FACTORS ASSOCIATED WITH PHYSICAL ACTIVITY IN PATIENTS UNDERGOING BARIATRIC SURGERY

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Physical activity is an important lifestyle target for post-bariatric surgery patients that may be associated with improved weight loss, lower incidence of weight regain, and improvements in selective health-related outcomes. Despite these benefits, engagement in physical activity in less than optimal in post-bariatric surgery patients. Identifying psychosocial variables associated with physical activity may lead to the development of interventions that better address the challenges to participating in physical activity experienced after bariatric surgery, and enhance physical activity in these patients. PURPOSE: To examine associations between selective psychosocial variables and physical activity in patients who had undergone bariatric surgery within the past 2 years. METHODS: Eighty-three patients who had undergone bariatric surgery (age 44.0±11.8 years, BMI 44.0±11.8 kg/m^2) self-reported current physical activity and select psychosocial constructs. Additionally, participants provided retrospective information on physical activity and select psychosocial constructs prior to surgery. RESULTS: Subjects increased leisure-time physical activity by a median 508.00 (48.00, 1138.00) kcal/week from pre- to post-bariatric surgery. Physical activity was significantly associated with a number of pre- and post-surgical psychosocial constructs in the bivariate analyses; however, only social support, fitness orientation, physical function and self-classified weight emerged as significant predictors of physical activity engagement in subsequent stepwise regression analyses. CONCLUSIONS: These findings may suggest that both pre- and post-bariatric surgery intervention may need to target important constructs that include the encouragement of social support, strategies to enhance the effort individuals put forward to engage in physical activity, focus on enhancing physical function, and awareness of weight status with the goal of improving engagement in physical activity.

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1.0 INTRODUCTION AND SCIENTIFIC PREMISE

1.1 BACKGROUND

Overweight and obesity continues to be highly prevalent in the United States, with greater than two-thirds of adults classified as overweight or obese based on body mass index (BMI), and approximately 37.7% of adults are classified as obese (BMI ≥30 kg/m^2).[1-4] At higher BMI levels, there is a greater risk of morbidity from chronic health conditions such as hypertension, dyslipidemia, and type 2 diabetes.[5] Excess body weight is also associated with an increased risk of cardiovascular disease, some cancers, and all-cause mortality.[5,6] In addition to the adverse health consequences, it is estimated that the annual health care costs attributed to obesity in the United States is $147 billion.[5,7]

Of concern is the prevalence of Class 2 (BMI ≥35-<40 kg/m^2) and Class 3 obesity (BMI ≥40 kg/m^2).[1-3,8] It is estimated that 14.5% of American adults had a BMI ≥35kg/m^2 in 2011-2012.[1,9] Moreover, the prevalence of adults with a BMI ≥40kg/m^2 has continued to rise from 5.7% in 2007-2008 to 6.4% in 2011-2012 and 7.7% in 2013-2014.[1,4,10] Given the prevalence of adults with a BMI ≥35 kg/m^2, effective approaches to treat this level of obesity is increasingly important.

Bariatric surgery procedures are recommended as one treatment option for adults with a BMI ≥35 kg/m^2.[11-13] Bariatric surgery is an effective and durable treatment for individuals with a

BMI ≥35kg/m^2 and accompanying comorbidities such as type 2 diabetes mellitus.[11,12,14-17] Bariatric surgery results in clinically significant weight loss of 60-80% excess weight loss (EWL) at 1 year following commonly performed procedures such as gastric bypass and sleeve gastrectomy, and an average 33-83% EWL at two years following all types of bariatric surgery procedures.[12,13,16,18-21]

Non-surgical lifestyle interventions that include a combination of diet (modest energy restriction) and physical activity results in approximately 8-10% weight loss in a non-surgical population.[22,23] Although significant weight loss is observed following lifestyle intervention, these behavioral modifications alone have not been demonstrated to be as effective as bariatric surgery for long-term weight loss or improvements in weight-related comorbidities in adults with obesity.[12,15,22-25] However, components of lifestyle interventions may be critically important following bariatric surgery to enhance weight loss success. Specifically, physical activity may be a particularly important lifestyle behavior after bariatric surgery that can lead to improved post-surgical success.[26]

Studies have shown that physical activity in the post-surgical period is related to greater weight loss, lower incidence of weight regain, and improvements in health-related quality of life.[27,28] Physical activity may also be important for health benefits beyond weight loss. For example, in non-bariatric surgery populations physical activity is related to a reduction in risk of all-cause mortality, cardiovascular morbidity and mortality, type 2 diabetes and certain cancers.[29] Additionally, physical activity improves cardiorespiratory fitness, which has also been associated with a reduction in risk of all-cause mortality and cardiovascular disease,[30,31] and this has been shown to be independent of weight status.[32-34] Despite these benefits of physical activity, individuals who undergo bariatric surgery are insufficiently active following their procedure, with data suggesting engagement in moderate intensity physical activity for only approximately 5% of their waking hours.[35-40] Thus, there is a need to implement effective interventions to promote physical activity engagement in this population. However, prior to program development and implementation, it may be prudent to understand factors associated with physical activity participation in post-bariatric surgery patients that can be used to inform these intervention approaches.

Behavior change interventions that target lifestyle factors, such as physical activity, may be most effective if supported by well-established behavioral theories. For example, a number of behavioral theories have been applied to lifestyle behavior change, which includes physical activity, in an attempt to modify these important behaviors. These theories have included, but are not limited to Social Cognitive Theory,[41-43] Expectancy Theory,[44,45] Health Belief Model,[41,43,46-48] and the Theory of Planned Behavior.[41,46]

Within these theories, key constructs have been identified that may be associated with physical activity (see Figure 1). For example, a systematic review conducted by Trost et al. established that there is an association between several key constructs from theories such as the social cognitive theory and the health belief model, and overall physical activity participation in adults.[48] These constructs include barriers to exercise, intention to exercise, self-efficacy, and expected benefits.[48] However, the majority of the literature reports on these constructs and their association with physical activity primarily in non-bariatric surgery samples of adults.

There are some studies that have examined behavioral constructs in bariatric surgery patients.[49-52] The behavioral theories shown in Figure 1 have largely been the focus of this research, yet not all constructs have been shown to be consistently associated with physical activity in patients who have undergone bariatric surgery. Those constructs that have been shown to be associated with physical activity in bariatric surgery patients have typically been constructs that are included in multiple theories (self-efficacy / perceived behavioral control, perceived expectations / benefits) or have focused on barriers to physical activity.[49-52] However, these individual studies have primarily focused on a single theory or construct, and therefore, it has not been established if some constructs are more predictive of physical activity than others in post-bariatric surgery patients. Moreover, there is little know about whether these behavioral constructs change in response to bariatric surgery, and whether the change in these constructs or the pre-surgical level of these constructs is most predictive of post-surgery physical activity in these patients.

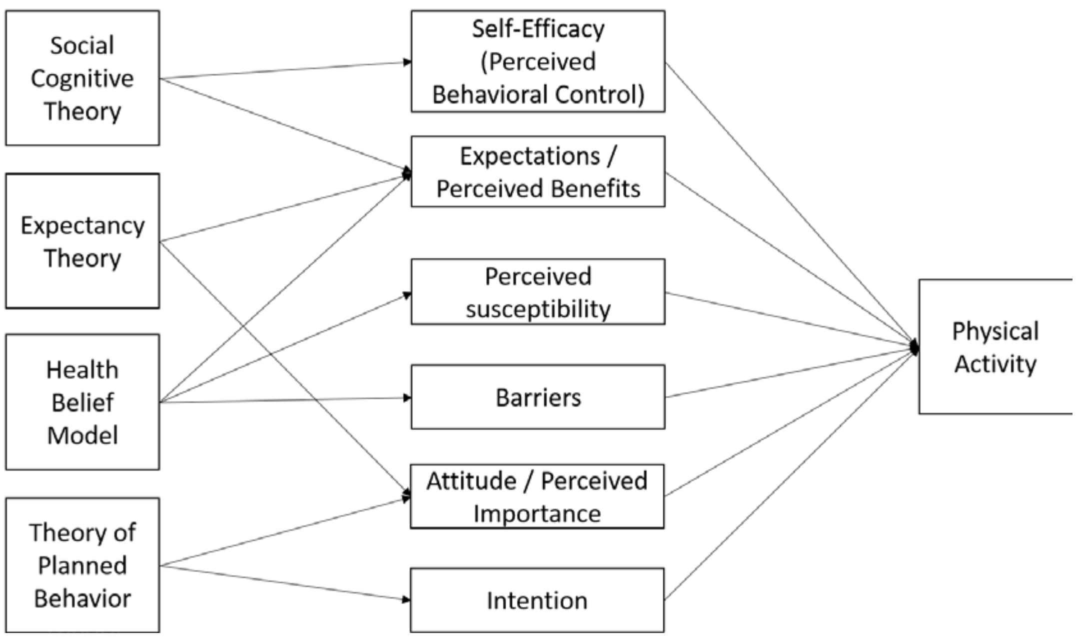

Figure 1. Theory-based Approaches to Modifying Physical Activity Behavior

1.2 CLINICAL RELEVANCE

Physical activity is an important lifestyle target for post-bariatric surgery patients. Engagement in physical activity has been shown to be associated with improved weight loss, lower incidence of weight regain, and improvements in selective health-related outcomes.[27,28] However, despite these benefits, engagement in physical activity in less than optimal in post-bariatric surgery patients.[35-40] Thus, there is a need for effective interventions to enhance engagement in physical activity in this patient population. While there are data to suggest that some behavioral constructs are associated with physical activity in these patients, these studies have been limited in scope, which limits the understanding of how best to develop effective theory-based interventions that are tailored to post-bariatric surgery patients. Therefore, additional data is needed to enhance the understanding of behavioral constructs that should be targeted in interventions to enhance physical activity and reduce sedentary behavior in these patients.

1.3 SPECIFIC AIMS

The aims of this study were the following:

1. To quantify physical activity (sedentary, leisure-time physical activity) in post-bariatric surgery patients, and examine whether there was a change in physical activity from the pre- to post-surgery period.
    a. Exploratory analyses were conducted to examine if physical activity differed by length of time following bariatric surgery, type of surgical procedure, or gender.

2. To quantify selective theory-based constructs of behavior change in post-bariatric surgery patients, and examine whether there was a change in these constructs from the pre- to post-surgery period.
    a. Post-hoc analyses were conducted to examine if these theory-based constructs differed by type of surgical procedure or gender.
3. To examine the association between physical activity and selective theory-based constructs (e.g., self-efficacy, barriers, and perceived benefits of physical activity, etc.) in post-bariatric surgery patients.
    a. Post-hoc analysis were conducted to examine if these associations were influenced by length of time following bariatric surgery, type of surgical procedure, or gender.

2.0 REVIEW OF THE LITERATURE

2.1 PREVELANCE OF OBESITY

Obesity, defined as a body mass index (BMI) ≥30kg/m^2, is prevalent, affecting more than one-third of American adults.[53] Obesity is subdivided into classes of obesity; Class 1 (BMI ≥30-<35kg/m^2), Class 2 (BMI ≥ 35-<40 kg/m^2) and Class 3 (BMI ≥40 kg/m^2).[10,54] Data from the Behavioral Risk Factor Surveillance System (BRFSS), collected between 1986 and 2010 indicates that the increase in prevalence of obesity (BMI ≥30) has begun to slow since 2005.[2] These findings are mirrored by results from nationally representative data collected using the National Health and Nutrition Examination Survey (NHANES).[9] Based on these surveys, approximately 14.5% of American adults had a BMI ≥35kg/m^2 in 2011-2012, similar to the 14.3% that was seen in 2008.[1,9] However, the prevalence of Class 3 obesity continues to rise.[2] Between 2000 and 2010, results from the BRFSS demonstrate that the prevalence BMI ≥40 kg/m^2 has increased by approximately 70%, and affects more than 15.5 million American adults.[2] Similarly, results from NHANES indicate that there continues to be an increase in the prevalence of Class 3 obesity, and this increased prevalence is primarily in women.[4] With the current prevalence of Class 2 and 3 obesity, it important to have effective approaches to treat these individuals. Bariatric surgery is one treatment available for patients with a BMI ≥35kg/m^2

and a minimum of 1 weight-related comorbidity, or BMI ≥40kg/m^2, regardless of the presence of medical comorbidities.[11,12]

2.2 CONSEQUENCES OF OBESITY

Obesity is associated with a number of chronic diseases and comorbidities including cardiovascular disease,[55] type 2 diabetes,[56-58] hypertension and dyslipidemia,[9,55,57-63] as well as some forms of cancer.[64-66] Obesity is also linked to an elevated risk for all-cause mortality.[8] A systematic-review, which included 97 articles and 2.88 million participants, reported that obesity is associated with a significantly higher risk of all-cause mortality, and that the risk of all-cause mortality was increased at higher levels of obesity.[8] Obesity resulted in a hazard ratio (HR) of 1.18 relative to individuals who were classified as normal based on BMI. When examined by class of obesity, Class 1 had a HR of 0.95 (95% CI, 0.88-1.01) while Class 2 and above had a HR of 1.29 (95% CI, 1.18-1.41), relative to those who were classified as normal weight.[8]

The prevalence of obesity also imposes a substantial economic burden. In 2010, the cost of obesity in the U.S. was estimated to total $315.8 billion, an increase of 48.3% from 2005.[67] Additionally, it was estimated that the increase in annual medical cost for an obese individual is $3,508 per year.[67] Compared to their normal weight counterparts, obese individuals have higher inpatient, outpatient, and prescription medication costs, and incur a greater number of physician visits.[5,7] Moreover, as BMI rises so does the associated healthcare cost, with health care costs increasing by an estimated 23% for Class 1, 45% for Class 2, and 81% for Class 3 obesity compared to costs for normal-weight adults.[68,69]

2.3 BEHAVIORAL TREATMENT OF OBESITY

Weight loss is recommended for obese individuals to improve weight-related comorbidities and reduce the risk of mortality.[15,70,71] The 2013 American Heart Association/American College of Cardiology/The Obesity Society Guideline for the Management of Overweight and Obesity in Adults recommends that weight loss be achieved through lifestyle modification that includes both a reduction in caloric intake and an increase in physical activity participation.[5] These behavioral lifestyle modifications should be the foundation of treatment for individuals with obesity.[5,22,71]

Behavioral lifestyle modification programs that include diet and physical activity components can induce clinically significant weight loss of approximately 8-10% of an individual's initial weight in the first 6 months of treatment.[60,71,72] However, lifestyle modification alone has not been shown to be effective long-term for many patients.[19,60,73] A review by Wadden et al. reported that after 20-30 weeks of lifestyle intervention, clinically significant weight loss was seen; however, 30-35% of weight lost was regained in the year following treatment. Additionally, it was estimated that half of all patients who received treatment would return to their baseline weight after 5 years.[71] While lifestyle modification results in clinically significant weight loss, the literature indicates that weight regain is commonly observed. Effective long-term treatment for obese individuals is important for reducing weight-related comorbidities and reducing the risk of all-cause mortality, which is associated with obesity. Bariatric surgery is a treatment option for patients with a BMI $\geq 35 kg/m^2$ that has been observed to be effective at inducing long-term weight loss.[15,73,74]

2.4 BARIATRIC SURGERY

Bariatric surgery is a treatment option available to obese patients who have a BMI $\geq 40 kg/m^2$. Patients are also eligible to undergo bariatric surgery if they have a BMI $\geq 35 kg/m^2$, have not been successfully able to lose weight with non-surgical medical treatment, and have a minimum of one weight-related comorbidity such as diabetes.[11,12,75] There is currently a lack of evidence to support the use of bariatric surgery in patients with a BMI $< 30 kg/m^2$.[12,75] It is estimated that approximately 154,276 bariatric surgery procedures were performed in the United States and Canada in 2013.[76]

Bariatric procedures include restrictive procedures, malabsorptive procedures, or a combination of both.[16] Restrictive procedures include gastric banding (adjustable and nonadjustable), vertical banded gastroplasty (VBG) and sleeve gastrectomy (SG).[16,19] These surgical procedures lead to weight loss by narrowing the size of the stomach to limit the amount of food an individual is able to ingest.[13,16,77] Similarly, the intragastric balloon is a temporary, non-surgical weight loss procedure. This procedure is also restrictive and works by inserting a balloon into the stomach that is then inflated with saline, taking up space in the stomach.[78] By reducing the stomach size, calorie intake is restricted resulting in a caloric deficit and weight loss following bariatric surgery.[77]

Roux-en-Y Gastric Bypass (RYGB) combines aspects of both restrictive and malabsorption procedures. This surgery involves creating a small gastric pouch, and bypassing the duodenum and part of the jejunum. This procedure not only limits the volume of food that can be ingested, but also reduces the amount of nutrients absorbed.[16] Weight loss following this procedure may also be due to a change in gastrointestinal hormones resulting from modifying the intestinal tract.[77] Gastrointestinal hormone changes that may facilitate weight loss following surgery include an increase in PYY and GLP-1; hormones associated with decreased hunger and increased satiety, and a decrease in fasting plasma ghrelin, a hunger stimulating hormone.[13,77]

Malabsorptive procedures include biliopancreatic diversion and biliopancreatic diversion with duodenal switch.[16] Malabsorptive procedures lead to weight loss by bypassing parts of the small intestine, and therefore, limiting the amount of nutrients that are absorbed.[16] Gastrointestinal hormone changes are also seen following these procedures, and may also contribute to weight loss. These procedures also include some restriction through the creation of a smaller gastric pouch. Following commonly performed bariatric surgery procedures such as gastric bypass and sleeve gastronomy, an excess weight loss of 60-80% is seen 1 year post-bariatric surgery. Regardless of procedure performed, an excess weight loss of 33-83% is achieved 2 years post-surgery.[12,13,16,18-21]

Several large-scale trials have evaluated the effectiveness of bariatric surgery, as well as its impact on comorbidities and mortality. The Swedish Obese Subjects Study included 2,010 obese subjects who elected to undergo bariatric surgery, and 2,037 matched obese controls. Individuals who elected to undergo bariatric surgery underwent either gastric bypass, gastric banding or a vertical banded gastroplasty procedure.[15] Findings show that individuals in the surgical group had considerably greater weight losses at 2, 10, 15 and 20 years, and a long-term reduction in weight-related comorbidities and all-cause mortality when compared to their matched controls.[15]

The Longitudinal Assessment of Bariatric Surgery (LABS) consortium, established by the National Institute of Diabetes and Digestive and Kidney Diseases, was a multi-center study that included 2,458 participants at baseline who were electing to undergo a first-time bariatric surgery procedure.[79] Three year results from LABS indicated that bariatric surgery results in significant weight loss ranging from a median of 15.9% of baseline weight in the participants who underwent laparoscopic adjustable gastric banding to 31.5% of baseline weight following Roux-en-Y gastric bypass procedure.[79] A reduction in the incidence of type 2 diabetes, dyslipidemia and hypertension was also seen, with a gradation effect based on procedure performed.[79] The gradation effect observed indicated that biliopancreatic diversion or duodenal switch procedures and gastric bypass had the greatest impact on these comorbidities when compared to gastric banding or other procedures.[19]

A randomized control trial conducted by Courcoulas et al. included 69 participants who randomized to one of three arms: (1) Roux-en-Y gastric bypass (RYGB), (2) laparoscopic adjustable banding (LAGB) or (3) intensive lifestyle weight loss intervention (LWLI).[80] All treatment groups achieved significant weight loss at 12 months, with the participants in the RYGB group achieving the greatest weight loss from baseline (-27%), followed by LAGB (-17.3%) and LWLI (-10.2%) ($p<0.001$). Partial and complete remission of type 2 diabetes was also seen in the groups that were randomized to a bariatric surgery procedure, and varied by procedure. RYGB resulted in 50% partial and 17% complete remission of type 2 diabetes, and LAGB resulted in 27% partial and 23% complete remission of type 2 diabetes. At the 12 month follow-up, no participants from the LWLI experienced partial or complete remission of their type 2 diabetes.[80] Long-term results from this trial indicate that 3 years following treatment, weight loss was greater following RYGB and LAGB than LWLI, and of the two surgical groups, RYGB resulted in a significantly greater reduction in weight ($P=0.0002$). Additionally, the greatest percentage of individuals who experienced partial or complete remission of type 2 diabetes was seen following RYGB (40%), compared to LAGB (29%). No participants in the LWLI experienced partial or complete remission of type 2 diabetes at the 3 year follow-up.[74]

2.5 PHYSICAL ACTIVITY

Physical activity is a key behavior for weight management, and can contribute to weight loss and prevention of weight re-gain. Physical activity alone, without dietary modification, has been observed to elicit a modest 2-3 kg of weight loss when performed at the nationally recommended level of 150 minutes per week.[6,81] Higher levels of physical activity, approximately 225-420 minutes per week has been observed to result in greater weight loss of 5-7.5 kg, indicating that larger doses of physical activity can lead to greater weight loss.[81,82]

Physical activity, in addition to dietary restriction, leads to an increase in weight loss when compared to physical activity alone or dietary restriction alone.[12,81] Jakicic et al. observed that following a lifestyle intervention that included a physical activity and a dietary component, weight loss at 18 months was greatest in individuals who reported 200 minutes or more of physical activity per week when compared to individuals who reported less than 200 minutes of activity.[82,83] Similarly, a study by Goodpaster et al. included severely obese participants without diabetes, and randomized them to either 12 months of diet plus physical activity intervention, or a group that received diet only for the first 6 months and both diet plus physical activity for the remaining 6 months. Results from this trial revealed that during the first 6 months, both groups lost a significant amount of weight, with greater weight loss seen in the physical activity plus diet group than the diet only group. At 12 months, both groups had still lost a significant amount of weight; however, a significant group by time interaction from baseline to 6 months reflected the greater initial weight loss in the group that was prescribed physical activity throughout the duration of the study.[84]

In addition to the studies described above, the 2009 American College of Sports Medicine Position Stand, “Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults", examined literature from 1999-2009 to determine if sufficient evidence was available to support the recommendation of participating in physical activity for weight loss. This position stand concludes that the combination of physical activity and caloric restriction will increase weight loss when compared to dietary restriction alone.[81]

There is additional evidence to support that individuals need to engage in a minimum of 200 minutes of moderate intensity physical activity per week to maintain weight loss.[81,85] Anderson et al. examined the effect of diet and physical activity on long term weight changes. Findings from this study indicate that the most active participants continued to lose weight at the 9 month follow-up, while the least active group had regained a significant amount of weight. At the 12 month follow up, the least active group regained significantly more weight than the middle and most active participants.[82,86] Moreover, studies such as the National Weight Control Registry, have identified that physical activity is a strong predictor of weight maintenance following weight loss.[81,87,88]

Beyond weight loss and weight management, evidence regarding physical activity in non-surgical populations has indicated that physical activity participation is also associated with a number of positive health outcomes, and these health benefits are realized independent of weight loss.[89] Physical activity, which improves cardiorespiratory fitness, has been observed to be associated with a reduction in risk for all-cause mortality, and cardiovascular morbidity and mortality.[29] Lee and colleagues conducted an observational cohort study that included 21,925 men, and determined that low-cardiorespiratory fitness was related to higher all-cause and cardiovascular disease mortality regardless of body composition. Results indicated that lean and unfit men had two times the risk of all-cause mortality than the lean and physically fit men. Additionally, the lean and unfit participants had a higher risk of mortality than those who were classified as fit and obese.[90] Similarly, a trial by Gulati et al. investigated the relationship between exercise capacity and risk of mortality in 5,721 women who had no symptoms of coronary artery disease. Results from this trial observed a 17% reduction in risk of all-cause mortality with every increase in exercise capacity of 1 MET.[91] Physical activity has also been demonstrated to reduce the risk of type 2 diabetes and certain cancers regardless of weight loss.[29] These findings indicate that physical activity engagement has benefits beyond weight management in non-surgical populations, regardless of weight status, making this an important lifestyle behavior.

2.6 PHYSICAL ACTIVITY IN BARIATRIC SURGERY

With the influence that physical activity has on weight management and health outcomes in the general population, it is hypothesized that it is also important for improved weight loss, weight maintenance and improvements in comorbid conditions following bariatric surgery. Despite the evidence from non-surgical populations, there are few trials that have solely investigated physical activity following bariatric surgery.[35]

Studies that have investigated the addition of physical activity following bariatric surgery have concluded that physical activity may have a positive impact on weight loss. A trial conducted by Bond et al. examined bariatric surgery patients' physical activity engagement at both pre- and 1 year post bariatric surgery, and observed that bariatric surgery patients who were inactive prior to surgery, but increased their activity to ≥200 minutes per week post-surgery saw greater reductions in weight when compared to patients who remained inactive following surgery.[27] Similar findings were reported in a systematic review by Livhits et al.[92] This review concluded that physical activity following bariatric surgery appears to lead to greater weight loss and reduction in BMI.[92]

Despite the evidence suggesting that physical activity is an important behavior following bariatric surgery, the majority of bariatric surgery patients do not participate in sufficient levels of physical activity.[35-40] An observational study conducted by Chapman et al. provided post-bariatric surgery patients objective physical activity monitors, and instructed participants to wear the monitor for 7 days. Results showed that the majority of waking hours were spent engaging in sedentary behavior, with these patients spending 5±3% (48±29 minutes/day) of their waking hours performing moderate-to-vigorous physical activity.[40] However, moderate-to-vigorous activity was rarely completed in a bout of at least 10 minutes, and none of the activity was accumulated in bouts of 30-<60 minutes or ≥60 minutes.[40]

Although it appears that bariatric surgery patients are insufficiently physically active following their surgical procedure, evidence from postoperative interventions have demonstrated that it is feasible for these patients to participate in physical activity programs and increase their physical activity.[35,93] Thus, determining factors associated with physical activity in this population could enhance future interventions that aim to improve physical activity participation in a post-bariatric surgery patients.

2.7 THEORIES OF BEHAVIOR CHANGE AND PHYSICAL ACTIVITY

Physical activity participation is influenced by a variety of factors. Many of these factors are derived from behavioral theories, which are often used to guide research.[41] There are several key theories that have been applied to physical activity studies, resulting in information on constructs that appear to be associated with physical activity participation.[41,94] These key theories include the social cognitive theory, expectancy theory, health belief model, and the theory of planned behavior.[94]

2.7.1 Social cognitive theory

Social cognitive theory proposes that an individual's behavior is influenced by cognitions, and these cognitions are learned from personal experiences, as well as a person's social and physical environment. This theory is based on the assumptions that behavior is a purposeful action that is under an individual's control; therefore, they are capable of making behavior changes.[41] Social cognitive theory is composed of four main constructs: (1) outcome expectancies, (2) outcome value, (3) intention, and (4) self-efficacy. Constructs from the social cognitive theory that are used to modify physical activity behavior are commonly self-efficacy and outcome expectations.[43]

Self-efficacy is one's confidence in their ability to successfully engage in a behavior.[41,46] It is hypothesized that self-efficacy impacts an individual's actions and ability to sustain a behavior when faced with barriers. Additionally, self-efficacy can impact motivation.[41,46], by either enhancing motivation, or in the case of low self-efficacy, impede motivation. Self-efficacy has been consistently reported to have a positive association with physical activity adoption and adherence.[41,43,48]

Outcome expectancies, specifically expected benefits has been observed to be positively associated with physical activity participation.[41,48] Outcome expectancies describe the belief that engaging in a given behavior will lead to a specific outcome.[43] These expected outcomes can be positive or negative, and likely play an important role in in determining an individual's intention to be physically active.[46]

2.7.2 Expectancy theory

Expectancy theory states that there is a relationship between a person's expected outcomes and their behavior, and proposes that individuals will choose to participate in a behavior because of the outcome they anticipate to achieve with that behavior.[44] Outcome expectancies are shaped by an individual's attitudes about a given behavior, as well as the perceived importance for engaging in a behavior. There are three key constructs within this theory that may affect physical activity behavior; valence, expectancy and instrumentality.

Valence is the anticipated value an individual places on an outcome.[45] Expectancy is the belief that engaging in a certain behavior will result in the anticipated outcomes. Expectancy is affected by an individual's self-efficacy for performing a behavior, perceived difficulty for achieving a goal, and perceived control to engage in a behavior. Instrumentality is the belief that the outcome, if met, will lead to the attainment of other outcomes and goals.[45] A review by Williams et al. investigated the constructs of outcome expectancy and their association with physical activity. Results indicate that there are mixed findings regarding the relationship between outcome expectancies and physical activity participation. While several studies have shown a small but significant association, collectively the results of these studies have shown mixed results between constructs within Expectancy Theory and physical activity.[48]

2.7.3 Health belief model

The health belief model aims to explain why individuals choose not to engage in certain health behaviors to prevent disease or negative health outcomes. This theory includes constructs that focus on a person's attitudes and beliefs. The primary constructs of this theory include perceived susceptibility, which suggests that an individual will take action to maintain or improve their health if they perceive that they are susceptible to ailment or negative health outcome, and perceived severity, which involves a person's perception of the severity of that health condition or outcome.[47] This theory also focuses on behavioral evaluation.[46] Behavioral evaluation incorporates a person's beliefs or efficacy for performing a health behavior such as physical activity, and the barriers that prevent an individual from engaging in that behavior.[41,46]

The health belief model states that behavior change is dependent on an individual's belief that the outcome of a behavior will offset the challenges associated with making the behavior change.[43] This model as a whole does not appear to be successful when applied to physical activity behaviors in the general population. This may be because physical activity is often viewed as a health promoting behavior, rather than a preventative health practice.[41,43] However, literature that has utilized components of this model for physical activity research has emphasized that barriers appear to be a strong predictor of physical activity participation.[43,48]

2.7.4 Theory of planned behavior

The theory of planned behavior proposes that people make decisions based on their knowledge and beliefs regarding a behavior and its consequences, in addition to their expectations, and the value they place on the expected outcomes.[41] This theory, which is an extension of the theory of reasoned action, incorporates the constructs of attitudes, social norms, intentions and perceived behavior control. The constructs from this theory that appear to impact physical activity are the intention to either engage in physical activity or remain inactive, and perceived behavioral control, which is the perception of having the means and opportunity to participate in physical activity behavior.[41,46]

Bauman et al. compiled evidence from previously published systematic reviews that had investigated factors associated with physical activity participation in adults. Results indicate that intention to be physically active is consistently associated with physical activity.[95] Furthermore, a meta-analysis conducted by Haggar and colleagues examined the relationship between physical activity behavior and key constructs derived from the theory of planned behavior and theories of reasoned action.[96] Seventy-two studies were included, and constructs investigated were intentions, attitudes, subjective norms, perceived behavioral control, self-efficacy and past behaviors. This meta-analysis concluded that attitudes, perceived behavioral control and self-efficacy influence intention and physical activity participation, indicating the theory of planned behavior contains key constructs related to physical activity participation.[96]

2.8 PSYCHOSOCIAL VARIABLES ASSOCIATED WITH PHYSICAL ACTIVITY PARTICIPATION

Studies that have aimed to examine factors related to physical activity engagement in adults have found that there are a variety of factors that are associated with physical activity in non-bariatric surgery populations. Understanding these factors may be necessary to develop interventions that effectively increase physical activity participation in bariatric surgery patients.

A systematic review by Trost et al. aimed to update previous reviews on correlates of adults' participation in physical activity. This review included 38 studies that had been published since the previous review in 1998, with 31 of the 38 studies using a cross-sectional design. Sample sizes for the studies included ranged from 56 to 16,178 participants. This study concluded that constructs derived from behavioral theory including self-efficacy, barriers to exercise, expected benefits, intention to exercise, self-motivation, social support, exercise enjoyment and body image are associated with physical activity.[48]

2.8.1 Self-efficacy

The construct of self-efficacy, an individual's confidence in their ability to participate in activity in specific situations, has been observed to be a strong and consistent positive correlate of physical activity participation in the general population, which includes adults with obesity.[43,48,95,97] Gallagher and colleagues investigated the association between self-efficacy and physical activity following a behavioral weight loss program that included 165 overweight women. At 6 months, self-efficacy for physical activity was significantly correlated with physical activity participation ($r= 0.30$, $p <0.05$).[98] Additionally, when participants were divided into groups based on their physical activity participation, the group that performed the least amount of weekly physical activity (<150 min/wk) had significantly lower levels of physical activity self-efficacy than the higher activity level groups (150-199 min/wk, 200-299 min/wk, ≥300 min/wk).[98]

Dunn et al. conducted a trial that included 116 men and 119 women who were randomized to receive a 6 month physical activity intervention that was either a lifestyle activity or a structured exercise intervention. Results indicated that regardless of randomization, those who increased physical activity self-efficacy were more likely to achieve CDC/ACSM physical activity recommendations of 30 minutes of moderate intensity physical activity on most days of the week.[81,99] Similarly, results from a Diabetes Prevention Trial sub-study that included 293 lifestyle intervention participants observed that higher baseline self-efficacy was associated with greater baseline physical activity, as well as physical activity at one year and the end of the study which was 2-3 years after randomization.[100] Furthermore, King et al. summarized the evidence available regarding self-efficacy and physical activity, and reported that several correlational studies have found an association between self-efficacy and physical activity in free-living and supervised settings in healthy adults, as well as some clinical populations.[43]

2.8.2 Barriers to physical activity

Barriers to physical activity are also commonly examined and found to have a negative association with physical activity participation. The most commonly reported barriers to physical activity are undesirable weather conditions, lack of access to exercise facility, disability/injury, lack of time, and other commitments.[43,101,102] Furthering these findings, a rapid evidence assessment was conducted in an effort to identify additional or unique barriers to exercise that individual's with obesity encounter. The barriers were classified as either a physical barrier, psychological barrier, or external barrier.[103] The most common physical barriers to physical activity reported by adults with obesity include excess weight making movement uncomfortable or challenging, decreased fitness capacity, and health problems/injury. Psychological barriers that have been consistently reported throughout studies in adults with obesity include a negative weight perception or feeling too overweight to be active, low mood, lack of enjoyment of physical activity, and lack of motivation. Lastly, external barriers include lack of time, adverse weather conditions and family/work commitments.[103]

Salmon et al. determined that in a population-based survey of 1,332 adults, higher scores on a barrier questionnaire, indicating the presence of more barriers, was associated with insufficient physical activity participation.[101] Gallagher and colleagues examined expected barriers and their association with physical activity following a behavioral weight loss program.[98] The expected barriers to physical activity included: time barriers, effort barriers, and obstacle barriers. A score for total barriers was also calculated. Following the 6 month intervention, a significant reduction in all expected barriers to physical activity was observed. There was a significant inverse association between 6 month physical activity participation and reported time barriers. The relationship between physical activity and barriers was also examined after physical activity was broken into four groups based on minutes of weekly moderate-intensity physical activity participation; (1) <150 min/wk, (2) 150-199 min/wk, (3) 200-299 min/wk, (4) ≥300 min/wk. There were significant differences between the four activity categories for effort barriers, obstacle barriers and total barriers, with the <150 min/wk group observed to have greater effort and total barriers than the other groups ($p<0.05$).[98]

Despite these findings, it is unclear if these same barriers to physical activity are present in patients who undergo bariatric surgery, which limits the understanding of how to effectively develop physical activity interventions in this patient population.

2.8.3 Outcome expectations / expected benefits

Outcome expectancies/expected benefits have also been shown to be associated with physical activity.[48] Heinrich et al. utilized data from a cross-sectional survey to determine the relationship between outcome expectancies and physical activity participation. Outcome expectancy for this study was defined as the amount of activity necessary for health benefits. Results from 3,607 participants indicated that positive health outcome expectancies were associated with greater self-reported physical activity.[44] Similarly, a summary of the evidence by King et al. reported that belief in the health benefits of physical activity was associated with adoption of physical activity participation in both men and women, while poor perceived health and the belief that exercise has little value for impacting health outcomes was related to less physical activity participation.[43]

2.8.4 Exercise enjoyment

The construct of exercise enjoyment has been reported to have a positive relationship with physical activity engagement.[48] Hagberg et al. conducted a trial to investigate the importance of exercise enjoyment for physical activity participation.[104] The study was conducted in two primary health care settings and placed a total of 120 participants in either a physical activity intervention or control group. The intervention group was offered group based exercise classes for three months, and follow-up for both groups continued until one year. Control group participants received a limited amount of physical activity advice at baseline in addition to usual care from their health care provider, but no further physical activity recommendations. In this sample, regardless of intervention group, exercise enjoyment was positively associated with change in physical activity level.[104] Another study conducted by Prichard et al. examined reasons for exercise in 571 female fitness class participants.[105] Time spend participating in physical activity at an exercise location was positively associated with exercise enjoyment and mood improvement.[105]

2.8.5 Behavioral control

Perceived behavioral control has also been identified as an important construct related to physical activity, and is similar to self-efficacy. Jewson et al. explored factors associated with physical activity in 30 overweight women.[106] Participants were classified as either active or inactive based on their self-reported physical activity, with active participants reporting greater perceived behavioral control compared to their inactive counterparts.[106]

In a study of 395 females participating in fitness club activity programs, participants were asked to complete a survey regarding their perceived behavioral control, as well as physical activity intentions, attitudes regarding physical activity and behavioral beliefs. Throughout the two month study period, participants received regular telephone contact where they were asked about their physical activity participation.[107] Additionally, physical activity participation at the fitness center was recorded by fitness center staff. This information was used to estimate the participants total physical activity participation. Perceived behavior control was observed to be the best predictor of physical activity participation, with higher self-reported perceived behavioral control being related to increased physical activity participation.[107]

Similarly, Norman and colleagues collected information on physical activity participation, and the following psychosocial constructs: attitudes, subjective norms, perceived behavioral control and past behavior.[108] Data were collected from a sample of 87 adults who attended a health promotion clinic. Results indicated that perceived behavioral control was the only significant predictor of physical activity participation observed in this sample.[108]

2.8.6 Motivation

Self-motivation has been repeatedly documented to have a strong, positive association with physical activity engagement.[48] Self-motivation is measured in different forms and these include external regulation (individual's interest in an extrinsic outcome), introjected regulation (individuals internalized obligation to engage in a behavior), identified regulation (personal importance of a behavior or outcome), and intrinsic motivation (individual's interest in a behavior or activity).[109] A systematic review including 66 studies that measured motivation, revealed that autonomous motivation was consistently important for physical activity engagement. Identified and intrinsic motivation were the two types of motivation found to be most important for long-term exercise adherence.[109] While motivation has been found to change throughout the lifespan, identified and intrinsic motivation have consistently emerged to be positively correlated with physical activity.[110]

2.8.7 Social support

Social support, the presence of interpersonal relationships, has been shown to influence the adoption of many health behaviors, including physical activity participation.[111] One study by Resnik et al. found that social support from friends was significantly related to exercise behavior in older adults.[112] Likewise, cross sectional study examining the relationship between physical activity engagement and social support in 402 adults ages 60 and older determined that individuals who were considered active reported having higher levels of social support compared to individuals who were considered inactive.[113] The US Women's Determinants Study, which included 2912 middle age women, found that women who had lower social support for physical activity were more likely to be sedentary. Additionally, those who reported high social support were significantly more likely to participate in 150 minutes or more per week of physical activity compared to those who reported not receiving social support.[114]

2.8.8 Body image

Body image is a psychosocial variable that encompasses appearance, fitness, health and illness components. [115,116] A meta-analysis examining exercise and body image included 121 studies with varying methodologies that included intervention trials, acute exercise bouts and cross-sectional studies. Findings indicate that physically active individuals had a more positive body image than those who were not physically active. Additionally, the meta-analysis revealed that exercise interventions resulted in significant improvements in body image.[117] A similar meta-analysis focusing on the impact of exercise interventions on body image also determined exercise interventions resulted in improved body image compared to controls.[118]

2.9 PSYCHOSOCIAL VARIABLES ASSOCIATED WITH PHYSICAL ACTIVITY PARTICIPATION FOLLOWING BARIATRIC SURGERY

Although many studies have identified behavior constructs that are associated with physical activity, there are few studies that have assessed physical activity related constructs in patients who have undergone bariatric surgery, which may differ from previously identified factors found to be associated with activity in non-surgical patients. The lack of studies investigating psychological constructs and their association with physical activity in bariatric surgery patients leaves a gap in the literature regarding physical activity correlates that may be important to target in interventions that aim to increase activity in these post-bariatric surgery patients.[49]

A study that aimed to examine barriers to physical activity was conducted by Peacock et al.[50] This cross-sectional study evaluated barriers to physical activity encountered by 366 patients who had undergone bariatric surgery.[50] Barriers were categorized as either external or internal, and internal barriers were further divided into either a motivational or a physical barrier category. The most commonly reported external barriers to physical activity were lack of time and the weather. At least one motivational barrier was reported by the majority of respondents. The most frequently reported internal motivational barriers to exercise were difficultly maintaining a consistent physical activity regimen, lack of priority for activity, general challenges with motivation to be active, lack of enjoyment and lack of self-efficacy. Participants also reported several internal physical barriers to exercise, including chronic illness and injury, pain and surgically related limitations such as lack of energy and diet/weight difficulties. However, this study did not investigate the association between these barriers and physical activity participation.[50]

Wouters and colleagues also examined bariatric surgery patients' beliefs about barriers to physical activity in addition to their beliefs regarding the benefits of physical activity participation. This trial included 42 participants who completed self-reported measures of exercise cognitions and current activity habits both pre- and post-bariatric surgery. Exercise cognitions; the patients perceived benefits and barriers to physical activity, were collected using the Physical Exercise Belief Questionnaire (PEBQ). This questionnaire includes four different scales, two for assessing barriers to exercise and two for assessing perceived benefits of physical activity.[51] The barriers targeted through this questionnaire are fear of injury and embarrassment, and two scales measure benefits and confidence for physical activity. Findings from this study indicate that at 1 year post-bariatric surgery there were improvements in exercise cognitions with no additional improvement observed between 1 and 2 years. Additionally, positive exercise cognitions were significantly correlated with higher physical activity participation 2 years post-surgery.[51]

Hunt et al. investigated the relationship between self-reported physical activity and the psychosocial constructs of attitudes, norms, perceived behavioral control and intention.[52] Participants in this study were recruited from private surgical clinics, and included 212 patients who presented at the clinic for either pre-operative evaluation or post-operative follow-up. Patients were all at different operative stages, with 16.5% of patients in the pre-operative stage, and 38.2% of patients having undergone surgery more than one year ago. Results from this investigation indicated that subjective norms and attitudes regarding physical activity may play a role in bariatric surgery patients' physical activity behavior; however, perceived behavior control was the single-best predictor of self-reported physical activity in this sample of bariatric surgery patients.[52]

However, not all evidence supports the relationship between previously identified theoretical constructs and physical activity in patients undergoing bariatric surgery. While few studies have investigated factors associated with physical activity in a post-bariatric surgery population specifically, there is some evidence to indicate that correlates of physical activity that are typically observed may not necessarily be present with bariatric surgery. For example, despite the relationship observed between self-efficacy and physical activity in the general population, Bond et al. observed a lack of association between change in objectively collected physical activity and self-efficacy, motivation and exercise enjoyment in 80 obese individuals scheduled to undergo bariatric surgery.[49] Similarly, lack of associations between outcome expectancies/health benefits and physical activity has been observed in adults with obesity, as well as adults with obesity who are candidates for bariatric surgery. A qualitative study by Zabatiero et al. found that adults with obesity awaiting bariatric surgery believed that physical activity resulted in health benefits; however, participants reported not engaging in enough activity to receive these benefits.[119]

Similar findings were observed following a study conducted by Leone and Ward.[120] This study aimed to collect qualitative data to describe attitudes towards physical activity and current activity behaviors among adults with obesity, then compare physical activity attitudes and behaviors of adults with and without obesity using a self-report survey.[120] Focus groups were conducted with 19 obese women, and qualitative findings from these focus groups identified that weight management and health improvement were the most commonly reported benefits of exercise. Focus group findings were then used to modify a survey on the perceived benefits of exercise that was completed by 96 obese and 99 non-obese women. Agreement for benefits of physical activity was 95% or greater for all of the following statements: (1) I will have more energy if I exercise, (2) I will control my weight if I exercise, (3) I will improve my health of I exercise, (4) exercising will decrease my chances of getting some diseases. There were no significant differences in agreement with these statements between obese and non-obese women. However, a significant difference between the groups was observed for enjoyment of activity, with 52.5% of obese women reported enjoying exercise while 72.9% of non-obese women reported enjoying exercise. Despite the perceived benefits of exercise reported by most of the obese women in this sample, they participated in significantly less physical activity then the non-obese women, highlighting that perceived benefits of activity in obese women may not be enough to increase physical activity in this population.[120] These results indicate that some constructs associated with physical activity in obese and pre-surgical population may differ from results that were previously seen in a general population. While there is some evidence to support that constructs associated with physical activity may differ in adults with obesity and bariatric surgery patients, the literature available is limited by small sample sizes and focus on single constructs rather than utilizing a multi-theoretical approach. Additionally, this literature does not examine these constructs in a post-bariatric surgery population, or examine whether theoretical constructs differ by length of time following bariatric surgery, type of surgical procedure, or gender. Quantifying theoretical constructs and examining the association between physical activity and these selective measures in post-bariatric surgery patients will help to better inform interventions that target physical activity behaviors in this population.

2.10 CONCLUSION

There is evidence to support the effectiveness of bariatric surgery as a treatment for obesity and associated comorbidities in individuals with a BMI $\geq$35 kg/m^2. Although bariatric surgery is effective at inducing weight loss, lifestyle modification is still essential following these surgical procedures. Physical activity is particularly important lifestyle behavior that may help post-surgical patients to maximize weight loss and enhance weight loss maintenance. Despite the importance of physical activity following bariatric surgery, the majority of bariatric surgery patients remain inactive. Examining selective theory based constructs in post-bariatric surgery patients and their association with physical activity engagement may be key for enhancing post-surgical success. Consequently, identifying psychosocial variables associated with physical activity may lead to the development of interventions that better address challenges in participating in physical activity faced by post-bariatric surgery patients.

3.0 METHODS

3.1 STUDY DESIGN

This study used a cross-sectional and retrospective design to examine physical activity and its association with selective theoretically-based psychosocial constructs. Details of the specific aims are presented in Chapter 1 with details of the specific measures described below. This study recruited adults who had undergone bariatric surgery.

3.2 SAMPLE POPULATION

This study recruited adult men and women who have undergone bariatric surgery. This study sample was recruited from individuals who live in the Greater Pittsburgh Region who were present to provide informed consent, an objective measure of weight, and complete study-related questionnaires. Inclusion and exclusion criteria for participation in this study are provided in Table 1.

Table 1. Study Inclusion and Exclusion Criteria

Inclusion Criteria

- ≥18 years of age
- Male or female
- Underwent a form of bariatric surgery; bariatric surgery procedures may include gastric bypass, gastric banding, and gastric sleeve within the past 2 years.
- Able to provide written informed consent
- Willingness to consent to data from their medical chart pertinent to this research study (see measures below) to be provided to the investigators.
- Willingness to provide objectively measured weight.
- Ability to read, write, and speak English.

Exclusion Criteria

- Women currently pregnant
- Participation in any other research study that would impact physical activity participation

3.3 RECRUITMENT PROCEDURES

Participants for this study were recruited through one of the following methods.

1. Participants were recruited from patients who had undergone a bariatric surgery procedure through the Minimally Invasive Bariatric and General Surgery Program at Magee-Women's Hospital of UPMC and who were present for a follow-up medical visit. Clinic staff identified patients who may be eligible to participate in this study, then obtained verbal consent from the patient indicating that they were willing to have study staff discuss this research project with them, and when appropriate referred the patient to the research staff who was present in the clinic during the patient visit. If a patient was

seen in the clinic and research staff were not present, the clinic staff obtained consent to have the patient contacted by the research staff to describe the study to them during an alternative non-clinic visit time.

2. Participants were recruited through the University of Pittsburgh's Clinical and Translational Science Institute (CTSI). This involved notifying patients within the clinical registry who had undergone bariatric surgery of this study and used other recruitment methods available through the CTSI to identify potential study participants (e.g., Pitt+Me, etc.). Individuals who expressed interest in this study were contacted by research staff to have the study explained and to determine eligibility.
3. Participants were recruited through other clinical registries available at the University of Pittsburgh (e.g., ONRC Clinical Registry, etc.) that may contain patients who have undergone bariatric surgery. Patients in these registries were contacted using methods approved by the Human Research Protection Office (HRPO) and were informed to contact the investigators if they were interested in participating in this study.

3.4 PARTICIPANT SCREENING AND INFORMED CONSENT

The following procedures were used to conduct eligibility screening and to obtain informed consent. These procedures varied slightly based on how the participant was recruited into this study as follows (Figure 2):

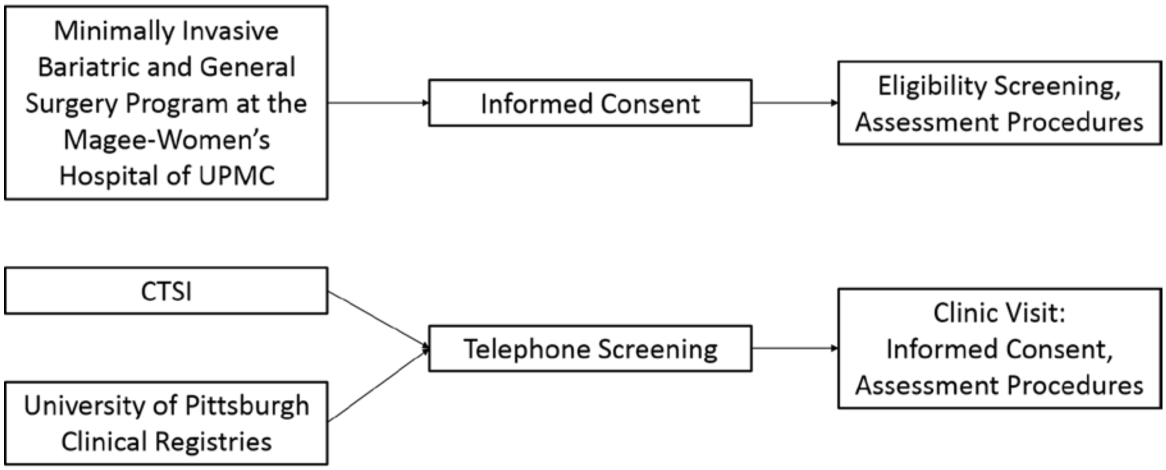

Figure 2. Recruitment and Screening Procedures

1. Participants recruited through direct contact at the Minimally Invasive Bariatric and General Surgery Program at Magee-Women's Hospital of UPMC met with a member of the research staff. The staff explained the study to the patient and allowed time for the patient to ask questions related to their participation. If the patient was interested in participating, written informed consent was obtained prior to any eligibility screening or data collection occurring. After informed consent was obtained, the patient completed a questionnaire to further determine study eligibility. Patients who remained eligible completed the assessments as described below.
2. Participants were recruited through methods other than an in-person clinical visit were screened for eligibility during a telephone call. This involved the research staff providing a brief description of the study to the individual and then obtaining verbal consent to query the participant on the eligibility criteria. Individuals who were eligible were scheduled to attend a brief clinic visit where written informed consent was obtained and assessments were completed.

3.5 ASSESSMENT PROCEDURES

Individuals who were eligible following the initial screening procedures completed a series of questionnaires that included demographics information, information on their bariatric surgery, medical health, physical activity and sedentary behavior, and selective psychosocial constructs. These data were collected to reflect their current status, and participants were also queried on these same measures to reflect their status during the pre-bariatric surgery period. These measures were to be completed during their clinic visit at the Minimally Invasive Bariatric and General Surgery Program at Magee-Women's Hospital of UPMC or during a separate non-clinical study visit. Due to the potential time constraints of participants seen at the Minimally Invasive Bariatric and General Surgery Program at Magee-Women's Hospital of UPMC, these participants were provided the opportunity to complete the questionnaires outside of the clinic. Outside of the clinic, the participants completed the questionnaires online using a Qualtrics survey link or by completing paper questionnaires that they were provided in addition to a postage paid envelope that was self-addressed, allowing the participant to return the questionnaires to investigators. In addition, objective height and weight were assessed. Post-surgical patients were compensated $40 for completion of all assessment procedures.

3.5.1 Demographics

Participants completed a questionnaire to identify their age, gender, ethnicity/race, education, marital status and household income. This also included the type of bariatric surgery procedure they received and date of their surgery. This questionnaire is provided in Appendix A.

Participants also provided consent to allow their type of bariatric surgery and date of their surgery to be obtained from their medical record.

3.5.2 Height and weight

Current height was assessed using a stadiometer with shoes removed to the nearest 0.1 cm. Current weight was assessed on scale to the nearest 0.1 kg with shoes removed and the participant in light-weight clothing. For participants seen in-person at Magee-Women's Hospital of UPMC, consent was given to allow the weight measured by the clinical staff to be shared with the research staff. For participants seen at a non-clinical visit, weight was assessed by research staff. Participants also provided consent to allow their pre-bariatric surgery weight to be obtained from their medical record. Height and weight was used to calculate both pre- and post-surgery body mass index (BMI). BMI was calculated by dividing body weight in kilograms by height in meters squared (kg/m^2).

3.5.3 Medical history

A modified health history questionnaire was completed by all participants. The questionnaire included questions regarding current health status, as well as health status prior to bariatric surgery.

Participants were also asked to complete a Depressive Symptoms questionnaire and the SF-36 Health Survey.

3.5.4 Physical activity and sedentary behavior

Physical activity was assessed using a modified version of the Paffenbarger Physical Activity Questionnaire. This subjective measure of physical activity participation had been validated for estimating activity through questions regarding the number of flights of stairs climbed, walking for exercise or transportation, and sports or recreational activity participated in throughout the past week.[121,122] Estimated energy expenditure from leisure-time physical activity is then computed according to previously published methods.[123] Participants completed this questionnaire to reflect their current level of physical activity and also completed this questionnaire to reflect their physical activity prior to their bariatric surgery procedure.

Sedentary behavior was obtained using a questionnaire that was used in the IDEA Study.[124] The questionnaire measures 8 non-work-related, work, and school-related sedentary behaviors. Time spent in all 8 activities is summed separately for weekdays and weekends and a weighted average is calculated. In addition, the sedentary behavior component of the Global Physical Activity Questionnaire which asks participants a single question about 'time spent sitting or reclining' on a 'typical day,' were included.[125]

3.5.5 Psychosocial constructs

3.5.5.1 Self-efficacy

This construct is included in a number of theories including the social cognitive theory, health belief model and expectancy theory. This was measured using two questionnaires. Both were used to assess the participant's confidence in being physically active. Current physical activity self-efficacy was assessed using a questionnaire by Marcus et al. and the Stanford Exercise Self-

Efficacy/Barriers Scale.[126,127] These questionnaires were also modified to retrospectively assess participant's physical activity self-efficacy prior to undergoing their bariatric surgery procedure.

3.5.5.2 Outcome expectations of Physical activity

Expectations/perceived benefits of physical activity is a construct that are incorporated into social cognitive theory, health belief model and expectancy theory. Outcome Expectations of Physical Activity were assessed using the questionnaire developed and validated by Steinhardt and Dishman.[128] This questionnaire uses a Likert scale that ranges from 1 (Strongly Disagree) to 5 (Strongly Agree) to assess participants' current perception of the benefits and expected outcomes of engaging in physical activity. This questionnaire includes a total score, and 3 subscales: psychological benefits (e.g., a major benefit of physical activity is its positive psychological effect), image benefits (e.g., a major benefit of physical activity is to enhance self-image and confidence), and health benefits (e.g., a major benefit of physical activity is good health and to feel better in general).[128] The questionnaire was also modified to retrospectively assess their perception of the benefits and expected outcomes of engaging in physical activity prior to undergoing bariatric surgery.

3.5.5.3 Barriers to physical activity

Barriers to physical activity is a construct that is incorporated into social cognitive theory, health belief model and expectancy theory. Barriers to Physical Activity were assessed using the questionnaire developed and validated by Steinhardt and Dishman.[128] This questionnaire used a Likert scale that ranges from 1 (Strongly Disagree) to 5 (Strongly Agree) to assess participants' perception of common barriers to engaging in physical activity. Barriers to physical activity were reported as a total score, and 3 subscales: time barriers (e.g., the major reason for not exercising is not having enough time), effort barriers (e.g., the major reason for not exercising is being too tired or lack motivation), and obstacle barriers (e.g., the major reason for not exercising is that the weather is bad).[128] The questionnaire was also modified to retrospectively assess their perception of those same common barriers to engaging in physical activity prior to undergoing bariatric surgery.

3.5.5.4 Behavioral control

Perceived behavioral control is a construct that is incorporated into the theory of planned behavior. Behavioral control was measured by assessing a person's beliefs about the controllability of a behavior, as well as their self-efficacy for a behavior.[129] Behavioral control was assessed using a questionnaire that has been previously utilized in adults who have undergone bariatric surgery.[52] This questionnaire uses a Likert scale that ranges from 1 to 7, with a higher score reflecting greater control over physical activity behaviors. The questionnaire was also modified to retrospectively assess perceived behavior control over participating in physical activity prior to undergoing bariatric surgery.

3.5.5.5 Motivation

Motivation for exercise was measured by assessing a variety of reasons why people exercise regularly. Self-motivation has been repeatedly reported to have a positive association with overall physical activity in adults.[48] Motivation was assessed using the Motivation for Exercise questionnaire.[130] This questionnaire includes 4 subscales. The subscales are external regulation (an individual's interest in an extrinsic outcome), introjected regulation (an individuals internalized obligation to engage in a behavior), identified regulation (personal importance of a behavior or outcome), and intrinsic motivation (an individuals interested in a behavior or activity). Motivation is also reported as the Relative Autonomy Index (RAI), a combination of subscale scores.[130] The questionnaire was also modified to retrospectively assess motivation for exercise prior to undergoing bariatric surgery.

3.5.5.6 Exercise enjoyment

Exercise enjoyment was assessed using a questionnaire developed by Kendzierski and DeCarlo.[131,132] This questionnaire included 18 pairs of statements that assessed a participant's exercise enjoyment. The pair of statements are on either side of a Likert scale that asks participants to indicate how they feel about physical activity; the values range from 1-7; with 1 indicating the participant strongly agrees with the statement on the left, 3 indicating they neither agree or disagree with either statement, and 7 indicating the participant strongly agrees with the statement on the right. The questionnaire was also modified to retrospectively assess exercise enjoyment prior to undergoing bariatric surgery.

3.5.5.7 Social support and exercise

Social support was assessed using the Social Support and Exercise Survey, validated by Sallis et al.[133] This questionnaire queried participants on the social support they received from family, friends and co-workers. A subscale of social support that measured supportive and non-supportive behaviors of family friends and co-workers was also included. This subscale is reported in previous literature as rewards/punishments, and queried participants on if family, friends or co-workers complained about the time they spend exercising, criticize or make fun of them for exercising, or provide a reward for exercising. This questionnaire was also modified to retrospectively assess perceived social support for exercise from family, friends and co-workers prior to undergoing bariatric surgery.

3.5.5.8 Body image

Body Image was assessed using the Multidimensional Body-Self Relations Questionnaire developed by Cash.[115] This 69-item, self-report questionnaire assesses body image using a 5-point disagree-agree response format. The questionnaire includes 7 factor subscales: appearance evaluation (satisfaction or dissatisfaction with physical appearance), appearance orientation (effort put into physical appearance), fitness evaluation (feeling of being physically active or inactive), fitness orientation (effort put into being physically activity), health evaluation (feeling healthy or unhealthy), health orientation (effort put into living a healthy lifestyle), and illness orientation (alertness to physical symptoms of illness) This questionnaire also includes an additional 3 subscales: body areas satisfaction scale (satisfaction or dissatisfaction with specific body areas), overweight preoccupation (reflects weight vigilance) and self-classified weight (reflects how a person perceives their weight).[115] The questionnaire was also modified to retrospectively assess body image prior to undergoing bariatric surgery.

3.6 POWER ANALYSIS

The study recruited a sample of 100 who had undergone a bariatric surgery procedure within the past 2 years. The primary statistical analysis (described below in Section 3.8) focused on computing correlations between physical activity and selective behavioral constructs. An *a-priori* decision was made to power this study on the ability to detect a bivariate correlation of at least 0.30 between physical activity and each of the behavioral constructs, which would reflect a modest statistical association between these two variables. Thus, a power analysis using

G*Power software (version 3.1.7) was performed to estimate the minimal sample size necessary to detect correlations of this magnitude in this study. Based on a two-sided bivariate association with power of 0.80 and alpha of 0.05, it was estimated that a sample of at least 84 participants would be required to detect a correlation of $r=0.30$ between physical activity and any of the behavioral constructs. However, to allow for the potential for some of the data not to be valid or to be incomplete, it was proposed that a sample of 100 participants be recruited to participate in this study.

3.7 STATISTICAL ANALYSIS

Statistical analyses were conducted using version 24.0 of the IBM Statistical Package for the Social Sciences (SPSS) software (IBM Armonk, NY). The *a-priori* level of statistical significance was set at $p<0.05$. Data were examined for normality prior to analysis, and when data were not normally distributed non-parametric analyses were performed.

Descriptive statistics were computed to examine demographic characteristics of the participants enrolled in this study and represented as either mean ± standard deviation or median (25^{th}, 75^{th} percentile). Descriptive data were also compared to examine potential differences by gender (male vs. female) and by the type of bariatric surgery that the patient received (gastric bypass vs. gastric sleeve) using either an independent t-test or Mann-Whitney U test.

Pre- and post-surgery behavioral constructs were compared using dependent t-tests for normally distributed data or Wilcoxon Signed Ranks tests for non-normally distributed data. Change in behavioral constructs from pre-to post-surgery were also examined for differences between gender and surgical procedures using an independent t-test for normally distributed data or a Mann-Whitney U test for non-normally distributed data.

The association between psychosocial constructs and physical activity were examined in a bivariate analysis using Spearman Rank Order Correlation Coefficients. Data were analyzed to examine the associations between 1) post-surgery physical activity and pre-surgery psychosocial constructs, 2) change in physical activity and pre-surgery psychosocial constructs, 3) change in physical activity and change in psychosocial constructs, 4) post-surgery physical activity change in psychosocial constructs, and 5) post-surgery physical activity and post-surgery psychosocial constructs. Constructs shown to be statistically correlated with physical activity in the bivariate analysis were included in the corresponding multivariate analysis using stepwise regression with physical activity as the dependent variable and psychosocial contracts as the independent variables. Length of time following bariatric surgery, type of surgical procedure, gender, and baseline physical activity were controlled for in each of the regression analyses.

4.0 RESULTS

The primary aim of this study was to examine if there were selective psychosocial variables associated with physical activity in patients who had undergone bariatric surgery. This was a cross-sectional and retrospective study that used questionnaires to identify selective theory-based constructs, and their association with physical activity behaviors in patients who have undergone bariatric surgery. All study related procedures (physical assessments and self-report questionnaires) were conducted at the University of Pittsburgh Physical Activity and Weight Management Research Center or at the Minimally Invasive Bariatric and General Surgery Program at the Magee-Women's Hospital of UPMC.

4.1 STUDY RECRUITMENT AND RETENTION

Figure 3 illustrates recruitment of patients who had undergone bariatric surgery. One-hundred and seven patients expressed interest in the study and agreed to meet with the study staff, or when study staff was not present at a clinic visit, signed an Authorization to be Contacted form. Of the 107 potential participants who expressed interest, 101 (94%) were screened for eligibility either in person or during a telephone call. One-hundred of the participants who were screened (99%) were deemed eligible for the study. Ninety-seven (N=97) eligible participants were recruited from the Minimally Invasive Bariatric and General Surgery Program at Magee

Women's Hospital of UPMC, and three (N=3) eligible participants were recruited through the University of Pittsburgh's Clinical and Translational Science Institute (CTSI).

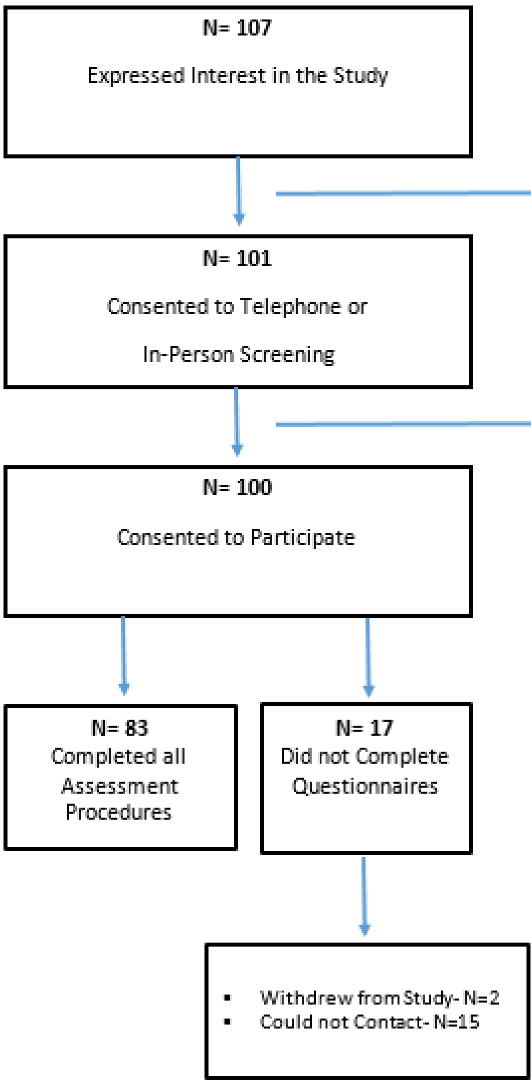

Figure 3. Study Recruitment and Retention

All eligible participants (N=100) provided authorization to release information from their medical record that included current weight, pre-surgical weight, pre-surgical height, surgical date and surgical procedure. Completed questionnaire data on physical activity, sedentary behavior and selective psychosocial variables were collected from 83 participants (83%).

4.2 STUDY PARTICIPANTS

One hundred (N=100) adult patients who underwent a gastric bypass or a gastric sleeve procedure within the past 2 years were consented to participate in this study. Mean post-surgical BMI was 36.2±5.9 kg/m^2, with 56% of participants having undergone gastric bypass and 44% having undergone a gastric sleeve procedure.

Baseline characteristics are shown in Table 2. Of the 100 consented participants, 83 participants provided complete questionnaire data. Mean age of completers was 44.0±11.8 years and mean post-surgical BMI was 35.9±5.9 kg/m^2, with 13.3% males and 18.1% non-white participants. Pre-surgical weight, pre-surgical BMI and time since surgery were not normally distributed. There were no significant differences in baseline characteristics between participants who completed the questionnaires and those who did not.

Table 2. Baseline Variables of Completers and Non-Completers

VARIABLES	TOTAL (N=100) Mean ± SD [Median (25%, 75%)]	COMPLETERS (N=83) Mean ± SD [Median (25%, 75%)]	NON-COMPLETERS (N= 17) Mean ± SD [Median (25%, 75%)]	p-value for comparison between completers and non-completers
Age (years)	43.7±12.0 [43.1 (33.9, 52.8)]	44.0±11.8 [43.0 34.6, 53.3)]	42.4±12.9 [43.2 (31.4, 51.3)]	0.665*
Height (cm)	165.1±7.5 [164.3 (160.2, 169.5)]	165.3±7.4 [165.1 (160.0, 169.5)]	164.1 ±8.1 [163.7 (160.3, 169.8)]	0.883*
Current Post-Surgical Weight (kg)	98.8±17.5 [98.3 (88.9, 108.8)]	98.0±17.3 [98.0 (87.9, 110.0)]	102.7±18.6 [98.8 (95.8, 107.3)]	0.692*
Pre-Surgical Weight (kg)	127.2±21.4 [122.8 (112.0, 135.8)]	126.5±20.8 [122.3 (112.0, 135.5)]	130.8±24.3 [124.0 (111.4, 148.4)]	0.582**
Current Post-Surgical BMI (kg/m^2)	36.2±5.9 [36.5 (31.6, 40.0)]	35.9±5.9 [36.0 (31.3, 39.7)]	38.0±5.7 [37.8 (34.2, 40.3)]	0.417*
Pre-Surgical BMI (kg/m^2)	46.6±6.3 [45.2 (41.8, 50.1)]	46.2±6.4 [45.2 (41.6, 49.5)]	48.3±5.7 [49.0 (42.0, 52.3)]	0.166**
Time Since Surgery (years)	0.7±0.6 [0.6 (0.1, 1.0)]	0.7±0.6 [0.6 (0.1, 1.0)]	0.5±0.6 [0.3 (0.0, 0.8)]	0.227**
Surgical Procedure				
Gastric Bypass N, %	56, 56%	46, 55.4%	10, 58.8%	0.797***
Gastric Sleeve N, %	44, 44%	37, 44.6%	7, 41.2%	
Gender				
Male N, %	13, 13%	11, 13.3%	2, 11.8%	0.868***
Female N, %	87, 87%	72, 86.7%	15, 88.2%	
Race				
White N, %	-----	68, 81.9%	-----	-----
Black or African American N, %	-----	13, 15.7%	-----	-----
Other N, %	-----	2, 2.4%	-----	-----
Depressive Symptoms (CES-D Score)	-----	6.8±5.5	-----	-----

*Computed using independent t-test
**Computed using non-parametric, Independent-samples Mann-Whitney U test
***Computed using a Pearson Chi-Square Test

Baseline characteristics of participants who completed all assessment procedures are also presented by gender (Table 3) and by type of bariatric surgery (Table 4) that the patient received.

Pre-surgical BMI and time since surgery were not normally distributed. Males were older (p=0.037), had a higher pre-surgical weight (p=0.010) and more time elapsed since surgery (p=0.003) compared to females. There were no significant differences for descriptive characteristics between the gastric bypass and gastric sleeve patients (Table 4).

Table 3. Baseline Characteristics by Male and Female Completers

VARIABLES	Males (N=11) Mean ± SD [Median (25%, 75%)]	Females (N=72) Mean ± SD [Median (25%, 75%)]	p-value for comparison between male and female completers
Age (years)	47.0±16.7 [43.9 (33.5, 60.3)]	43.5±11.0 [42.6 (34.6, 52.8)]	0.037*
Height (cm)	176.7±5.7 [177.8 (173.5, 182.0)]	163.5±6.0 [163.7 (159.6, 167.6)]	0.809*
Current Post-Surgical Weight (kg)	109.1±17.9 [107.2 (95.0, 116.6)]	96.4±16.6 [97.6 (85.7, 107.5)]	0.980*
Pre-Surgical Weight (kg)	150.2±28.3 [151.8 (126.4, 171.0)]	122.9±17.0 [120.0 (110.0, 133.0)]	0.010*
Current Post-Surgical BMI (kg/m^2)	34.8±4.7 [33.4 (30.7, 37.9)]	36.0±6.1 [36.3 (31.3, 40.2)]	0.381*
Pre-Surgical BMI (kg/m^2)	47.9±7.6 [45.4 (43.0, 51.8)]	45.9±6.2 [45.1 (41.5, 48.8)]	0.428**
Time Since Surgery (years)	1.2±0.6 [1.1 (0.7, 2.0)]	0.6±0.6 [0.5 (0.1, 1.0)]	0.003**
Surgical Procedure			
Gastric Bypass N, %	9, 82%	37, 51%	0.059***
Gastric Sleeve N, %	2, 18%	35, 49%	
***Computed using independent t-test** ****Computed using non-parametric, Independent-samples Mann-Whitney U test** *****Computed using a Pearson Chi-Square Test**			

Table 4. Baseline Characteristics by Surgical Procedure

VARIABLES	Gastric Bypass (N=46) Mean ± SD [Median (25%, 75%)]	Gastric Sleeve (N=37) Mean ± SD [Median (25%, 75%)]	p-value for comparison between surgical groups of completers
Age (years)	45.2±13.0 44.7 (34.8, 55.8)	42.4±10.1 39.5 (33.6, 52.0)	0.096*
Height (cm)	166.5±7.7 166.0 (160.5, 172.0)	163.8±6.9 164.3 (159.3, 167.5)	0.277*
Current Post-Surgical Weight (kg)	96.3±17.9 97.4 (85.0, 107.5)	100.2±16.5 99.0 (91.9, 112.8)	0.842*
Pre-Surgical Weight (kg)	130.1±22.3 126.2 (113.7, 140.0)	121.9±18.0 120.0 (108.9, 130.9)	0.148*
Current Post-Surgical BMI (kg/m^2)	34.7±5.6 34.6 (30.8, 38.9)	37.3±6.1 37.4 (34.2, 41.3)	0.958*
Pre-Surgical BMI (kg/m^2)	46.8±6.1 45.4 (42.8, 50.2)	45.5±6.7 43.9 (41.2, 47.5)	0.160**
Time Since Surgery (years)	0.8±0.7 0.7 (0.2, 1.5)	0.5±0.5 0.3 (0.1, 0.9)	0.420**
Gender **Male N, %** **Female N, %**	 9, 20% 37, 80%	 2, 5% 35, 95%	 0.059***

***Computed using independent t-test**
****Computed using non-parametric, Independent-samples Mann-Whitney U test**
*****Computed using a Pearson Chi-Square Test**

4.3 SURGICAL OUTCOMES

Pre-surgical and current post-surgical weights are presented by gender and surgical procedure (Table 4 and Table 5). Because of the variability in time since surgery, patients were grouped into one of 5 categories based on their time since undergoing bariatric surgery. Pre-surgical weight, current post-surgical weight, weight change, and average time since surgery are presented for the following 5 categories in Table 5: 1) immediately following surgery to 3 months post-surgery (≤3 months), 2) >3 months to 6 month post-surgery (>3-6 months), 3) >6 months to 12 months post-surgery (>6-12 months), 4) >12 months to 18 months post-surgery (>12-18 months), and 5) >18 months to 24 months post-surgery (>18-24 months).

The mean weight change ≤3 months post-bariatric surgery was -12.4±5.4 kg, with patients being an average of 1.09±0.56 months post-surgery. The mean weight change was -32.2 ±8.0 kg at >3-6 months, and -35.4 ±9.4 kg in the >6-12 month participants. Average time since surgery was 4.15±0.77 months in the >3-6 month group and 8.83±2.12 months in the >6-12 month group. Participants who were >12-18 months post-surgery had a weight change of 35.7 ±16.5 kg and those in the >18-24 months group had a weight lost -42.6 ±16.9 kg. Participants in the >12-18 months post-surgery group were an average of 13.38±1.55 months post-surgery and the >18-24 months group was 22.30±2.44 months post-surgery. There were no significant differences between categories for pre-surgical weight (p=0.107) or post-surgical weight (p=0.550); however, there were significant differences between categories for weight change (p<0.001) and time since surgery (p<0.001). Post hoc analysis revealed that weight change 0-3 months post-surgery was significantly less than weight change seen in each of the other categories (Table 5).

An analysis to examine the correlation between pre- to post-surgery weight change and physical activity was also conducted. Weight change and change in physical activity were not significantly correlated (r=0.009, p=0.934). Similarly, weight change was not significantly correlated with post-surgery physical activity (r=0.009, p=0.935).

Table 5. Surgical Outcomes by Months Post-Surgery

	≤ 3 Months (N=28) Mean ± SD [Median (25%, 75%)]	>3-6 months (N=9) Mean ± SD [Median (25%, 75%)]	>6-12 months (N=22) Mean ± SD [Median (25%, 75%)]	>12-18 months (N=11) Mean ± SD [Median (25%, 75%)]	>18-24 months (N=13) Mean ± SD [Median (25%, 75%)]	p-value
Pre-surgical weight (kg)	117.1±11.3 [117.5 (108.5, 127.6)]	131.6 ±19.3 [134.3 (114.6, 137.1)]	129.2 ±18.9 [125.8 (118.3, 141.4)]	134.3 ±30.3 [120.5 (108.1, 149.5)]	132.0 ±26.7 [130.0 (109.1, 158.7)	0.107
Current Post-surgical weight (kg)	104.7±11.3 [104.3 (96.6, 113.5)]	99.4 ±15.3 [98.6 (89.9, 102.8)]	93.8 ±17.2 [92.3 (78.8, 105.3)]	98.5 ±24.4 [95.0 (74.9, 107.0)]	89.5 ±18.8 [98.0 (69.6, 104.8)]	0.550
Weight Change (kg)	-12.4±5.4 [A,B,C,D] [-11.3 (-15.3 -8.9)	-32.2 ±8.0 [A] [-31.6 (-39.1, -27.7)	-35.4 ±9.4 [B] [-34.4 (43.6-28.8)]	-35.7 ±16.5 [C] [-36.9 (-48.7, -22.8)	-42.6 ±16.9 [D] [-40.4 (-55.6, -32.0,)	0.000
Time Since Surgery (months)	1.09±0.56 [A.B.C] [1.3 (0.5, 1.45)]	4.15±0.77 [D,E] [4.17 (3.50, 4.76)]	8.83±2.12 [A,F] [8.21 (6.9, 10.69)]	13.38±1.55 [B,D] [13.1 (12.45, 13.37)]	22.30±2.44 [C,E,F] [23.23 (20.04, 24.2)	0.000

Post Hoc-Analysis: Categories with same superscripts are significantly different at p<0.05

4.4 PHYSICAL ACTIVITY

Table 6 provides self-report physical activity data collected using the Paffenbarger Physical Activity Questionnaire for the 83 participants who completed this questionnaire. Participants self-reported median (25th and 75th percentile) leisure-time physical activity energy expenditure of 156.00 (56.00, 600.00) kcal/week prior to undergoing bariatric surgery, and 976.00 (344.00, 1832.00) kcal/week following surgery. Leisure-time physical activity was not normally distributed. Wilcoxon Signed Ranks Tests showed that there was a significant increase in leisure-time physical activity energy expenditure from pre-to post-surgery (508.00 (48.00, 1138.00) kcal/week, p<0.001). A similar pattern was observed when the analysis was repeated without including stair climbing in the total energy expenditure, with energy expenditure increasing significantly post-bariatric surgery (p<0.001). There were no significant differences for change in physical activity by surgical procedure, gender or time since surgery (Appendix B).

Table 6. Self-reported Physical Activity and Sedentary Behavior

Physical Activity	**Pre-surgery [Median (25%, 75%)]**	**Current Post-Surgery [Median (25%, 75%)]**	**Change*** [Median (25%, 75%)]**	**p-value**
Leisure-time Physical Activity with Stairs (kcal/wk)	156.00 (56.00, 600.00)	976.00 (344.00, 1832.00)	508.00 (48.00, 1138.00)	0.000
Leisure-time Physical Activity without Stairs (kcal/wk)	0.000 (0.00, 450.00)	720 (216.00, 1572.00)	480.00 (0.00, 1008)	0.000
Sedentary Behavior				
Weekday Sedentary Time (hours/day)*	14.00 (9.50, 18.00)	11.50 (7.75, 14.50)	-1.50 (-4.25, 1.25)	0.003
Weekend Sedentary Time (hours/day)*	12.00 (8.25, 16.5)	3.25 (2.25, 5.50)	-8.50 (-13.00, -4.75)	0.000
GPAQ Weekday Sedentary Time (hours/day)**	8.00 (4.5, 11.75)	5.25 (3.00, 9.06)	-2.00 (-4.00, 0.00)	0.000
GPAQ Weekend Sedentary Time (hours/day)**	6.50 (4.75, 10.00)	5.00 (3.00, 8.00)	-2.00 (-4.00, 0.00)	0.000

*Collected using the 8-item Sedentary Behavior Questionnaire
** Collected using the Global Physical Activity Questionnaire (GPAQ)
***Change score computed as post-surgery value minus pre-surgery value

Self-reported sedentary behavior (Table 6), collected from the Sedentary Behavior Questionnaire, showed that on weekdays, sedentary behavior decreased from 14.00 (9.5, 18.00) hours/day prior to bariatric surgery to 11.50 (7.75, 14.50) hours/day post-bariatric surgery (change= -1.50 (-4.25, 1.25) hours/day, (p=0.003). On weekend days, participants reported engaging in 12.00 (8.25, 16.5) hours/day of sedentary behavior prior to surgery, decreasing to 3.25 (2.25, 5.50) hours/day post- surgery [change= -8.50 (-13.00, -4.75) hours/day, p<0.001].

Self-reported weekday sedentary behavior collected using the Global Physical Activity Questionnaire showed that sedentary time significantly decreased from 8.00 (4.5, 11.75) hours/day prior to bariatric surgery to 5.25 (3.00, 9.06) hours/day following surgery [change= 2.00 (-4.00, 0.00) hours/day ($p<0.001$)]. Weekend day sedentary time also significantly decreased from 6.50 (4.75, 10.00) hours/day prior to surgery to 5.00 (3.00, 8.00) hours/day post-bariatric surgery (change= -2.00 (-4.00, 0.00) hours/day ($p<0.001$)). There were no significant differences in change in sedentary behavior by surgical procedure, gender or time since surgery (Appendix B).

4.5 PSYCHOSOCIAL VARIABLES

4.5.1 Health-related quality of life

Quality of life data, as assessed by the SF-36, are presented in Table 7 and Table 8. The data are presented as non-standardized and standardized scores. Results are presented for the following subscales: physical functioning, role limitations due to physical health, role limitation due to emotional problems, energy/fatigue, emotional well-being, social functioning, pain and general health. There was a significant increase in each of the subscale from pre-to post bariatric surgery ($p \leq 0.001$) when using the non-standardized scores. The same pattern was observed when examining the standardized scores ($p \leq 0.001$).

The data were also examined by surgical procedure and gender. There were no significant differences between surgical procedures for the change in health-related quality of life subscales pre-to post-surgery for the non-standardized or the standardized scores. There were also no differences between male and female participant's SF-36 outcomes from pre-to post-surgery. Data by surgical procedure and gender are shown in Appendix C.

Table 7. Quality of Life (Non-standardized Scores)

Quality of Life	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Physical Functioning	20.00 (15.00, 23.00)	28.00 (24.00, 30.00)	8.00 (2.00, 11.00)	0.000
Role limitation due to physical health	5.00 (4.00, 7.00)	8.00 (7.00, 8.00)	2.00 (0.00, 4.00)	0.000
Role limitation due to emotional problems	4.00 (3.00, 5.00)	6.00 (5.00, 6.00)	1.00 (0.00, 2.00)	0.000
Energy/fatigue	10.00 (7.00, 12.00)	16.00 (13.00, 19.00)	6.00 (2.00, 10.00)	0.000
Emotional well-being	19.00 (15.00, 21.00)	25.00 (20.00, 27.00)	5.00 (2.00, 8.00)	0.000
Social functioning	6.00 (5.00, 7.00)	9.00 (7.00, 10.00)	2.00 (0.00, 4.00)	0.000
Pain	6.00 (5.00, 8.00)	8.00 (7.00, 10.00)	2.00 (0.00, 4.00)	0.000
General health	16.00 (15.00, 17.40)	17.40 (16.4, 18.4)	1.00 (-0.600, 2.40)	0.001

*Change score computed as post-surgery value minus pre-surgery value

Table 8. Quality of Life (Standardized Scores)

Quality of Life	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Physical Functioning	50.00 (25.00, 65.00)	90.00 (70.00, 100.00)	40.00 (10.00, 55.00)	0.000
Role limitation due to physical health	25.00 (0.00, 75.00)	100.00(75.00, 100.00)	50.00 (0.00, 100.00)	0.000
Role limitation due to emotional problems	33.33 (0.00, 66.67)	100.00 (66.67, 100.00)	33.33 (0.00, 66.67)	0.000
Energy/fatigue	30.00 (15.00, 40.00)	60.00 (45.00, 75.00)	30.00 (10.00, 50.00)	0.000
Emotional well-being	56.00 (40.00, 64.00)	80.00 (60.00, 88.00)	20.00 (8.00, 32.00)	0.000
Social functioning	50.00 (37.50, 62.50)	87.50 (62.5, 100.00)	25.00 (0.00, 50.00)	0.000
Pain	40.00 (30.00, 60.00)	60.00 (50.00, 80.00)	20.00 (0.00, 40.00)	0.000
General health	55.00 (50.00, 62.00)	62.00 (57.00, 67.00)	5.00 (-3.00, 12.00)	0.001

*Change score computed as post-surgery value minus pre-surgery value

4.5.2 Physical activity barriers

Data from the Physical Activity Barriers Questionnaire are presented as a total score, with subscales of time barriers, effort barriers and obstacle barriers. Data are presented in Table 9. There was a significant reduction in total perceived barriers to physical activity from pre- [3.00 (2.62, 3.54)] to post- [2.54 (2.08, 2.85)] surgery (p=<0.001). There were also significant reductions in effort barriers (p<0.001) and obstacle barriers (p<0.001) pre-to post-bariatric surgery. There were no significant change in time barriers (p=0.662) from pre-to post-surgery.

Change in barriers from the pre-to-post surgical time point were also examined by surgical procedure and gender. There were no significant differences for the change in total barriers (p=0.207), time barriers (p=0.971), effort barriers (p=0.258), and obstacle barriers (p=0.536) between patients who underwent gastric bypass versus gastric sleeve bariatric surgery procedures. There was also no significant differences in the change in total barriers (p=0.721), time barriers (p=0.829), effort barriers (p=0.239), and obstacle barriers (p=0.617) between male and female participants. Data by surgical procedure and gender are shown in Appendix D.

Table 9. Barriers to Physical Activity

Barriers	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Time	2.33 (1.67, 3.67)	2.67 (1.67, 3.67)	0.00 (-0.67, 0.67)	0.662
Effort	3.67 (2.83, 4.33)	2.67 (2.17, 3.17)	-0.83 (-1.67, -0.33)	0.000
Obstacles	2.50 (1.75, 3.00)	2.00 (2.08, 2050)	-0.50 (-1.00, 0.00)	0.000
Overall	3.00 (2.62, 3.54)	2.54 (2.08, 2.85)	-0.46 (-1.15, -0.15)	0.000

*Change score computed as post-surgery value minus pre-surgery value

4.5.3 Outcome expectations (benefits) of physical activity

Outcome Expectations of Physical Activity Questionnaire included a total score, with subscales of psychological, image and health expectations. Data are presented as median (25th, 75th percentile) in Table 10. The total score increased from 3.42 (2.50, 4.00) prior to surgery to 4.08 (3.50, 4.42) post-surgery ($p<0.001$). In addition, there were statistically significant increases in psychological expectations ($p<0.001$), image expectations ($p<0.001$) and health expectations ($p<0.001$) from the pre-to post-surgical time periods.

Change in outcome expectations were also examined by surgical procedure and gender. There were no significant differences between surgical procedure for change in psychological expectations (p=0.822), image expectations (p=0.138), health expectations (p=0.297) or total outcome expectations of physical activity (p=0.362). When examined by gender, there were no significant differences between male and female participants for change in psychological expectations (p=0.385), image expectations (p=0.211), health expectations (p=0.587) or total outcome expectations of physical activity (p=0.259). Data by surgical procedure and gender are shown in Appendix E.

Table 10. Outcome Expectations for Physical Activity

Expectations (Benefits)	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Psychological	2.80 (1.80, 3.60)	3.40 (2.80, 4.00)	0.40 (0.00, 1.40)	0.000
Image	4.00 (3.00, 4.75)	4.75 (4.00, 5.00)	0.50 (0.00, 1.00)	0.000
Health	3.67 (3.00, 4.67)	5.00 (4.00, 5.00)	0.67 (0.00, 1.67)	0.000
Overall	3.42 (2.50, 4.00)	4.08 (3.50, 4.42)	0.58 (0.00, 1.17)	0.000

*Change score computed as post-surgery value minus pre-surgery value

4.5.4 Motivation

Data from the Motivation for Exercise Questionnaire are presented in Table 11. Data are presented as relative autonomy index (RAI) and by autonomous motivation subscales which include external regulation (individual's interest in an extrinsic outcome), introjected regulation (individuals internalized obligation to engage in a behavior), identified regulation (personal importance of a behavior or outcome), and intrinsic motivation (individual's interest in a behavior or activity). There was no significant change in external regulation following bariatric surgery (p=0.922). Introjected regulation increased from 2.25 (1.00, 3.50) pre-surgery to 3.00 (1.75, 4.00) post-surgery (p=0.006). Identified regulation and intrinsic motivation also increased, with identified regulation increasing from 4.00 (2.00, 5.75) to 6.00 (4.75, 6.75) pre-to post-surgery (p<0.001) and intrinsic motivation increasing from 3.00 (1.50, 4.00) pre-surgery to 4.25 (3.25, 5.50) post-surgery (p<0.001). RAI, a combined motivation subscale score, also significantly increased from 3.00 (0.00, 7.00) prior to surgery to 7.25 (3.75, 11.5) following bariatric surgery (p<0.001).

Changes in motivation were also examined by surgical procedure and gender. There were no significant differences between surgical procedures for change in external regulation (p=0.803), introjected regulation (p=0.627), identified regulation (p=0.183), intrinsic motivation (p=0.062) or RAI (p=0.121) pre-to post-surgery. Similarly, there were no significant differences between males and female participants for pre- to post-surgical change in external regulation (p=0.695), introjected regulation (p=0.731), identified regulation (p=0.559), intrinsic motivation (p=0.420) or RAI (p=0.344). Data by surgical procedure and gender are shown in Appendix F.

Table 11. Motivation for Exercise

Motivation for Exercise	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
External Regulation	1.25 (1.00, 2.25)	1.25 (1.00, 2.25)	0.000 (-0.25, 0.50)	0.922
Introjected Regulation	2.25 (1.00, 3.50)	3.00 (1.75, 4.00)	0.25 (-0.500, 1.50)	0.006
Identified Regulation	4.00 (2.00, 5.75)	6.00 (4.75, 6.75)	1.50 (0.00, 3.00)	0.000
Intrinsic Motivation	3.00 (1.50, 4.00)	4.25 (3.25, 5.50)	1.25 (0.25, 2.25)	0.000
Relative Autonomy Index (RAI)	3.00 (0.00, 7.00)	7.25 (3.75, 11.5)	3.25 (-0.25, 7.00)	0.000

*Change score computed as post-surgery value minus pre-surgery value

4.5.5 Self-efficacy

Physical activity self-efficacy data is presented in Table 12. Self-efficacy was measuring using the Stanford Self-Efficacy Scale and the Physical Activity Self-efficacy form. Self-efficacy measured using the Stanford Self-efficacy scale increased from 2.07 (0.86, 3.93) pre-surgery to 5.36 (3.50, 6.93) post-surgery (p<0.001). The change in Stanford self-efficacy scores were not significantly different between surgical procedures (p=0.256), or between male and female participants (p=0.697). The 5-item physical activity self-efficacy form was also used, and results are presented as a average score (Table 12). The average score increased from 1.80 (1.20, 2.40) pre-surgery to 3.00 (2.40, 3.60) post-surgery (p<0.001). The change in physical activity self-efficacy scores were not different by surgical procedure (p=0.565) or gender (p=0.819). Data by surgical procedure and gender are shown in Appendix G.

Table 12. Physical Activity Self-efficacy

Physical Activity Self-efficacy	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Stanford Self-efficacy Scale**	2.07 (0.86, 3.93)	5.36 (3.50, 6.93)	2.36 (0.64, 4.14)	0.000
Physical Activity Self-efficacy***	1.80 (1.20, 2.40)	3.00 (2.40, 3.60)	1.00 (0.20, 1.80)	0.000

*Change score computed as post-surgery value minus pre-surgery value
**Measured using the Stanford Self-efficacy Scale
***Measured using the Physical Activity Self-efficacy form

4.5.6 Exercise enjoyment

Data from the Exercise Enjoyment Questionnaire are presented in Table 13. Exercise enjoyment increased significantly from pre- [65.00 (46.00, 75.00)) to post- (87.00 (66.00, 106.00)] surgery ($p<0.001$). There were no significant differences between gastric bypass patients and gastric sleeve patients for pre-to post-surgery change in exercise enjoyment ($p=0.993$). Similarly, there were also no differences in pre-to post-surgical change in exercise enjoyment between male and female patients ($p=0.519$). Data by surgical procedure and gender are shown in Appendix H.

Table 13. Exercise Enjoyment

Exercise Enjoyment	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Overall Enjoyment	65.00 (46.00, 75.00)	87.00 (66.00, 106.00)	23.00 (3.00, 39.00)	0.000

*Change score computed as post-surgery value minus pre-surgery value

4.5.7 Social support for exercise

Data from the Social Support and Exercise Questionnaire are presented in Table 14. Social support from family increased significantly from 14.00 (10.00, 21.00) prior to surgery to 18.00 (13.00, 25.00) post-surgery ($p<0.001$). Similarly, there was a significant increase in perceived social support from friends [1.00 (0.00, 5.00), $p<0.001$], and co-workers [0.00 (0.00, 3.00), $p=0.002$] pre-to post-bariatric surgery. There were no significant differences for change from pre- to post-surgery in perceived supportive and non-supportive behaviors received from friends ($p=0.959$) or co-workers ($p=0.200$); however, there was a significant change in perceived supportive and non-supportive behaviors received from family (0.031). There were no significant differences between surgical procedures or genders for pre-to post-surgical change in any of the perceived social support measures. Data by surgical procedure and gender are shown in Appendix I.

Table 14. Social Support for Exercise

Social Support	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Family Social Support	14.00 (10.00, 21.00)	18.00 (13.00, 25.00)	3.00 (0.000, 7.00)	0.000
Friend Social Support	12.00 (10.00, 18.00)	15.00 (10.00, 23.00)	1.00 (0.00, 5.00)	0.000
Co-worker Social Support	10.00 (10.00, 14.00)	10.00 (10.00, 16.00)	0.00 (0.00, 3.00)	0.002
Family Supportive/Non-supportive Behaviors	15.00 (13.00, 15.00)	15.00 (15.00, 15.00)	0.00 (-1.00, 0.00)	0.031
Friends Supportive/Non-supportive Behaviors	15.00 (15.00, 15.00)	15.00 (15.00, 15.00)	0.00 (0.00, 0.00)	0.825
Co-worker Supportive/Non-supportive Behaviors	15.00 (13.00, 15.00)	15.00 (15.00, 15.00)	0.00 (0.00, 0.00)	0.925

*Change score computed as post-surgery value minus pre-surgery value

4.5.8 Perceived behavioral control

Physical activity perceived behavioral control data are presented in Table 15. This construct was assessed using a Perceived Behavioral Control Questionnaire previously used by Hunt et al.[52] Perceived behavioral control increased from 3.75 (2.75, 4.75) pre-surgery to 6.00 (5.00, 6.75) post-surgery ($p<0.001$). There were no significant differences between gastric bypass and gastric sleeve patients for change in perceived behavioral control pre-to post-surgery ($p=0.566$). There were also no differences observed between male and female patients for pre-to post-surgical change in perceived behavioral control (p=0.291). Data by surgical procedure and gender are shown in Appendix J.

Table 15. Physical Activity Perceived Behavioral Control

Perceived Behavioral Control	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Total Perceived Behavioral Control	3.75 (2.75, 4.75)	6.00 (5.00, 6.75)	2.00 (0.50, 3.00)	0.000

*Change score computed as post-surgery value minus pre-surgery value

4.5.9 Body image

Body image data, assessed using the Multidimensional Body-Self Relations Questionnaire, are presented in Table 16. A significant increase was observed from pre-to post surgery for appearance evaluation ($p<0.001$), appearance orientation (p=0.001), fitness evaluation ($p<0.001$), fitness orientation ($p<0.001$), health evaluation ($p<0.001$), health orientation ($p<0.001$), illness orientation ($p<0.001$), body areas satisfaction ($p<0.001$), and overweight perception (p=0.0027). There was also a statistically significant decrease in self-classified weight from pre-surgery to post-surgery ($p<0.001$).

Data were also analyzed by surgical procedure and gender. Pre-to post-surgical changes in appearance evaluation (p=0.133), appearance orientation (p=0.933), fitness evaluation (p=0.228), fitness orientation (p=0.239), health evaluation (p=0.068), health orientation (p=0.074), illness orientation (p=0.210) and body areas satisfaction (p=0.131) did not differ by surgical procedure. Change in overweight perception increased significantly more in the patients who underwent gastric bypass (p=0.042), and self-classified weight decreased significantly more in patients who underwent gastric bypass, when compared to patients who underwent a gastric sleeve procedure.

Pre-to post-surgical change in appearance evaluation (p=0.117), appearance orientation (p=0.57), fitness evaluation (p=0.989), fitness orientation (p=0.648), health evaluation (p=0.941), health orientation (p=0.752), illness orientation (p=0.935) body areas satisfaction (p=0.600), and self-classified weight (p=0.260) did not differ by male and female patients. Pre-to post-surgery change in overweight perception increased significantly more in male patients compared to female patients (p=0.024). Data by surgical procedure and gender are shown in Appendix K.

Table 16. Body Image

Body Image	Pre-surgery [Median (25%, 75%)]	Current Post-Surgery [Median (25%, 75%)]	Change* [Median (25%, 75%)]	p-value
Appearance Evaluation	1.71 (1.29, 2.43)	2.57 (2.00, 3.14)	0.57 (0.14, 1.29)	0.000
Appearance Orientation	3.21 (2.67, 3.60)	3.42 (3.00, 3.83)	0.17 (-0.17, 0.58)	0.001
Fitness Evaluation	2.67 (2.33, 3.33)	3.33 (2.67, 3.637)	0.33 (0.00, 1.33)	0.000
Fitness Orientation	2.62 (2.08, 2.85)	3.08 (2.77, 3.46)	0.54 (0.23, 1.08)	0.000
Health Evaluation	2.83 (2.17, 3.17)	3.33 (2.83, 3.83)	0.50 (0.00, 1.17)	0.000
Health Orientation	2.63 (2.00, 3.13)	3.38 (3.00, 3.88)	0.88 (0.38, 1.38)	0.000
Illness Orientation	3.00 (2.40, 3.40)	3.20 (2.60, 3.80)	0.20 (-0.20, 0.60)	0.000
Body Areas Satisfaction	2.11 (1.67, 2.67)	2.78 (2.33, 3.22)	0.56 (0.00, 1.11)	0.000
Overweight Perception	3.25 (2.75, 4.00)	3.75 (3.00,4.00)	0.25 (-0.25, 0.75)	0.027
Self-classified Weight	5.00 (4.50, 5.00)	4.00 (3.50, 4.50)	-0.50 (-1.00, 0.00)	0.000

*Change score computed as post-surgery value minus pre-surgery value

4.6 ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND PSYCHOSOCIAL VARIABLES

The following sections present data for bivariate analyses and multivariate regression analyses to examine the associations between physical activity and psychosocial constructs. For these analyses, the measure of physical activity that included flights of stairs climbed, walking, and other sport, fitness, or recreational activity was used.

4.6.1 Association between current post-surgery physical activity and pre-surgery psychosocial variables

The association between current post-surgery physical activity and each of the pre-surgery behavioral constructs were examined. The bivariate analyses revealed a number of significant correlations between current post-surgery physical activity and selective pre-surgery psychosocial variables, and these are shown in Table 17.

Pre-surgery psychosocial variables found to be significantly associated with current post-surgery physical activity were considered in a stepwise regression analysis. The results from this regression are shown in Table 18. This analysis controlled for pre-surgical physical activity, gender, type of surgical procedure, and time since surgery when post-surgery data were collected. This analysis showed that higher pre-surgical family supportive and non-supportive behaviors ($p<0.001$), and higher pre-surgical co-worker social support ($p<0.001$) emerge as psychosocial variables that significantly predicted greater current post-surgical physical activity.

Table 17. Spearman Rank Order Correlation Coefficients between Current Post-Surgery Physical Activity and Pre-Surgery Psychosocial Variables

Pre-surgery Psychosocial Variable		Post-surgery Physical Activity	p-value
Health-Related Quality of Life	physical function	0.103	0.354
	social function	0.140	0.207
	role limitation due to physical health	0.149	0.178
	role limitation to emotional problems	0.126	0.256
	emotional well-being	-0.017	0.882
	energy/fatigue	-0.109	0.326
	pain	0.138	0.213
	general health	0.014	0.898
Barriers to Physical Activity	time barriers	0.037	0.742
	effort barriers	-0.004	0.971
	obstacle barriers	-0.145	0.192
	total barriers	-0.21	0.853
Perceived Benefits to Physical Activity	psychological benefits	-0.010	0.928
	image benefits	0.134	0.228
	health benefits	.018	0.875
	total benefits	0.057	0.607
Motivation for Physical Activity	external regulation	0.125	0.262
	introjected regulation	0.121	0.276
	identified regulation	0.053	0.634
	intrinsic motivation	0.068	0.543
	RAI	0.032	0.776
Physical Activity Self-efficacy	physical activity self-efficacy	0.075	0.500
	Stanford self-efficacy	0.173	0.119
Exercise Enjoyment	exercise enjoyment	-0.065	0.560
Social Support	family social support	***0.232***	***0.035***
	friend social support	***0.235***	***0.033***
	co-worker social support	***0.335***	***0.002***
	family supportive/non-supportive behaviors	***-0.333***	***0.002***
	friends supportive/non-supportive behaviors	*-0.129*	*0.246*
	co-worker supportive/non-supportive behaviors	0.091	0.415
Perceived Control	perceived behavioral control	0.073	0.512
Body Image	appearance evaluation	0.096	0.387
	appearance orientation	0.131	0.239
	fitness evaluation	0.132	0.234
	fitness orientation	-0.022	0.847
	health evaluation	-0.005	0.963
	health orientation	-0.063	0.573
	illness orientation	-0.084	0.448
	body areas satisfaction	0.056	0.612
	overweight preoccupation	-0.013	0.908
	self-classified weight	0.123	0.267
Note: Correlation coefficients and p-values that are bold/italicized are statistically significant			

Table 18. Stepwise Regression Analysis to Predict Current Post-Surgery Physical Activity from Pre-Surgery Psychosocial Variables

Dependent variable	Independent Variable [1]	Intercept	Beta Coefficient	Standard Error	p-value	R^2
Current Post-Surgery Physical Activity						
Final Model		6822.812		1541.619	0.000	0.493
	*Time Since Surgery		0.104	193.435	0.229	
	*Surgical Procedure		-0.030	232.732	0.723	
	*Gender		-0.184	344.857	0.037	
	*Pre-surgery Physical Activity		0.201	0.147	0.032	
	Pre-surgery family supportive/non-supportive behaviors		0.405	95.529	0.000	
	Pre-surgery co-worker social support		0.399	17.529	0.000	

[1]Only pre-surgery to post-surgery changes in psychosocial variables shown to be associated in the bivariate analysis were included in the stepwise regression
*Controlling for pre-surgical physical activity, years post-surgery, surgical procedure, gender

4.6.2 Association between change in physical activity and pre-surgery psychosocial variables

The association between pre- to post-surgery change in physical activity and each of the pre-surgery behavioral constructs were examined. Results of the bivariate analysis, shown in Table 19, revealed that there were a number of significant correlations between pre- to post-surgery change in physical activity and pre-surgery psychosocial variables.

Pre-surgery psychosocial variables found to be significantly correlated with pre- to post-surgery change in physical activity were included in the stepwise regression. The results from this regression are shown in Table 20. The analysis controlled for pre-surgical physical activity, gender, type of surgical procedure, and time since surgery when post-surgery data were collected. This analysis showed higher pre-surgical family supportive and non-supportive behaviors ($p<0.001$) emerged as a pre-surgical psychosocial variable that significantly predicted greater increases in pre-to post-surgery change in physical activity.

Table 19. Spearman Rank Order Correlation Coefficients between Change in Physical Activity and Pre-Surgery Psychosocial Variables

Pre-surgery Psychosocial Variable		Change in Physical Activity	p-value
Health-Related Quality of Life	physical function	***-0.252***	***0.021***
	social function	-0.055	0.620
	role limitation due to physical health	-0.116	0.297
	role limitation to emotional problems	-0.087	0.437
	emotional well-being	-0.112	0.315
	energy/fatigue	***-0.344***	***0.001***
	pain	-0.150	0.175
	general health	-0.134	0.227
Barriers to Physical Activity	time barriers	0.130	0.241
	effort barriers	0.109	0.326
	obstacle barriers	0.028	0.801
	total barriers	0.123	0.267
Perceived Benefits to Physical Activity	psychological benefits	***-0.220***	***0.046***
	image benefits	-0.036	0.749
	health benefits	-0.096	0.389
	total benefits	-0.146	0.187
Motivation for Physical Activity	external regulation	0.074	0.505
	introjected regulation	-0.006	0.955
	identified regulation	-0.202	0.067
	intrinsic motivation	-0.185	0.095
	RAI	-0.182	0.100
Physical Activity Self-efficacy	physical activity self-efficacy	***-0.233***	***0.034***
	Stanford self-efficacy	***0.227***	***0.039***
Exercise Enjoyment	exercise enjoyment	***-0.229***	***0.038***
Social Support	family social support	0.092	0.407
	friend social support	0.091	0.412
	co-worker social support	0.209	0.058
	family supportive/non-supportive behaviors	***0.264***	***0.016***
	friends supportive/non-supportive behaviors	-0.070	0.531
	co-worker supportive/non-supportive behaviors	0.062	0.577
Perceived Control	perceived behavioral control	***-0.269***	***0.014***
Body Image	appearance evaluation	***-0.223***	***0.043***
	appearance orientation	-0.017	0.880
	fitness evaluation	-0.127	0.254
	fitness orientation	***-0.306***	***0.005***
	health evaluation	***-0.234***	***0.033***
	health orientation	***-0.240***	***0.029***
	illness orientation	-0.058	0.600
	body areas satisfaction	-0.149	0.178
	overweight preoccupation	-0.051	0.649
	self-classified weight	***0.342***	***0.002***
Note: Correlation coefficients and p-values that are bold/italicized are statistically significant			

Table 20. Stepwise Regression Analysis to Predict Pre- to Post-Surgery Change in Physical Activity from Pre-Surgery Psychosocial Variables

Dependent variable	Independent Variable [1]	Intercept	Beta Coefficient	Standard Error	p-value	R^2
Change in Physical Activity**						
Final Model		8382.697		1694.425	0.000	0.247
	*Time Since Surgery		0.041	214.886	0.686	
	*Surgical Procedure		-0.002	261.394	0.985	
	*Gender		-0.139	384.783	0.185	
	*Pre-surgery Physical Activity		-0.405	0.165	0.000	
	Pre-surgery family supportive/non-supportive behaviors		-0.482	107.008	0.000	

[1]Only pre-surgery to post-surgery changes in psychosocial variables shown to be associated in the bivariate analysis were included in the stepwise regression
*Controlling for pre-surgical physical activity, years post-surgery, surgical procedure, gender
**Change score computed as post-surgery value minus pre-surgery value.

4.6.3 Association between change in physical activity and change in psychosocial variables

The association between the pre-to post-surgery change in physical activity and pre-to post-surgery change in each of the psychosocial variables was examined. The results of the bivariate analysis for correlations between pre- to post-surgery change in physical activity and change in selective psychosocial variables, and are shown in Table 21.

Change in pre- to post-surgery psychosocial variables found to be significantly associated with change in pre- to post-surgery physical activity were considered in the stepwise regression analysis. The analysis controlled for pre-surgical physical activity, gender, type of surgical procedure, and time since surgery when post-surgery data were collected, and the results are shown in Table 22. The analysis revealed that an increase in fitness orientation ($p=0.001$), an increase in social support from friends ($p=0.005$) and a decrease in self-classified weight ($p=0.012$) significantly predicted pre- to post-surgical increase in physical activity.

Table 21. Spearman Rank Order Correlation Coefficients between Pre- to Post-Surgery Change in Physical Activity and Change in Psychosocial Variables

Change in Psychosocial Variable		Change in Physical Activity	p-value
Health-Related Quality of Life	physical function	***0.517***	***0.000***
	social function	***0.314***	***0.004***
	role limitation due to physical health	***0.329***	***0.002***
	role limitation to emotional problems	*0.240*	*0.029*
	emotional well-being	***0.261***	***0.017***
	energy/fatigue	***0.387***	***0.000***
	pain	***0.364***	***0.001***
	general health	0.103	0.357
Barriers to Physical Activity	time barriers	0.067	0.546
	effort barriers	***-0.239***	***0.030***
	obstacle barriers	-0.174	0.115
	total barriers	-0.177	0.109
Perceived Benefits to Physical Activity	psychological benefits	0.170	0.125
	image benefits	0.146	0.188
	health benefits	0.144	0.195
	total benefits	0.146	0.187
Motivation for Physical Activity	external regulation	-0.064	0.563
	introjected regulation	0.148	0.183
	identified regulation	***0.342***	***0.002***
	intrinsic motivation	***0.331***	***0.002***
	RAI	***0.360***	***0.001***
Physical Activity Self-efficacy	physical activity self-efficacy	***0.422***	***0.000***
	Stanford self-efficacy	***0.463***	***0.000***
Exercise Enjoyment	exercise enjoyment	***0.271***	***0.013***
Social Support	family social support	***0.342***	***0.002***
	friend social support	***0.283***	***0.010***
	co-worker social support	0.069	0.537
	family supportive/non-supportive behaviors	-0.039	0.728
	friends supportive/non-supportive behaviors	-0.123	0.269
	co-worker supportive/non-supportive behaviors	-0.120	0.280
Perceived Control	perceived behavioral control	***0.457***	***0.000***
Body Image	appearance evaluation	***0.379***	***0.000***
	appearance orientation	0.203	0.068
	fitness evaluation	***0.285***	***0.009***
	fitness orientation	***0.566***	***0.000***
	health evaluation	***0.399***	***0.000***
	health orientation	***0.393***	***0.000***
	illness orientation	0.160	0.149
	body areas satisfaction	***0.401***	***0.000***
	overweight preoccupation	***0.321***	***0.003***
	self-classified weight	***-0.430***	***0.000***
Note: Correlation coefficients and p-values that are bold/italicized are statistically significant			

Table 22. Stepwise Regression Analysis to Predict Pre-to Post-Surgery Change in Physical Activity from Change in Psychosocial Variables

Dependent variable	Independent Variable [1]	Intercept	Beta Coefficient	Standard Error	p-value	R^2
Change in Physical Activity**						
Final Model		42.510		397.335	0.915	0.360
	*Time Since Surgery		0.113	198.385	0.235	
	*Surgical Procedure		0.031	243.303	0.749	
	*Gender		-0.044	338.084	0.627	
	*Pre-surgery Physical Activity		-0.141	0.139	0.136	
	**Change in Fitness Orientation		0.357	175.890	0.001	
	**Change in Friend Social Support		0.269	19.733	0.005	
	**Change in Self-reported Weight		-0.250	140.104	0.012	

[1]Only pre-surgery to post-surgery changes in psychosocial variables shown to be associated in the bivariate analysis were included in the stepwise regression
*Controlling for pre-surgical physical activity, years post-surgery, surgical procedure, gender
**Change score computed as post-surgery value minus pre-surgery value.

4.6.4 Association between current post-surgery physical activity and change in psychosocial variables

The association between current post-surgical physical activity and change in each of the psychosocial variables from pre- to post-bariatric surgery were examined. Spearman's Rank Order Correlation Coefficients were computed for bivariate analysis. The bivariate analysis, shown in Table 23, revealed there were changes in selective psychosocial variables that were significantly associated with post-surgical physical activity.

Change in pre- to post-surgical psychosocial variables that were significantly correlated with current post-surgery physical activity in the bivariate analysis were considered in the stepwise regression. The results from this regression are shown in Table 24. The analysis controlled for pre-surgical physical activity, years post-surgery, surgical procedure, gender. The analysis showed that a greater increase in pre- to post-surgery fitness orientation ($p=0.001$), social support from friends ($p=0.005$), and a greater decrease in self-classified weight ($p=0.012$) significantly predicted higher current post-surgical physical activity.

Table 23. Spearman Rank Order Correlation Coefficients between Current Post-Surgery Physical Activity and Change in Psychosocial Variables

Change in Psychosocial Variable		Post-surgery Physical Activity	p-value
Health-Related Quality of Life	physical function	***0.277***	***0.011***
	social function	0.201	0.069
	role limitation due to physical health	0.133	0.231
	role limitation to emotional problems	0.111	0.316
	emotional well-being	0.181	0.102
	energy/fatigue	***0.304***	***0.005***
	pain	***0.222***	***0.044***
	general health	-0.045	0.689
Barriers to Physical Activity	time barriers	0.094	0.398
	effort barriers	***-0.255***	***0.020***
	obstacle barriers	-0.047	0.674
	total barriers	-0.144	0.195
Perceived Benefits to Physical Activity	psychological benefits	-0.081	0.464
	image benefits	-0.029	0.794
	health benefits	0.022	0.845
	total benefits	-0.068	0.544
Motivation for Physical Activity	external regulation	-0.125	0.260
	introjected regulation	0.113	0.310
	identified regulation	0.185	0.094
	intrinsic motivation	0.210	0.057
	RAI	***0.273***	***0.013***
Physical Activity Self-efficacy	physical activity self-efficacy	0.184	0.095
	Stanford self-efficacy	***0.261***	***0.017***
Exercise Enjoyment	exercise enjoyment	***0.228***	***0.038***
Social Support	family social support	***0.227***	***0.039***
	friend social support	***0.243***	***0.027***
	co-worker social support	0.115	0.302
	family supportive/non-supportive behaviors	-0.213	0.053
	friends supportive/non-supportive behaviors	0.187	0.091
	co-worker supportive/non-supportive behaviors	-0.124	0.265
Perceived Control	perceived behavioral control	0.190	0.086
Body Image	appearance evaluation	***0.393***	***0.000***
	appearance orientation	-0.003	0.976
	fitness evaluation	***0.217***	***0.049***
	fitness orientation	***0.381***	***0.000***
	health evaluation	***0.299***	***0.006***
	health orientation	***0.289***	***0.008***
	illness orientation	0.124	0.260
	body areas satisfaction	***0.288***	***0.008***
	overweight preoccupation	0.158	0.153
	self-classified weight	***-0.351***	***0.001***
Note: Correlation coefficients and p-values that are bold/italicized are statistically significant			

Table 24. Stepwise Regression Analysis to Predict Current Post-Surgery Physical Activity from Change in Psychosocial Variables

Dependent variable	Independent Variable [1]	Intercept	Beta Coefficient	Standard Error	p-value	R^2
Current Post-Surgery Physical Activity						
Final Model		42.510		397.335	0.915	0.494
	*Time Since Surgery		0.105	0.105	0.235	
	*Surgical Procedure		0.029	0.029	0.749	
	*Gender		-0.041	-0.041	0.627	
	*Pre-surgery Physical Activity		0.494	0.494	0.000	
	**Change in Fitness Orientation		0.332	0.332	0.001	
	**Change in Friend Social Support		0.250	0.250	0.005	
	**Change in Self-classified Weight		-0.233	-0.233	0.012	

[1]Only pre-surgery to post-surgery changes in psychosocial variables shown to be associated in the bivariate analysis were included in the stepwise regression
*Controlling for pre-surgical physical activity, years post-surgery, surgical procedure, gender
**Change score computed as post-surgery value minus pre-surgery value.

4.6.5 Association between current post-surgery physical activity and post-surgery psychosocial variables

The association between current post-surgery physical activity and post-surgery behavioral constructs were examined. The results from the bivariate correlations are shown in Table 25.

Current post-surgery psychosocial variables found to be significantly correlated with post-surgery physical activity were included in the stepwise regression. The analysis controlled for pre-surgical physical activity, years post-surgery, surgical procedure, gender, and results from this regression are shown in Table 26. The analysis showed that higher post-surgical fitness orientation ($p<0.001$), social support from co-workers ($p=0.002$) and physical function ($p=0.023$) significantly predict higher current post-surgical physical activity.

Table 25. Spearman Rank Order Correlation Coefficients between Current Post-Surgery Physical Activity and Current Post-Surgery Psychosocial Variables

Post-surgery Psychosocial Variable		Post-surgery Physical Activity	p-value
Health-Related Quality of Life	physical function	***0.574***	***0.000***
	social function	***0.365***	***0.001***
	role limitation due to physical health	***0.350***	***0.001***
	role limitation to emotional problems	***0.229***	***0.038***
	emotional well-being	0.203	0.065
	energy/fatigue	***0.328***	***0.002***
	pain	***0.419***	***0.000***
	general health	-0.710	0.525
Barriers to Physical Activity	time barriers	0.108	0.330
	effort barriers	***-0.312***	***0.004***
	obstacle barriers	-0.190	0.085
	total barriers	***-0232***	***0.034***
Perceived Benefits to Physical Activity	psychological benefits	-0.560	0.613
	image benefits	0.072	0.518
	health benefits	0.109	0.328
	total benefits	0.010	0.931
Motivation for Physical Activity	external regulation	-0.032	0.776
	introjected regulation	***0.270***	***0.014***
	identified regulation	***0.391***	***0.000***
	intrinsic motivation	***0.353***	***0.001***
	RAI	***0.282***	***0.010***
Physical Activity Self-efficacy	physical activity self-efficacy	***0.261***	***0.017***
	Stanford self-efficacy	***0.421***	***0.000***
Exercise Enjoyment	exercise enjoyment	0.158	0.153
Social Support	family social support	***0.393***	***0.000***
	friend social support	***0.405***	***0.000***
	co-worker social support	***0.391***	***0.000***
	family supportive/non-supportive behaviors	-0.110	0.322
	friends supportive/non-supportive behaviors	-0.141	0.203
	co-worker supportive/non-supportive behaviors	-0.047	0.672
Perceived Control	perceived behavioral control	***0.280***	***0.010***
Body Image	appearance evaluation	***0.363***	***0.001***
	appearance orientation	0.133	0.230
	fitness evaluation	***0.388***	***0.000***
	fitness orientation	***0.459***	***0.000***
	health evaluation	***0.326***	***0.003***
	health orientation	0.200	0.069
	illness orientation	0.041	0.715
	body areas satisfaction	***0.372***	***0.001***
	overweight preoccupation	0.113	0.310
	self-classified weight	***-0.295***	***0.007***
Note: Correlation coefficients and p-values that are bold/italicized are statistically significant			

Table 26. Stepwise Regression Analysis to Predict Current Post-Surgery Physical Activity from Current Post-Surgery Psychosocial Variables

Dependent variable	Independent Variable [1]	Intercept	Beta Coefficient	Standard Error	P-value	R^2
Current Post-Surgery Physical Activity						
Final Model		-4011.690		964.941	0.000	0.496
	*Time Since Surgery		0.154	196.800	0.081	
	*Surgical Procedure		-0.033	237.574	0.705	
	*Gender		-0.038	347.468	0.661	
	*Pre-surgery Physical Activity		0.277	0.141	0.002	
	Fitness Orientation		0.355	212.453	0.000	
	Co-worker Social Support		0.294	17.390	0.002	
	Physical Function		0.205	25.634	0.023	

[1]Only pre-surgery to post-surgery changes in psychosocial variables shown to be associated in the bivariate analysis were included in the stepwise regression
*Controlling for pre-surgical physical activity, years post-surgery, surgical procedure, gender

Because depression is prevalent in patients who seek and undergo bariatric surgery,[134] an exploratory analysis was conducted to control for current post-surgical depressive symptoms, collected using the CES-D Questionnaire, in each of the final stepwise regression models. When controlling for depressive symptoms, the variable included in the final stepwise-regression model to predict current post-surgery physical activity from pre-surgery psychosocial variables (Table 18) and to predict pre- to post-surgery change in physical activity from pre-surgery psychosocial variables (Table 20) were unchanged.

In the final stepwise regression model to predict pre-to post-surgery change in physical activity from change in psychosocial variables (Table 22), change in fitness orientation, change in friend social support and change in self-reported weight remained after controlling for depressive symptoms; however, added to the model were also change in health orientation (β= -

0.372, p= 0.005) and change in family social support (β= 0.205, p= 0.048). When depressive symptoms was added to the model to predict current post-surgery physical activity from change in psychosocial variable (Table 24), change in fitness orientation and change in friend social support remained predictive of post-surgery physical activity, while change in self-classified weight was no longer significant; however, change in health orientation (β= -0.372, p= 0.005) and change in social support from family (β= 0.205, p= 0.048) also emerged as predictors within this model. When controlling for depressive symptoms, fitness orientation and co-worker social support remained predictive of post-surgery physical activity (Table 26), while physical function was no longer a predictor in the step-wise regression model. Thus, it may be important for future investigations to consider depression symptoms in analyses examining psychosocial factors associated with physical activity in patients undergoing bariatric surgery.

5.0 DISCUSSION

This study was conducted to examine associations between selective psychosocial variables and physical activity in patients who had undergone bariatric surgery within the past 2 years. Few trials have been conducted to examine psychosocial constructs and their association with physical activity in patients who have recently undergone bariatric surgery. Moreover, studies that have investigated psychosocial variables and physical activity participation in patients who have undergone bariatric surgery do not focus on psychosocial constructs from multiple behavior change theories. The current investigation examined multiple theory-based constructs and their association with post-surgical physical activity engagement.

5.1 PHYSICAL ACTIVITY

This study aimed to quantify physical activity in patients who have undergone bariatric surgery and determine if there was a change in physical activity engagement from pre-to post-surgery. The results demonstrate that there was a median increase of 508 kcal/week in self-reported leisure-time physical activity from pre- to post-surgery. This pre-to post-surgical increase in weekly energy expenditure suggests that in the absence of an intervention specifically targeting physical activity, patients significantly increase their leisure-time physical activity. While physical activity increased significantly post-surgery, the median post-surgical leisure-time physical activity was 976.00 kcal/week. This indicates that participants were not participating in the >150 min/week (~1200 to 2000kcal/week) of physical activity recommended to prevent weight gain in most adults.[81] Furthermore, when examined by length of time post-surgery, there were no significant differences in energy expenditure for physical activity in patients who were 0-3, >3-6, >6-12, >12-18 or >18-24 months post-surgery. These results may suggest that while physical activity increases initially following bariatric surgery, it does not appear to continue to increase over time across the two-years examined in this study.

Physical activity following bariatric surgery may assist patients with weight loss and weight maintenance, in addition to improving weight-related comorbidities.[27,92] Previous studies indicate that greater participation in post-surgical physical activity is related to improved weight loss outcomes, and that becoming physically activity post-surgery results in greater weight loss than when patients remained inactive.[27] While this study demonstrated that there was a significant median increase of 508 kcal/week in physical activity post-bariatric surgery, physical activity was collected through self-report measures, and pre-surgery physical activity was collected retrospectively. Previous trials have compared self-report physical activity measures with objective physical activity measures, and demonstrated that objective change in physical activity may be significantly lower than self-report.[135] Therefore, it is unclear if this increase in physical activity accurately reflects improvements in physical activity following bariatric surgery. Moreover, of clinical importance, post-surgical interventions may need to focus on maintaining the increase in physical activity that appears to occur initially following bariatric surgery, in addition to progressively increasing physical activity engagement over time to achieve the >200 min/week of physical activity recommended for long term weight loss[81,136].

In this study, weekday sedentary time decreased significantly by 1.5 hours per day when measured by the sedentary behavior questionnaire and by 2 hours per day when measured by the GPAQ. Weekend sedentary time also significantly decreased by 8.5 hours when measured by the sedentary behavior questionnaire and 2 hours when measured using the GPAQ. The change in weekday and weekend sedentary time did not differ by length of time post-surgery. Previous studies have reported that bariatric surgery patients spend the majority of their waking hours engaging in sedentary behavior both pre-and post-surgery.[37,38,40] However, the self-reported post-surgery sedentary time reported in this study was lower than the objectively measured sedentary time previously reported in the literature.[40] The discrepancies in sedentary time reported in this study compared to other studies is unclear, but may be a result of differences in measurement.

There is a growing body of literature to indicate that sedentary behavior is associated with poor cardiometabolic health and pre-mature death; however, the relationship between sedentary behavior and weight loss is not well understood. For example, findings from the IDEA study demonstrated that sedentary behavior was not predictive of 6-month weight loss in young adults, but light and moderate-to-vigorous intensity activity were predictive of weight loss.[137] This may suggest that while reducing sedentary behavior may be important for improving cardiometabolic health, targeting an increase in physical activity following bariatric surgery may be more beneficial for weight loss.

5.2 PSYCHOSOCIAL CONSTRUCTS

In an effort to examine the relationship between select psychosocial variables and physical activity, data on pre- and post-surgical behavioral constructs were collected in this study. Of interest, this study observed a significant change in a number of psychosocial variables despite not receiving an intervention targeted at modifying these constructs. A significant change was observed in the majority of sub-constructs in a pattern of improvement in the expected direction. The constructs included quality of life, barriers, outcome expectations, motivation, self-efficacy, exercise enjoyment, social support, perceived behavioral control and body image. The pre- to post-surgical changes observed in psychosocial factors in the current study are similar to results seen following a behavioral weight loss intervention in non-surgical populations. For example, a study by Gallagher et al. reported that following a group-based behavioral weight loss intervention, there was an increase in physical activity self-efficacy and psychological benefits, in addition to a decrease in physical activity barriers.[98] Furthermore, 6-month physical activity was positively associated with physical activity self-efficacy and negatively associated with barriers reported at 6-months.

While many of the psychosocial factors in this current study changed significantly from pre-to post-bariatric surgery, most did not emerge as significant predictors of physical activity in the bivariate or stepwise regression analyses. Despite the lack of associations between these constructs and physical activity observed in the current sample, these may still be critically important for behavior change following bariatric surgery to improve weight loss success. Thus, the complexity of behavior change in patients undergoing bariatric surgery, particularly related to physical activity, warrants further investigation.

5.3 FACTORS ASSOCIATED WITH PHYSICAL ACTIVITY PARTICIPATION FOLLOWING BARIATRIC SURGERY

Physical activity and psychosocial constructs were collected in a systematic manner that allowed examination of factors associated with physical activity in patients who have undergone bariatric surgery. Pre-and post-surgical psychosocial factors were first examined in a bivariate analysis, then significantly correlated constructs were included in a stepwise regression analysis. The stepwise regression revealed that the constructs of social support, body image and health-related quality of life included sub-scales that predicted physical activity participation in patients who have undergone bariatric surgery (Tables 18, 20, 22, 24, 26). A summary of findings from both the bivariate and regression analysis are illustrated in Table 27.

Table 27. Summary of Associations between Physical Activity and Psychosocial Constructs

		Post-Surgery Physical Activity and Pre-Surgical Psychosocial Constructs	Change in Physical Activity and Pre-Surgical Psychosocial Constructs	Change in Physical Activity and Change in Psychosocial Constructs	Post-Surgery Physical Activity and Change in Psychosocial Constructs	Post-Surgery Physical Activity and Post-Surgery Psychosocial Constructs
Health-Related Quality of Life	physical function		-	+	+	++
	social function			+		+
	role limitation due to physical health			+		+
	role limitation to emotional problems			+		+
	emotional well-being			+		
	energy/fatigue		-	+	+	+
	pain			+	+	+
	general health					
Barriers to Physical Activity	time barriers					
	effort barriers			-	-	-
	obstacle barriers			-		
	total barriers					-
Perceived Benefits to Physical Activity	psychological benefits		-			
	image benefits					
	health benefits					
	total benefits					
Motivation for Physical Activity	external regulation					
	introjected regulation					+
	identified regulation			+		+
	intrinsic motivation			+		+
	RAI			+	+	+
Physical activity self-efficacy	physical activity self-efficacy		-	+		+
	Stanford self-efficacy		+	+	+	+
Exercise Enjoyment	exercise enjoyment		-	+	+	
Social Support	family social support	+		+	+	+
	friend social support	+		++	+	+
	co-worker social support	++				++
	family supportive/non-supportive behaviors	++	+			
	friends supportive/non-supportive behaviors					
	co-worker supportive/non-supportive behaviors					
Perceived Control	perceived behavioral control		-	+		+
Body Image	appearance evaluation		-	+	+	+
	appearance orientation					
	fitness evaluation			+	+	+
	fitness orientation		-	++	+	++
	health evaluation		-	+	+	+
	health orientation		-	+	+	
	illness orientation					
	body areas satisfaction			+	+	+
	overweight preoccupation			+		
	self-classified weight		+	--	-	-

\+ Significant positive coefficient at p≤0.05

\- Significant negative coefficient at p≤0.05

++ Variable remained significantly positively associated in stepwise regression at p≤0.05

-- Variable remained significantly negatively associated in stepwise regression at p≤0.05

Lack of + or - denotes lack of significant association

Social support emerged as the construct that predicted physical activity participation within the regression analyses. Social support is the presence of interpersonal relationships, and has been repeatedly shown to influence the adoption of many health behaviors, including physical activity participation.[111] The sub-constructs of social support that emerged as predictive included social support received from friends and co-workers, and family supportive and non-supportive behaviors. Supportive and non-supportive behaviors, also referred to as the rewards and punishment subscale in previous literature, is a score that reflects how frequently a participant reports that family, friends, or co-workers,: 1) complained about the amount of time they spent exercising, 2) criticized or made fun of the amount of time they spent exercising, and 3) provided a reward for exercising.[133] However, there was not a consistent pattern of these subscales to predict physical activity in the patterns examined in this study.

Previous studies have shown that social support is key for physical activity engagement in non-surgical populations.[112-114] For example, the US Women's Determinants Study, which included 2912 middle age women, reported that those with high social support from friends and family were significantly more likely to report 150 minutes or more of leisure-time physical activity per week than those who reported little or no social support.[114] Likewise, a cross-sectional study examining physical activity and social support in older adults determined that individuals who were more active reported a higher level of social support compared to individuals who were not physically active.[113] Furthermore, it was reported that a higher frequency of friends or family participating in physical activity was present in the active group compared to the inactive group.[113]

While the relationship between social support and physical activity in patients who have undergone bariatric surgery has not been well investigated, there is evidence of a relationship between social support and weight loss in patients within a behavioral intervention that did not involve bariatric surgery. For example, a study by Wing and Jeffery, included participants who were recruited into a standard behavioral treatment program (SBT) either alone or with a group of friends, family or co-workers.[138] Those entering alone were randomized to an individual SBT program or SBT plus social support. Similarly, those entering the study with a group received either SBT or SBT plus social support. Results indicated that participants who entered as a group and received additional social support had the least number of drop-outs, and the highest percent of participants who maintained their weight loss throughout the study. Additionally, higher reported social support from group members (in both groups who received SBT plus social support) was associated with greater weight losses.[138] While not specific to bariatric surgery, these findings appear to highlight the important role social support may have for weight loss and weight loss maintenance.

In studies including bariatric surgery patients, social support has also been shown to be important for weight loss. A systematic review by Livhits et al. examined social support and weight loss following bariatric surgery.[139] This review reported that there was a consistent positive association between post-operative support groups and weight loss; however not all studies included in this review showed this relationship with social support received from family, friends and co-workers.[139] Within this review, two studies reported a trend towards greater weight loss in patients who had more social support[140,141], while there were no significant relationships seen between social support and post-operative weight loss in another trial.[142] This review may suggest that social support can play an important role in weight loss following bariatric surgery; however, more research is needed to examine the impact of family, friend and co-worker social support on post-surgical outcomes, with a particular focus on physical activity.

Of interest is the finding that pre-surgical supportive and non-supportive behaviors from family members predicted post-surgical physical activity; however, the post-surgical measure of this type of support was not predictive of physical activity engagement. Furthermore, as shown in Table 14, while there were statistically significant increases in pre-to post-surgery supportive and non-supportive behaviors from family members, the magnitude of this change was very modest, which may explain the lack of relationship between the post-surgical measure of this sub-construct and physical activity. This finding may highlight an important target for future interventions. Future studies may need to enhance social support from family members following bariatric surgery above the pre-surgical level. In a clinical setting, this may involve including patient's family members in discussions regarding physical activity and instructing family members how to encourage and support physical activity behaviors.

Despite the importance of social support for physical activity engagement and weight loss in non-surgical populations, there is a lack of data regarding social support and physical activity following bariatric surgery. This study adds to the literature by examining the associations between pre-and post-surgical social support and physical activity engagement. Findings reveal that social support both pre- and post-surgery may be an important predictor of physical activity, and therefore may be an important intervention target for increasing physical activity in patients who have undergone bariatric surgery. Social support and physical activity in patients undergoing bariatric surgery warrants investigation through intervention trials and within clinical settings. Intervention trials should aim to examine the impact of enhancing social support received from family members following bariatric surgery, in addition to investigating additional forms of support (social support groups) and their relationship with physical activity participation. Similarly, clinical practice should target social support both before and after bariatric surgery to assist patients with improving physical activity and post-surgical outcomes.

Body image also emerged as a construct that predicted physical activity participation in the regression analyses. Body image is a multifaceted psychosocial variable that encompasses appearance, fitness, health and illness components.[115,116] Body image also includes body area satisfaction, overweight preoccupation and self-classified weight subscales.[115] The sub-constructs of body image that emerged as predictive were an increase in fitness orientation and a reduction in self-classified weight.

Higher fitness orientation indicates that a person is actively participating in physical activity aimed at improving or maintaining their fitness level.[115] Thus, one might expect that focusing on physical activity would be one behavior that would result in improved fitness orientation. Results from this study showed that an increase in pre-to post-surgery fitness orientation, and a higher post-surgical fitness orientation were predictive of physical activity after bariatric surgery. Previous studies have shown that patients who have undergone bariatric surgery self-report a significant increase in physical activity participation.[135] Self-reported physical activity in an observational study conducted by Bond et al. increased from 44.6±80.8 min/week prior to surgery to 212.3±212.4 min/week after bariatric surgery.[135]

Participants in the current study also self-reported a significant increase in physical activity and reduction in sedentary time from pre-to post-surgery. However, physical activity did not increase sufficiently enough to result in patients meeting the recommended levels of physical activity associated with improved weight loss. Regardless, this increase in activity level may be one explanation for the observed increase in fitness orientation. Physical activity following bariatric surgery may enhance weight loss and weight maintenance, and therefore is an important intervention target.[27,92] Future investigations should aim to identify strategies for improving fitness orientation both before and after bariatric surgery.

A reduction in self-classified weight was also predictive of a greater increase in physical activity in the current study. Previous studies have shown that patients undergoing bariatric surgery report a number of barriers to physical activity, which include negative weight perception or feeling too overweight to be active.[103 143 19] Weight loss following bariatric surgery may decrease weight-related physical activity barriers and their negative impact on physical activity participation; however, there is a lack of evidence regarding this relationship. Furthermore, there was not a consistent pattern of this subscale to predict an increase in physical activity examined in this study. Future studies may need to investigate the impact of weight loss on self-classified weight, and how a change in self-classified weight impacts physical activity.

The post-surgical construct of health-quality of life also emerged as a predictor of post-surgical physical activity. A systematic review by Bize et al.[144] included 14 studies that assessed physical activity and health-related quality of life. Seven of the studies included were cross-sectional, 2 were cohort studies, 4 were randomized controls and one study was a mixed design. Results from this systematic review showed that greater health-related quality of life appears to be associated with higher levels of physical activity engagement.[144]

In the current study, post-surgical physical functioning was the only sub-construct of health-related quality of life that was predictive of post-surgical physical activity. A previous study by Josbeno et al.[145] reported that physical function increased significantly from pre-surgery to 3 months post-bariatric surgery, and a significant correlation between physical activity and physical function was observed. [145] Similarly, Boan et al. reported a significant improvement in self-reported physical function 6 months post-bariatric surgery.[146]

This study adds to the literature by further supporting previous findings of an increase in physical functioning following bariatric surgery, and this increase in physical functioning appears to be associated with greater physical activity participation. While physical function was not a predictor of physical activity across all patterns examined, the findings may highlight the important role that physical functioning may have for physical activity participation. However, given the nature of this study, the direction of this relationship cannot be determined. This may require future trials to prospectively investigate physical function and physical activity within the context of bariatric surgery. Moreover, studies may be warranted that focus on improving physical function beyond what is achieved through bariatric surgery to determine if this further increases physical activity.

5.4 LIMITATIONS AND FUTURE DIRECTIONS

While this study adds to the literature regarding physical activity following bariatric surgery, it is not without limitations that could impact the interpretation of the observed results. These limitations should also be considered as an opportunity for improving future research in this area of study. These include:

1. This study used a cross-sectional and retrospective design, and therefore causality of the relationship cannot be established. Participants were asked about their current post surgical physical activity and psychosocial behavioral constructs, and to reflect on their physical activity, and those behavioral constructs prior to surgery. This may

have resulted in recall bias. Therefore, results from this study should be confirmed in a prospective cohort study that includes pre-surgical measures, and regular follow-up post-surgery. Moreover, prospective intervention studies are needed to determine whether targeting select psychosocial constructs during treatment results in desired improvements that may be associated with improved physical activity.

2. The sample was limited to subjects who had undergone bariatric surgery within the past 2 years. It is unclear how these results would compare to findings of post-bariatric surgery patients who are more than 2 years post-surgery. Future studies should consider examining physical activity and psychosocial constructs beyond 2 years following bariatric surgery.
3. Subjects self-selected to participate in this study, and may have resulted in a selection bias with regard to weight loss, type of surgical procedure, physical activity and time since bariatric surgery. Future studies should aim to address this potential bias, and recruit a diverse group of subjects.
4. This study was limited to recruiting patients who underwent gastric bypass or gastric sleeve; however, no patients who underwent gastric banding participated in the study. It is unclear if similar results would be observed for patients who underwent the gastric banding procedure, which is a less common procedure. Future studies should consider examining physical activity and psychosocial constructs across other bariatric surgery procedures, including non-surgical procedures such as the intragastric balloon.
5. Psychosocial variables were assessed using questionnaires that have been shown to evaluate constructs associated with physical activity in non-surgical populations.

However, these were not validated in a pre- or post-bariatric surgery population. Research may need to be conducted to establish the validity and reliability of these questionnaires in this patient population.

6. Physical activity was assessed using a self-report measure. Previous studies indicate that objectively measured changes in physical activity from pre-to-post-bariatric surgery are smaller than the self-reported changes.[135] Future studies should examine the association between the selected behavioral constructs and objectively measured physical activity.
7. Sedentary behavior was assessed using self-report measures previously used in the IDEA study.[124] Results from the IDEA study illustrate the potential limitations of these questionnaires to assess physical activity. Therefore, future investigations should use objective measures to quantify sedentary behavior.

5.5 CLINICAL IMPLICATIONS

The results of this study have important implications for both research and clinical settings. Findings of this study indicate that there appears to be an increase in physical activity engagement from pre- to post-bariatric surgery, and this increase does not differ by length of time post-surgery. This finding demonstrated that without an intervention targeting physical activity behaviors, patients who undergo bariatric surgery appear to increase their pre- to post-surgical physical activity. However, the current study observed that while there was an increase in physical activity, this increase was not sufficient for patients to reach physical activity recommendations for enhanced weight loss or weight maintenance. While there are currently no evidence-based guidelines for physical activity before or after bariatric surgery, these results demonstrate this need for a focus on post-surgical physical activity engagement.

Several psychosocial constructs, previously reported to be associated with physical activity engagement in non-surgical populations, were observed to change in the desired direction following bariatric surgery. These results indicate that without a behavior change intervention, there appears to be a pre-to post-surgical improvement in many behavioral constructs that have previously been shown to be associated with physical activity. These results are similar to psychosocial changes observed following a behavioral weight loss program in non-surgical populations.[98] While there were significant changes in psychosocial variables after bariatric surgery, many did not emerge as significantly associated with physical activity. It is possible that psychosocial variables not measured in this study may be important for physical activity participation in patients undergoing bariatric surgery. Moreover, the selected psychosocial constructs may be important for other behavior changes in patients undergoing bariatric surgery, and this warrants further investigation.

An increase in social support, fitness orientation and physical function, as well as a reduction in self-classified weight were each predictive of physical activity participation in this study. These constructs may be important targets that may increase physical activity after bariatric surgery. Physical activity has been observed to assist with weight loss and weight maintenance, and result in additional health benefits, highlighting the importance increasing physical activity participation. Incorporating these predictive psychosocial variables into interventions for patients undergoing bariatric surgery may assist in improving surgical outcomes and better address challenges in participating in physical activity experienced by patients after bariatric surgery.

5.6 SUMMARY

In summary, this study quantified physical activity participation in patients who underwent bariatric surgery in the past 2 years (Specific Aim 1). This study observed an increase in self-reported physical activity, and concluded that increase was significant; however not sufficient to meet the recommended amount of physical activity for enhanced weight loss. Psychosocial constructs that have been previously reported to be associated with physical activity were also measured in this study (Specific Aim 2). This study concluded that there were many significant pre- to post-surgical changes in psychosocial variables; however, these changes were not predictive of physical activity participation in this sample of patients who underwent bariatric surgery. The key findings of this study were that increases in social support, fitness orientation and physical function, as well as a reduction in self-classified weight were predictive of physical activity participation in post-bariatric surgery patients (Specific Aim 3). This suggests that these are important intervention targets both before and after bariatric surgery. Furthermore, this study provides evidence that there are forms of social support both pre-and post-bariatric surgery that should be targeted to improve physical activity and surgical outcomes.

APPENDIX A

DEMOGRAPHIC QUESTIONNAIRE

1. Are you of Hispanic or Latino origin?

- ☐ Yes
- ☐ No

2. Which race best describes you? *(Check all that apply)*
NIH Census labels

- ☐ White or Caucasian
- ☐ Black or African American
- ☐ American Indian/Native American
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Asian
- ☐ Other: ________________________

3. What is your gender? *(Check one)*

- ☐ Male
- ☐ Female

4. Date of birth: ______/_____/_____

5. What is the highest grade in school you have finished? *(Check one)*

- ☐ Did not finish elementary school
- ☐ Finished middle school (8th grade)
- ☐ Finished some high school
- ☐ High school graduate or G.E.D
- ☐ Vocational or training school after high school
- ☐ Some College or Associate degree
- ☐ College graduate or Baccalaureate Degree
- ☐ Masters or Doctoral Degree (PhD, MD, JD, etc)

6. How many children under the age of 18 live in your home? ______

7. How many adults (age 18 or older) live in your home (include yourself)? ______

8. What is your current marital status? (Check One)

- ☐ Married
- ☐ Separated
- ☐ Divorced
- ☐ Widowed
- ☐ Single / Not Married

9. Which of these categories best describe your income (not the income of your household, but your own income) for the past 12 months? This should include income (before taxes) from all sources, wages, veteran's benefits, help from relatives, rent from properties and so on.

- ☐ Less than $5,000
- ☐ $5,000 through $11,999
- ☐ $12,000 through $15,999
- ☐ $16,000 through $24,999
- ☐ $25,000 through $34,999
- ☐ $35,000 through $49,999
- ☐ $50,000 through $74,999
- ☐ $75,000 through $99,999
- ☐ $100,000 and greater
- ☐ Don't know

10. Bariatric Surgery Information

Date of Bariatric Surgery: Month: ________ Year: ______________________

Type of Surgical Procedure (select of the following):

- ☐ Gastric bypass
- ☐ Gastric Sleeve
- ☐ Gastric Band

Pre-Surgical Weight (pounds): ____

APPENDIX B

CHANGE IN PHYSICAL ACTIVITY

Change in physical activity by surgical procedure

Physical Activity	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Leisure-time Physical Activity with Stairs (kcal/wk)	524.00 (43.00, 1479.75)	508.00 (42.00, 953.00)	0.683
Leisure-time Physical Activity without Stairs (kcal/wk)	151.00 (0.00, 1356.00)	432.00 (432.00, 849.00)	0.529
Sedentary Behavior			
Weekday Sedentary Time (hours per day)*	-2.50 (-6.69, 0.06)	-1.00 (-3.63, 1.88)	0.126
Weekend Sedentary Time (hours per day)*	-10.5 (-14.56, -6.25)	-7.00 (-10.13, -3.88)	0.050
GPAQ Weekday Sedentary Time (hours per day)**	-2.00 (-3.50, -0.25)	-1.25 (-5.19, 0.00)	0.804
GPAQ Weekend Sedentary Time (hours per day)**	-2.00 (-4.00, 0.00)	-1.75, (-4.00, 1.00)	0.258
*Collected using the 8-item Sedentary Behavior Questionnaire ** Collected using the Global Physical Activity Questionnaire (GPAQ) ***Change score computed as post-surgery value minus pre-surgery value			

Change in physical activity by gender

Physical Activity	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Leisure-time Physical Activity with Stairs (kcal/wk)	674.00 (200.00, 1832.00)	452.00 (28.00, 1121.50)	0.361
Leisure-time Physical Activity without Stairs (kcal/wk)	672.00 (96.00, 1776.00)	384.00 (0.00, 947.25)	0.329
Sedentary Behavior			
Weekday Sedentary Time (hours/day)*	-0.75 (-11.25, 1.25)	-1.50 (-4.00, 1.19)	0.493
Weekend Sedentary Time (hours/day)*	-12 (-14.75, -7.00)	-7.63 (-12.69, -4.06)	0.052
GPAQ Weekday Sedentary Time (hours/day)**	-2.00(-5.00, -1.50)	-2.00 (-4.00, 0.00)	0.375
GPAQ Weekend Sedentary Time (hours/day)**	-2.00 (-5.00, -1.17)	-2.00 (-4.00, 0.00)	0256
*Collected using the 8-item Sedentary Behavior Questionnaire ** Collected using the Global Physical Activity Questionnaire (GPAQ) ***Change score computed as post-surgery value minus pre-surgery value			

Change in physical activity by time since surgery

Physical Activity	**0-3 Months (N=28) Mean ± SD [Median (25%, 75%)]**	**>3-6 months (N=9) Mean ± SD [Median (25%, 75%)]**	**>6-12 months (N=22) Mean ± SD [Median (25%, 75%)]**	**>12-18 months (N=11) Mean ± SD [Median (25%, 75%)]**	**>18-24 months (N=13) Mean ± SD [Median (25%, 75%)]**	**p-value**
Leisure-time Physical Activity with Stairs (kcal/wk)	574.00(172.00, 964.00)	122.00(-156.00, 567.00)	855.50 (54.00, 1849.00)	835.00 (48.00, 1872.00)	344.00 (28.00, 1248.00)	0.313
Leisure-time Physical Activity without Stairs (kcal/wk)	5500.00(144.00, 844.25)	180.00(-120.00, 396.00)	734.00 (0.00, 1646.25)	611.00 (0.00, 1578.00)	288.00 (0.00, 1332.00)	0.337
Sedentary Behavior						
Weekday Sedentary Time (hours per day)*	-1.25(-4.00, -0.13)	0.50(-4.06, 3.13)	-0.63 (-6.75, 6.00)	-3.25 (-6.88, 0.13)	-3.50 (-7.25, 1.75)	0.574
Weekend Sedentary Time (hours per day)*	-8.00 (-12.25, -4.25)	-7.75(-11.75, -3.00)	-7.50 (-14.00, -5.25)	-11.50 (-3.00, -0.58)	-6.75 (-17.75, -4.25)	0.723
GPAQ Weekday Sedentary Time (hours per day)**	-2.00(-5.13, -0.75)	0.00(-2.00, 2.00)	-2.00 (-4.00, 0.00)	-2.00 (-3.79, 1.00))	-3.00 (-4.00, 0.00)	0.073
GPAQ Weekend Sedentary Time (hours per day)**	-2.00(-3.75, -1.58)	0.00 (-2.00,1.00)	-2.00 (-5.00, 0.00)	-1.00 ()	-2.00 (-4.00, 0.00)	0.241

*Collected using the 8-item Sedentary Behavior Questionnaire
** Collected using the Global Physical Activity Questionnaire (GPAQ)
***Change score computed as post-surgery value minus pre-surgery value

APPENDIX C

CHANGE IN QUALITY OF LIFE

Change in quality of life by surgical procedure (unstandardized scores)

Quality of Life	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Physical Functioning	8.00 (1.75, 12.00)	8.00 (2.00, 11.0)	0.762
Role limitation due to physical health	2.00 (0.00, 4.00)	1.00 (0.00, 3.50)	0.364
Role limitation due to emotional problems	1.00 (0.00, 2.00)	1.00 (0.00, 3.00)	0.831
Energy/fatigue	7.00 (2.00, 10.00)	6.00 (1.50, 9.50)	0.776
Emotional well-being	5.00 (2.00, 8.00)	5.00 (2.00, 8.50)	0.440
Social functioning	2.00 (0.00, 4.00)	2.00 (1.00, 4.00)	0.443
Pain	2.00 (0.00, 4.25)	2.00 (0.00, 4.00)	0.691
General health	1.4 (-1.00, 3.20)	1.00 (-0.30, 2.00)	0.664

*Change scores computed as post-surgery value minus pre-surgery value

Change in quality of life by gender (unstandardized scores)

Quality of Life	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Physical Functioning	8.00 (2.00, 17.00)	8.00 (2.00, 11.00)	0.310
Role limitation due to physical health	3.00 (0.00, 4.00)	1.00 (0.00, 3.00)	0.230
Role limitation due to emotional problems	1.00 (0.00, 3.00)	1.00 (0.00, 2.00)	0.813
Energy/fatigue	9.00 (6.00, 11.00)	6.00 (2.00, 9.00)	0.061
Emotional well-being	6.00 (2.00, 7.00)	5.00 (2.00, 8.00)	0.995
Social functioning	3.00 (0.00, 5.00)	2.00 (0.25, 4.00)	0.855
Pain	1.00 (0.00, 4.00)	2.00 (0.00, 4.00)	0.424
General health	1.4 (-2.00, 3.4)	1.00 (-0.60, 2.40)	0.843

*Change scores computed as post-surgery value minus pre-surgery value

Change in quality of life by surgical procedure (standardized scores)

Quality of Life	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Physical Functioning	40.00 (8.75, 60.00)	40.00 (10.00, 55.00)	0.762
Role limitation due to physical health	50.00 (0.00, 100.00)	25.00 (0.00, 87.50)	0.364
Role limitation due to emotional problems	33.33 (0.00, 66.67)	33.33 (0.00, 100.00)	0.831
Energy/fatigue	35.00 (10.00, 50.00)	30.00 (7.50, 47.50)	0.776
Emotional well-being	20.00 (8.00, 32.00)	20.00 (8.00, 34.00)	0.440
Social functioning	25.00 (0.00, 50.00)	25.00 (12.5, 50.00)	0.443
Pain	20.00 (0.00, 42.50)	20.00 (0.00, 40.00)	0.691
General health	7.00 (-5.00, 16.00)	5.00 (-1.50, 10.00)	0.664

*Change score computed as post-surgery value minus pre-surgery value

Change in quality of life by gender (standardized scores)

Quality of Life	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Physical Functioning	40.00 (10.00, 85.00)	40.00 (10.00, 55.00)	0.310
Role limitation due to physical health	75.00 (0.00, 100.00)	25.00 (0.00, 75.00)	0.230
Role limitation due to emotional problems	33.33 (0.00, 100.00)	33.33 (0.00, 66.67)	0.813
Energy/fatigue	45.00 (30.00, 55.00)	30.00 (10.00, 45.00)	0.061
Emotional well-being	24.00 (8.00, 28.00)	20.00 (8.00, 32.00)	0.995
Social functioning	37.50 (0.00, 62.50)	25.00 (3.13, 50.00)	0.855
Pain	10.00 (0.00, 40.00)	20.00 (0.00, 40.00)	0.424
General health	7.00 (-10.00, 17.00)	5.00 (-3.00, 12.00)	0.843

*Change score computed as post-surgery value minus pre-surgery value

APPENDIX D

CHANGE IN BARRIERS TO PHYSICAL ACTIVITY

Change in barriers to physical activity by surgical procedure

Barriers	**Gastric Bypass (N=46) [Median (25%, 75%)]**	**Gastric Sleeve (N=37) [Median (25%, 75%)]**	**p-value for comparison between surgical procedures**
Time	0.00 (-0.67, 0.667)	0.00 (-0.50, 1.00)	0.971
Effort	-1.00 (-1.71, -0.458)	-0.83 (-1.5, -0.17)	0.258
Obstacles	-0.50 (-1.13, 0.00)	-0.50 (0.88, 0.00)	0.536
Overall	-0.58 (-1.15, -0.29)	-0.46 (-1.12, 0.08)	0.207

*Change score computed as post-surgery value minus pre-surgery value

Change in barriers to physical activity by gender

Barriers	**Males (N=11) [Median (25%, 75%)]**	**Females (N=72) [Median (25%, 75%)]**	**p-value for comparison between males and females**
Time	0.00 (-1.00, 0.67)	0.00 (-0.58, 0.92)	0.829
Effort	-1.17 (-1.83, -0.67)	-0.83 (-1.46, -0.21)	0.239
Obstacles	-0.50 (-0.75, 0.50)	-0.50 (-1.00, 0.00)	0.617
Overall	-0.77 (-1.15, -0.23)	-0.46 (-1.13, -0.10)	0.721

*Change score computed as post-surgery value minus pre-surgery value

APPENDIX E

CHANGE IN OUTCOME EXPECTATIONS

Change in outcome expectations by surgical procedure

Expectations (Benefits)	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Psychological	0.40 (-0.05, 1.40)	0.60 (0.00, 1.30)	0.822
Image	0.50 (0.00, 1.250)	0.00 (0.00, 1.00)	0.138
Health	0.83 (0.00, 1.67)	0.67 (0.00, 1.17)	0.297
Overall	0.583 (0.08, 1.33)	0.50 (-0.08, 1.04)	0.362

*Change score computed as post-surgery value minus pre-surgery value

Change in outcome expectations by gender

Expectations (Benefits)	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Psychological	0.60 (0.20, 1.80)	0.40 (0.00, 1.35)	0.385
Image	0.75 (0.00, 2.50)	0.38 (0.00, 1.00)	0.211
Health	1.33 (0.00, 2.00)	0.67 (0.00, 1.33)	0.587
Overall	0.67 (0.08, 2.33)	0.58 (0.00, 1.06)	0.259

*Change score computed as post-surgery value minus pre-surgery value

APPENDIX F

CHANGE IN MOTIVATION

Change in motivation by surgical procedure

Motivation	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
External Regulation	0.00 (-0.25, 0.25)	0.00 (-0.63, 0.75)	0.803
Introjected Regulation	0.25 (-0.25, 1.31)	0.25 (-0.50, 1.88)	0.627
Identified Regulation	1.00 (0.00, 2.81)	1.75 (0.38, 3.13)	0.183
Intrinsic Motivation	0.75 (0.00, 1.81)	1.75 (0.38, 3.00)	0.062
Relative Autonomy Index (RAI)	1.88 (-1.25, 6.81)	3.75 (0.50, 7.38)	0.121

*Change score computed as post-surgery value minus pre-surgery value

Change in motivation by gender

Motivation	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
External Regulation	0.00 (-0.25, 0.50)	0.00 (-0.25, 0.50)	0.695
Introjected Regulation	0.50 (-0.25, 2.25)	0.25 (-0.50, 1.50)	0.731
Identified Regulation	2.00 (0.00, 4.50)	1.50 (0.00, 3.00)	0.559
Intrinsic Motivation	1.25 (0.50, 3.00)	1.13 (0.06, 2.19)	0.420
Relative Autonomy Index (RAI)	3.75 (1.75, 7.25)	2.75 (-0.44, 6.94)	0.344

*Change score computed as post-surgery value minus pre-surgery value

APPENDIX G

CHANGE IN PHYSICAL ACTIVITY SELF-EFFICACY

Change in physical activity self-efficacy by surgical procedure

Self-efficacy	**Gastric Bypass (N=46) [Median (25%, 75%)]**	**Gastric Sleeve (N=37) [Median (25%, 75%)]**	**p-value for comparison between surgical procedures**
Stanford Self-efficacy Scale	2.96 (0.64, 4.59)	2.07 (0.79, 3.82)	0.256
Average Physical Activity Self-efficacy	1.20 (0.20, 1.85)	1.00 (0.20, 1.80)	0.656

*Change score computed as post-surgery value minus pre-surgery value

Change in physical activity self-efficacy by gender

Self-efficacy	**Males (N=11) [Median (25%, 75%)]**	**Females (N=72) [Median (25%, 75%)]**	**p-value for comparison between males and females**
Stanford Self-efficacy Scale	1.93 (0.64, 3.36)	2.46 (0.67, 4.14)	0.697
Average Physical Activity Self-efficacy	1.00 (0.40,2.00)	1.10 (0.20, 1.80)	0.819

*Change score computed as post-surgery value minus pre-surgery value

APPENDIX H

CHANGE IN EXERCISE ENJOYMENT

Change in exercise enjoyment by surgical procedure

Exercise Enjoyment	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Overall Enjoyment	24.00 (3.00, 39.25)	21.00 (3.50, 38.00)	0.993

*Change score computed as post-surgery value minus pre-surgery value

Change in exercise enjoyment by gender

Exercise Enjoyment	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Overall Enjoyment	24.00 (-2.00, 29.00)	22.00 (3.25, 39.75)	0.519

*Change score computed as post-surgery value minus pre-surgery value

APPENDIX I

CHANGE IN SOCIAL SUPPORT

Change in social support by surgical procedure

Social Support and Exercise	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Family Social Support	3.00 (0.00, 6.25)	2.00 (-1.50, 7.50)	0.312
Friend Social Support	0.500 (0.00, 5.25)	2.00 (0.00, 5.00)	0.413
Co-worker Social Support	0.00 (0.00, 1.00)	0.00 (0.00, 4.50)	0.438
Family Supportive/Non-supportive Behaviors	0.00 (-1.00, 0.00)	0.00(0.00, 0.00)	0.667
Friends Supportive/Non-supportive Behaviors	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.916
Co-worker Supportive/Non-supportive Behaviors	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.295

*Change score computed as post-surgery value minus pre-surgery value

Change in social support by gender

Social Support and Exercise	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Family Social Support	2.00 (0.00, 4.00)	3.00 (0.00, 7.00)	0.652
Friend Social Support	0.00 (0.00, 7.00)	2.00 (0.00, 5.00)	0.344
Co-worker Social Support	0.00 (0.00, 2.00)	0.00 (0.00, 3.00)	0.771
Family Supportive/Non-supportive Behaviors	0.00 (0.00, 0.00)	0.00 (-1.00, 0.00)	0.786
Friends Supportive/Non-supportive Behaviors	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.614
Co-worker Supportive/Non-supportive Behaviors	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.523

APPENDIX J

CHANGE IN PERCIEVED BEHAVIORAL CONTROL

Change in perceived behavioral control by surgical procedure

Perceived Behavioral Control	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Total	2.00 (0.50, 3.31)	2.00 (0.13, 3.00)	0.566

*Change score computed as post-surgery value minus pre-surgery value

Change in perceived behavioral control by gender

Perceived Behavioral Control	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Total	1.00 (0.00, 3.00)	2.00 (0.50, 3.19)	0.291

*Change score computed as post-surgery value minus pre-surgery value

APPENDIX K

CHANGE IN BODY IMAGE

Change in body image by surgical procedure

Body Image	Gastric Bypass (N=46) [Median (25%, 75%)]	Gastric Sleeve (N=37) [Median (25%, 75%)]	p-value for comparison between surgical procedures
Appearance Evaluation	0.93 (0.29, 1.43)	0.43 (0.00, 1.07)	0.133
Appearance Orientation	0.17 (-0.19, 0.63)	0.21 (-0.08, 0.58)	0.993
Fitness Evaluation	0.33 (0.25, 1.33)	0.33 (0.00, 1.00)	0.228
Fitness Orientation	0.65 (0.31, 1.23)	0.54 (0.19, 1.00)	0.239
Health Evaluation	0.67 (0.17, 1.50)	0.33 (-0.08, 0.83)	0.068
Health Orientation	1.00 (0.38, 1.5)	0.63 (0.25, 1.19)	0.074
Illness Orientation	0.20 (0.00, 0.60)	0.00 (-0.20, 0.60)	0.210
Body Areas Satisfaction	0.67 (0.19, 1.22)	0.44 (0.00, 0.94)	0.131
Overweight Perception	0.50 (-0.25, 1.00)	0.00 (-0.50, 0.38)	0.042
Self-classified Weight	-1.00 (-1.13, 0.00)	0.00 (-1.00, 0.00)	0.014

*Change score computed as post-surgery value minus pre-surgery value

Change in body image by gender

Body Image	Males (N=11) [Median (25%, 75%)]	Females (N=72) [Median (25%, 75%)]	p-value for comparison between males and females
Appearance Evaluation	1.14 (0.57, 1.43)	0.57 (0.04, 1.29)	0.117
Appearance Orientation	0.17 (-0.08)	0.17 (-0.17, 0.58)	0.571
Fitness Evaluation	0.33 (0.00, 1.33)	0.33 (0.00, 1.25)	0.989
Fitness Orientation	0.69 (0.31, 1.23)	0.54 (0.23, 1.08)	0.648
Health Evaluation	0.33 (0.00, 1.33)	0.50 (0.04, 1.17)	0.941
Health Orientation	0.63 (0.25, 1.50)	0.88 (0.38, 1.34)	0.752
Illness Orientation	0.20 (-0.20, 0.60)	0.20 (-0.15, 0.60)	0.935
Body Areas Satisfaction	0.78 (-0.11, 1.22)	0.56 (0.00, 1.11)	0.600
Overweight Perception	0.50 (0.25, 1.25)	0.25 (-0.50, 0.75)	0.024
Self-classified Weight	-1.00 (-1.25, 0.00)	-0.50 (-1.00, 0.00)	0.260

*Change score computed as post-surgery value minus pre-surgery value

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