).

APPENDICES

Appendix A: Results of Secondary Analyses

Table A1

Past Stress Predicting BMI Change over 12 Months following Bariatric Surgery including Functional Support and Patient Gender as Moderators

	Model S1	Model S2	Model S3	Model S4
Fixed effects				
Intercept	49.03***	50.99***	48.17***	48.03***
Time	-7.92***	-7.66***	-6.64***	-6.53**
$Time^2$	1.23***	1.09***	1.06**	1.04**
Age	-.07*	-.07*	-.07*	-.07*
EMP	-2.80**	-2.72**	-2.72**	-2.72**
Procedure Type				
AGB	2.64			
SG	-.30			
EDU	.07			
Race	2.11**	2.02**	2.01**	2.01**
Gender	-1.42	-2.59	.74	.95
STR_P	-.04	-.33	.52	.56
FS	-.06	-.60	2.75	4.54
2-Way Interactions				
Time *STR_P		-.13	-.44	-.47
Time*FS		-.01	-.91	-2.23
Time*Gender		.21	-.90	-1.06
STR*FS		.27	-.62	-1.11
STR_P*GEN		.26	-.73	-.79
FS*GEN		-.41	-2.95	-5.04
$Time^2$ *STR_P		.05	.06	.07
$Time^2$*FS		.00	.13	.39
$Time^2$*Gender		-.03	-.04	.00
3-Way Interactions				
Time*STR_P*FS			.26	.62
Time*GEN*STR_P			.34	.39
Time*GEN*FS			.16	1.71
STR_P*GEN*FS			.59	1.19
$Time^2$*STR_P*FS			-.04	-.12
$Time^2$*GEN* STR_P			.00	-.01
$Time^2$*GEN*FS			.01	-.30
4- Way Interaction				
Time*STR_P *FS*GEN				-.44
$Time^2$*STR_P*FS*GEN				.09
Random effects				
σ^2	3.40	3.40	3.40	3.39
τ_{00}	66.99	66.56	66.31	66.29
τ_{11}	4.20	4.17	4.12	4.10
τ_{22}	.07	.07	.07	.07
τ_{10}	-10.90	-10.80	-10.68	-10.66
τ_{20}	1.37	1.36	1.35	1.34
τ_{12}	-.47	-.46	-.46	-.45
Deviance (-2LL)	14471.66*	14481.42	14483.41	14484.96
Explained variance[a]		.01	.01	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. FS = Functional support. STR_P = Perceived stress past 6 months . GEN = Gender. [a] Baseline model is previous model and explained variance is for the linear slope (τ_{11}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table A2

Past Stress Predicting BMI Change over 12 Months following Bariatric Surgery including Structural Support and Patient Gender as Moderators

	Model S5	Model S6	Model S7	Model S8
Fixed effects				
Intercept	50.25***	52.90***	52.52***	52.35***
Time	-7.92***	-7.67***	-6.43**	-5.98*
Time^2	1.23***	1.04***	1.04**	.89
Age	-.06			
EMP	-2.61**	-2.15*	-2.16*	-2.16*
Procedure Type				
AGB	2.82			
SG	-.33			
EDU	.06			
Race	1.88**	2.03**	2.02**	2.02**
Gender	-1.70	-4.72	-5.26	-5.07
STR_P	-.03	-.04	.23	.29
SS	-1.55*	-3.29	-5.96	-5.74
2-Way Interactions				
Time *STR_P		-.13	-.58	-.73
Time*SS		.00	-.36	-.91
Time*Gender		.21	-.83	-1.33
STR_P*SS		-.20	.45	.37
STR_P*GEN		.24	.23	.16
SS*GEN		2.24	7.50	7.22
Time^2 *STR_P		.05	.06	.11
Time^2*SS		.06	.05	.23
Time^2*Gender		-.02	-.02	.15
3-Way Interactions				
Time*STR_P*SS			.20	.38
Time*GEN*STR_P			.41	.56
Time*GEN*SS			-.36	.29
STR_P*GEN*SS			-1.39	-1.29
Time^2*STR_P*SS			.00	-.06
Time^2*GEN* STR_P			-.01	-.06
Time^2*GEN*SS			.04	-.18
4- Way Interaction				
Time*STR_P *SS*GEN				-.20
Time^2*STR_P*SS*GEN				.07
Random effects				
σ^2	3.40	3.40	3.40	3.40
τ_{00}	66.36	68.51	68.22	68.25
τ_{11}	4.20	4.17	4.13	4.14
τ_{22}	.07	.07	.07	.07
τ_{10}	-10.94	-11.40	-11.31	-11.33
τ_{20}	1.40	1.46	1.46	1.46
τ_{12}	-.47	-.46	-.46	-.46
Deviance (-2LL)	14463.15	14456.35	14450.35	14450.78
Explained variance[a]		.01	.01	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. SS = Structural support. STR_P = Perceived stress past 6 months. GEN = Gender. [a] Baseline model is previous model and explained variance is for the linear slope (τ_{11}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table A3

Past Stress Predicting BMI Change over 12 Months following Bariatric Surgery including Emotional Support and Patient Gender as Moderators

	Model S9	Model S10	Model S11	Model S12
Fixed effects				
Intercept	48.68***	49.04***	43.32***	43.80***
Time	-7.92***	-7.19***	-6.57**	-6.31*
$Time^2$	1.23***	.99***	1.12*	.95
Age	-.07*	-.06*	-0.06*	-.06*
EMP	-2.76**	-2.64	-2.65**	-2.65**
Procedure Type				
AGB	2.63			
SG	-.28			
EDU	.07			
Race	2.12**	2.12**	2.08**	2.08**
Gender	-1.49	-3.80	5.06	4.55
STR_P	-.03	.10	1.62	1.47
ES	.14	.92	2.45	2.23
2-Way Interactions				
Time *STR_P		-.14	-.31	-.39
Time*ES		-.25**	-.03	-.17
Time*Gender		.34	-1.35	-1.66
STR_P*ES		-.19	-.52	-.45
STR_P*GEN		.36	-1.92	-1.76
ES*GEN		.28	-2.39	-2.16
$Time^2$ *STR_P		.05	.05	.10
$Time^2$*ES		.05**	-.03	.06
$Time^2$*Gender		-.06	-.12	.07
3-Way Interactions				
Time*STR_P*ES			-.08	-.04
Time*GEN*STR_P			.41	.51
Time*GEN*ES			.19	.35
STR_P*GEN*ES			.59	.51
$Time^2$*STR_P*ES			.01	-.02
$Time^2$*GEN* STR_P			.00	-.06
$Time^2$*GEN*ES			.04	-.05
4- Way Interaction				
Time*STR_P *ES*GEN				-.05
$Time^2$*STR_P*ES*GEN				.03
Random effects				
σ^2	3.40	3.40	3.40	3.40
τ_{00}	66.30	66.30	64.92	64.91
τ_{11}	4.20	4.20	3.50	3.50
τ_{22}	.07	.07	.04	.04
τ_{10}	-10.73	-10.73	-9.84	-9.84
τ_{20}	1.34	1.34	1.18	1.18
τ_{12}	-.47	-.47	-.34	-.34
Deviance (-2LL)	14469.31	14456.07	14419.07*c	14482.51
Explained variance[a]		.00	.17 | .43[b]	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. ES = Emotional support. STR_P = Perceived stress past 6 months. GEN = Gender. [a] Baseline model is previous model, explained variance is for linear slope (τ_{11}). [b]Explained variance for quadratic effect (τ_{22}). [c]Baseline model is model 4. *$p < .05$ **$p < .01$ ***$p < .001$

Table A4

History of Depression Predicting BMI Change over 12 Months following Bariatric Surgery including Functional Support and Patient Gender as Moderators

	Model S13	**Model S14**	**Model S15**	**Model S16**
Fixed effects				
Intercept	47.73***	48.46***	47.70***	47.84***
Time	-7.92***	-7.96***	-7.53***	-7.61***
Time^2	1.23***	1.25***	1.19***	1.20***
Age	-.07*	-.07*	-.06*	-.06*
EMP	-2.47**	-2.39**	-2.37**	-2.37**
Procedure Type				
AGB	2.51			
SG	-.25			
EDU	.08			
Race	2.29**	2.23**	2.23**	2.23**
Gender	-1.80*	-1.86	-.82	-.99
DEP_HX	1.94*	3.33	5.16*	4.73*
FS	-.04	.36	.35	.02
2-Way Interactions				
Time *DEP_HX		-.29	-1.44*	-1.20
Time*FS		-.01	.06	.25
Time*Gender		.24	-.37	-.28
DEP_HX*FS		.17	1.10	2.60*
DEP_HX*GEN		-.94	-3.31	-2.78
FS*GEN		-.60	-.75	-.30
Time^2 *DEP_HX		.01	.19	.16
Time^2*FS		.00	-.04	-.06
Time^2*Gender		-.03	.06	.04
3-Way Interactions		48.46		
Time*DEP_HX*FS			-.40	-1.24
Time*GEN*DEP_HX			1.53*	1.23
Time*GEN*FS			.05	-.20
DEP_HX*GEN*FS			-.56	-2.44
Time^2*DEP_HX*FS			.09	.20
Time^2*GEN* DEP_HX			-.24	-.20
Time^2*GEN*FS			.02	.06
4- Way Interaction				
Time*DEP_HX *FS*GEN				1.05*
Time^2*DEP_HX*FS*GEN				-.14
Random effects				
σ^2	3.40	3.40	3.40	3.40
τ_{00}	65.70	64.72	64.39	64.17
τ_{11}	4.20	4.19	4.06	3.99
τ_{22}	.07	.07	.06	.06
τ_{10}	-10.77	-10.48	-10.28	-10.15
τ_{20}	1.36	1.33	1.29	1.28
τ_{12}	-.47	-.47	-.44	-.44
Deviance (-2LL)	14463.36	14474.55	14469.53	14466.40
Explained variance a		.00	$.03 \mid .14^{b}$	.02

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. FS = Functional support. DEP_HX = History of depression. GEN = Gender. [a] Baseline model is previous model and explained variance is for the linear slope (τ_{11}). [b]Explained variance for the quadratic function (τ_{22}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table A5

History of Depression Predicting BMI Change over 12 Months following Bariatric Surgery including Structural Support and Patient Gender as Moderators

	Model S17	Model S18	Model S19	Model S20
Fixed effects				
Intercept	48.86***	50.69***	48.34***	48.05***
Time	-7.92***	-7.92***	-7.18***	-7.36***
$Time^2$	1.23***	1.19***	1.11***	1.23***
Age	-.06*	-.06*	-.06*	-.06*
EMP	-2.33**	-2.16*	-2.16*	-2.16*
Procedure Type				
AGB	2.66			
SG	-.29			
EDU	.08			
Race	2.08**	2.05**	2.06**	2.06**
Gender	-2.01*	-3.92	-1.75	-1.43
DEP_HX	1.79*	3.96	8.81*	9.32
SS	-1.30	-2.51	-.68	-.36
2-Way Interactions				
Time *DEP_HX		-.30	-1.93*	-1.60*
Time*SS		-.05	-.38	-.16
Time*Gender		.23	-.49	-.28
DEP_HX*SS		-1.40	-4.85	-5.48
DEP_HX*GEN		-.76	-5.37	-5.93
SS*GEN		2.00	.79	.42
$Time^2$ *DEP_HX		.02	.20	.02
$Time^2$*SS		.07	.08	-.07
$Time^2$*Gender		-.02	.10	-.04
3-Way Interactions				
Time*DEP_HX*SS			.43	.02
Time*GEN*DEP_HX			1.63*	1.26
Time*GEN*SS			.08	-.16
DEP_HX*GEN*SS			2.36	3.07
$Time^2$*DEP_HX*SS			.04	.31
$Time^2$*GEN* DEP_HX			-.24	.00
$Time^2$*GEN*SS			-.03	.13
4- Way Interaction				
Time*DEP_HX *SS*GEN				.48
$Time^2$*DEP_HX*SS*GEN				-.31
Random effects				
σ^2	3.40	3.40	3.40	3.40
τ_{00}	65.29	64.24	64.02	64.04
τ_{11}	4.20	4.19	4.12	4.13
τ_{22}	.07	.07	.07	.07
τ_{10}	-10.81	-10.54	-10.43	-10.45
τ_{20}	1.39	1.36	1.35	1.36
τ_{12}	-.47	-.47	-.46	-.46
Deviance (-2LL)	14456.56	14449.95	14436.19	14431.26
Explained variance[a]		.00	.02	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. SS = Structural support. DEP_HX = History of depression. GEN = Gender. [a] Baseline model is previous model and explained variance is for the linear slope (τ_{11}). $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table A6

History of Depression Predicting BMI Change over 12 Months following Bariatric Surgery including Emotional Support and Patient Gender as Moderators

	Model S21	Model S22	Model S23	Model S24
Fixed effects				
Intercept	47.31***	47.96***	45.48***	46.18***
Time	-7.92***	-7.51***	-6.94***	-7.20***
$Time^2$	1.23***	1.15***	1.16***	1.16***
Age	-.06*	-.06*	-.06*	-.06*
EMP	-2.40**	-2.28**	-2.32**	-2.32**
Procedure Type				
AGB	2.49			
SG	-.22			
EDU	.08			
Race	2.29**	2.26**	2.28**	2.28**
Gender	-1.89*	-2.56	.16	-.63
DEP_HX	2.00*	3.01	7.91*	6.05
ES	.18	.28	1.35	.93
2-Way Interactions				
Time *DEP_HX		-.35	-1.95**	-1.29
Time*ES		-.25**	-.34	-.18
Time*Gender		.39	-.12	.17
DEP_HX*ES		.22	-1.51	-.42
DEP_HX*GEN		-.91	-5.90	-3.80
ES*GEN		.15	-.91	-.45
$Time^2$ *DEP_HX		.03	.31	.31
$Time^2$*ES		.05*	.01	.01
$Time^2$*Gender		-.06	-.10	-.11
3-Way Interactions				
Time*DEP_HX*ES			.24	-.15
Time*GEN*DEP_HX			1.31	.56
Time*GEN*ES			.01	-.16
DEP_HX*GEN*ES			1.58	.39
$Time^2$*DEP_HX*ES			-.05	-.05
$Time^2$*GEN* DEP_HX			-.20	-.21
$Time^2$*GEN*ES			.07	.07
4- Way Interaction				
Time*DEP_HX *ES*GEN				.43
$Time^2$*DEP_HX*ES*GEN				.00
Random effects				
σ^2	3.40	3.40	3.40	3.40
τ_{00}	64.86	63.78	63.70	63.61
τ_{11}	4.20	3.90	3.79	3.78
τ_{22}	.07	.06	.05	.05
τ_{10}	-10.56	-10.01	-9.96	-9.93
τ_{20}	1.32	1.22	1.21	1.21
τ_{12}	-.47	-.41	-.39	-.39
Deviance (-2LL)	14460.36	14447.92	14426.99*c	14424.58
Explained variance[a]		.07 | .14	.03 | .17[b]	.00

Note. EMP= Employment Status. AGB =Adjustable gastric banding. SG = Sleeve gastrectomy. EDU = Years of Education. ES = Emotional support. DEP_HX = History of depression. GEN = Gender. [a] Baseline model is previous model, explained variance is for linear slope (τ_{11}). [b]Explained variance for quadratic effect (τ_{22}). [c]Baseline model is model 4. *$p < .05$ **$p < .01$ ***$p < .001$

Appendix B: Bariatric Intake Packet: Stress (Wadden & Foster, 2006)

Primary measure:

Please indicate if you are currently experiencing any stress in your life related to the following.

A. Work □ Yes □ No
B. Health □ Yes □ No
C. Relationship with spouse/significant other □ Yes □ No
D. Activities related to your children □ Yes □ No
E. Activities related to your parents □ Yes □ No
F. Legal/financial trouble □ Yes □ No
G. School □ Yes □ No
H. Moving □ Yes □ No

Secondary measure:

How stressful has your life been during the past 6 months? Pick a number between 1 and 5, in which:

1= much less stressful than usual
2= less stressful than usual
3= average level of stress
4= more stressful than usual
5= much more stressful than usual

Your number is ___

Appendix C: Bariatric Intake Packet: Social Support (Wadden & Foster, 2006)

Structural support:

Currently, I am (Check all that apply):

□ Living alone
□ Living with a spouse/partner
□ Living with a significant other
□ Living with children
□ Living with parents/step-parents
□ Living with other relatives
□ Living with roommates

Emotional support:

Q1: How many people do you talk to about your weight when you are upset about it? ___

Q2: How many of these people are helpful to you? ___

Appendix D: IRB Approval Letter

USF UNIVERSITY OF SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX(813)974-7091

12/6/2016

Erica Ahlich
Psychology
Tampa, FL 33612

RE: **Expedited Approval for Initial Review**
IRB#: Pro00026065
Title: Psychosocial Predictors of Bariatric Surgery Outcomes

Study Approval Period: 12/6/2016 to 12/6/2017

Dear Ms. Ahlich:

On 12/6/2016, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents contained within, including those outlined below.

Approved Item(s):
Protocol Document(s):
Protocol_v1_r.docx

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis).

Your study qualifies for a waiver of the requirements for the informed consent process for this retrospective chart review as outlined in the federal regulations at 45CFR46.116 (d) which states that an IRB may approve a consent procedure which does not include, or which alters, some or all of the elements of informed consent, or waive the requirements to obtain informed consent provided the IRB finds and documents that (1) the research involves no more than minimal risk to the subjects; (2) the waiver or alteration will not adversely affect the rights and welfare of the subjects; (3) the research could not practicably be carried out without the waiver or alteration; and (4) whenever appropriate, the subjects will be provided with additional pertinent information after participation.

Your study qualifies for a waiver of the requirement for signed authorization as outlined in the HIPAA Privacy Rule regulations at 45CFR164.512(i) which states that an IRB may approve a waiver or alteration of the authorization requirement provided that the following criteria are met (1) the PHI use or disclosure involves no more than a minimal risk to the privacy of individuals; (2) the research could not practicably be conducted without the requested waiver or alteration; and (3) the research could not practicably be conducted without access to and use of the PHI. A waiver of HIPAA Authorization is granted for this retrospective chart review of Tampa General Hospital patients 18 and older who underwent bariatric surgery at TGH between January 1, 2005 and December 31, 2015. This waiver allows the study team to obtain PHI of patients in this cohort from the TGH electronic medical record (ChartView and/or EPIC).

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

V Jorgensen MD

E. Verena Jorgensen, M.D., Chairperson
USF Institutional Review Board