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Purpose: To investigate the effect of the 12-week Active Living Every Day (ALED) internet-based PA intervention on PA levels, health profile, and health-related psychosocial factors in bariatric patients. Methods: Efficacy of the ALED program was compared across three study time points; pre-intervention, post-intervention and six month post-surgery. PA was objectively measured at all study time points using the Omron pedometer (HJ-720ITC) and the Actigraph GT3X accelerometer in 19 bariatric patients (2 male, 17 female, 43 ± 12 years). Results: Significant improvements (P < 0.05) in body composition (weight, percent body fat, waist and hip circumference) occurred from pre-intervention to post-intervention and from post-intervention to six month post-surgery. Additionally, significant improvements were observed in BMI from pre-intervention to six months post-surgery and from post-intervention to six months post-surgery. Furthermore, significant improvements were observed in LDL cholesterol and self-efficacy from pre-intervention to six months post-surgery. Mean steps/day and time spent in sedentary, light, and MVPA increased from pre-intervention through six months post-surgery; however, these changes were not statistically significant. Participants that
used the online step log ≥ 65 times increased their mean steps/day and spent less time in SB at pre-intervention, post-intervention and six month post-surgery. Additionally, compliant participants spent more time participating in light and MVPA at pre-intervention and post-intervention than non-compliant participants. Changes observed in compliant participants were not at the level of statistical significance. **Conclusion:** The 12-week ALED PA intervention did not significantly improve PA levels in previously sedentary bariatric surgery patients who were non-compliant prior to bariatric surgery or six months post-surgery; however, the intervention led to improvements in cardiovascular risk factors, RPE and self efficacy.

**Keywords:** Obesity, Pedometer, Accelerometer, Internet, Physical Activity Intervention
CHAPTER I
INTRODUCTION

Statement of the Problem

In less than 40 years, the prevalence of obesity in the U.S. has increased by over 50%, so that two of every three American adults are now overweight (body mass index (BMI) 25-29.9 kg/m^2) or obese (BMI ≥ 30 kg/m^2). Since the 1980s, the prevalence of obesity in the United States has increased by ~50% per decade (47, 103). Currently, 68% of US adults (73% of men and 64% of women) are considered overweight or obese (104). Furthermore, 5% of adults are considered to be extremely or morbidly obese (BMI ≥ 40 kg/m^2) (34, 103). Forecasts suggest that by 2030, 51% of the population will be obese and 11% of the population will be severely obese (49). In addition, the obesity epidemic is rapidly spreading to children. In 2000, 18% of US children and adolescents six to 19 years of age had BMI-for-age values ≥ 95th percentile on the CDC growth charts (104). Even more astonishing, nearly 8% of U.S. children four to five years of age are overweight (33). This rapid rise in obesity has come at a significant health cost to the American population because excess weight is a risk factor for numerous conditions including diabetes, hypertension, hyperlipidemia, stroke, heart disease, cancer, osteoarthritis, and other diseases (46, 47). Obese and overweight individuals account for
nearly one of every ten American deaths (3). Obesity has many health, social, psychological, and economic consequences. Obese individuals are found to have medical costs that are approximately 30% greater than normal weight individuals (48, 140, 143). Depending the source of total national healthcare expenditures used, the direct medical cost of individuals who are overweight or obese combined is approximately five to 10% of US healthcare spending (132). The growing prevalence of obesity was responsible for almost $40 billion of increased medical spending from 1998 to 2006, including $7 billion in Medicare prescription drug costs (51). The aggregate national cost of overweight and obesity combined was $113.9 billion in 2008 (132). If the current growth trends of obesity continue, it is projected that the total healthcare costs attributable to obesity could reach $861 to $957 billion by 2030, which would account for 16 to 18% of US health expenditures (140). It is important to understand the magnitude of costs that could potentially be saved by prevention and treatment of obesity.

Substantial long-term successes of lifestyle modifications and drug therapy have been disappointing in the obese population. Currently, bariatric surgery is considered the most effective method to induce and maintain significant weight loss (~70% of excess weight) (27). The National Institute of Health has suggested that surgical therapy be proposed to those patients with BMI ≥ 40 kg/m² or ≥ 35 kg/m² with serious obesity-related co-morbidities such as systemic hypertension, type 2 diabetes mellitus, and obstructive sleep apnea (111, 123). Bariatric surgery is associated with major improvements in co-morbidities, psychosocial factors, eating behavior, physical activity (PA) levels, and physical capacity (36, 111, 123). Recent studies suggest that success following bariatric surgery may also be associated with the individual’s ability to make
lifestyle changes, especially by increasing PA levels (16, 30). PA has been shown to be a key component for successful weight loss and maintenance of weight loss in overweight and obese individuals (39, 75, 78).

Unfortunately, physical inactivity remains a pressing public health issue. One study indicated that bariatric surgery patients are extremely sedentary preoperatively, spending over 80% of their daily waking time in SB (20). Compared to the general population, bariatric surgery candidates spend an additional three hours per day or 26% more of their time in SB (20). Lifestyle PA interventions (i.e. research studies) have been developed as a means to promote PA among sedentary U.S. adults. Previous research shows that lifestyle PA interventions are effective at increasing and maintaining levels of PA short-term (41); however, less is known about the long-term effects (≥ six months) that lifestyle PA interventions have on PA levels and perceptions of PA in previously sedentary adults. Evans et al. compared the amount of weight lost at three, six, and 12 months after gastric bypass surgery between patients who met or exceeded the American College of Sports Medicine (ACSM) recommended 150 min/wk of moderate or vigorous PA to those who did not meet the recommendation (45). Results showed that bariatric patients that participated in a minimum of 150 min/wk of moderate or higher intensity PA experienced significantly greater weight loss at six and 12 months post-surgery than those not meeting the recommendation.

The current study focused on PA levels in bariatric patients six months after bariatric surgery. The previous study evaluated the effectiveness of a structured PA intervention on changing PA behavior and perceptions of PA in the bariatric population prior to surgery (25, 44). This study utilized the Active Living Every Day® (ALED)
program created by Blair et al. (125). The ALED program is a 12-week internet-based PA intervention that utilizes self-monitoring tools (i.e. pedometer/accelerometer), considers readiness to change behavior, helps solve problems and overcome obstacles, and gives tips for making other healthy lifestyle changes.

**Purpose of the Study**

The primary purpose of this study was to determine the short-term and long-term effects of the ALED intervention on PA levels in bariatric patients. The second purpose of this study was to determine the short-term and long-term effects of the ALED intervention on the health profile of bariatric patients. The final purpose of this study was to determine the short-term and long-term effects of the ALED intervention on health-related psychosocial factors in bariatric patients.

**Hypothesis Statement**

The primary hypothesis of this study was that bariatric patients completing the internet-based 12-week ALED program will see improvements in PA levels from pre to post ALED intervention and will continue improving through six-months post-surgery follow-up. The second hypothesis of this study was that bariatric patients will see improvements in health profile from pre to post ALED intervention and will continue improving through six-months post-surgery follow-up. The final hypothesis of this study was that bariatric patients will see improvements in health-related psychological factors from pre to post ALED intervention and will continue improving through six-months post-surgery follow-up.

**Significance of the Study**
Previous research found that individuals that become physically active prior to surgery have better results with weight loss post-surgery; however, 40% of bariatric patients report non-compliance with PA pre and post-surgery (25, 44). Furthermore, non-compliance with PA pre-surgery leads to non-compliance with PA post-surgery (44, 130, 141). Most PA interventions utilize behavior change theories such as the Social Cognitive Theory, the Transtheoretical Model, and Behavioral Learning to shape the interventions. The Transtheoretical Model suggests that maintenance of behavior change takes more than six months (113). Additionally, the North American and European bariatric surgery guidelines emphasize the need for regular and prolonged follow-up assessments after bariatric surgery in order to reinforce a change in PA habits (74). Previous research showed that lifestyle PA interventions were effective at increasing and maintaining levels of PA that meet public health guidelines for PA in representative samples of previously sedentary adults (41). However, it is still unclear whether PA interventions are effective at increasing PA levels and perceptions of PA in bariatric patients up to six-months after surgery; therefore, this study focused on PA levels in bariatric patients six-months after bariatric surgery.

**Delimitations**

Participants needed to meet the following inclusion criteria to participate in the ALED intervention. Participants needed to be ≥ 18 years of age and needed to meet the guidelines set by Indiana University Ball Memorial Hospital Bariatric Center (IUHBC) to qualify for bariatric surgery. These include a BMI ≥ 40 kg/m² and completion of all IUHBC pre-surgery nutritional and psychological assessments. In addition, study participants needed to have bariatric surgery at an Indiana University Hospital within four
to six months of recruitment. Individuals were excluded from the study if they had a physical condition that limits their ability to walk, if they are unable to read and write, if they do not have access to the internet, or if they have been told by their doctor to limit the amount of moderate intensity PA they perform.

**Limitations**

A limitation of the present study was a small sample size (n = 19) and an unequal distribution of males (n = 2) to females (n = 17). Additionally, all participants in this study were Caucasian and had access to the internet. Therefore, findings from this study cannot be generalized to the entire bariatric population. Another limitation to this study was that individuals preparing for bariatric surgery were on strict liver reduction diets; therefore, dietary intake is not controlled for in the current study. As a result, it is difficult to determine the extent that the liver reduction diet accounted for changes in body composition throughout the intervention.
Definition of Terms

**Obesity** - A BMI of ≥ 30 kg/m² (1).

**Morbid Obesity** - A BMI of ≥ 40 kg/m² (1).

**Bariatric surgery** - Bariatric surgery encompasses several different surgical procedures (Rouxen-Y gastric bypass (RYGB), Laparoscopic adjustable gastric banding (LAGB), and bilio-pancreatic duodenal switch (BPDS)) that produce weight loss primarily through gastric restriction and/or intestinal malabsorption (14).

**Physical Activity** - Any bodily movement produced by the contraction of skeletal muscles that results in an increase in energy expenditure over resting (1).

**Accelerometer** - An instrument that assesses frequency, duration, and intensity of physical activity by measuring acceleration and deceleration of the body (2).

**Pedometer** - An instrument that detects vertical accelerations of the body and records a “step” when vertical acceleration exceeds a threshold value (2).

**Quality of life** - Health status, environmental and economic factors (i.e. income, educational attainment, etc.) that can substantially affect well-being (53).

**Self-Efficacy** - One’s perception of having the necessary capabilities to learn and navigate the many challenges of daily life (2).

**Transtheoretical Model** - An overarching, integrative model of health behavior interventions that incorporates many different intervention techniques and conceptual approaches into a longitudinal approach that takes into account stages of readiness for change with respect to physical activity and other health behaviors (2).

**Social Cognitive Theory** - Fundamental theories of behavior that emphasize the role of social mediating factors on psychological development and learning (2).
Internet-Based Physical Activity Program - A program that utilizes the internet as a medium for delivering population-based physical activity interventions (26).
CHAPTER II

REVIEW OF LITERATURE

**Obesity**

Obesity has become an epidemic in the United States among both children and adults. Since the 1980s, the prevalence of obesity has increased by ~50% per decade. Currently, 68% of US adults (73% of men and 64% of women) are considered overweight or obese (104). Furthermore, 5% of adults are considered to be extremely or morbidly obese (BMI $\geq 40$ kg/m$^2$) (34, 103). In 2005, the World Health Organization (WHO) estimated that at least 400 million adults were obese worldwide and they project this number to nearly double by 2015 (143). The rapid expansion of obesity has come at a significant health cost to the American population because obesity is associated with numerous co-morbidities such as cardiovascular disease (CVD), type 2 diabetes, hypertension, certain cancers, and sleep apnea. Obesity is also an important risk factor for coronary heart disease, ventricular dysfunction, congestive heart failure, stroke, and cardiac arrhythmias (47, 82, 110). The problems associated with obesity are not restricted simply to causing or exacerbating medical conditions; obesity appears to have a substantial impact on a person’s functional capacity and quality of life (53, 119, 126).
Furthermore, obesity is associated with an increased risk of morbidity and premature mortality. In the U.S. it is estimated that between 280,000 and 325,000 deaths a year are attributable to obesity, making it second only to smoking as a preventable cause of death (5, 53). If the obesity epidemic cannot be controlled, the current generation of children may have a shorter life expectancy than their parents.

The economic impact of obesity is especially evident in health-care costs. Depending on the source of total national healthcare expenditures used, the direct medical cost of overweight and obesity combined is approximately five to 10% of US healthcare spending (132). It is estimated that medical expenditures attributed to overweight and obesity accounted for 9% of total US medical expenditures in 1998 reaching $78.5 billion (28, 140, 144). Treatment for obesity-related diseases accounted for 27% of the rise in inflation-adjusted per capita medical spending between 1987 and 2001. During this time, medical costs required to treat obesity related diseases exceeded $90 billion per year (4, 48, 50, 129). Additionally, Medicare prescription drug costs increased $7 billion in 2006 and the associated medical costs of obesity rose to $147 billion per year in 2008 (51). Furthermore, obese individuals were found to have medical costs that were approximately 30% or $1,429 higher than their normal weight peers (51, 132, 143). This largely preventable condition and its associated co-morbidities place an undue stress on healthcare systems. It is important to understand the magnitude of costs that could be saved through better prevention and treatment of obesity. Accumulating evidence shows that dietary therapy and behavior modification do not result in long-term weight loss for the obese; therefore, an alternate treatment for weight loss among this population is necessary (62).
**Bariatric Surgery**

Bariatric surgery has come to the forefront as a successful mode of therapy for obese (BMI $\geq 35$ kg/m$^2$) and morbidly obese individuals (BMI $\geq 40$ kg/m$^2$) with accompanying co-morbidities. Research shows that bariatric surgery markedly lowers body weight and results in complete or partial resolution of obesity related co-morbidities, most notably type 2 diabetes, within the first one to two post-operative years (14, 24, 73, 97). Several surgical procedures are utilized to produce weight loss through gastric restriction and/or intestinal malabsorption. Restrictive procedures decrease the amount of food a person can consume by narrowing the opening to the stomach and malabsorptive procedures reduce the potential for the absorption of nutrients by bypassing a portion of the small intestine. The four most popular bariatric surgeries are the Rouxen-Y Gastric Bypass (RYGB), the Laparoscopic Adjustable Gastric Banding (LAGB), the Laparoscopic Sleeve Gastrectomy (LSG) and the Bilio-Pancreatic Duodenal Switch (BPDS). The RYGB procedure utilizes both restrictive and intestinal malabsorption mechanisms by creating a three oz. stomach pouch that is connected to an intestinal limb to limit nutrient absorption. The LAGB procedure is a restrictive operation that places a synthetic band around the upper stomach to limit food intake. The LSG and the BPDS procedures are suggested to patients who are extremely obese (BMI $\geq 60$ kg/m$^2$) with severe co-morbidities. The LSG removes 80% of the stomach and creates a tube like conduit that restricts food intake. The BPDS involves bypassing the sleeve stomach to the distal portion of the small intestine to limit nutrient absorption. In the US today, the RYGB is the most commonly performed bariatric procedure; however, the LAGB procedure is becoming increasingly popular. LAGB is considered by some to be
the gold standard procedure in bariatric surgery (14, 24).

**Bariatric Surgery and Weight Loss**

Bariatric surgery can produce significant weight loss in morbidly obese individuals. In most bariatric surgery literature, weight loss is reported as a mean percentage of excess weight loss (%EWL). Changes in absolute weight, BMI and percentage of initial weight are also reported in bariatric surgery literature. %EWL is calculated by dividing an individual’s weight loss by their excess weight and multiplying it by 100. Weight loss is equal to their surgical weight minus their follow-up weight and their excess weight is equal to their preoperative weight minus their ideal weight. Ideal weight is derived from the 1983 Metropolitan Life Insurance Company height and weight tables, and is the weight for each height at which mortality is lowest. The ideal weight for an adult female that is five ft. tall is 119 lbs. and the ideal weight for an adult male that is five ft. three inches tall is 135 lbs. For both adult females and males, three lbs. should be added for each additional inch of height (67).

At present, bariatric surgery is considered to be the most effective method to achieve major, long-term weight loss (22, 98). The most successful bariatric operations reduce body weight by 35–40%, and maintain weight loss for at least 15 years; however, success of short-term (three to five years) %EWL varies across bariatric procedures (31). Research suggests that restrictive procedures can lead to an average loss of 40 to 50% of excess body weight (EBW), RYGB can lead to an average loss of 60 to 70% of EBW, and malabsorption procedures can lead to an average loss of 75 to 80% of EBW in three to five years (52). Suter et al. found that approximately 60% of patients, without major surgery related complications, are able to maintain an acceptable EWL (EWL > 50%)
long-term after bariatric surgery (127). Recent US data on weight loss outcomes after LAGB, RYGB, and malabsorptive procedures are encouraging. Rubenstein et al. reported a mean %EWL of 54% at three years post-surgery follow-up among 63 patients, Ren et al. reported a mean %EWL of 41% at one year post-surgery follow-up among 115 patients, and more recently Ren and Allen et al. reported a mean %EWL of 44% at one year post-surgery follow-up among 445 patients who underwent LAGB (116-118). Furthermore, RYGB procedures have been shown to successfully produce long-term (five to 14 years) weight loss, with losses ranging from 49 to 62% of EBW (52). Pories and et al. reported that some of the most successful RYGB procedures have resulted in an average weight loss of up to 65% EBW at two years, with approximately 15% weight regain over 14 years (52, 112). Malabsorptive procedures have also produced excellent long-term (18 years) weight loss results, including losses of up to 78% EBW (52).

Significant %EWL among the obese population corresponds to significant reductions in co-morbidities including diabetes, hypertension, dyslipidemia, sleep apnea, obesity-hypoventilation syndrome, cardiac dysfunction, reflux esophagitis, some cancers, arthritis, and infertility (96, 98, 112). In a meta-analysis of 22,000 bariatric surgery patients, Buchwald et al. found that an average %EWL of 61% was accompanied by improvements in type 2 diabetes mellitus, systemic hypertension, obstructive sleep apnea, and dyslipidemia (23). Another meta-analysis found that bariatric surgery that resulted in weight loss of 20 to 30 kg, that was maintained up to ten years, was associated with a reduction of co-morbidities and an overall mortality rate of < 1% (64, 115). In patients with morbid obesity and impaired glucose tolerance, most studies report a 99–100% prevention rate of type 2 diabetes with bariatric surgery (55). Resolution of the disease is
reported in 64–93% of cases, occurs as early as the third post-operative month, and is sustained long term (23). A substantial reduction in oral medications or insulin doses has also been observed after bariatric surgery (8, 23, 55, 84). Weight loss after bariatric surgery also results in substantial improvements and/or resolution of hypertension and reduces the need for anti-hypertensive agents. In a recent study, 46% of patients achieved complete resolution of hypertension while 19% of patients showed an improvement in resting blood pressure (BP) (8, 70, 107). Up to 50% of morbidly obese patients who undergo bariatric surgery have dyslipidemia. In a study in patients undergoing RYGB, a %EWL of 66% 12 months post-surgery was associated with a 31% decrease in low-density lipoprotein (LDL) cholesterol levels, a 39% increase in high-density lipoprotein (HDL) cholesterol levels and a 63% decrease in triglycerides (TG) (8, 9, 37, 101). Furthermore, bariatric surgery is considered the most successful treatment for obstructive sleep apnea. The sleep apnea status of obese individuals has been shown to improve by 80% following bariatric surgery (23, 61, 111). The AHA recognizes that the magnitude of improvements in cardiovascular risk factors, metabolic syndrome, and overall mortality are dependent upon the percentage of weight lost (111). The net effect of these changes is an increase in quality of life and decrease in overall mortality among the obese population (31, 63, 69).

**Weight Regain Post-Surgery**

To achieve and maintain optimal weight loss after bariatric surgery, certain lifestyle changes are critical. These include nutritional optimization, a commitment to regular structured exercise, increased lifestyle PA, stress management, realistic goal setting, environmental control strategies, support systems, and cognitive restructuring
The primary challenges for weight-loss surgery patients may stem from failure to embrace these lifestyle changes (71, 120). A study by Odom et al. was conducted to better understand the influence of behaviors on post-operative weight regain (102). Patients who had bariatric surgery after the inception of the surgical treatment program in 2001 were identified through the William Beaumont Hospital Weight Control Center patient database. In total, 203 participants participated in this study and each one was sent a study survey in the mail. The administered survey contained questions about sources of post-operative stress and related behaviors, including control over food urges. The amount of weight regained post-surgery was self-reported. This study demonstrated that lack of control over food urges, concerns regarding addictive behaviors, decreased overall post-operative well-being, lack of self-monitoring, and fewer post-operative follow-up visits were associated with weight regain. The data from this study substantiated the idea that coupling weight-loss surgery with behavioral interventions, similar to what is used for traditional weight control patients, may help to prevent weight regain.

Most bariatric patients achieve their lowest weight between 18 to 24 months after surgery; however, certain weight regain occurs between two to five years after surgery. A study by Magro et al. sought to evaluate weight regain between 18 and 60 months after surgery in patients having gastric bypass (90). The study was a longitudinal follow-up study and was conducted on 782 morbidly obese and severely obese (BMI > 50 kg/m²) patients seen at the Obesity Surgery Center of Campinas, State of São Paulo, Brazil. Magro et al. found that weight loss was no longer significant 24 months after surgery, and that weight regain became significant 48 months after surgery, with a mean BMI
increase of 0.84 kg/m\(^2\). The weight regained after surgery, ranged from 46 to 64% between 24 and 48 months post-surgery. Therapeutic failure of weight loss surgery was evaluated and defined as the presence of one of the following factors: \(\%\text{EWL} \leq 50\%\) or \(\text{BMI} > 35 \text{ kg/m}^2\) for patients with a preoperative \(\text{BMI} < 50 \text{ kg/m}^2\) but \(> 40 \text{ kg/m}^2\), or for patients with a preoperative \(\text{BMI} > 50 \text{ kg/m}^2\) (11). The surgical failure rate was higher in severely obese (\(\text{BMI} > 50 \text{ kg/m}^2\)) patients than in morbidly obese patients at all times studied. Among patients whom surgery failed, 60% never underwent nutritional follow-up, and 80% never underwent psychological follow-up. Multidisciplinary support groups including psychologists, psychiatrists, nutritionists, surgeons, clinical exercise physiologists (CEPs), and endocrinologists assist in the search for solutions and alternatives to help patients maintain their weight and control binge eating disorders (30).

Margo et al. concluded that the intensity and/or frequency of care and/or follow-up visits most likely contributed to the failure or success of surgery.

**Physical Activity and Weight Control**

For approximately one in 20 individuals who are severely obese, bariatric surgery is considered the most effective method for producing long-term weight loss (23, 89, 105). On average, individuals who have bariatric surgery lose about 25% of their initial body weight within 12 months following surgery (79, 123). Comparatively, individuals in behavioral weight-loss treatments typically lose 10% of their body weight (85, 138). A study by Bond et al. sought to evaluate whether The National Weight Control Registry (NWCR) participants, who had lost and maintained comparable large amounts of weight through either bariatric surgery or non-surgical methods, differed in weight regained over time (18). The study compared the groups on weight maintenance behaviors and
psychological characteristics at registry entry and one year to evaluate whether the contribution of behaviors and psychological characteristics to one year weight regain was a function of weight-loss methods (83). Of the 315 participants eligible for this study, 251 (80%) completed the one year assessment. At entry into the registry, participants provided demographic information (age, ethnicity, education level and marital status) and details of their weight history. Weight history information was used to calculate BMI (kg/m²). The Paffenbarger Activity Questionnaire was used to provide estimates of total PA-related energy expenditure during the past seven days as well as energy expended through various modes (walking and stair climbing) and intensities (light, medium and heavy) of PA (106). Non-surgical participants reported expending significantly more calories through PA than surgical participants (83). Specifically, non-surgical participants reported expending $796 \pm 1,209$ kcal/wk in moderate intensity activity and $1,137 \pm 1,887$ kcal/wk in heavy intensity activity at study entry while the surgical participants reported expending $482 \pm 1,022$ kcal/wk in moderate intensity activity and $386 \pm 863$ kcal/wk in heavy intensity activity at study entry. Furthermore, non-surgical participants reported expending $733 \pm 1,584$ kcal/wk in moderate intensity activity and $1,134 \pm 2,270$ kcal/wk in heavy intensity activity at one year follow-up while surgical participants reported expending $433 \pm 923$ kcal/wk in moderate intensity activity and $414 \pm 965$ kcal/wk in heavy intensity activity at one year follow-up. In addition, only one third of the surgical group reported engaging in a level of PA consistent with recommendations for prevention of weight regain compared with 60% of the non-surgical group (76). The American College of Sports Medicine recommends that obese individuals participate in approximately 250 to 300 min/wk of moderate intensity PA, equal to approximately
2,000 kcal/wk, to prevent weight regain (76). This study found no significant differences in the amount of weight regained between surgical and non-surgical participants. Both groups had an average weight regain of approximately two kg per year and most participants remained within ± five kg of their baseline weight at years one and two of follow-up. This study suggests that weight loss and weight maintenance, comparable to that observed after bariatric surgery, can be accomplished through behavioral methods alone, although this may involve more intensive efforts over a longer duration. Bond et al. concluded that future research should focus on ways to increase and maintain PA and better monitor psychological parameters in bariatric surgery patients to facilitate optimal long-term weight control (18).

It is well known that PA plays an important role in non-surgical weight control and health related outcomes; however, less is known about the impact of PA on these variables following bariatric surgery. Research suggests that behavioral modifications and support from a multidisciplinary team are necessary for successful weight loss. Unsuccessful weight loss or weight regain are predicted to be the result of a lack of patient follow-up or adherence to post-operative recommendations (44, 90). It is important to understand the factors that influence weight regain after bariatric surgery, so that it can be minimized and/or prevented.

**Behavior Compliance and Weight Loss Outcomes**

Despite impressive weight losses associated with bariatric surgery, there appears to be significant patient-to-patient variability in post-operative outcomes. Literature reviews have concluded that between 10–20% of patients fail to achieve significant weight loss or experience premature and/or sizable weight regain (12, 69, 120). The
reasons for these suboptimal outcomes are not well understood; however, it is thought that adherence to rigorous post-operative behavioral guidelines (regarding diet and exercise) contributes to positive surgery outcomes (71). A study conducted by Sarwer et al. investigated the relationship of 92-week post-operative weight losses to preoperative psychosocial variables (i.e., self-esteem and mood), preoperative eating behaviors (i.e., cognitive restraint, disinhibition, and hunger), dietary intake (i.e., daily kcals, % kcals from fat, protein) and self-reported adherence to post-operative diet (121). Participants consisted of 200 RYGB patients that were required to complete psychosocial/behavioral evaluations and the Weight and Lifestyle Inventory (WALI) (139). Questionnaires were mailed to study participants approximately 20, 40, 66 and 92 weeks following surgery. Two weeks prior to surgery, study participants met with a registered dietitian and patients were instructed on dietary and behavioral changes necessary for a successful post-operative outcome. At each post-surgery assessment, study investigators inquired about how well each participant was following the diet plan given to them (approximately 1,000 – 1,200 kcal/day). Body weight was measured during preoperative assessments (139 ± 26 kg) and was self-reported at all post-operative assessments. Adherence was self-reported on a nine-point Likert scale that ranged from one (“not well at all”) to nine (“very well”). Study investigators found that at week 20, the low dietary adherence group lost 26% of their initial weight and the high adherence group lost 27% of their initial weight. From week 20 to week 40 those high in dietary adherence lost an additional 13% of their weight, which was significantly greater than the 11% lost by those with lower dietary adherence (P = 0.02). By week 92, those high in dietary adherence lost 16% of their weight since week 20, compared to only 12% for those in the low dietary adherence
group (P = 0.02), representing a 28% difference in weight loss between the two groups. Study investigators also examined whether dietary adherence changed over time. At week 20, the low adherence group had a mean adherence level of 4.59. This did not significantly change in weeks 40, 66, and 92. At week 20, the high adherence group had a mean adherence level of eight out of nine on the Likert scale, which was significantly different from the remaining weeks (6.79 at week 40, 6.34 at week 66, 6.52 at week 92). Interestingly, the high dietary adherence group reported a significant deterioration in adherence to the post-operative diet over the course of the study even though their adherence remained significantly greater at week 92 than those low in dietary adherence. This study, like others, suggests that while patients often are able to decrease their caloric intake within the first post-operative year, caloric intake increases over time (6, 86, 100, 123). This study is the first to provide evidence that adherence to post-operative diet is predictive of post-operative changes in weight. A limitation to this study is that it did not assess behavioral adherence to PA variables and weight loss outcomes post-surgery. Further research should seek to identify the relationship of behavioral adherence to PA variables and weight loss outcomes post-surgery as well as identify effective ways to maintain behavioral compliance over time.

A study by Toussi et al. investigated the relationship between weight loss and compliance with physician instructions before (n = 112) and after (n = 67) RYGB surgery (130). Participants included in the study had a mean age of 45 ± 11 years and mean BMI of 49 ± 8 kg/m². Study investigators designed a method for coding compliance to physician instructions before and after surgery and then examined the relationship of pre- and post-surgical compliance to a participant’s post-surgical weight loss, demographic
characteristics, and physical and psychological co-morbid conditions at the time of pre-surgical intake. Compliance was defined in this study as the necessary steps or behaviors to which a patient had to adhere in order to finish any treatment plan or health improvement strategy. A total of 156 different types of non-compliance issues were identified from participant records and were reduced to five major categories: exercise adherence, weight loss plan adherence, medication adherence, missed appointments, and poor food choices (58). Each compliance category was assessed before and after surgery and non-compliance issues were coded as “present” or “absent” for data analysis. All participants had three appointments before surgery (12-months, six-months, and just prior to surgery) with the treatment team (member of research team, a physician, a psychologist, a registered dietitian, and a bariatric surgeon). After surgery, participants had regular appointments with a member of the research team (one month, three months, six months, 12 months, 18 months, and 24 months), two appointments with a dietitian, and two appointments with psychologists. During visits with a member of the research team, all participants were asked about their exercise behaviors, diet behaviors, medical complaints, and existing medical conditions. Study investigators found that both pre- and post-surgery, participants had the most trouble keeping all of their appointments (65% missed ≥ once before and 72% missed ≥ once after), complying with prescribed exercise routines (39% before and 51% after), and complying with weight loss instructions (42% before and 57% after) (44). Prescribed exercise routines or specific PA variables were not reported in this study. Participants who reported ≥ one missed appointment had a higher BMI at the time of their surgery (P = 0.03) and were more likely to have depression (P = 0.003) or some other psychological disorder (P = 0.01). No participation in exercise was
reported by 39% (n = 22) of pre-surgery participants and 51% (n = 27) of 24-month post-surgery participants. Although poor food choices were not frequently a problem before surgery (11%), they increased significantly after surgery (37%). In addition to the specific non-compliance categories, the average number of compliance issues significantly increased after surgery from two ± one to two ± three (P = 0.005). Additionally, the most common reasons for not exercising were pain, gout, injury, no access, social factors, asthma, cold/illness, and not liking to exercise. Post-surgery participants reported similar reasons for exercise non-compliance at 24-months, which included foot problems, eating too much, no time and other surgeries. This study suggested that having more contact with participants and requiring adherence to behavioral changes, especially with respect to exercise and dietary restrictions, might improve the long-term outcomes for bariatric procedures (130).

Another study by Elkins et al. examined the incidence of non-compliance with behavioral recommendations and identified the incidence of psychological concerns at six- and 12-months following bariatric surgery (44). A total of 100 participants (81 women and 19 men) that underwent RYGB were identified from an active clinical database of all bariatric surgery patients. Study investigators completed chart reviews that entailed reviewing clinic visit notes to gather demographic data and to identify the prevalence of non-compliance with the following recommendations: eat protein first, avoid snacking, avoid drinking sodas, drink adequate amounts of water (64 oz.), avoid alcohol, take vitamins, avoid high fat foods, exercise (one hour per day) and no binge eating. Prior to surgery, participants completed preoperative assessments (six months of diet-counseling and a psychological evaluation) conducted by a multidisciplinary team.
consisting of a dietitian, endocrinologist, physiologist, and surgeon. Since diet and exercise can positively affect weight loss, patients were given dietary and exercise recommendations to follow after surgery; however, details of these recommendations were not reported in this study. Following surgery, participants completed follow-up visits with a surgeon or bariatric nurse practitioner at one week, two weeks, one month, and then every other month for one year. Participants were given the option of attending a support group bi-monthly for up to 12-months after surgery. Additionally, dietary counseling was provided and the surgeon or bariatric nurse reinforced exercise. Of 100 study participants, 21% reported not attending support group at six-months and 25% at 12-months post-surgery. Study investigators found that at both six- and 12-months, snacking and recommendations to exercise had the greatest degree of non-compliance of all the behavioral recommendations. Of the individuals surveyed, 44% were non-compliant with instructions to avoid snacking at six-months, which decreased to 37% non-compliance at 12-months. At six-month follow-up, 40% of the individuals surveyed were non-compliant with recommendations to exercise and 41% were non-compliant at 12-months. Based on these results, it appears that the suggested exercise guidelines of exercising one hour per day were not effective in changing exercise behavior in at least 40% of participants. It is unknown whether participants assumed to be compliant with exercise recommendations increased their exercise levels throughout the study or met the PA guidelines.

Current research shows that the majority of bariatric patients remain non-compliant with PA recommendations prior to and following bariatric surgery. Bond et al. found that bariatric patients tend to over-report their PA levels after bariatric surgery,
which suggests that non-compliance with PA is more severe than previously reported (19). A recent, unpublished, thesis by Kayla Campbell entitled, Pre-Bariatric Surgery PA Intervention, utilized a pedometer and accelerometer to objectively measure PA levels among bariatric surgery patients prior to their surgery (25). Campbell utilized a 12-week internet based intervention known as Active Living Every Day (ALED), which encouraged patients to log their step counts and provided them with healthy tips to increase their PA. The results showed that participants that were less compliant with PA recommendations prior to the ALED PA intervention were less compliant with PA recommendations following the intervention. Additionally, the results showed a statistically non-significant increase (15%) in average steps/day from pre-intervention to post-intervention and that bariatric patients spend approximately 74% of their day being sedentary.

Identifying the prevalence and areas of non-compliance among bariatric surgery patients post-surgery is important in order to design interventions to increase compliance and improve surgical outcomes (44). Further research is warranted to examine the impact of non-compliance pre- and post-surgery on long-term outcomes and to design interventions that can affectively measure PA levels as well as improve compliance with PA and/or exercise following bariatric surgery.

**Health Benefits of Physical Activity**

Being physically active is one of the most important steps that Americans of all ages can take to improve or maintain their health. Studies clearly demonstrate that participating in regular PA provides many health benefits. The 2008 PA Guidelines for Americans identifies the health benefits associated with PA and provides science-based
guidance to help Americans aged six and older improve or maintain their health through appropriate PA (29). According to the guidelines, PA is associated with the following benefits: lower risk of early death, coronary heart disease, stroke, hypertension, dyslipidemia, type 2 diabetes mellitus (DM), metabolic syndrome, colon cancer, breast cancer and weight gain. Additionally, PA is associated with weight loss (in those that need it especially when combined with reduced caloric intake), increased bone density, improved sleep quality, improved cardiorespiratory/muscular fitness, prevention of falls, reduced depression, and better cognitive function (for older adults). To achieve health benefits, the guidelines suggest that adults participate in at least 150 minutes per week of moderate intensity, or 75 minutes per week of vigorous intensity aerobic PA. Participating in an equivalent combination of moderate-to-vigorous physical activity (MVPA) is also acceptable. To achieve health benefits, aerobic activity needs to be maintained in bouts lasting at least ten minutes in duration and should be performed five days a week. Additional health benefits are achieved by engaging in amounts of PA that exceed these amounts. To achieve additional health benefits, adults are encouraged to participate in muscle-strengthening activities that involve all major muscle groups, two or more days per week. Weight loss and weight maintenance can be achieved by increasing PA levels to 300 minutes per week of moderate intensity, or 150 minutes per week of vigorous intensity aerobic PA, or an equivalent combination of MVPA.

**Assessment of Physical Activity**

Health-related PA recommendations, such as those presented in the 2008 PA Guidelines for Americans, focus on multiple elements of PA such as frequency, intensity, duration, and mode. Body-worn motion sensor technology, such as accelerometers and
pedometers, are becoming increasingly popular and make it easier for individuals to track their daily-accumulated PA (135). Of the two motion sensors, pedometers are generally considered the most practical (i.e., simple to use, affordable) for individual and population level applications (57, 136). Pedometers provide a simple and affordable means of tracking daily PA in a summary output of steps per day (steps/day). Researchers and practitioners require practical guidelines, such as daily step indices, associated with important health-related outcomes (i.e., obesity, hypertension, etc.) and health-related levels of PA (i.e., translations of public health recommendations) to better assess and motive PA behaviors (133). According to Tudor-Locke and Bassett, a value of 10,000 steps/day is recommended for apparently healthy adults and is associated with significant health benefits (133). Preliminary evidence suggests that a goal of 10,000 steps/day may not be obtainable for some populations including overweight and obese individuals. Tudor-Locke et al. used data from the 2005 and 2006 National Health and Nutrition Examination Survey (NHANES), a health survey that combines interviews and physical exams, that provided objectively measured step data and activity counts per minute for normal, overweight and obese U.S. men and women (n = 3,522) (134). Study investigators concluded that as BMI increased, volume of PA, MVPA, and objectively measured step counts significantly decreased. For example, U.S. adults averaged 6,564 ± 107 censored steps/day. Additionally, they spent approximately 57% of their day in sedentary time (< 100 activity counts/minute), 24% in low intensity activities (< 500 activity counts/minute), 17% in light intensity (500 - 2,019 activity counts/minute), 3% in moderate intensity (2,020 - 5,999 activity counts/minute), and 0.2% in vigorous intensity activities (>5,999 activity counts/minute). Overall, approximately 3% of U.S. adults
achieved public health guidelines for PA. Comparatively, obese adults (n = 1,242) averaged 5,784 steps/day, spent approximately 58% of the day in sedentary time, 24% of the day in low intensity activities, 16% in light intensity, 2% in moderate intensity and 0.4% in vigorous intensity activities. Overall, approximately 2% of obese adults achieved recommended public health guidelines for PA. Tudor-Locke and Bassett proposed preliminary indices, which included time indicators (activity counts/minute) and step-defined activity levels, to be used to classify intensity thresholds (Table 2.1).

Similar to Tudor-Locke, Freedson et al. conducted a study to determine accelerometer cut-points that represented meaningful intensity categories for normal weight (mean BMI 22.8 kg/m²) adults (56). These categories were correlated to MET values used in the literature that represent light, moderate, and vigorous activity. The established cut-points included non-wear time, time spent in light (≤ 2.99 METs), moderate (3.0-5.99 METs), hard (6.0-8.99 METs) and very hard (≥ 9.0 METs) intensity PA. The cut-points were obtained from a treadmill experiment in which normal weight adult participants (n = 50) performed six minute bouts of slow walking, fast walking, and jogging. Steady-state parameters were calculated by averaging the final three minutes (minutes four to six) of exercise for each condition. METs were calculated by dividing the steady-state VO₂ by 3.5 mL/kg/min. The defined activity cut-points are defined in activity counts/min for each of the intensity ranges (Table 2.2).

One of the most important factors in preventing and treating obesity as well as some of the co-morbidities associated with it, namely type 2 DM, is PA. PA increases caloric expenditure and should be considered one of the most important factors in weight control (88). It is important to note that PA intensity levels vary between normal weight
and obese individuals as well as between younger and older individuals. For example, obese adults tend to put forth more effort while working at the same intensity than their normal weight counterparts. Since accelerometers are effective tools for measuring locomotor activities it is important to identify specific threshold counts for different populations. Lopes et al. conducted a study to calibrate Actigraph accelerometers in obese/overweight (mean BMI 30 kg/m²) and type 2 diabetic adults (mean age 63 years) as a means to determine threshold counts for sedentary, light, moderate, and vigorous levels of PA (88). Since walking was identified as a main form of PA among study participants, PA cut-points for this study were obtained through the use of a laboratory protocol which included walking on a treadmill. To evaluate VO₂ and Actigraph counts simultaneously, each participant was required to complete certain PA activities in sequence: resting, sitting, standing and walking at 1.49 mph, 3.11 mph and 3.73 mph. These activities were designed so participants would participate in rest, light, moderate, and vigorous PA intensities. Corresponding MET levels for these intensities were calculated by dividing the participant’s measured resting metabolic rate by their energy expenditure in each PA intensity. The established MET thresholds for each PA intensity are as follows: sedentary < 1.5 METs, light 1.5-3.0 METs, moderate 3.0-5.9 METs, and vigorous 6.0-9.0 METs. The threshold counts determined by Lopes et al. and Freedson et al. are presented in Table 2.3.

Lopes et al. (88) found that activity counts were lower for a given intensity range in the overweight/obese population when compared to the threshold ranges for a normal weight population defined by Freedson et al. (56). Lopes et al. concluded that the Actigraph accelerometer threshold ranges for overweight/obese and type 2 diabetic adults
were highly correlated with MET scores used to define light (< 3 METs), moderate (3-5.9 METs), and vigorous (≥ 6 METs) activity. Study investigators also concluded that Actigraph accelerometers are a valid way to measure PA intensity levels among the overweight/obese population. The difference in threshold ranges between studies suggests that overweight/obese participants reached a higher MET level, with less relative effort, compared to normal weight adults. Relative intensity markers should be used to accurately compare intensity levels between normal weight and overweight/obese individuals. The accelerometer intensity markers created by Lopes et al. seem most appropriate for defining exercise intensity with an Actigraph among the overweight/obese population.
Table 2.1 Definition of accelerometer PA/inactivity indicator variables in activity counts/minute and steps/day created by Tudor-Locke and Bassett et al. (133).

<table>
<thead>
<tr>
<th>Accelerometer Variable</th>
<th>Activity counts/minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary intensity</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>Low intensity</td>
<td>100-499</td>
</tr>
<tr>
<td>Light intensity</td>
<td>500-2,019</td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>2,020-5,999</td>
</tr>
<tr>
<td>Vigorous intensity</td>
<td>&gt; 5,999</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accelerometer Variable</th>
<th>Step-Defined Activity Levels (Steps/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal activity</td>
<td>&lt; 2,500</td>
</tr>
<tr>
<td>Limited activity</td>
<td>2,500-4,999</td>
</tr>
<tr>
<td>Low active</td>
<td>5,000-7,499</td>
</tr>
<tr>
<td>Somewhat active</td>
<td>7,500-9,999</td>
</tr>
<tr>
<td>Active</td>
<td>10,000-12,499</td>
</tr>
<tr>
<td>Highly active</td>
<td>≥ 12,500</td>
</tr>
</tbody>
</table>
Table 2.2 Definition of accelerometer PA/inactivity indicator variables in activity counts/minute and its associated MET range created by Freedson et al. (56).

<table>
<thead>
<tr>
<th>Accelerometer Variable</th>
<th>Activity Counts (counts/minute)</th>
<th>MET Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light intensity</td>
<td>&lt; 1,952</td>
<td>&lt; 3.00</td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>1,952-5,724</td>
<td>3.00-5.99</td>
</tr>
<tr>
<td>Hard intensity</td>
<td>5,725-9,498</td>
<td>6.00-8.99</td>
</tr>
<tr>
<td>Very hard intensity</td>
<td>&gt; 9,498</td>
<td>&gt; 8.99</td>
</tr>
</tbody>
</table>
Table 2.3 Definition of accelerometer PA/inactivity indicator variables in activity counts/minute created by Lopes et al. (88) and Freedson et al. (56).

<table>
<thead>
<tr>
<th>Accelerometer Variable</th>
<th>Lopes et al. (counts/minute)</th>
<th>Freedson et al. (counts/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light intensity</td>
<td>&lt; 1,240</td>
<td>&lt; 1,952</td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>1,240-2,400</td>
<td>1,952-5,724</td>
</tr>
<tr>
<td>Hard intensity</td>
<td>≥ 2,400</td>
<td>&gt; 5,725</td>
</tr>
</tbody>
</table>
Physical Activity Pre-Bariatric Surgery

Evidence supports that most bariatric surgery candidates are not participating in enough PA prior to surgery (81) and are spending less time in MVPA than normal-weight controls (15). While it is evident that most bariatric surgery candidates are not participating in enough MVPA, it is not clear how much time they are spending in sedentary behaviors (SB; i.e., television, internet, and sitting) opposed to light-intensity PA (i.e., slow walking and household chores). Bond et al. conducted a study to objectively quantify the amount of time that bariatric surgery candidates (18-65 years, mean BMI ≥ 35 kg/m²) spent in SB (15). This study monitored SB via the SenseWear Pro2 Armband®. Study investigators found that surgery participants spent nearly 11 h/day (81% of total wear time) preoperatively in SB. Time spent in SB was similar on weekdays (11 ± 2 h/day, 81% of wear time) and weekends (10 ± 3 h/day, 81% of wear time). Additionally, greater time spent in SB was associated with less time spent in light PA and MVPA. These findings suggest that bariatric surgery patients are extremely sedentary preoperatively, spending over 80% of their daily waking time in SB. Recent NHANES data indicates Americans on average spend eight h/day or approximately 55% of objectively monitored time in SB (95). Compared to the general population, the results of Bond et al. suggest that bariatric surgery candidates spend an additional three h/day or 26% more of their time in SB. These results are concerning because greater time spent in SB is associated with higher risk of weight gain, morbidity and mortality (65, 72, 80).

The Pre-Bariatric Surgery PA Intervention study conducted by Kayla Campbell, objectively measured PA among obese individuals prior to bariatric surgery (25). This study utilized the Active Living Every Day Intervention (ALED) an internet based
intervention designed to help sedentary adults become more active. The intervention utilized the Transtheoretical Model of behavior change, a steps-log, and two PA monitors; an Omron pedometer and a GT3X accelerometer. PA was assessed both prior to and following the administration of the ALED intervention. This study found no significant differences in average steps/day and average time spent in sedentary, light, and MVPA from pre-ALED to post-ALED intervention. More specifically, bariatric surgery patients spent the majority of their day (74%) in SB prior to surgery, which is 40% higher than the normal weight population. The ALED intervention resulted in a statistically significant decrease in exercise barriers, improved ratings of perceived exertion at four METs, and statistically non-significant improvements in self-efficacy prior to surgery. Observational evidence suggests that participants that were more involved with the intervention were likely more involved in PA and improved the most.

A study by Hatoum et al. performed a chart review of 300 consecutive patients who underwent RYGB from August 1999 to November 2002 (66). The purpose of this study was to examine a broad array of potential clinical, psychological and physical predictors in order to determine which, if any, have a significant effect on weight loss outcomes after RYGB. One variable assessed in this study was limited PA and it was defined as the inability to climb two flights of stairs or walk two city blocks. During the study, each participant’s ability to perform physical activities was determined through the use of the Paffenberger PA Scale during a dietician assessment. Study investigators found that five of the 20 variables examined (limited PA, high initial BMI, lower education level, diabetes, and fewer post-operative appointments attended in the year following surgery) were associated with diminished weight loss after RYGB. Of these, higher initial
BMI and limited PA had the greatest adverse effect on post-operative weight loss. Specifically, those with limited PA prior to surgery exhibited an average of 17% less excess weight loss after surgery. These findings are similar to those of Dixon et al. who conducted a study to identify potential predictors of outcomes and their associations with weight loss (35, 38). Results showed Lap-Band patients (n = 440), who reported a poor PA score on the SF-36 quality of life measure before surgery, had less success with weight loss one year post-surgery. In the future, it may prove beneficial to build PA training and education into pre- and post-operative care guidelines. Furthermore, as bariatric surgery continues to grow in popularity, effective methods to increase PA both pre and post bariatric surgery need to be developed.

*Physical Activity Post-Bariatric Surgery*

Recent studies suggest that success following bariatric surgery is associated with an individual’s ability to make lifestyle changes prior to surgery (i.e. PA modifications); however, most adults preparing for bariatric surgery are not participating in enough PA to attain health benefits and many of them are not successful at changing their PA behavior (16, 30). A study by King et al. compared pre-surgery PA levels of bariatric surgery candidates (n = 757) to a cohort of “healthy” adults (n = 12) and found that bariatric surgery candidates appear to be less active as a group (81). It is well known that PA is a key component for successful weight loss and maintenance of weight loss in overweight and obese individuals (39, 75, 142). Therefore, additional research is needed to determine appropriate PA recommendations for individuals in preparation for and following bariatric surgery; as well as, to investigate the relationship between PA levels and long-term surgery outcomes. To increase the likelihood of successful weight loss and weight
maintenance among the obese population post-surgery, it is imperative that future research focuses on ways to help obese individuals make lifestyle changes to increase their participation in PA.

A study by Bond et al. examined the importance of self-reported PA in relation to the proportion of excess weight loss and BMI reduction among patients ($n = 1,585$, presurgical BMI = 50 ± 7 kg/m$^2$) who underwent RYGB at Southeastern University Medical Center from 1988 to 2001 (16). Study investigators hypothesized that engagement in postsurgical PA would be associated with a significantly greater proportion of excess weight loss and greater reduction in BMI two years post-surgery. In this study RYGB patients were categorized into one of two groups based on their self-reported PA participation. Group one represented study participants that reported PA ($n = 1,479$) at their office visits and group two represented study participants that did not report PA ($n = 106$) at any office visits through two years post-surgery. Results of this study suggest that engagement in postsurgical PA was associated with a significantly greater proportion of excess weight loss and a greater reduction in BMI two years post-surgery. Results also showed that patients who engaged in aerobic forms of PA experienced significantly greater percentage of excess weight loss ($\%\text{EWL} = 68 \pm 17\%$) and demonstrated a greater decrease in BMI (Post-surgical BMI = 18 ± 6 kg/m$^2$) than their sedentary counterparts. Patients were also stratified by preoperative BMI and results showed a significant increase in the $\%\text{EWL}$ observed among physically active patients in the higher BMI group (50–70 kg/m$^2$) during the two year post-surgery period. In this study participation in PA was self-reported at follow-up visits through two years post-surgery; therefore, it is important to note that some participants may have over reported their participation.
Additionally, future studies would benefit from objectively measuring PA through the use of a pedometer, accelerometer, or structured/supervised PA programs. This study showed that regular engagement in appropriately programmed exercise following bariatric surgery could maximize the amount of EWL and ensure long-term maintenance of EWL. Furthermore, participation in habitual PA could lead to a quick resolution of co-morbidities, improve physical fitness, and enhance perceived quality of life (16).

Objectively Assessed Physical Activity in Bariatric Patients

Currently, very few studies have objectively assessed PA participation in the obese population following bariatric surgery. One study by Bond et al. compared self-reported and accelerometer based estimates of pre to six months post-operative changes in MVPA (17). They also examined how participant’s adherence to recommendations to accumulate ≥ 150 min/week of MVPA in ≥ ten minute bouts differed according to measurement type at each time point. Participants (ages 18-65 years, pre-surgery BMI ≥ 35 kg/m²) were ambulatory and on schedule to have RYGB or LAGB. Each participant was given an RT3 waist mounted accelerometer to wear for seven consecutive days. A previously published cutoff (≥ 984 activity counts/min) was used to define MVPA (≥ three METs). For data to be valid, participants had to have ≥ eight hours of RT3 wear time per day for ≥ four days at both pre- and post-operative intervals. Self-report data on PA was assessed via the International Physical Activity Questionnaire Short Form (IPAQ-short). During the study, participants were also encouraged by their surgeon to increase engagement in PA; however, they were not given a formal exercise prescription. Study investigators found that participants self-reported a near five-fold increase in MVPA, while objective accelerometer data indicated no significant changes in MVPA
prior to surgery. Post-operatively, 55% of participants reported engaging in ≥ 150 minutes per week of MVPA while only one participant met this recommendation according to the RT3 accelerometer. This indicates that participants are clearly over-reporting their involvement in PA post-operatively. Accurate changes in PA among the bariatric population may be obtained through the use of objective measurements. Furthermore, providing clear definitions of what constitutes structured MVPA, as well as having patients monitor their engagement in activities, may help enhance the validity and reliability of self-reported PA and may aid in increasing MVPA post-operatively.

A study by Josbeno et al. sought to define a PA profile of bariatric surgery patient’s (n = 40, preoperative mean BMI of 49 ± 7 kg/m²) two to five years post bariatric surgery by characterizing their PA participation (via objective measurement) and examining the relationship between the level of weight loss (78). In addition, this study examined the association between physical function and the level of PA in participant’s who underwent bariatric surgery. The BodyMedia SenseWear® Pro (SWPro) armband was worn by participants to measure PA. In this study PA was defined as the minutes spent weekly in greater than one minute bouts of MVPA (≥ three METs). Sample activities that constitute MVPA include brisk walking, cycling, or jogging. Weekly minutes spent performing MVPA in bouts ≥ ten minutes were also examined to determine the level of compliance with public health guidelines (150 min/week of MVPA in bouts of ≥ ten minutes). Study investigators found that participants in this study participated in 213 ± 41 min/week of MVPA in bouts ≥ one minute at two to five years post bariatric surgery. Furthermore, 32% of study participants did not participate in
sustained bouts (≥ ten minutes in duration) of MVPA and only 10% of the participants met the national PA recommendation guidelines. Despite that participants were active throughout the day, the majority of these post bariatric surgery patients were not participating in recommended levels of PA to enhance health-related benefits. This study also showed that physical function is not correlated with PA, which may suggest that the capacity to engage in PA does not necessarily translate into greater levels of activity participation. This indicates that study participants feel they are capable of performing most activities associated with exercise and/or PA but are not participating daily which suggests other issues are interfering with the creation of an active lifestyle in post bariatric surgery patients. Other studies of weight loss have shown that barriers to PA, self-efficacy, and additional behavioral and/or cognitive factors contribute to PA adoption and maintenance (59, 87).

**Physical Activity Pre and Post Bariatric Surgery**

Research assessing the role of PA on weight loss prior to and following bariatric surgery is limited. A study by Bond et al., prospectively evaluated the importance of preoperative to post-operative changes in PA, including walking and activities of moderate and vigorous intensity, in relation to both weight loss and health-related quality of life (HRQoL) improvements in RYGB patients (19). Participants (ages 18-65 years, pre surgery BMI ≥ 35 kg/m²) were ambulatory and on schedule to have RYGB surgery at Virginia Commonwealth University’s Surgical Weight Loss Center from January 2004 to March 2007. In this study 200 minutes of PA per week was used as a cutoff criterion for categorization of active and inactive RYGB patients. Based on this criterion, study participants were separated into three groups: Inactive/Active (< 200 min per week
preoperatively/≥ 200 min per week post-operatively), Active/Active (≥ 200 min per week preoperatively/≥ 200 min per week post-operatively), and Inactive/Inactive (< 200 min per week preoperatively/< 200 min per week post-operatively). In this study PA levels were objectively measured through the use of an RT3 waist mounted accelerometer that each participant was instructed to wear for seven consecutive days. Self-reported data on PA was assessed via the IPAQ-short. Study investigators hypothesized that participants, who either went from being inactive preoperatively to being active at one year post-operatively or who were active at both time points, would experience greater weight change than patients who remained inactive at both time points. This study found that 68 participants (36% of the sample) reported at least 200 minutes of activity at baseline and remained active post operatively (Active/Active). Of the 122 participants who were inactive preoperatively 83 participants (68% of the sample) became active post-operatively (Inactive/Active), and 39 participants (29% of the sample) reported continuing to be inactive (Inactive/Inactive). Post-operatively, Active/Active participants reported more total PA minutes than either the Inactive/Active or Inactive/Inactive participants. Weight loss, BMI reduction, percent weight loss and %EWL were greater in the Inactive/Active group as compared to the Inactive/Inactive and Active/Active groups. Participants who went from being inactive to becoming active at one year after surgery (Inactive/Active) lost an additional six kg, reduced their BMI by two more units, and lost 8% more of their excess weight compared to those who remained inactive after surgery (Inactive/Inactive). This data suggests that future research should focus on ways to help individuals who are inactive before bariatric surgery to initiate and maintain higher levels of PA after surgery.
Future research on PA among obese individuals should focus on increasing PA levels, as part of an overall lifestyle change, both prior to and following bariatric surgery. Currently few studies have evaluated the effectiveness of PA interventions at increasing PA levels among this population. Based on previous research findings, PA interventions that include education on the benefits of becoming more physically active, provide steps on how to make PA a part of everyday life, utilize objectively monitored PA, and that address behavioral barriers (i.e., psychosocial factors) to becoming physically active should be evaluated. This research will aid in the development of effective post-surgical exercise guidelines and in designing effective interventions for weight management.

**Theories of Behavior Change**

A variety of social and psychological theories have been used to promote PA and health among a variety of populations. Recently these behavior theories have been applied to studies of PA determinants and interventions. Doshi et al. identified five key theories for health promotion, which include the health belief model, the theory of reasoned action/planned behavior, the Transtheoretical Model, the social cognitive theory/social learning theory and the ecological models (40). Of these, the social cognitive theory and the Transtheoretical Model are the most commonly used and have been shown to be the most effective behavioral theories for promoting PA behavior change (93, 99).

The social cognitive theory was derived by Albert Bandura in the 1980s and emphasizes that personal, environmental, and behavioral factors play a key role in PA behavior change and maintenance. It also places priority on examining cognitive processes and emphasizes that individuals have the ability to self-regulate their behaviors
by setting goals and by strategically altering their environment to support these goals (43). The social cognitive theory specifies a core set of determinants, the mechanisms through which they work, and the optimal ways to translate this knowledge into effective health practices. The core determinants include, knowledge of health risks and benefits of different health practices, perceived self-efficacy that one can exercise control over one’s health habits, outcome expectations about the expected costs and benefits for different health habits, the health goals people set for themselves and the concrete plans and strategies for realizing them, and the perceived facilitators and social and structural impediments to the changes they seek (10). Additionally, Bandura et al. suggests that self-regulation of behavior change will depend upon how a person perceives the behavior change will affect them and whether they have the ability to make that change (self-efficacy). These factors are influenced by observational learning and modeling by others (2, 10, 43). Research by Dzewaltowski et al. identified a strong sense of self-efficacy, dissatisfaction with past substandard attainment, and strong challenging goals as effective cognitions for motivation that should be evaluated within Bandura’s social cognitive theory (43).

Through their research, Prochaska et al. found that college students attempting to quit smoking moved through a series of behavior changes (113). The Transtheoretical Model was created based on this idea and consists of five stages: precontemplation (not thinking about changing behavior), contemplation (thinking about changing behavior), preparation (making small changes in behavior, but not totally changing behavior), action (behavior changed), and maintenance (maintaining behavior change for > six months) (2). This theory is successful at creating behavior change because it creates a progressive
shift from verbal strategies to behaviorally based therapies while controlling for environmental stimuli with each succeeding stage (2). The Transtheoretical Model has also developed ten different processes of change or strategies that are used to progress from one stage of change to the next. However, this behavioral intervention was originally developed to eliminate negative health behaviors such as smoking and drug use. More recently, it has been shown to be moderately affective at promoting good health behaviors such as exercise (2). Research by Marcus et al., suggests that utilizing these ten processes within PA interventions may help to speed the progress of individuals through the Transtheoretical Model stages of change which will increase the likelihood of exercise adoption (94).

A study by Dallow et al used the Transtheoretical Model and the theory of self-efficacy to develop a 24-week PA intervention for obese, sedentary women (n = 58, mean age 47 years, mean BMI 36 kg/m²) (32). This research was designed to help interventionists and health professionals create successful PA programs for obese, sedentary individuals. Assessments of motivational readiness and use of the processes of change, along with energy expenditure in PA, cardiorespiratory fitness level, and other physical parameters, were conducted at baseline, 24-weeks (intervention effects) and 48-weeks (maintenance of intervention effects). Study participants were divided into two intervention groups that aimed to increase PA and cardiorespiratory fitness levels. Group one consisted of a theory-based group process intervention (lifestyle group, n = 29) and group two consisted of a standard exercise program with access to a fitness facility (usual care group, n = 29). Throughout the study, participants within the lifestyle group met with study investigators weekly for 16 weeks, then once every other week for the
remaining eight weeks. During weekly meetings, the curriculum focused on identifying barriers to PA and using each of the ten cognitive and behavioral processes of change to reduce or eliminate the barriers to PA based on the stages of change model. Participants were encouraged to integrate shorter, frequent bouts of activity into their daily PA routines. Field trips were incorporated as a means to increase self-efficacy by allowing participants to try various types of activities. Participants within the usual care group were provided with an individualized exercise prescription based on ACSM guidelines and a free 24-week membership to a local health club with state-of-the-art fitness equipment. The gym also provided participants with four educational group classes on how to start and maintain an exercise program. Participants in this group could choose to workout at home or at the local health club and were strongly urged to exercise with a partner and to keep a log of their exercise participation. In addition, both groups were given the same PA goal based on national recommendations of 30 minutes of moderate intensity activity on most days of the week. Participants were encouraged to gradually increase PA levels so as to reach this goal by the end of the 24-week study. PA was measured using the PAR, a six-item phone interviewer-administered instrument designed to estimate energy expenditure in PA during a seven day period. The PAR includes questions related to participation in moderate, hard, and very hard physical activities and sleep time during the previous week. The gathered information is then converted to calories per kilogram of body weight by multiplying the time spent in each intensity category by a metabolic equivalent (MET). Cardiorespiratory fitness was assessed as estimated maximal oxygen uptake using the Astrand-Ryhming protocol for bicycle ergometry and guidelines established by the ACSM. Dallow et al. found that after 24-
weeks of intensive intervention only 19 lifestyle (66%) and 14 usual care (48%) participants completed the study (32). Of these, approximately 90% of participants in the lifestyle group were in the contemplation stage at baseline and after 24 weeks more than half of the participants moved to the action (16%, n = 3) or maintenance (47%, n = 9) stages. The progression of change through the stages of the Transtheoretical Model, paralleled the increased energy expenditure from baseline to 24- (3% increase) and 48- (5% increase) weeks. It also paralleled the increase in cardiovascular fitness observed in this group at 24- (13% increase) and 48- (11% increase) weeks. In the usual care group, 71% (n = 21) of participants were in the contemplation stage at baseline and after 24-weeks 7% (n = 1) of participants moved to the action stage and 50% (n = 5) moved to the maintenance stage. Furthermore, no change occurred in energy expenditure or fitness in this group from baseline to 48-week follow-up. These results show that both groups had similar cardiovascular fitness levels at 24- and 48-weeks meaning the lifestyle group improved their fitness level while the usual care group remained the same. Similar to these findings the lifestyle group had a significant improvement in self-efficacy at 24-and 48-weeks relative to baseline values, while the lifestyle group showed no change through the intervention. Lastly, significant changes were observed in eight of the ten processes of change in the lifestyle group and two of the ten processes of change in the control group at 24-weeks. The significant improvements in self-efficacy for PA observed in the lifestyle group suggests that this intervention was successful in changing participant’s perceptions about being physically active, particularly in challenging situations, such as poor weather or when feeling tired. This indicates that participants are more confident in their ability to be physically active in a variety of situations. In addition, the significant
increases in energy expenditure and cardiorespiratory fitness observed among lifestyle participants provide further evidence that the investigation of behavior change theory was effective in changing SB. The results of this study suggest that theory-based interventions are more likely to increase PA in obese, sedentary women than traditional programs that provide only information and access to a fitness club. Furthermore, the cognitive and behavioral strategies for behavior change that participants learned during the lifestyle intervention will better prepare these women for living in a sedentary society and enable them to self-direct their efforts toward a physically active lifestyle.

The findings of Dallow et al. confirm the findings of the Project Active study by Dunn et al. (42, 92). This study utilized a two year randomized trial to compare a lifestyle PA intervention to a traditional structured exercise program. Both programs entailed six months of active treatment and 18 months of maintenance intervention. Study participants included sedentary men (n = 116) and women (n = 119) with a mean age of 46 ± 7 years and mean BMI of 28 ± 4 kg/m². At baseline and six month follow-up, cholesterol, blood pressure, body composition, cardiorespiratory fitness level and behavioral processes of change were assessed. The lifestyle group members met with study investigators for hourly meetings one time weekly for four months, at which point weekly meetings gradually decreased to once every other week. Meeting curriculum targeted cognitive and behavioral strategies (i.e. enlisting social support, rewarding oneself, and reminding oneself) for change based on the Transtheoretical Model stages of change. Participants within this group were encouraged to utilize the behavioral skills they acquired to select a variety of moderate-to-vigorous activities to integrate into their daily routines. Participants within the structured group were issued a membership to a
state-of-the-art health club where they worked with a trainer to increase their PA levels to five days per week of activity. Results showed both interventions were effective at improving cholesterol, increasing physical fitness, decreasing blood pressure, and decreasing body fat percentage. Results also showed that incorporating behavioral strategies into daily routines during the first six months predicted PA behavior at 24 months that would meet the recommended guidelines (CDC/ACSM) for PA. At six months both groups became significantly more active with the structured group becoming more physically fit than the lifestyle group. At one-year follow-up, after 18 months of minimal contact by investigators, 20% of participants from both groups were meeting or exceeding CDC/ACSM recommended PA criteria. Similar to Dallow’s results, significant improvements were seen in self-efficacy, motivational readiness, and processes of change (three of the ten for the lifestyle group and four out of ten for the structure exercise group) (32). Both groups also experienced significant improvement in energy expenditure and cardiorespiratory fitness from baseline.

Research shows that behaviorally based lifestyle interventions are effective tools for increasing PA levels to meet individual and public health recommendations (32, 42, 92). Additionally, theory-based PA interventions are more likely to change the way sedentary individuals think and behave in relation to PA than traditional exercise programs. There seems to be strong support for combining the Transtheoretical Model for behavior change with the social cognitive theory to enhance the likelihood for increasing PA in sedentary individuals. Research on the effectiveness of behavior change theories on long-term maintenance of PA habits is in an early stage; therefore, continued research in this area is necessary.
**Lifestyle Physical Activity Interventions**

The adoption and maintenance of weight reduction behaviors have proven difficult for many individuals. Lifestyle interventions targeting dietary patterns, weight reduction, and new PA habits have resulted in impressive rates of initial behavior change, but frequently are not translated into long-term behavioral maintenance (7). Additional research that focuses on behavioral maintenance, PA, and weight loss among bariatric surgery patients is needed. Currently most obesity research focuses on the effectiveness of lifestyle interventions on weight loss. One study by Goodpaster et al. was conducted to evaluate the efficacy of a weight loss and PA intervention on the adverse health risks of severe obesity (60). Specifically, study investigators examined whether the adoption of a PA program, in addition to a dietary intervention, would promote additional weight loss compared with a dietary intervention alone. Changes in waist circumference, visceral abdominal fat, hepatic steatosis and other cardiometabolic risk factors were examined. Participants (n = 130) were 30-55 years of age and had severe obesity (BMI between 35 to 39.9 kg/m²). Participants were divided into two study groups that were randomized to a one year lifestyle intervention consisting of diet and PA. The lifestyle intervention was designed to help participants increase their PA levels to meet current PA guidelines of 60 minutes of moderate intensity continuous (≥ ten minutes/bout) PA per day, five days per week. To promote adherence to the lifestyle intervention, participants were given low-cost supplies such as a pedometer and exercise video. Group one (initial PA) was randomized to diet and PA for the entire 12 months and group two (delayed PA) had the identical dietary intervention but did not participate in PA until six months into the intervention. Both groups participated in a lifestyle intervention that was delivered to
participants via group, individual, and telephone contact. In months one through six, participants received three group meetings and one individual contact per month and during months seven through twelve, participants received two group sessions and two telephone contacts per month. Furthermore, energy intake was reduced to 1,200-2,100 kcal/day and nutrient composition consisted of 20-30% fat, 50-55% carbohydrate and 20-25% protein. Body weight, height, waist circumference, percent body fat, and blood variables were obtained at baseline, six-months, and 12-months. Additionally, participants were issued a pedometer, with a step goal of > 10,000 steps/day and were instructed to track their PA levels in a PA journal. Results showed that both groups experienced significant weight loss at six-months (11 kg for the initial PA group and eight kg for the delayed PA group) and at 12-months (12 kg for the initial PA group vs. ten kg for the delayed PA group). While the magnitude of weight loss, body fat, and waist circumference did not differ at 12-months between groups, the initial PA group lost significantly more weight and had greater reductions in body fat and waist circumference at six months compared to the delayed PA group. At six-months, the initial PA group significantly increased the number of steps/day from 7,048 to 8,475 steps and engaged in approximately twice the amount of vigorous PA than the delayed PA group. While the initial PA group maintained their level of PA (steps/day) and minutes in vigorous activity/week through 12-months, the delayed PA group significantly increased their steps by 13% and minutes of vigorous activity/week by 47% during the later six months of the study. Study investigators concluded that intensive lifestyle interventions using a behavior-based approach resulted in clinically significant and meaningful weight loss and improvements in cardiometabolic risk factors in severely obese individuals.
Another study by Jakicic et al. examined the effect of exercise of varying duration and intensity on weight loss and fitness in overweight adult women during a 24-month period (77). Secondary analyses examined the amount and intensity of exercise necessary to sustain varying levels of weight loss at a 24-month follow-up. For this study, participants (n = 201 women, BMI = 20-40 kg/m²) were issued a home treadmill and a specific PA program. Participants were randomized into one of four groups: moderate intensity/moderate energy expenditure, moderate intensity/high energy expenditure, vigorous intensity/moderate energy expenditure, or vigorous intensity/high energy expenditure. Group randomization was based on estimated energy expenditure (moderate, 1,000 kcal/week; high, 2,000 kcal/week) and exercise intensity (moderate vs. vigorous). Participants were encouraged to spread exercise over five days of the week and to exercise for ten minutes each time. Intensity was prescribed as percentage of age-predicted maximal heart rate (moderate, 50-65%; vigorous, 70-85%) and rating of perceived exertion (moderate, 10-12; vigorous, 13-15) (68). It is important to note that PA was self-reported in this study not objectively measured. Study investigators concluded that relatively high levels of PA appear to contribute to sustained weight loss. Specifically, the addition of 275 min/wk of PA, in combination with a reduction in energy intake, is important in allowing overweight women to sustain a weight loss of greater than 10%. These findings, in addition to the findings of Goodpaster et al., show that PA is effective for the maintenance of weight loss among morbidly obese individuals (60). Furthermore, lifestyle interventions that utilize PA, behavioral theories, and dietary restrictions are effective tools for weight loss among the morbidly obese.

*Internet Based Physical Activity Interventions*
With advancements in technology, more and more Americans use the internet for things such as health or medical information. A recent survey indicated that 55% of internet users access the internet for health or medical information and 13% seek information specifically about fitness and nutrition (114). For health promotion, the internet can help target audiences, tailor messages, and engage people in interactive discussions about health (128). Advantages of interactive health communication include instantaneous interactivity, convenience, appeal, flexibility, individual tailoring, automated data collection, credible simulations, openness of communication, and multimedia interfaces (54). Websites promoting PA are becoming increasingly common since PA is a high priority for health promotion (91, 109). A study by Doshi et al., aimed to evaluate the effectiveness of a variety of behavioral change theories in health promotion websites (40). Five key health promotion theories were evaluated and include the health belief model, the theory of reasoned action/planned behavior, the Transtheoretical Model, social cognitive theory/social learning theory, and ecological models. Health promotion and health communication experts (n = 13) were recruited for the evaluation of these PA websites (n = 24). Each website was scored on a 100 point scale based on content validity and reliability. Researchers found substantial differences among current PA websites in the use of established theories of behavioral change and in the level of interaction with the user. They also found that PA websites were effective at providing knowledge-based information. Most websites also provided guidelines for PA as well as helpful site navigation tips. One evaluated website, www.justmove.org, consistently made use of the behavioral change theory and provided assessment, feedback, and individualized assistance. Study researchers suggested that the majority of
PA websites should improve their delivery of theory-based interventions to promote and maintain PA. It was also suggested that future research focus on randomized controlled trials to assess the effectiveness of internet-based PA interventions for long-term maintenance of PA.

One study by Napolitano et al. was designed to evaluate the efficacy of an internet intervention that consisted of a website plus 12 weekly e-mail tip sheets sent to a waiting list control group (99). Study participants (n = 65, BMI = 27 ± 4 kg/m²) were sedentary (PA level averaged 75 ± 69 minutes/week) adult hospital employees (nine men and 56 women) that were divided into an intervention (n = 30) and control (n = 35) group. This intervention was three months in duration and study measures included the Physical Activity Readiness Questionnaire (PAR-Q), demographics questions, questions regarding computer usage, and questions regarding comfort and skill with using the internet and e-mail. The primary PA measures for the study were the PA stage of change (SOC; i.e. stages of motivational readiness) and the behavioral risk factor surveillance system (BRFSS) PA items. Study participants in the intervention group received access to the website for three months, along with weekly e-mail tip sheets. The website was based on the social cognitive theory and Transtheoretical Model SOC. For each SOC (i.e. pre-contemplation, contemplation, preparation, action, and maintenance) targeted information and links to other websites were provided. The precontemplation page provided links to teach participants about PA such as the PA guidelines, examples of PA, benefits of PA and overcoming barriers to PA. The contemplation page had links on how to get started with PA such as a walking program, an activity planner, preparing for PA, choosing activities and a walking test. The preparation stage contained links such as measuring
heart rate, body circumference and recording daily PA. The action and maintenance pages focused on maintaining PA and contained links such as exercise safety, measuring progress, and relapse prevention. Additionally, e-mails were sent to participants within the intervention group containing PA behavior change tips and a link back to the original intervention website. An e-mail tip sheet, consisting of the following topics: getting started, monitoring your progress, setting goals, rewarding yourself and getting support was sent to participants each week. The weekly tip sheet encouraged study participants to access the PA website. While on the website, participants were required to take a short quiz that was utilized to assess their SOC. Furthermore, a PA goal of engaging in moderate intensity exercise at least five days a week, as well as guidance on how to reach this goal were listed on both the website and e-mail tip sheet. Participants in the waiting list control group had to wait three months to participate in the online portion of the intervention. The PA SOC were analyzed on the basis of whether participants progressed (moved up ≥ one stage) or regressed (moved down a stage or stayed the same). The BRFSS results were reported for moderate minutes of PA and walking minutes. Researchers found that 88% of participants completed the one-month assessment. Of these, participants in the intervention group experienced significantly greater progression through the PA SOC, were participating in a larger amount of moderate intensity PA (112 ± 76 vs. 82 ± 87 minutes/week) and spent more time walking (100 ± 68 vs. 68 ± 85 minutes) than the control group. Participants in the intervention group were more likely to progress in SOC than participants in the control group. This implies that the PA website was successful at promoting changes in moderate intensity PA and in motivating individuals to be physically active. Researchers found that 80% of participants completed
the three-month assessment. At three months, participants in the intervention group were more likely than participants in the control group to progress through the SOC; however, there was no change in progression through the stages from one to three months of assessment. This implies that movement through the SOC occurs early in an intervention. A significant difference (P < .05) in walking minutes was observed between groups at month three but not at month one. It was found that the intervention group walked 100 ± 68 minutes/week while the control group walked 68 ± 85 minutes/week. Because this intervention was only three months in duration it cannot be assumed that participants maintained or improved their level of readiness for PA long-term. Therefore, long-term re-assessment of these participants would be beneficial to determine if this intervention would be effective in promoting long-term behavior change. It was also noted that progress through the SOC for (movement of ≥ one stage) lead to increased amounts of moderate intensity PA, time spent walking and increased motivation to become physically active. Limitations to this study include participants no longer using the website after one month of the intervention due to the material never changing and no information was provided on the number of actual hits to the website or whether e-mails were being received. This makes it difficult to determine how much of the intervention each participant was involved in and whether or not changes in PA levels and movement through the SOC are due to the website/e-mail materials. Another limitation to the current study is that PA levels were obtained via self-report methods, which are typically less accurate than objective measures of PA. Future research should utilize objective measures of PA (via a pedometer and/or accelerometer), which would allow researchers to validate changes in motivational readiness. Due to a variety of behavioral change
influences it is unclear which part of the intervention is responsible for eliciting changes in motivation. The results of this study demonstrate that the internet is a low-cost, powerful tool for changing health behavior. Continued research is necessary to determine the long-term effectiveness of web-based PA interventions.

*Internet-Based Physical Activity Intervention*

A study by Marcus et al. evaluated the efficacy of an individually tailored internet-based PA intervention to an individually tailored print-based PA intervention (93). A secondary objective was to determine the efficacy of a tailored internet intervention to a standard internet intervention. A total of 249 individuals participated in this study and were randomized into three groups: a tailored internet arm, a tailored print arm and a standard internet arm. Participants in the tailored internet arm (n = 81) were instructed to log in and utilize the study website and associated materials. The website contained a variety of PA educational and motivational materials including a goal setting function and links to other sites. Participants in this group were also contacted via e-mail and were encouraged to complete monthly online questionnaires. Each participant received immediate feedback, according to their responses, based on the Transtheoretical Model and social cognitive theory. In addition participants in this group set PA goals and completed online PA participation logs daily. Participants in the tailored print arm group (n = 86) participate in the same intervention as those in the tailored internet arm group. The participants within this group received all intervention materials and feedback from study investigators in the mail instead of through the internet. The participants within the standard internet arm group (n = 82) completed questionnaires and PA logs at the same intervals as the other groups but did not receive tailored feedback reports. These
participants assessed a study web page that contained links to six PA web sites available to the public (American Heart Association-Just Move, Shape Up America, Mayo Clinic Fitness and Sports Medicine Center, American Academy of Family Physicians-PA section, American Council on Exercise and American College of Sports Medicine health and fitness information). According to Doshi and Marcus et al. the American Heart Association’s Just Move program proved to incorporate the Transtheoretical Model and social cognitive theory the most (40, 93). Assessments were completed at baseline and follow-up assessments were completed at six-months by 89% of participants and at 12-months by 87% of participants. Baseline PA characteristics did not differ significantly between groups. Most of the reported PA minutes were in the moderate intensity range. At baseline 91%, at six-month follow-up 84% and at 12-month follow-up 84% of PA was in the moderate intensity range. The most common type of activity reported across all three groups was walking. Additionally, at baseline participants reported engaging in ≤ ten minutes of MVPA/week. No differences in reported moderate intensity PA were observed at six-months in the tailored print group that reported 113 minutes/week, the internet tailored group that reported 120 minutes/week and the standard internet group reporting 90 minutes/week. (P = 0.15). At 12-month follow-up there was no differences in PA (P = 0.74) among the groups. Specifically, the tailored internet and tailored print groups reported engaging in 90 minutes of PA/week and the standard internet group reported 80 minutes/week. At six-months, 37% of the tailored print group, 44% of the tailored internet group and 37% of the standard internet group were meeting the PA guidelines of 150 minutes/week of moderate intensity PA (P=0.52). Study investigators concluded that all three of the interventions assessed in this study proved to be effective
tools for improving PA behavior in previously sedentary adults; however, no significant differences in PA variables were found across groups. It is unclear whether the different interventions, research procedures and/or variables in the environment influenced the PA increase. Furthermore, the standard internet group was allowed to choose an internet-based program that utilized the Transtheoretical Model and/or social cognitive theory. It is unknown whether these theories of behavior change influenced the effectiveness of the PA intervention. Research supports that the Transtheoretical Model and the social cognitive theory are successful in changing PA behaviors among previously sedentary individuals (99). Based on the findings from this study it is unclear whether the delivery method or technique of presenting information motivates change. As internet use among Americans continues to increase, the likelihood of reaching sedentary individuals with internet based PA interventions also increases. For this reason, study investigators suggested that future research evaluate the effectiveness of tailored internet interventions in “real-life” settings.

Carr et al. conducted randomized control trials to determine whether the Active Living Every Day PA behavior change program (ALED) increased PA to a similar extent as a counterpart classroom-delivered program and a traditional individualized exercise prescription program (26). Aims of this study were to determine whether the ALED program increased PA in an overweight/obese adult population and to determine whether the program improved cardiometabolic disease risk factors in this population. The ALED program, developed by Human Kinetics®, is a commercially available internet delivered PA intervention that is based on the Transtheoretical Model and social cognitive theory (122). The content of the ALED program is modeled after the American Heart
Associations Project Active, a randomized clinical trial that compared the effectiveness of a lifestyle PA intervention (based on the Transtheoretical Model) to a traditional structured exercise intervention (137). The ALED program consists of an online website and an interactive textbook that provide step-by-step instructions on how to become more physically active. The website contains helpful links to supplemental information pertaining to topics discussed within the textbook and also provides links to websites that provide information on becoming active. The ALED textbook contains 12 chapters and each one is designed to teach a new lesson. The sequence of these chapters aids participants in determining what stage of readiness for change they are in, as well as helpful tips and guidance on how to progress through the stages. The topics of the ALED textbook chapters are: Ready-Set-Go (understanding the process of successful lifestyle change), Finding New Opportunities, Overcoming challenges, Setting goals and Rewarding Yourself, Gaining Confidence, Enlisting support, Avoiding Pitfalls, Step by step (learning to use a step counter), Defusing stress, Finding New Opportunities to Be Active, Positive Planning and Making Lasting Changes (125). Throughout these chapters, a variety of signposts are included such as: activity alerts (hands-on activities), myth busters (identifies common PA misconceptions), real life (testimonies from people who have made lifestyle changes), did you know (facts, information, and recent research related to PA), and weighing in (weight loss advice) (125). To evaluate the effectiveness of the ALED program Carr et al. randomized 32 overweight/obese adults (BMI 31.5 ± 0.09kg/m²) into a control group (n = 18) and an ALED intervention group (n = 14). For both groups, baseline and follow-up PA (steps/day) were measured using the Yamax Digiwalker® SW-200 pedometer during the first and last week of the 16-week
intervention. Throughout the intervention control participants were instructed to maintain their current lifestyle behaviors while the ALED intervention participants were issued a pedometer and were instructed to keep track of their daily steps in a PA journal. Members of this group also met with a research professional bi-monthly to increase their weekly step goal by 10%. All participants in the intervention group were provided an ALED textbook, were given access to the ALED website and were encouraged to complete the program at their own pace. Study investigators kept contact with participants to once a month but were able to monitor participation in the online website throughout the intervention. Study investigators found that the ALED group had higher triglycerides, a higher overall coronary risk ratio and a larger waist circumference at baseline. However, baseline steps/day did not differ between groups. The ALED group experienced a statistically significant increase (17%) in PA levels from baseline to follow-up. Following the intervention, the control group experienced a significant increase in body fat percentage (3%) and a significant decrease in lean body mass percentage (2%). Furthermore, the control groups PA levels did not vary from baseline to follow-up. After controlling for age, study investigators found that the ALED group experienced a reduction in waist circumference and coronary risk ratio that was not found in the control group. This suggests that PA level and overall body composition were correlated. Study investigators concluded that the ALED program was effective at increasing PA and played a protective role in the overweight/obese population by reducing central adiposity. This study confirmed previous research findings that using the internet delivered ALED program was just as effective as using a small group delivery format (42).
A study by Patrick et al. recently assessed the effect of a one year internet based weight loss intervention on weight related behaviors in a total of 441 male participants (108). These participants were categorized based on their BMI: 69 participants were in the overweight category (BMI 25-29.9 kg/m²), 39 were in the obesity I category (BMI 30-34.9 kg/m²), 149 were in the obesity II category (BMI 35-39.9 kg/m²) and 39 were in the obesity III category (BMI > 40 kg/m²). Study participants were randomly assigned to a control group (n = 217) or an intervention group (n = 224) and underwent assessments at baseline, six-months and 12-months. It was hypothesized that men enrolled in the intervention would show improvement in diet and PA behaviors and weight loss at one year. It was also hypothesized that weight related outcomes would be related to adherence to the intervention. The baseline and 12-month follow-up assessments took place in person at the research office while the six-month follow-up was conducted online via a personal computer. The intervention utilized in this study was based primarily on the social cognitive theory and the behavior determinants model (an approach that describes the social cognitive theory related behavioral correlates of exercise). This intervention was designed to improve diet and PA behaviors in five areas as a means to promote weight loss: increase fruit and vegetable intake (five to nine serving/day), increase consumption of whole grain products (≥ three servings/day), decrease saturated fat intake to ≤ 20 g/day, increase steps/day to at least 10,000/day (five days/week) and engage in strength training at least twice per week (targeting upper body, core and lower body). The number of times men logged onto the intervention website, to set a weekly behavior goal, was summed and used to estimate intervention dose. Participants in the intervention group participated in an internet based intervention that
consisted of individualized behavioral assessment, which were used to tailor recommendations for behavioral targets, weekly web-based learning activities and individualized feedback on progress. Participants were re-assessed for health behaviors frequently as a means for study investigators to individualize study content. Participants in this group also set individualized goals for both dietary and PA behaviors based on findings from an internet-based assessment. This intervention gave participants the ability to choose which behaviors they wanted to work on and encouraged them to make small changes over time. These participants were issued a Yamax Digiwalker® pedometer and were encouraged to log their daily steps on a provided website. Participants were also required to report PA not measureable by the pedometer (i.e. swimming and cycling). Additionally, the IPAQ was used to derive two estimates of PA, total walking minutes/day and moderate to vigorous MET minutes/week. Researchers contacted intervention participants over the phone or via e-mail when necessary to encourage website participation. Participants in the control group were given access to a website that contained general information of interest to men (i.e. information on stress, hair loss and worksite injury prevention) as opposed to information related to diet and PA behavior change. The dietary recommendations in this study focused on behavior change rather than specific calorie restriction goals. Study investigators found that the intervention group reduced their intake of fat and saturated fat and increased their daily servings of fruits and vegetables over the course of the study. Furthermore, the lack of change in body mass between groups was attributed to not having specific dietary recommendations. Study investigators also found a significant increase in total walking (minutes/day) for the intervention group. Specifically, the intervention group walked
about 16 minutes/day more than the control group at 12-months. Participation in the weight loss intervention was based on the number of website log-ins (i.e. intervention dose) by each participant to complete goal setting. Participants that logged in to complete at least 60% of the recommended goal setting sessions (once weekly) lost more weight, had greater reductions in their BMI, had greater reductions in their waist circumference and were more likely to lose 5% of their initial body weight than those who used the intervention less frequently (logged in < 31 weeks). Study investigators concluded that obese men who actively participated in an internet-based weight loss intervention (> 60% of the time) made positive behavioral changes in their diet and PA levels, which resulted in weight loss.

*Pre-Bariatric Surgery Physical Activity Interventions*

Research is lacking on the effectiveness of behavior modification programs on improving objective PA levels both pre- and post-bariatric surgery. A study by Brandenburg et al. investigated bariatric surgery patients’ satisfaction and perceived usefulness of participation in a six-week pre-surgery behavior modification program organized to assist patients in making lifestyle changes to facilitate long-term weight loss after bariatric surgery (21). Participants consisted of 124 bariatric surgery patients (mean pre-surgical BMI was 55 kg/m$^2$, range was 36-88 kg/m$^2$) that had RYGB at the McLaren Regional Medical Center in Michigan from August 2000 to December 2002. Prior to surgery, each surgery candidate was required to complete physical and psychological screenings by trained personnel. If no contraindications to exercise were found, the patients were allowed to enter the six-week pre-surgical behavior modification program that follows a multi-modality treatment model, which includes behavior modification,
caloric restriction, nutritional education and exercise prescription. The pre-surgical program consists of a liquid supplemental diet combined with attendance at weekly behavioral modification groups. The purpose of the liquid supplemental diet was to train patients to follow the nutritional guidelines required of them following their surgery. Weekly group meetings were held to discuss topics such as: the previous weeks successes and obstacles, review of food diaries, use of exercise resistance bands, the presentation of a psycho-educational topic, cognitive and emotional components to eating, relapse prevention, setting goals, exercise, stress management and changing self-talk. Study participants were also required to meet one-on-one with a dietician twice preoperatively and three times post-operatively to review specific dietary information. The ultimate goal of the pre-surgical modification program was to provide patients the ability to learn skills that would help them to succeed with post-surgical weight loss. Researchers mailed all participants that successfully completed the program a letter explaining the study as well as a self-report questionnaire. They sought to evaluate the usefulness of the pre-surgery program and its effect on weight loss, PA and dietary changes. Respondents provided information about their personal background, their lifestyle behaviors at the time they received the questionnaire, their perceptions of various components of the pre-surgery behavior modification program, the programs usefulness and satisfaction with the program. They were also asked to report their current weight, employment status, how many minutes/day they were physically active, how often they were eating, whether they were binge eating and how much water they were drinking. Of the participants that chose to return the survey (n = 70), 55 were female (79%), 68 were Caucasian (99%), 56 were married (80%), 39 had a college degree (55%) and 48 were employed (69%). Prior to
surgery participants lost an average of 15 kg (range 45-36 kg). Some form of exercise was reported by 80% of participants. More specifically, 44% reported exercising at least three to four times per week and 81% reported engaging in at least one to two exercise sessions each week. Of those who reported exercise participation, 32% engaged in at least 90 minutes of exercise each week. The intensity of exercise was not reported in this study. Lastly, participants indicated that they would have liked more specific information about exercise in general and about appropriate exercises from a trained exercise specialist. More research is necessary to obtain objective evidence on the influence of psychosocial and behavioral aspects on behavior change on post-surgical weight loss outcomes.

*Post-Bariatric Surgery Physical Activity Interventions*

Current research supports the inclusion of PA in programs designed to promote weight loss and long-term weight loss maintenance (13, 16). Unfortunately, PA recommendations on the amount of PA needed to maximize weight loss after weight loss surgery have not yet been established. A study by Evans et al. sought to compare weight loss at three- (n = 178), six- (n = 128) and 12- (n = 209) months after RYGB surgery between patients meeting the ACSM recommended ≥ 150 minutes of moderate or higher intensity PA and those not meeting the recommendation (< 150 minutes/week) (45). It was hypothesized that individuals meeting the ACSM recommendation would achieve greater weight loss and greater reductions in BMI at each post-operative point (three-, six- and 12- months). Participants were randomly assigned to one of two groups, based on whether or not they reported participating in ≥ 150 minutes of moderate or higher intensity PA at each follow-up visit as assessed by the self-administered short version of
the International PA questionnaire. Self-reported moderate and vigorous activities were combined and were reported as MVPA/week. In this study, moderate activity was defined as activities that take moderate effort and cause one to breathe somewhat harder than normal (i.e. carrying light loads or cycling at a regular pace). Vigorous activities were defined as activities that take hard physical effort and cause one to breathe much harder than normal (i.e. heavy lifting, digging or aerobics). Activities that were performed continuously (≥ ten minutes) were used in the data analysis. This study was the first to show a relationship between participation in a recommended amount of PA and improved weight loss outcomes in RYGB patients 12-months post-surgery. Study investigators found that participants that participated in ≥ 150 minutes of MVPA had significantly greater reductions in weight loss variables and BMI at six- and 12-month follow-up visits. At three months post-surgery, no significant reductions were seen in weight loss variables or BMI across both groups. One limitation to this study is that PA participation was self-reported, which may have resulted in over reporting of PA participation. Results of this study suggest that RYGB patients should be encouraged to participate in a minimal requirement of PA (150 minutes of moderate intensity/week) as tolerated to improve their post-RYGB weight loss outcomes. Additional studies are needed to establish PA recommendations necessary for greater weight loss and weight loss maintenance after bariatric surgery.

Summary

Obesity has become an epidemic in the United States among both children and adults. The increasing prevalence of obesity has come at a significant health cost to the American population because obesity is known to be associated with numerous co-
morbidities. In response to the obesity epidemic, bariatric surgery has become an effective weight loss intervention. Evidence supports that bariatric surgery results in substantial weight loss among obese and morbidly obese individuals but does not lead to successful behavior change in the majority of bariatric patients. Researchers are recognizing the need for effective behavior change strategies to prevent weight regain and to increase participation in PA among the obese population. PA plays a vital role in successful weight loss and maintenance of weight loss; therefore, future research needs to focus on ways to promote PA behavior change pre- and post- bariatric surgery. Additional research efforts should also focus on identifying what influences PA behavior among this population. One strategy that is becoming increasingly popular in the promotion of behavior change is the use of internet-based PA interventions. These interventions provide an efficient way to present educational materials on behavior change strategies. They also provide a platform for obese individuals to learn about and utilize self-monitoring tools such as a pedometer or accelerometer. Further research is needed to investigate the effectiveness of self-monitoring devices as a potential behavior change strategy among the obese. Furthermore, research on the efficacy of pre- and post-surgery behavior change modification programs is lacking. Additional studies should be conducted to aid in the establishment of effective behavior change strategies and definitive PA recommendations to maximize weight loss and weight maintenance after bariatric surgery.
CHAPTER III

METHODOLOGY

Bariatric surgery is quickly emerging as a standard treatment for severely obese individuals, due to its significant long-term effects on body weight, obesity-related co-morbidities and health-related quality of life. Additionally, cross-sectional studies suggest that post-operative PA is associated with enhanced weight loss and maintenance following bariatric surgery (16, 19, 79, 83, 89). In order to maintain the health benefits associated with PA, a physically active lifestyle needs to be maintained long term. Few prospective studies have assessed pre- to post-operative changes in PA among bariatric surgery patients.

Purpose 1: The primary purpose of this study was to determine the short-term and long-term effects of the ALED intervention on PA levels in bariatric patients.

Specific Aim 1: To determine whether levels of SB, light, moderate, and vigorous PA changed from pre-intervention to post-intervention (three month follow-up) through six-month post-surgery follow-up.
**Hypothesis 1**: The primary hypothesis of this study was that bariatric patients completing the internet-based 12-week ALED program would see improvements in PA levels from pre to post ALED intervention and would continue improving through six-month post-surgery follow-up.

**Purpose 2**: The second purpose of this study was to determine the short-term and long-term effects of the ALED intervention on the health profile of bariatric patients.

**Specific Aim 2**: To determine whether resting metabolic rate (RMR), body composition, blood profile and aerobic capacity changed from pre-intervention to post-intervention (three month follow-up) through six-month post-surgery follow-up.

**Hypothesis 2**: The second hypothesis of this study was that bariatric patients would see improvements in health profile from pre to post ALED intervention and would continue improving through six-month post-surgery follow-up.

**Purpose 3**: The third purpose of this study was to determine the short-term and long-term effects of the ALED intervention on health-related psychosocial factors in bariatric patients.

**Specific Aim 3**: To determine whether PA self-efficacy, quality-of-life, readiness for change, perceived exercise barriers, and exercise thoughts changed from pre-intervention to post-intervention (three month follow-up) through six-month post-surgery follow-up.

**Hypothesis 3**: The final hypothesis of this study was that bariatric patients would see improvements in health-related psychological factors from pre to post ALED
intervention and would continue improving through six-month post-surgery follow-up.

**Study Design**

The Institutional Review Boards at Ball State University and Indiana University Health Ball Memorial Hospital approved this study. This study used a quasi-experimental, one-group pre-and post-test study design. Study participants were recruited at bariatric seminars conducted once a month at the Indiana University Health Ball Memorial Bariatric Center (IUHBC) or during one-on-one nutritional/psychological counseling sessions with the bariatric staff dietician and nurse. The study investigator contacted recruited participants for an orientation meeting at the IUHBC. After obtaining consent, directions were given to the Human Performance Laboratory (HPL) at Ball State University. Participants met with the study investigator at the HPL for pre and post ALED assessments and for six-month post-surgery follow-up assessments. During the 12-week ALED intervention, participants also returned to the HPL for monthly downloads of their pedometer. In total, participants met with the study investigator on seven separate occasions (once at orientation, twice at pre ALED assessments, twice at post ALED assessments, and twice at 6 month post-surgery assessments).

**Participant Recruitment**

Monthly seminars were conducted at the IUHBC to inform bariatric surgery candidates about the surgical procedures available and to outline mandatory pre-surgical nutritional and psychological counseling. These seminars also allowed the study investigator to present the study procedures and guidelines to bariatric surgery
candidates. Recruited participants (n = 36) completed a study orientation and were preparing for bariatric surgery at Indiana University Health Ball Memorial Hospital in Muncie, IN or Indiana University Health in Indianapolis, IN. Of the 36 participants recruited, 19 participants completed post-intervention assessments, and of those 19 participants, six participants completed six-month post-surgery assessments. Participants consisted of 17 female and two male Caucasian adults who were either overweight or obese (average BMI 49 ± 8 kg/m²) and ranged in age from 22-65 years (mean age 43 ± 12 years). During the study, all participants were actively participating in the pre-surgery preparatory requirements at IUHBC, which included four to six months of required nutritional sessions.

Methods

Visit One

The investigator contacted interested participants and scheduled a brief orientation meeting at the IUHBC where the study timeline and all study procedures were explained in full. An informed consent and a protected health information form were reviewed and questions regarding study methodology were encouraged. Upon consent, a satisfaction of life survey, stage of change questionnaire, exercise barrier questionnaire, exercise thoughts questionnaire, and self-efficacy survey were administered (Appendices B-F).

The participant was issued an Omron pedometer (Omron Healthcare Model HJ-720ITC dual-axis pedometer; Omron Healthcare, Inc., Bannockburn, IL, USA) and a GT3X accelerometer (Actigraph Model GT3X tri-axial accelerometer; Actigraph, Pensacola, FL, USA). The participant’s stride length and weight were obtained for the
initialization of both devices. The GT3X accelerometer was initialized using the ActiLife (version 6.4.5) software (Actigraph, Pensacola, FL). To determine stride length, the participant walked at a comfortable pace for a total of ten steps. Distance walked was measured with a tape measure and total distance was divided by ten to determine approximate stride length in inches. The participant’s weight was measured on a calibrated digital scale (Toledo iD1 Multirange, Model KC240; Toledo Scale Corporation, Worthington, Ohio, USA). The participant was asked to remove their shoes, to take off heavy or bulky clothing/jewelry, and to empty their pockets. A brief tutorial on the use and proper placement of both PA monitors was given. The participant was instructed to wear the monitors upon waking and was asked to remove them when around water and when in bed. An elastic waistband, to hold the activity monitors, was issued to the participant to ensure accurate data collection. A PA log sheet was issued and was to be filled out during the seven days of assessment. Participants that did not wear the devices eight hours a day for at least four days were asked to wear the devices for another week.

Visit two was scheduled at the HPL at Ball State University. A packet was issued to each participant containing a health and medical history questionnaire (HHQ) and a Ball State University campus map. A completed version of the HHQ was to be returned to the investigator at the start of the second visit.

Visit Two

The participant arrived at the HPL at Ball State University one to two weeks after visit one. The HHQ, PA log sheet, GT3X accelerometer, and Omron pedometer were returned to the investigator. The HHQ was reviewed with the participant as they rested in
a seated position for five minutes prior to having their blood pressure measured. Resting blood pressure, resting pulse rate, and body composition measurements were obtained using standardized laboratory procedures outlined by the American College of Sports Medicine (ACSM) (1). The participant sat quietly in a chair with both feet flat on the floor and left arm supported at heart level. Blood pressures were obtained using a Littman stethoscope and an aneroid sphygmomanometer (Baumanometer®; W.A. Baum Co, Inc., Copiague, NY, USA). A total of two blood pressure measurements were taken with one minute of rest between measurements. If consecutive blood pressure measurements were not within two mmHg, a third measurement was obtained. The two closest measurements were averaged and used for analysis. The participant’s resting pulse rate was obtained between blood pressure measurements. Pulse rate was measured by a 30-second palpation of the radial artery in the anatomical left wrist.

Body composition measurements obtained at this visit include weight, height, waist, hip, bicep, thigh, and calf circumference measurements. Weight was measured at this visit on a calibrated digital scale to account for changes since visit one. The participant’s height was measured with a calibrated stadiometer (Seca 222; Vogel & Halke GmbH & Co, Hamburg, Germany). For height measurements, the participant stood erect with their feet flat on the floor and if possible was encouraged to have their heels, mid-body, and upper body touching the wall. To insure accuracy of weight and height measurements, the participant was asked to remove their shoes, to take off heavy or bulky clothing/jewelry, and to empty their pockets. Waist, hip, bicep, thigh, and calf circumference measurements were obtained on the anatomical right side of the participant’s body using the anatomical landmark guidelines outlined by ACSM (1).
Circumference measurements were taken twice and needed to be within two cm. Measurements greater than two cm apart were taken a third time and the two closest measurements were averaged and used for analysis.

A Lunar iDXA™ Dual-energy x-ray absorptiometer (enCORE software, version 13.40.038; GE Healthcare, Madison, WI, USA) (DXA) scan was performed to assess total body and regional adiposity. Participants were asked to remove all metal, belts, watches, and glasses. The participant was positioned on the iDXA table in a supine position in the alignment box. Participants that did not fit entirely in the alignment box were positioned so the anatomical right side of their body remained fully in the box while the anatomical left side of their body extended outside the alignment box. The participant was instructed to lie still and to keep their hands at their sides for the duration of the scan. A black Velcro band was wrapped around the participant’s ankles to minimize leg movement. The iDXA software automatically utilized the “thick mode” setting to scan individuals who had a body thickness greater than 25 cm. Body thickness is determined from height and weight values entered into the program at the start of the scan. At the completion of the scan, the iDXA estimates body adiposity values for participants that are unable to fit completely in the alignment box.

A submaximal treadmill test was performed and consisted of a warm-up that was one minute in duration at a speed of 1.2 mph, followed by one four minute stage of walking at 1.5mph at 1% grade (~2.4 METs) and one four minute stage of walking at 2.3mph at 4% grade (~4 METs). During the test, participants were connected to telemetry monitoring on the 12-lead electrocardiogram (Case P2 Series; GE Medical Information Technologies, Milwaukee, WI, USA). Additionally, oxygen consumption (VO₂), carbon
dioxide production (VCO₂), and respiratory exchange ratio (RER) were measured continuously via the Parvo Trueone 2400 Metabolic Measurement system (ParvoMedics, Inc., Sandy, UT, USA). Data was analyzed using one minute averages. Treadmill testing procedures and the Borg rating of perceived exertion scale (RPE) were reviewed with the participant prior to testing. Blood pressures were obtained in the supine and standing positions from the anatomical left arm of the participant. A headpiece, mouthpiece, and nose clip were put on the participant and were adjusted for best fit. Heart rate and RPE were recorded each minute and blood pressure measurements were obtained during minute four and eight of the test. The test was terminated early if the participant reached 85% of their max HR (220 minus their age) or if the participant experienced signs, symptoms, or responses established as termination criteria (1).

The Omron pedometer and GT3X accelerometer were downloaded at the completion of visit two and the Omron pedometer was returned to the participant to be used throughout the study. A blood analysis requisition form was issued to the participant and was to be taken to LabCorp in Muncie, IN within one to two days of testing. The participant was instructed to fast for ten to 12 hours prior to having their blood drawn at LabCorp. Variables assessed from the fasting blood sample include glucose, insulin, LDL-cholesterol, HDL-cholesterol, and triglycerides. The participant was scheduled for visit three at the HPL and was asked to arrive well rested, fasted for at least four hours, and was instructed not to consume caffeine or tobacco prior to this visit.

Visit Three

The participant arrived at the HPL one to two weeks after visit two for a resting metabolic rate (RMR) measurement via the dilution method (ParvoMedics, Inc.). Prior to
the RMR measurement, confirmation of a four hour fast was obtained. The participant was left to lie in a dark room for 30 minutes prior to data collection. A hood was placed over the participant’s head and shoulders and was connected to the metabolic measurement system via a breathing tube. Throughout the test, the hood was supplied with a steady flow of oxygen that was closely monitored to prevent hyperventilation. The participant was instructed to lie still throughout the measurement and was told not to fall asleep. Energy expenditure was calculated by analyzing VO$_2$ for 15-30 minutes. Duration of the measurement varied based on the time it took to stabilize FeCO$_2$% values (0.8-1.2) (25).

After the RMR measurement, the participant was issued an Active Living Every Day (ALED) textbook. Online instructions and demonstration were provided to the participant on how to use the online ALED program, how to begin the 12-week PA intervention, and how to obtain online/Web site technical support if needed (25). The participant was instructed to read one chapter from the ALED textbook a week and was strongly encouraged to record their daily steps in the online ALED steps-log. Prior to leaving, the participant was reminded that one month from visit three they would need to return to the lab for a download of their Omron pedometer.

**Monthly Downloads**

One month after visit three participants return to the HPL for a download of their Omron pedometer. Monthly download meetings were roughly ten minutes in duration and were necessary to clear the 41-day memory capacity of the Omron. Progress through the ALED program was also discussed and the investigator provided encouragement and support when necessary. Monthly downloads continued for a total of three month. Future
meeting dates/times were discussed with the participant prior to departure.

Visit Four and Five

At the completion of the ALED 12-week PA intervention, participants were scheduled to return to the HPL to repeat the testing completed during visits two and three. Re-testing must be completed prior to bariatric surgery.

Visit Six and Seven

Participants were contacted six months post bariatric surgery and were asked to return to the HPL to repeat the testing completed during visits four and five. Participants were asked to bring their Omron pedometers to visit six so the 41-day memory capacity of the device could be cleared. The Omron is worn for the remainder of the study.

PA Assessment Devices

PA levels were monitored throughout the study by the Actigraph Model GT3X tri-axial accelerometer and the Omron Healthcare Model HJ-720ITC dual-axis pedometer. The accelerometer was used to assess activity counts, steps taken, energy expenditure, and activity levels. In this study, activity counts from the GT3X accelerometer were used to analyze PA levels and sedentary, light, and MVPA among study participants. Lopes et al. validated activity count cut-points for sedentary (0-199 counts/minute), light (200-1,239 counts/minute), and MVPA (≥ 1240 counts/minute) in the overweight and obese population using the Actigraph (88). These cut-points were used to define sedentary (< 1.5 METs), light (1.5-2.9 METs), and MVPA (≥ 3 METs) in the present study. Each participant’s Actigraph accelerometer dataset in the present study was assessed via Actilife software (version 6.4.5) for data validation purposes; the
Actilife software was used to convert the downloaded Actigraph data into files that were opened and analyzed in a Microsoft Excel 2007 spreadsheet (Microsoft Corporation, Redman, Washington, USA) by the investigator. The Omron pedometer was used to quantify steps taken per day by the participant. The Omron pedometer can be worn on a waistband at the midline of the thigh; however, the device is validated for alternate mounting positions among the obese population such as a pocket (16). Omron pedometer data was assessed via Omron Health Management Software (version 1.3) (25). For assessment, the accelerometer needed to be worn a minimum of four days and each day must contain at least eight hours of wear time. Furthermore, Omron data was excluded from the data analysis if it contained <1,000 steps/day. The GT3X accelerometer and Omron pedometer were worn during pre-ALED, post-ALED, and six-month post-surgery assessments. Furthermore, the Omron pedometer was worn continuously throughout the 12-week ALED intervention.

Active Living Every Day Program

The ALED program is a 12-week, step-by-step plan, for building a healthier life and integrating PA into everyday living. The primary goal of the ALED program is to help people make positive changes in their life that will benefit their health and well-being. The ALED program is delivered in a variety of ways to match each participants learning style, readiness to change, self-confidence, and lifestyle. Participants are supported through learning activities, online assessments, books, and guidance from the study investigator (125). In this study, the PA intervention was conducted through the use of a supplemental ALED textbook that was issued to each study participant. Participants were shown how to access the secure website where they were strongly encouraged to log
their daily steps and participate in learning activities and assessments. The supplemental online program contains 12 sections that correspond to the 12 chapters in the ALED textbook; online versions of the activities offered in the book, links to other Web sites, and suggested readings for further self-study are provided within each of the sections (25).

**Statistical Analysis**

Descriptive statistics were used to describe baseline characteristics of participants. Paired samples t-tests were used to examine differences in primary (PA) and secondary outcomes (health profile, and psychosocial factors) from pre-intervention to six-month post-intervention. One-way repeated measures of analysis of variance (ANOVA) was used to test whether primary and secondary outcomes were different across pre-intervention, post-intervention and six-month post-surgery. A total of 19 participants were analyzed using paired samples t-tests and six participants were analyzed using one-way repeated measures ANOVA. Post-hoc tests with LSD adjustment were performed if $F$-tests in ANOVA were statistically significant. All analyses were conducted using the SPSS version 20.0 (IBM, Chicago, IL) and an alpha value of .05 was used to indicate statistical significance.
CHAPTER IV

RESEARCH MANUSCRIPT

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BARIATRIC SURGERY PHYSICAL ACTIVITY INTERVENTION

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ABSTRACT

Purpose: To investigate the effect of the 12-week Active Living Every Day (ALED) internet-based PA intervention on PA levels, health profile, and health-related psychosocial factors in bariatric patients. Methods: Efficacy of the ALED program was compared across three study time points; pre-intervention, post-intervention and six-month post-surgery. PA was objectively measured at all study time points using the Omron pedometer (HJ-720ITC) and the Actigraph GT3X accelerometer in 19 bariatric patients (2 male, 17 female, 43 ± 12 years). Results: Significant improvements (P < 0.05) in body composition (weight, percent body fat, waist and hip circumference) occurred from pre-intervention to post-intervention and from post-intervention to six-month post-surgery. Additionally, significant improvements were observed in BMI from pre-intervention to six-month post-surgery and from post-intervention to six-month post-surgery. Furthermore, significant improvements were observed in LDL cholesterol and self-efficacy from pre-intervention to six-months post-surgery. Mean steps/day and time spent in sedentary, light, and MVPA increased from pre-intervention through six-month post-surgery; however, these changes were not statistically significant. Participants that used the online step log ≥ 65 times increased their mean steps/day and spent less time in SB at pre-intervention, post-intervention and six-month post-surgery. Additionally, compliant participants spent more time participating in light and MVPA at pre-intervention and post-intervention than non-compliant participants. Changes observed in compliant participants were not at the level of statistical significance. Conclusion: The 12-week ALED PA intervention did not significantly improve PA levels in previously sedentary bariatric surgery patients who were non-compliant prior to bariatric surgery or
six months following surgery; however, the intervention led to improvements in cardiovascular risk factors, RPE and self efficacy.

Keywords: Obesity, Pedometer, Accelerometer, Internet, Physical Activity Intervention
**Introduction**

In less than 40 years, the prevalence of obesity in the U.S. has increased by over 50%, so that two of every three American adults are now overweight or obese (2). Specifically, 68% of US adults (73% of men and 64% of women) are currently considered overweight or obese (30) and 5% of adults are considered to be extremely or morbidly obese (11, 29). Forecasts suggest that by 2030, 51% of the population will be obese and 11% of the population will be severely obese (18). This rapid rise in obesity has come at a significant health cost to the American population because excess weight is a risk factor for numerous conditions including diabetes, hypertension, hyperlipidemia, stroke, heart disease, cancer, osteoarthritis, and other diseases (15, 16).

Obese individuals are found to have medical costs that are approximately 30% greater than their normal weight peers (17, 37, 38). The growing prevalence of obesity was responsible for almost $40 billion of increased medical spending from 1998 to 2006, including $7 billion in Medicare prescription drug costs (19). The aggregate national cost of overweight and obesity combined was $113.9 billion in 2008 (35). If the current growing trends of obesity continue, it is projected that the total healthcare costs attributable to obesity could reach $861 to $957 billion by 2030, which would account for 16 to 18% of US health expenditures (37). Given the high economic burden of obesity, it is important to develop effective interventions to help obese individuals lose and maintain weight loss.

Long-term successes of lifestyle modifications and drug therapy have been disappointing in the obese population. Currently bariatric surgery is considered the most effective method to induce and maintain significant weight loss (~70% of excess weight).
among the morbidly obese (9). The National Institute of Health has recommended surgical therapy (i.e. bariatric surgery) for patients with a body mass index (BMI) \( \geq 40 \text{ kg/m}^2 \) or \( \geq 35 \text{ kg/m}^2 \) with serious obesity-related co-morbidities such as systemic hypertension, type 2 diabetes mellitus, and obstructive sleep apnea (31). Recent studies suggested that success following bariatric surgery may also be associated with the individual’s ability to make lifestyle changes, especially by increasing physical activity (PA) levels (4, 10). Lifestyle PA interventions have been developed as a means to promote PA among sedentary U.S. adults. Lifestyle PA is defined as the daily accumulation of at least 30 minutes of self-selected activities, which includes all leisure, occupational, or household activities. These activities are moderate-to-vigorous in their intensity and could be planned or unplanned activities that are part of everyday life (13). Previous research showed that lifestyle PA interventions were effective at increasing and maintaining levels of PA, as well as improving perceptions of PA, in sedentary adults (13). Additional research is necessary to better understand the impact of PA interventions on PA levels over longer periods of time.

The current study focused on PA levels in bariatric patients six months after bariatric surgery. This study utilized the Active Living Every Day® (ALED) program created by Blair et al. (34). The ALED program is a 12-week internet-based PA intervention that utilizes self-monitoring tools (i.e. pedometer/accelerometer), considers readiness to change behavior, helps solve problems and overcome obstacles, and gives tips for making other healthy lifestyle changes. The primary purpose of this study was to determine the short-term and long-term effects of the ALED intervention on PA levels, health profile and psychosocial factors in bariatric patients. Therefore, the hypothesis of
this study was that bariatric patients completing the internet-based 12-week ALED program would see improvements in PA levels, health profile and health-related psychosocial factors from pre- to post- ALED intervention and would continue improving through six-month post-surgery follow-up.

**Methods**

**Participant Recruitment**

The Institutional Review Boards at Ball State University and Indiana University Health Ball Memorial Hospital approved this study. This study used a quasi-experimental, one-group pre-and post-test study design. Study participants were recruited at bariatric seminars conducted once a month at the Indiana University Health Ball Memorial Bariatric Center (IUHBC). Recruited participants (n = 36) completed a study orientation where an informed consent and a protected health information form were reviewed with the participant. In total, participants met with the study investigator on seven separate occasions, once at the IUHBC and six times at the Human Performance Laboratory (HPL) at Ball State University. To be included in the study participants needed to be 18 years of age or older, needed to be scheduled to undergo bariatric surgery at an Indiana University Hospital location within four to six months of their recruitment date, and needed to be participating in the pre-surgery preparatory requirements at IUHBC. Participants were excluded from the study if they were unable to walk, if they did not have weekly access to the internet, and if they were unable to read or write.

**Physical Activity Measurements**

PA was objectively measured in this study through the use of an Omron pedometer (Omron Healthcare Model HJ-720ITC dual-axis pedometer; Omron
Healthcare, Inc., Bannockburn, IL, USA) and a GT3X accelerometer (Actigraph Model GT3X tri-axial accelerometer; Actigraph, Pensacola, FL, USA). Participants were instructed to wear both monitors upon waking and were asked to remove them when around water and when in bed. Additionally, participants were issued a PA log sheet and were instructed to complete it during the seven days of assessment at pre-intervention, post-intervention and six-month post-surgery follow-up. In this study, PA questionnaires were utilized as a means to compare subjectively measured PA to objectively measured PA. These questionnaires assessed whether or not participants were currently physically active (performing PA such as walking briskly, jogging, cycling, swimming or other activities of similar intensity) and if they were currently regularly active (participate in ≥ 30 minutes of PA, five days/week).

PA Assessment Devices

The Actigraph Model GT3X tri-axial accelerometer was used to assess activity counts, steps, energy expenditure, and activity levels. In this study, activity counts from the GT3X accelerometer were used to analyze PA and sedentary, light, and moderate-to-vigorous activity among study participants. Lopes et al. validated activity count cut-points for sedentary (0-199 counts/minute), light (200-1,239 counts/minute), and moderate-to-vigorous (≥ 1240 counts/minute) activity in the overweight and obese population using the Actigraph (26). These cut-points were used to define sedentary (< 1.5 METs), light (1.5-2.9 METs), and moderate-to-vigorous activity (≥ 3 METs) in the present study. The Omron pedometer was used to quantify steps taken per day by the participant. Omron pedometer data was assessed via Omron Health Management Software (version 1.3) (7). Data inclusion criteria were that the accelerometer needed to
be worn a minimum of four days and each day must contain at least eight hours of wear time. Additionally, the Omron pedometer needed to contain > 1,000 steps/day to be included in the data analysis. The accelerometer and pedometer were worn during pre-intervention, post-intervention, and six-month post-surgery assessments. Furthermore, the Omron pedometer was worn continuously throughout the 12-week ALED intervention.

**Health Profile Measurements**

Resting blood pressure, resting pulse rate, and body composition measurements were obtained using standardized laboratory procedures outlined by the American College of Sports Medicine (ACSM) (1). Body composition measurements obtained include weight, height, waist, hip, bicep, thigh, and calf circumference measurements. Circumference measurements were obtained on the anatomical right side of the participants’ body using the anatomical landmark guidelines outlined by ACSM (1). A Lunar iDXA™ Dual-energy x-ray absorptiometer (enCORE software, version 13.40.038; GE Healthcare, Madison, WI, USA) (DXA) scan was performed to assess total body and regional adiposity. The submaximal treadmill test protocol consisted of a warm-up that was one minute in duration at a speed of 1.2 mph, followed by one four minute stage of walking at 1.5 mph at 1% grade (~2.4 METs) and one four minute stage of walking at 2.3 mph at 4% grade (~4 METs). During the treadmill test, participants were connected to telemetry monitoring on the 12-lead electrocardiogram (Case P2 Series; GE Medical Information Technologies, Milwaukee, WI, USA). Additionally, oxygen consumption (VO₂), carbon dioxide production (VCO₂), and respiratory exchange ratio (RER) were measured continuously via the Parvo Trueone 2400 Metabolic Measurement system (ParvoMedics, Inc., Sandy, UT, USA). During the treadmill test, heart rate (HR) and RPE
were recorded each minute and blood pressure measurements were obtained during minute four and eight. The test was terminated early if the participant reached 85% of their maximal HR (220 minus their age in years) or if the participant experienced signs, symptoms, or responses established as termination criteria (1). Blood samples were analyzed at LabCorp in Muncie, IN. Variables assessed from the fasting blood sample include glucose, insulin, LDL-cholesterol, HDL-cholesterol, and triglycerides. Lastly, a resting metabolic rate measurement (RMR) was obtained via the dilution method (ParvoMedics, Inc.). After lying in a dark room for 30 minutes, a hood was placed over the participant’s head and shoulders and was connected to the metabolic measurement system via a breathing tube. Resting energy expenditure was calculated by averaging ten minutes of steady state kcal values. Duration of the measurement varied (15-30 minutes) based on the time it took to stabilize FeCO$_2$% values (0.8-1.2).

**Psychosocial Measurements**

Health-related psychosocial variables were analyzed in this study through the use of a satisfaction of life survey, self-efficacy survey, stage of change questionnaire, exercise barrier questionnaire and exercise thoughts questionnaire (12, 24, 28, 33).

**Active Living Every Day Program**

The ALED program is a 12-week, step-by-step plan, for building a healthier life and integrating PA into everyday living. The primary goal of the ALED program is to help people make positive changes in their life that will benefit their health and well-being (34). In this study, the PA intervention was conducted through the use of a supplemental ALED textbook that was issued to each study participant. Participants were shown how to access the secure web site where they were strongly encouraged to log
their daily steps and participate in learning activities and assessments. The supplemental online program contains 12 sections that correspond to the 12 chapters in the ALED textbook; online versions of the activities offered in the book, links to other Web sites, and suggested readings for further self-study are provided within each of the sections.

Procedures

Recruited participants were scheduled for a brief orientation meeting at the IUHBC where the study timeline, study procedures, informed consent and protected health information form were reviewed with the participant. Upon consent, psychological questionnaires were administered and the participant was issued an Omron pedometer and a GT3X accelerometer. The participant was also issued a health and medical history questionnaire (HHQ) to return at visit two.

The participant arrived at the HPL at Ball State University one to two weeks after orientation. The HHQ and PA log sheet were returned and reviewed. Resting blood pressure, resting pulse rate, and body composition measurements were obtained. A Lunar iDXA™ Dual-energy x-ray absorptiometer scan was performed to assess total body and regional adiposity and a submaximal treadmill test was performed using the IPAC protocol. The Omron pedometer and GT3X accelerometer were downloaded and the Omron pedometer was returned to the participant to be used throughout the study. A blood analysis requisition form was issued to the participant and visit three was scheduled one to two weeks later at the HPL. At visit three the participant completed a resting metabolic rate measurement and received an ALED textbook and access to the secure ALED internet site. Instructions were provided regarding proper use of the online ALED program.
One month after visit three participants returned to the HPL for a download of their Omron pedometer. Monthly downloads continued for a total of three months. At the completion of the ALED 12-week PA intervention, participants were scheduled to return to the HPL to repeat the testing completed during visits two and three. Re-testing was completed prior to bariatric surgery. Participants were contacted six months post bariatric surgery and were asked to return to the HPL to repeat the testing completed during visits four and five.

**Statistical Analysis**

Descriptive statistics were used to describe baseline characteristics of participants. Paired samples t-tests were used to examine differences in primary (PA) and secondary outcomes (health profile, and psychosocial factors) from pre-intervention to six-month post-intervention. One-way repeated measures of analysis of variance (ANOVA) was used to test whether primary and secondary outcomes were different across pre-intervention, post-intervention and six month follow-up. A total of 19 participants were analyzed using paired samples t-tests and six participants were analyzed using one-way repeated measures ANOVA. Post-hoc tests with LSD adjustment were performed if F-tests in ANOVA were statistically significant. All analyses were conducted using the SPSS version 20.0 (IBM, Chicago, IL) and an alpha value of .05 was used to indicate statistical significance.

**Results**

Of the 36 participants recruited for this study, 19 participants completed post-intervention assessments, and of those 19 participants, six participants completed six-month follow-up assessments. Participants were not contacted for six-month post-surgery
assessments due to not being approved for surgery, for choosing not to have surgery, or for dropping out of the current study early. Participants consisted of 17 female and two male Caucasian adults who were either overweight or obese (BMI 49 ± 8 kg/m²) and ranged in age from 22-65 years (43 ± 12 years). Participant baseline characteristics are displayed in Table 4.1. Mean steps/day did not increase significantly from pre-intervention through six-months post-surgery (7% increase from pre-intervention to post-intervention and 33% increase from post-intervention at six months post-surgery). The mean pedometer step data is presented in Figure 4.1 and Figure 4.2. The mean accelerometer wear time (time spent in sedentary, light, and MVPA) also did not change significantly from pre-intervention through six-months post-surgery. Mean accelerometer wear time data is presented in Table 4.4 and Figure 4.3.

Subjectively measured PA variables did not significantly change from pre-intervention through six-months post-surgery. Although not significant, participants reported becoming more regularly active (11% at pre-intervention, 21% at post-intervention and 50% at six months post-surgery) and physically active (37% at pre-intervention, 63% at post-intervention and 100% at six months post-surgery) from pre-intervention through six-months post-surgery.

Significant decreases (P < .05) in weight, percent body fat, waist circumference and hip circumference measurements were observed from pre-intervention to post-intervention (2%) and from pre-intervention to six months post-surgery (weight 24%, percent body fat 2%, waist circumference 19% and hip circumference 13%). In addition, a significant decrease was observed in BMI from pre-intervention to six-months post-
surgery (20%) as well as from post-intervention to six-months post-surgery (19%). Body composition variables are presented in Table 4.2.

A significant decrease in LDL cholesterol was observed from pre-intervention through six-months post-surgery (12%); however, triglycerides, HDL cholesterol, glucose and insulin did not change significantly from pre-intervention through six-months post-surgery. Blood profile variables are presented in Figure 4.4.

A significant decrease in submaximal RPE was observed from pre-intervention to post-intervention (10%) and from post-intervention to six-months post-surgery (18%). Additionally, resting SBP, resting DBP, submaximal peak HR and submaximal peak VO2 did not change significantly from pre-intervention through six-month follow-up. Submaximal treadmill data are presented in Table 4.3.

Significant improvements were observed in self-efficacy from pre-intervention to six-months post-surgery (6%). Exercise barriers, life satisfaction and exercise thoughts did not change significantly from pre-intervention through six-months post-surgery. Health-related psychosocial factors are presented in Figure 4.5.

**Discussion**

The primary finding of this study was that participants did not significantly increase their steps/day or significantly change time spent in sedentary, light and moderate-to-vigorous intensity activities after 12-weeks of the ALED PA intervention or six months post-surgery. Previous research findings are consistent with the current study. Carr et al. found that the internet-delivered ALED PA intervention significantly increased PA (17%) and significantly decreased CVD risk factors in sedentary, overweight adults (8). The results of Carr et al. may vary from the current study results due to differences in
participant baseline characteristics and differences in intervention length (16-week vs. 12-week intervention). Specifically, current study participants were slightly older (43 ± 12 vs. 41 ± 4 years), had higher BMI values (49 ± 9 vs. 32 ± 1 kg/m²) and had lower pre-intervention step averages (3756 ± 1765 vs. 7215 ± 869 steps/day). One explanation for the non-significant changes in PA levels observed in the current study may be due to poor study adherence. Current research shows that the majority of bariatric patients remain non-compliant with PA and other physician recommendations prior to and following bariatric surgery. Furthermore, unsuccessful weight loss or weight regain are predicted to be the result of a lack of patient follow-up or adherence to post-operative recommendations, such as increasing PA (14, 27). In the current study, only 32% of all study participants (n = 19) were considered adherent (≥65 step log logins) to the ALED intervention (Figure 4.1).

The baseline steps/day (3756 ± 1765) achieved by the bariatric patients participating in this study were much less than those found in other studies. Tudor-Locke et al. (36) found that obese adults (BMI ≥ 30kg/m²) took 5,784 ± 124 steps/day and spent 17 ± 1 minutes/day in moderate intensity activities and 3.2 ± 0.4 minutes/day in vigorous intensity activities. Goodpaster et al. (22) found that the baseline step average for the 67 severely obese subjects (BMI 44 ± 5 kg/m²) that participated in the study was 7,048 ± 2,886 steps/day. It is important to note that baseline steps/day may vary between these studies and the current study due to differences in baseline BMI. Specifically, participants in the current study had a higher baseline BMI than participants in Tudor-Locke et al. and Goodpaster et al. studies, which may explain why current study participants had lower
baseline steps/day. Baseline steps/day may also vary between these studies due to the method by which steps/day were measured. Tudor-Locke et al. utilized the Actigraph AM-7164 accelerometer and Goodpaster et al. utilized the SenseWear Pro3 Armband, while the current study utilized an Omron pedometer and an Actigraph accelerometer. Of the PA devices used in these studies and in the current study, the Omron pedometer and the Actigraph accelerometer are the only ones that have been validated for use among the obese/overweight adult population but not for the bariatric population (3, 23, 26). Previous research found that PA devices (such as the Yamax SW digi-walker, StepWatch 3, Actical and SenseWear Pro 2 armband) overestimated steps/day to a greater degree in the obese population. This was due to decreased sensitivity as the pedometer is tilted away from the vertical axis (3). Therefore, the step averages reported by the Omron pedometer and Actigraph accelerometer in the current study may more accurately represent the PA behavior of most bariatric patients.

The ALED program utilized in the current study was designed based on the principle that moderate amounts and intensities of PA have health benefits. Specifically, adults who are unable to meet the recommendations for PA outlined by ACSM can benefit from engaging in amounts of PA less than recommended. Additionally, decreasing time spent in sedentary pursuits and incorporating short bouts of standing and PA during sedentary time is associated with health benefits (21). Based on these findings, the non-significant increases in steps/day observed in the current study represent a beneficial or clinically meaningful lifestyle change.

Results of the current study also revealed that bariatric patients spent approximately 79% of their time in sedentary behavior (SB), 17% of their time
performing light intensity activities and 4% of their time performing moderate-to-vigorous intensity activities at pre-intervention. Results of the current study are consistent with findings of Bond et al. (3, 6) who sought to objectively quantify the amount of time that bariatric surgery candidates spent in SB (SB < 1.5 METs). This study examined the SB of 42 bariatric surgery candidates (BMI 50 ± 8 kg/m², body weight 136 ± 25 kg and age 45 ± 9 years) using the SenseWear Pro2 Armband. Bond et al. found that bariatric patients spend approximately 81% of their day in SB, 15% of their day participating in light intensity activities and only 4% of their day participating in moderate-to-vigorous intensity activities prior to surgery. Participants in the current study had very similar baseline characteristics to those in the study by Bond et al (BMI 49 ± 8 kg/m², body weight 136 ± 25 kg and age 43 ± 12 years). In the current study, the changes in PA levels that occurred among these participants were not at the level of statistical significance. Specifically, participants spent approximately 75% of their time in SB, 27% of their time in light intensity activity and 10% of their time in moderate-to-vigorous intensity activity at six-months post-surgery. Of the entire study cohort (n = 19), nine participants decreased SB from pre-intervention to post-intervention and two participants continued to decrease SB through six-month follow-up (n = 6). Furthermore, five participants increased time spent in moderate-to-vigorous PA from pre-intervention to post-intervention and four participants increased time spent in moderate-to-vigorous PA through six-month follow-up. In general, PA was most often represented in bouts < ten minutes in duration. The entire study cohort averaged approximately one bout > ten minutes in duration at baseline and increased their average to approximately two bouts > ten minutes in duration through six-months post-surgery.
Participants in the current study were asked to login to the ALED website and record their daily steps into the online step-log. Throughout the three month intervention, participants logged into the online intervention an average of 13 times, utilized the step log an average of 55 days (65% of study intervention days), and utilized an average of nine non-tool pages (4% of study non-tool pages). Additionally, participants used the non-tool pages for an average of 63 minutes throughout the intervention (Table 4.5). The use of the online ALED program materials, such as the step log, appeared to be related to mean steps/day and time spent in SB. Richardson et al. reported that objective monitoring and step-count feedback can increase walking (32). Participants that used the online step log $\geq 65$ times were considered compliant. These participants increased their mean steps/day and spent less time in SB at pre-intervention, post-intervention and six months post-surgery. Additionally, compliant participants spent more time participating in light and moderate-to-vigorous activities at pre-intervention and post-intervention than non-compliant participants. Changes observed in compliant participants were not at the level of statistical significance.

In this study PA questionnaires were utilized to subjectively measure PA. These questionnaires asked patients to answer yes or no to the following statements: “I am currently physically active” or “I am currently regularly active.” These variables did not significantly change across all study time points; however, over the course of the study participants reported becoming more physically and regularly active. Specifically, 37% of participants reported being physically active at pre-intervention 63% reported being physically active at post-intervention and 100% reported being physically active at six-months post-surgery. In addition, 11% of participants reported being regularly active at
pre-intervention while 21% reported being regularly active at post-intervention and 50% reported being regularly active at six-months post-surgery. Subjectively measured PA was compared to the values obtained through objective measures of PA and it was found that bariatric patients in the current study were over-reporting their PA levels. Previous research by Bond et al. (5) supports that bariatric patients tend to over-report their PA levels from pre to six-months post-surgery. Specifically, Bond et al. found that study participants self-reported a near five-fold increase in MVPA from pre- to six-months post-surgery when objective accelerometer data indicated no significant changes in MVPA. Both studies utilized similar follow-up assessment time points and study participants had similar baseline characteristics. Based on the findings of Bond et al. and of the current study, it is suggested that objective measurements of PA be used when working with the bariatric population.

A statistically significant decrease in submaximal peak RPE was also observed during the submaximal exercise test following the 12-week intervention and six-months post-surgery. This means that participants perceived the maximal absolute workload (4 METs) to be less difficult at follow-up and six-months post-surgery than at baseline. This is encouraging because this could translate into a decreased RPE for home activities of the same intensity as the submaximal treadmill test. A lower perception of difficulty for home exercises could lead to increases in lifestyle PA while at home and could ultimately lead to significant increases in PA levels long-term. Current study results also showed a significant increase in self-efficacy from baseline to six-months post-surgery. The significant decrease observed in submaximal peak RPE and the significant increase observed in self-efficacy implies that participants perceive PA to be less difficult and are
more confident in their ability to participate in it. Both of these findings may result in increased lifestyle PA levels long term. Furthermore, current study results showed non-significant changes in life satisfaction, exercise barriers, and exercise thoughts across all study time points. Even though the results did not reveal statistically significant changes in these variables, they all improved from pre-intervention through six-months post-surgery. This means participants could be identifying less obstacles to being active at post-intervention and six-months post-surgery than at pre-intervention. Additionally, participants identified fewer thoughts regarding whether or not to exercise at post-intervention and six-months post-surgery than at pre-intervention. This is encouraging because having fewer obstacles to being active and thinking about exercise participation differently could translate into increased PA levels long term. Studies of weight loss have shown that barriers to PA, self-efficacy, and additional behavioral and cognitive factors contribute to PA adoption and maintenance (20, 25).

Limitations to the current study include a small sample size and a lack of diversity (race and gender) among study subjects. The current study population consisted of Caucasian women; therefore, it is unclear whether a similar change in PA levels would occur in a different study population. Additionally, having a larger more diverse sample would make findings more generalizable. Another limitation to the current study is that consistency and compliance to pre-surgery dietary recommendations were not controlled for. As a result, it is unclear how much of an impact diet had on body composition changes. An additional limitation to this study is that we were not able to control for the body composition changes that occurred as a result of having bariatric surgery. Therefore, it is unclear how much bariatric surgery impacted the body composition changes that
took place after the 12-week ALED intervention. It is difficult to discern whether PA levels increased and sedentary time decreased as a result of the ALED PA intervention or if they occurred in response to body composition changes that accompany bariatric surgery.

**Conclusion**

The 12-week ALED PA intervention utilized in the current study was not effective at improving PA levels in previously sedentary bariatric surgery patients who were not compliant to the ALED program. Bariatric patients did not significantly increase their PA levels after 12-weeks of the ALED PA intervention or six-months after surgery; however, improvements in steps/day occurred from baseline to follow-up (7%) through six-months post-surgery (33%) (21). Compared to the values obtained through objective measures of PA, bariatric patients in this study over reported their PA levels. The significant decrease in submaximal peak RPE and significant improvement in self efficacy that occurred suggests that participants perceived physical activities to be easier for them, which means they may be more likely to increase their lifestyle PA levels. It appears that the ALED PA intervention created minimal improvement in psychosocial factors among bariatric patients. Future researchers should consider repeating the current study with a larger sample size and a standard care control group. It would also be beneficial to assess dietary changes that are required of bariatric patients prior to surgery.
Figure Legend

Figure 4.1: Individual mean steps/day at pre-intervention, month one, month two, month three, post-intervention and six-months follow-up for participants who used the online ALED step-log ≥ 65 times and for participants who used the step log < 65 times throughout the study intervention.

Figure 4.2: Change in PA level (average steps/day) from pre-intervention to post-intervention and from post-intervention to six-month follow-up.

Figure 4.3: Change in mean monitored wear time (hr/day) from pre-intervention to post-intervention and from post-intervention to six month follow-up.

Figure 4.4: Change in blood profile variables from pre-intervention to post-intervention and from post-intervention to six-month follow-up.

Figure 4.5: Change in psychosocial factor scores from pre-intervention to post-intervention and from post-intervention to six-month follow-up.
Table 4.1: Participant descriptive characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-intervention (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>43 ± 12</td>
</tr>
<tr>
<td>Gender (n)</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>2</td>
</tr>
<tr>
<td>Women</td>
<td>17</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>136 ± 25</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>49 ± 8</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>52.4 ± 6.3</td>
</tr>
</tbody>
</table>

Values are means ± SD. SD, standard deviation; BMI, body mass index.
**Table 4.2:** Body composition variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-intervention (n = 19)</th>
<th>Post-intervention (n = 19)</th>
<th>Six month Post-surgery (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>136.5 ± 25.3</td>
<td>132.5 ± 24.0*</td>
<td>103.4 ± 19.1(\Delta^†)</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>49.3 ± 8.2</td>
<td>48.3 ± 7.3</td>
<td>38.6 ± 8.2(\Delta^†)</td>
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<tr>
<td>Body Fat (%)</td>
<td>52.4 ± 6.3</td>
<td>51.6 ± 6.5*</td>
<td>50.6 ± 5.6(\Delta^†)</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>122.5 ± 14.4</td>
<td>120.1 ± 13.4*</td>
<td>99.5 ± 6.7(\Delta^†)</td>
</tr>
<tr>
<td>Hip (cm)</td>
<td>150.1 ± 14.2</td>
<td>147.3 ± 13.1*</td>
<td>130.8 ± 11.3(\Delta^†)</td>
</tr>
</tbody>
</table>

Values are means ± SD. SD, standard deviation; BMI, body mass index; * Significant difference between pre-intervention and post-intervention (P < .05); \(\Delta\) Significant difference between pre-intervention and six month post-surgery (P < .05); \(^†\) Significant difference between post-intervention and six month post-surgery (P < .05).
<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-intervention (n = 19)</th>
<th>Post-intervention (n = 19)</th>
<th>Six month Post-surgery (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic BP (mmHg)</td>
<td>122.2 ± 14.3</td>
<td>120.7 ± 12.7</td>
<td>110.3 ± 6.9</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>75.0 ± 7.7</td>
<td>73.8 ± 7.9</td>
<td>71.3 ± 6.4</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>138.2 ± 20.5</td>
<td>134.1 ± 19.9</td>
<td>125.0 ± 16.1</td>
</tr>
<tr>
<td>RPE</td>
<td>12.2 ± 2.1</td>
<td>11.0 ± 3.0*</td>
<td>9.0 ± 2.8^†</td>
</tr>
</tbody>
</table>

Values are means ± SD. SD, standard deviation; BP, blood pressure; HR, heart rate; RPE, rating of perceived exertion; * Significant difference between pre-intervention and post-intervention (P < .05); † Significant difference between pre-intervention and six month post-surgery (P < .05); †† Significant difference between post-intervention and six month post-surgery (P < .05).
### Table 4.4: Mean monitored wear time across intensity levels

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>Six month post-surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sedentary</strong> (n = 18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time (hr/day)</td>
<td>11.5 ± 3.5</td>
<td>10.0 ± 1.2</td>
<td>10.0 ± 0.7</td>
</tr>
<tr>
<td>% Wear Time</td>
<td>79</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>P Value</td>
<td>0.148</td>
<td>0.717</td>
<td></td>
</tr>
<tr>
<td><strong>Light</strong> (n = 15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time (hr/day)</td>
<td>2.5 ± 1.1</td>
<td>2.8 ± 1.0</td>
<td>3.5 ± 2.0</td>
</tr>
<tr>
<td>% Wear Time</td>
<td>17</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>P Value</td>
<td>0.769</td>
<td>0.266</td>
<td></td>
</tr>
<tr>
<td><strong>Moderate-to-Vigorous</strong> (n = 6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time (hr/day)</td>
<td>0.6 ± 0.4</td>
<td>0.6 ± 0.4</td>
<td>1.3 ± 1.1</td>
</tr>
<tr>
<td>% Wear Time</td>
<td>4</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>P Value</td>
<td>0.368</td>
<td>0.243</td>
<td></td>
</tr>
</tbody>
</table>

Values are means ± SD. Mean monitored wear time (hr/day) and proportion of mean monitored wear time (%) spent in sedentary, light and moderate-to-vigorous activity. One participant was excluded at pre-intervention and four participants were excluded from the analysis at post-intervention due to missing data.
Table 4.5: Online ALED program compliance

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step Log (days used)</td>
<td>55 ± 38</td>
</tr>
<tr>
<td>Non-tool pages (pages visited)</td>
<td>9 ± 12</td>
</tr>
<tr>
<td>Non-tool pages (minutes used)</td>
<td>63 ± 144</td>
</tr>
<tr>
<td>Logins (total)</td>
<td>13 ± 9</td>
</tr>
</tbody>
</table>

Values are means ± SD. SD, standard deviation. Descriptive characteristics for the average number of days the online ALED step log was used, the average number of non-tool pages that were visited, the average number of minutes spent on non-tool pages and the average number of logins to the online program. Four participants were excluded from the analysis due to never using the online ALED program and one additional participant was excluded from the step log analysis due to never utilizing it.
Figure 4.1

Individual Mean Steps/Day

Measurement Time Points

Pre-intervention  Month 1  Month 2  Month 3  Post-intervention  Six month post-surgery

≥ 65 Step Log Uses
< 65 Step Log Uses
Figure 4.2

Mean Steps/day

Measurement Time Points

Pre-intervention  Post-intervention  Six month post-surgery
Figure 4.3

The figure shows the mean monitored wear time (hr/day) across different activity levels: Sedentary Behavior, Light Activity, and Moderate/Vigorous Activity, at three different time points: Pre-intervention, Post-intervention, and Six month post-surgery.
Figure 4.4

Change in Blood Profile Variables (mg/dL and μIU/mL)

- Pre-intervention
- Post-intervention
- Six month post-surgery
Figure 4.5

Psychosocial Factor Scores

- Life Satisfaction
- Self Efficacy
- Exercise Barriers
- Exercise Thoughts

- Pre-intervention
- Post Intervention
- Six month post-surgery
REFERENCES


CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Long-term successes of lifestyle modifications and drug therapy have been disappointing in the obese population. Currently bariatric surgery is considered the most effective method to induce and maintain significant weight loss (~70% of excess weight) (27). It is known that bariatric surgery is associated with major improvements in co-morbidities, psychosocial factors, eating behavior, physical activity (PA) levels, and physical capacity. Recent studies suggest that success following bariatric surgery may also be associated with the individual’s ability to make lifestyle changes, especially by increasing PA levels (16, 30). Previous research shows that lifestyle PA interventions are effective at increasing and maintaining levels of PA short-term (41); however, less is known about the long-term effects (≥ six months) on PA levels and perceptions of PA in previously sedentary adults.

This study was one of the first to evaluate the effect of a PA intervention on PA levels among bariatric surgery patients six-months post-surgery. Current study participants underwent pre- and post-intervention assessments prior to bariatric surgery and participated in an additional assessment six-months post-surgery. All participants were given access to the Active Living Every Day® (ALED) program created by Blair et
al. (125). The ALED program is a 12-week internet-based PA intervention that utilizes self-monitoring tools (i.e. pedometer/accelerometer), considers readiness to change behavior, helps solve problems and overcome obstacles, and gives tips for making healthy lifestyle changes. This intervention is designed to equip each participant with the knowledge and tools necessary to increase PA levels prior to and following bariatric surgery.

The primary purpose of this study was to determine the short-term and long-term effects of the ALED PA intervention on PA levels in bariatric patients. Results of this study indicate that bariatric patients did not significantly increase their PA levels after 12-weeks of the ALED PA intervention or six-months after surgery; however, improvements in steps/day occurred from pre-intervention to post-intervention through six-months post-surgery. As a result of having six participants complete the six-month post-surgery follow-up assessments it is difficult to It is important to note that significant differences in steps/day may not have been observed due to only six of the 19 participants completing 6-month post-surgery assessments. Individual data suggests that participants that utilized the ALED website and accompanying tools were successful at increasing PA levels across study time points. Specifically, participants who recorded their daily steps into the online ALED step log ≥ 65 times (n = 6) had higher pre-intervention (4,547 ± 1,284 steps/day), post-intervention (6,156 ± 2,191 steps/day) and six-month post-surgery (7,708 ± 3,901 steps/day) steps/day than those that used the step log < 65 times (pre-intervention 3,391 ± 1,879 steps/day, post-intervention 3,036 ± 1,734 steps/day and six-month post-surgery 4,151 ± 992 steps/day). Statistically significant differences could not be determined due to a small sample size. Compliant participants also showed better
improvements in average steps/day from pre-intervention to post-intervention (35%) and from post-intervention to six-month post-surgery (25%). Additionally, compliant participants that had the lowest average steps/day at pre-intervention experienced greater improvements in their average steps/day at post-intervention and six-months post-surgery than their non-compliant counterparts. These improvements were not at the level of statistical significance. Carr et al. (26) found that the degree of baseline PA predicted the efficacy of the ALED program, meaning the ALED program may be best suited for the least active (i.e. less than ~7,000 steps/day). Furthermore, participants that used the step log < 65 times decreased their average steps/day from pre-intervention to post-intervention (10%) but observed increases from post-intervention to six-month post-surgery (37%).

Results of the current study also showed that SB did not significantly decrease after 12-weeks of the ALED intervention. Additionally, time spent in light and MVPA did not significantly increase after 12-weeks of the ALED intervention or six-months post-surgery. Participants that used the online step log ≥ 65 times averaged less SB at pre-intervention (9 ±1 h/day), post-intervention (9 ± 2 h/day) and six-months post-surgery (9 ± 1 h/day) than those who used the step log < 65 times (pre-intervention 13 ± 4 h/day, post-intervention 10 ± 1 h/day and six-months post-surgery (10.1 ± 0.5 h/day). Compliant participants also spent more time participating in light and MVPA at pre-intervention and post-intervention than non-compliant participants. The results of this study are consistent with findings from previous research that found that obese individuals spend the majority of their time in SB and very little time in MVPA (56, 131).
The second purpose of this study was to determine the short-term and long-term effects of the ALED intervention on the health profile of bariatric patients. Results of the current study showed significant improvements in body composition from pre-intervention through six-months post-surgery. Specifically, a significant decrease in weight, percent body fat, waist circumference and hip circumference measurements occurred from pre-intervention to post-intervention and from post-intervention to six-months post-surgery. A significant decrease in BMI also occurred from pre-intervention to six-months post-surgery and from post-intervention to six-months post-surgery. Furthermore, results of the current study showed a significant decrease in submaximal peak RPE and LDL cholesterol from pre-intervention through six-months post-surgery. The significant decrease in submaximal peak RPE could indicate that participants perceived the maximal absolute workload (four METs) to be easier at post-intervention and six-month post-surgery than at pre-intervention. This is encouraging because this could translate into a decreased RPE for home activities of the same intensity which could lead to increases in lifestyle PA and could ultimately lead to increases in PA levels long-term. Bariatric surgery candidates are required by the IUHBC to start a liver reduction diet within three months of their bariatric surgery. Since the implementation of the liver reduction diet was not part of the PA intervention but was a requirement for patients at IUHBC, diet was not assessed in the current study. Additionally, since participants consistency and compliance to the liver reduction diet was not controlled for in the current study, it is unclear how much of an impact the diet had on body mass/composition; therefore is difficult to reach specific conclusions. Research shows
that successful bariatric operations reduce body weight by 35-40% and maintain weight loss long term (15 years) (31).

The final purpose of this study was to determine the short-term and long-term effects of the ALED intervention on health-related psychosocial factors in bariatric patients. Results of the current study showed significant increases in self-efficacy from pre-intervention to six-months post-surgery, with non-significant increases in life satisfaction, exercise thoughts, and exercise barriers across all study time points. It should be noted that even though the change in these variables were not statistically significant, improvements in life satisfaction, exercise thoughts, and exercise barriers were observed across all study time points. The ALED PA intervention is designed to move individuals through the Transtheoretical Models stages of change. It is possible that the non-significant improvements in PA, from pre-intervention to post-intervention, represented the beginning of behavior change. Participants who used the step log ≥ 65 times averaged less SB at pre-intervention and therefore were more likely to be in a higher stage of change (preparation or action stage) at pre-intervention than those that used the step log < 65 times. Based on the current objective PA data, it would appear that most participants did not improve to a higher stage of the Transtheoretical Model at post-intervention and six-months post-surgery. Participants that used the online step log < 65 times were more likely in a lower stage of the Transtheoretical Model at pre-intervention (contemplation or preparation stage) and were not only recognizing the need for behavior change but were taking steps to begin making successful behavior changes. Previous research supports that the social cognitive theory and the Transtheoretical Model are the most effective behavioral theories for promoting PA behavior change (93, 99). Research also
shows that behaviorally based lifestyle interventions are effective tools for increasing PA levels to meet individual and public health recommendations (32, 42, 92). Theory-based PA interventions are more likely to change the way sedentary individuals think and behave in relation to PA than traditional exercise programs. There seems to be strong support for combining the Transtheoretical Model for behavior change with the social cognitive theory and PA interventions to enhance the likelihood for increasing PA in sedentary individuals.

**Conclusion**

The 12-week ALED PA intervention utilized in the current study was not effective at significantly improving PA levels in previously sedentary bariatric surgery patients who were not compliant to the ALED program. Participants that used the online step log ≥ 65 times experienced a non-significant increase in mean steps/day and spent less time in SB at pre-intervention, post-intervention and six-month post-surgery. Additionally, compliant participants spent more time participating in light and MVPA at pre-intervention and post-intervention than non-compliant participants. Bariatric patients did not significantly increase their PA levels after 12-weeks of the ALED PA intervention or six-months after surgery. Additionally, time spent in sedentary, light and MVPA did not significantly change after 12-weeks of the ALED intervention or at six-months post-surgery. Despite the lack of change in overall PA levels, significant improvements in body composition measurements (weight, percent body fat, BMI, waist circumference and hip circumference measurements) occurred pre-intervention through six month post-surgery. Based on these findings, changes in body composition were most likely due to having bariatric surgery or pre-surgery dietary requirements.
participant consistency and compliance to dietary requirements were not controlled for in the current study, it is unclear how much of an impact diet had on body composition. These confounding variables, in addition to having a small sample size, make it difficult to reach specific conclusions.

**Recommendations for future study**

Future researchers should consider repeating the current study with a larger sample size and a standard care control group. A larger sample size would increase statistical power and the implementation of a standard care control group would aid in the determination of differences in PA outcomes between pre-surgery PA advice and a structured pre-surgery PA intervention. It would also be beneficial to assess dietary changes that are required of bariatric patients prior to surgery. Implementing nutritional assessments would allow researchers to better understand whether body composition changes were due to dietary changes, increased PA levels or bariatric surgery. Based on anecdotal evidence from the current study, participant’s success with increasing PA levels is largely based on the intrinsic motivation of the participant. Therefore, it would be wise for future researchers to evaluate the format (web-based, one-on-one, support groups, etc.) of PA interventions as a means to optimize PA behavior change and increase motivation among study participants. As a means to increase study compliance and outcomes, future researchers should consider providing incentives to participants that complete the study. Furthermore, it would be beneficial for physicians and bariatric centers to make physical activity a mandatory pre-surgery requirement along with the mandatory nutritional and psychological assessments. Requiring potential surgery
candidates to become physically active prior to surgery could potentially increase study participation and compliance.
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APPENDIX A

ALED TABLE OF CONTENTS
**Active Living Every Day®**

**Table of Contents**

**Chapter 1: Ready, Set, Go:** Understanding the process of successful lifestyle change, discovering how you spend your time, and looking for opportunities to add activity to your daily life.

**Chapter 2: Finding New Opportunities:** Finding more opportunities to be active, exploring the benefits of walking, and creating an activity plan.

**Chapter 3: Overcoming Challenges:** Recognizing the challenges you face in being active every day, reviewing the benefits of physical activity, and practicing the art of problem solving.

**Chapter 4: Setting Goals and Rewarding Yourself:** Setting goals, identifying rewards that will help you stay motivated, and creating positive messages to encourage yourself.

**Chapter 5: Gaining Confidence:** Learning how to determine the energy expenditure of physical activity, replacing negative thoughts with positive messages, and turning errands into opportunities for activity.

**Chapter 6: Enlisting Support:** Turning to friends and family for encouragement and support, practicing stretching and muscle strengthening exercises, and assessing your progress.

**Chapter 7: Avoiding Pitfalls:** Identifying pitfalls that can make you stumble, learning how to deal with setback and planning for high-risk situations.

**Chapter 8: Step by Step:** Learning to use a step counter, keeping a weekly log of your activities, and revisiting your goals and rewards.

**Chapter 9: Defusing Stress:** Identifying stressful situations, exploring ways to reduce stress, and finding ways to more effectively manage your time.

**Chapter 10: Finding New Opportunities to Be Active:** Exploring activities in your community, learning how to evaluate in-home exercise equipment, and adding extra activities to your weekly calendar.

**Chapter 11: Positive Planning:** Preparing for situations that can throw you off track, setting reasonable goals for weight loss, and making a new plan to increase your activity level.

**Chapter 12: Making Lasting Changes:** Celebrating your accomplishments, discovering ways to renew your motivation to remain active, and troubleshooting problems so that you remain on track.
APPENDIX B

PHYSICAL ACTIVITY STAGE OF CHANGE QUESTIONNAIRE
PHYSICAL ACTIVITY QUESTIONNAIRE

For each of the following questions, please circle Yes or No. Please be sure to read the questions carefully, noting the descriptions of “physical activity” and “regular.”

Physical activity or exercise includes activities such as: walking briskly, jogging, bicycling, swimming, or any other activity in which the exertion is at least as intense as these activities.

1. I am currently physically active.  
   No   Yes

2. I intend to become more physically active in the next 6 months.  
   No   Yes

For the activity to be regular, it must add up to a total of 30 minutes or more per day and be done at least 5 days per week. For example, you could take one 30-minute walk or take three 10-minute walks for a daily total of 30 minutes.

3. I currently engage in regular physical activity.  
   No   Yes

4. I have been regularly active for the past 6 months.  
   No   Yes
APPENDIX C

SATISFACTION WITH LIFE SCALE
Pre-Bariatric Surgery Physical Activity Intervention

**Satisfaction with Life Scale**

Below are five statements with which you may agree or disagree. Using the 1-7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding. The 7-point scale is as follows:

1 = strongly disagree
2 = disagree
3 = slightly disagree
4 = neither agree nor disagree
5 = slightly agree
6 = agree
7 = strongly agree

__ 1. In most ways my life is close to my ideal.
__ 2. The conditions of my life are excellent.
__ 3. I am satisfied with my life.
__ 4. So far I have gotten the important things I want in life.
__ 5. If I could live my life over, I would change almost nothing.
APPENDIX D

SELF-EFFICACY SCALE
Subject Name:_________________________________

Confidence (Self-efficacy)

Please rate how confident you are that you could really motivate yourself to do things like these consistently, for at least 6 months:

Scale:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sure I could NOT do it</td>
<td>Sure I could do it</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Stick to your exercise program when your family is demanding. ____
2. Stick to your exercise program when you have household chores to attend to. ____
3. Stick to your exercise program when you have excessive demands at work. ____
4. Stick to your exercise program when social obligations are very time consuming. ____
5. Read/study or work less in order to exercise more. ____
6. Get up early to exercise. ____
7. Get up early, even on weekends, to exercise. ____
8. Stick to your exercise program after a long, tiring day at work. ____
9. Exercise even though you are feeling depressed. ____
10. Set aside time for a physical activity program, such as walking, jogging, swimming, biking or other continuous activity for at least 30 minutes 3 times per week. ____
11. Continue to exercise with others even though they seem too fast or too slow for you. ____
12. Stick to your exercise program when undergoing a stressful life change (e.i. moving, a divorce, a death in the family, etc.) ____
APPENDIX E

EXERCISE THOUGHTS QUESTIONNAIRE
Subject Name:_________________________________

Exercise Thoughts

Below is a list of thoughts that people sometimes have when they consider whether or not to exercise. It is important that you read each thought carefully. Next to each thought, please indicate how frequently you had that thought during the past week. Use the following scale:

1  2  3  4  5
Not at all  Sometimes  Moderately Often  Often  All the time

1. ____ I’m too tired to exercise
2. ___ I need to sleep
3. ____ I would rather get some sleep
4. ____ There are more important things I have to do
5. ___ I’m too busy
6. ____ I haven’t got time
7. ___ It’s not that important right now
8. ____ I’d rather relax
9. ___ I’d rather watch TV
10. ____ I’d rather socialize
11. ____ I’d rather do something else
12. ___ I have social obligations
13. ___ I don’t feel good enough to exercise
14. ___ Exercising will only make me more tired
15. ___ It will take a lot of energy
16. ___ It will take too long
17. ____ I’m just not motivated enough to exercise
18. ___ I don’t feel like exercising
19. ___ I’ll make it up later
20. ___ I’ll do it tomorrow
21. ___ I’ll do it later
22. ___ I’ll work out extra hard tomorrow
23. ___ I’ll cut down on eating instead
24. ___ Missing one day won’t make that much of a difference
25. ___ I can afford to miss one day
APPENDIX F

EXERCISE BARRIERS QUESTIONNAIRE
Exercise Barriers

These are potential situations that may interfere with or prevent you from exercising. For each item indicate how often it interferes with or prevents you from exercising. The response options are:

1 = never
2 = rarely
3 = sometimes
4 = often
5 = very often

How often does any of the following interfere with or prevent you from exercising?

_____ 1. Not having someone to exercise with
_____ 2. Having other people discourage you
_____ 3. Feeling self-conscious about your looks
_____ 4. Being afraid of injury
_____ 5. Not having time
_____ 6. Feeling too tired
_____ 7. Not having a safe place to exercise
_____ 8. Caring for children