PRE-BARIATRIC SURGERY PHYSICAL ACTIVITY INTERVENTION

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ABSTRACT

THESIS: Pre-Bariatric Surgery Physical Activity Intervention

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To investigate the effect of a 12-week internet-based PA intervention (Active Living Every Day (ALED)) on average steps/day and time spent in sedentary, light, and moderate/vigorous activity/day, PA was objectively measured at baseline and follow-up using the Omron pedometer and the Actigraph GT3X in 11 bariatric patients (2 male, 9 female; 41±12 years). Significant changes (p<.05) were found in weight, BMI, body fat %, waist and hip circumference, submaximal RPE, percentage of individuals reporting PA and perceived exercise barriers from baseline to follow-up. No significant differences were found in steps/day or daily activity level from baseline to follow-up. Bariatric participants averaged 4454±203 steps/day and 74% of their day was spent sedentary. Based on this data it appears that the 12-week PA intervention was not effective in significantly changing PA behavior in the pre-surgery, but lead to improvements in cardiovascular risk factors, RPE and potential exercise barriers.
CHAPTER I
INTRODUCTION

Statement of the Problem

Obesity, the leading preventable cause of death worldwide, affects nearly 33% of the US population and is considered the most serious public health issue. Obesity is defined as a body mass index (BMI) of ≥30.0 kg/m\(^2\). It is predicted that by 2030, 50% of the US population will be obese and before then, over 31 million Americans will qualify for bariatric surgery by becoming morbidly obese (BMI of ≥40.0 kg/m\(^2\)).

Research has shown that bariatric surgery has a significant effect on short-term weight loss and the incidence of diabetes, hypertension, hypertriglyceridemia, low HDL levels, sleep apnea, and quality-of-life. In addition, one study found that patients with the metabolic syndrome showed a 95.6% cure rate one year post-bariatric surgery. Decreases in risk factors and improvement in overall health profile are primarily associated with the weight loss achieved by bariatric surgery. However, without lifestyle modifications and long-term maintenance of weight reduction, the initial improvement in risk factors diminishes.

It is well established that physical activity (PA) helps to maintain weight loss and prevent weight re-gain, while improving overall cardiovascular risk. Bariatric patients who become physically active show greater improvements in weight loss, short-term
surgery complications, and quality-of-life compared to those who remain inactive. Nevertheless, up to 44% of bariatric patients do not engage in regular PA one year post-surgery and therefore, have not changed their behavior. Health behavior change and compliance with behavior recommendations have been linked to motivation and self-efficacy. As a result, readiness-for-change, as defined by the Transtheoretical Model, has been recommended as one of the backbones to effective behavior change interventions.

Most insurance companies require bariatric surgery candidates to demonstrate that they are willing to attempt behavior change by participating in a 6 month, physician supervised, weight loss regimen. However, neither demonstration of actual weight loss nor diet and exercise prescription is a requirement of these insurance-driven programs and therefore, PA behavior change prior to bariatric surgery is frequently overlooked.

Very few PA interventions have been studied in the bariatric population and a small number have looked at the effectiveness of a pre-surgery PA intervention to change short-term and long-term behavior, ultimately promoting weight loss and PA maintenance. In sedentary populations, self-monitoring tools such as pedometers and internet-based programs have been shown to be an effective way to promote behavior change. Pedometers, when used in combination with goal setting and PA recording, may be used as a motivational tool to increase PA and promote behavior change. Internet-based programs that incorporate individualized feedback have been successful in promoting weight loss and improving levels of PA. In addition PA programs that
focus on lifestyle change have been shown to be successful in changing PA behavior \cite{14, 20, 21} as much as a structured exercise program taking place in a fitness center setting \cite{20}. Using a combination of these techniques, Blair et al \cite{14} has designed a 12-week internet-based program called Active Living Every Day® (ALED) with the goal of improving people’s health and quality of life through a variety of lifestyle PA recommendations specific to the person’s motivational readiness for change and through the use of self-monitoring tools \cite{14}. Because most bariatric patients are low active or sedentary prior to their surgery \cite{10}, a PA intervention that focuses on individualizing PA recommendations based on the patient’s motivational readiness for change and the use of self-monitoring tools seem most appropriate.

**Purpose of the Study**

The primary purpose of this current study was to assess whether the ALED PA intervention, a structured 12-week internet-based program, would promote an increase in average steps taken/day, total aerobic steps walked/week, total time spent in moderate/vigorous activity/week, and a decrease in total sedentary time/day in bariatric patients prior to their bariatric surgery. Additionally, by using objective measurements for PA, resting metabolic rate (RMR), body composition, and aerobic capacity, the health profile of the bariatric subjects in this study can be compared to other chronic disease or healthy populations. Secondly, PA self-efficacy, quality-of-life, readiness for change, perceived exercise barriers, and exercise thoughts were also assessed to determine any changes in psychological factors and PA habits and/or PA behavior change, specifically self-efficacy and readiness for change and average steps/day pre to post-intervention.
Hypothesis Statement

The hypothesis was that bariatric patients completing the internet-based 12-week ALED program would increase their level of PA from baseline to post-intervention follow-up. In addition to an improvement in PA, it was hypothesized that patients would have an improvement in quality of life, self-efficacy, perception of exercise barriers, satisfaction with life, and exercise thoughts. Accompanying the proposed increase in PA habits, it was hypothesized that patients would have a decrease in body weight, body fat %, and an improvement in CVD risk factors from baseline to post-intervention follow-up with an increase in RMR.

Delimitations

The subject population was restricted to those 18 years of age or older, who were scheduled to undergo bariatric surgery at an Indiana University Hospital location within 4-6 months of their recruitment date. Subjects were included if they were participating in the pre-surgery preparatory requirements at Indiana University Ball Memorial Hospital Bariatric Clinic (IUBMHBC) and classified as morbidly obese (BMI ≥40.0 kg/m² or BMI ≥35.0 kg/m² with 2 comorbidities). Exclusion criteria included individuals who were immobile due to orthopedic limitations or other medical conditions, those without weekly access to internet, and individuals unable to read or write.

Significance of the Study

Few studies have assessed PA levels of the bariatric population prior to bariatric surgery and few to no studies have determined the effectiveness of a structured pre-
bariatric surgery PA program in changing PA behavior and PA perceptions prior to surgery. The majority of bariatric patients are significantly inactive prior to surgery and the benefits of immediate PA adoption post-bariatric surgery are well-established. Despite this and the fact that readiness for change prior to bariatric surgery is a surgery requirement for all modifiable risk factors, PA assessment and demonstration of readiness for PA adoption before surgery has often been overlooked. Therefore, there is a need for the assessment of early PA interventions that are successful at changing PA behavior prior to surgery in the bariatric population.

Limitations

A limitation in the present study is the small participant sample size (n=11) and the distribution of males (n=2) to females (n=9), which prevent the results from this study to be generalizable to the entire bariatric patient population. The addition of a control group would have strengthened the results of this study and allowed for greater comparisons to be made. Because diet plays a role in body mass changes and was not controlled for in the current study, it cannot be determined to what effect the diet may have influenced the body mass changes throughout the study intervention. Additionally, because participants were required to complete the PA intervention unmonitored, the assumption is being made that the participants read each of the chapters and followed the program as suggested. Variations in how well the material was reviewed among participants may have affected the results.
Definition of Terms

Accelerometer- A body-worn device that is used to objectively measure and quantify the amount of time spent during sedentary, light, moderate, and vigorous activity based on accelerations and decelerations of the body 23.

Bariatric Surgery- Refers to any surgical procedure, either malabsorptive or restrictive, that reduces the caloric intake by modifying the anatomy of the gastrointestinal tract 24.

Morbid Obesity- Excess body fat with a BMI ≥40.0 kg/m² 2.

Internet-Based Physical Activity Program- Refers to computer-tailored interventions used to promote physical activity behavior change through education and interactive activities 18.

Metabolic Syndrome- Characterized by a combination of cardiovascular risk factors including high triglycerides and glucose, low high-density lipoprotein cholesterol, high blood pressure, and abdominal obesity putting a person at an increased risk for developing cardiovascular disease and type II diabetes mellitus 7.

Obesity- Excess body fat with a BMI ≥30.0 kg/m² 2.

Pedometer- A body-worn device that is used to objectively measure daily-step counts 25.

Physical Activity (PA)- Any movement of the body caused by muscular contraction that substantially increases energy expenditure relative to a resting state 2.

Quality-of-Life- Refers to a person’s overall well-being including physical functioning, mental health, social-interaction, and general health 26.
**Transtheoretical Model** - Involves 5 different categories including: precontemplation, contemplation, action, maintenance, and relapse, and is used to define a person’s readiness for change \(^{13}\).

**Self-Efficacy** - Refers to a person’s perception of their ability to change \(^{12}\).

**Social Cognitive Theory** - Based on the idea that self-efficacy, goals, outcome expectations, and perceived barriers are what facilitate a person’s motivation, behavior, and well-being \(^{27}\).
CHAPTER II
LITERATURE REVIEW

Obesity

It has been well documented that obesity is on the rise in the United States and is one of the leading health threats \(^3\) and costs \(^{28}\) to our society. Obesity is defined as a body mass index (BMI) of $\geq 30 \text{ kg/m}^2$ \(^{21,29}\). In addition to a rise in obesity \(^3\), the prevalence of morbid obesity (BMI $>40 \text{ kg/m}^2$) continues to rise \(^{30}\). Between 2000 and 2005, and the prevalence of morbid obesity increased 50% and superobesity (BMI $>50 \text{ kg/m}^2$) increased 75%.

Obesity decreases overall life-expectancy \(^{31}\) and health-related quality of life \(^{32,33}\) and increases risk for cardiovascular disease, type II diabetes, hypertension, certain cancers, and sleep apnea \(^{34,35}\). Approximately 34% of American adults are obese, with the greatest prevalence found in Black, non-Hispanic individuals at 44% \(^{29}\). After smoking, obesity is considered the second leading cause of preventable, premature death in the United States \(^{36}\). Based on survey data from the National Health and Nutrition Examination Study (NHANES) and the assumption that obesity trends will continue to increase, it is projected that by the year 2030 approximately 90% of the US population will be overweight or obese and approximately 50% will be obese \(^3,37\). These numbers are expected to increase total-health care costs by approximately 686-763 billion
dollars/year and account for 15.8-17.6% of total-health care costs compared to 12.2-13.5% in 2010 \textsuperscript{28, 37}. Reports from a systematic review of literature between the years of 1990 and 2009 showed that individuals with a BMI $\geq 30$ kg/m$^2$ spent 30% more dollars on medical expenses in 2006 compared to those with a normal BMI \textsuperscript{38}. Additionally, obesity continues to impose economic burden on both public and private payers \textsuperscript{28}. Across all payers, per capita medical spending for obesity in 2006 was $1,429 higher/year, or roughly 42% higher, than for someone of normal weight. Prescription drug spending is driving much of these obesity-attributable costs with an estimated $32$ million dollars spent on obesity-attributable prescription drugs across all payers \textsuperscript{28}.

Considering the continuous rise in the prevalence of and cost associated with obesity there is an obvious need for immediate intervention targeting weight loss. Unfortunately, obese individuals, specifically those considered morbidly or extremely obese (BMI $\geq 40$ kg/m$^2$), are difficult to treat \textsuperscript{30}. Research suggests that attempting to promote behavior change and sustained long-term weight loss through the use of lifestyle modifications and drug therapy alone is not successful for the majority of these patients \textsuperscript{22, 39}. As a result, alternative treatments for weight loss are being recommended for this population such as bariatric surgery \textsuperscript{22}.

**Bariatric Surgery**

Studies have shown that bariatric surgery, also known as weight-loss surgery, is the most effective weight loss intervention for the treatment of morbid obesity (BMI $\geq 40$ kg/m$^2$ or BMI $>35$ kg/m$^2$ paired with serious obesity-related co-morbidities) \textsuperscript{4, 22} and its related cardiovascular risk factors and comorbidities \textsuperscript{22}. Bariatric surgery limits the
amount of calories a person can consume by manipulating the anatomy of the gastrointestinal tract through restrictive or malabsorptive techniques. Restrictive procedures use stapling or an adjustable band to create a narrow outlet from the stomach thereby decreasing the amount of food a person can consume. Restrictive operations include sleeve gastrectomy and Lap-Band. Malabsorptive procedures decrease the potential of the body to absorb food by bypassing a portion of the small intestine, where the majority of food absorption takes place. Malabsorptive operations include Roux-en-Y Gastric Bypass (RYGB) and a duodenal switch. The most commonly performed surgery is Laproscopic Gastric Bypass (LGB) and has been considered by some as the gold standard.

**Bariatric Surgery and Weight Loss**

Changes in weight as a result of bariatric surgery are best described through 2 methods: change in BMI or percentage of excess weight loss (%EWL). %EWL is calculated by the following equation: 

\[
%\text{EWL} = \left(\frac{\text{Surgery Weight} - \text{Follow-up Weight}}{\text{Surgery Weight} - \text{Ideal weight}}\right) \times 100
\]

and is most often used when comparing changes between individuals. Ideal weight is based on the 1983 Metropolitan insurance height and weight table and is the weight for a given height which represents the lowest risk of mortality. For women, ideal weight is calculated by the following equation: 5 feet tall = 119 pounds and for each additional inch, add 3 pounds. For men: 5 feet 3 inches tall = 135 pounds and for each additional inch, add 3 pounds.

On average patients who have bariatric surgery lose the most weight (approximately 25%) within the first year after surgery while patients who participate
in non-surgical weight-loss methods lose the most weight (approximately 1.2%) within the first 6 months of starting a non-surgical weight loss intervention. The difference in weight reduction between bariatric patients that choose a surgical versus non-surgical weight loss intervention affects the magnitude of cardiovascular risk factor reduction or resolution. According to a meta-analysis of 22,094 bariatric patients completed by Buchwald et al., a %EWL of approximately 61% resulted in the resolution of type II diabetes mellitus in 76.8% of patients, dyslipidemia in 70% of patients, systemic hypertension in 61.7% of patients, and obstructive sleep apnea in 85.7% of patients. Sjorstrom et al. reported that the majority of surgically treated patients had a significantly lower incidence of dyslipidemia and type II diabetes at 2 and 10 years post-surgery and a greater improvement in high-density lipoprotein (HDL) cholesterol at 2 years post-surgery when compared to patients receiving non-surgical conventional weight-loss treatment. Additionally, the surgery patients had a higher prevalence of resolution from hypertension, type II diabetes mellitus, hypertriglyceridemia, low HDL-cholesterol, and hyperuricemia both compared to the non-surgical weight loss patients at both 2 and 10 years. These findings are supported by the American Heart Association (AHA) which endorses bariatric surgery as an effective method for weight loss and recognizes that the magnitude to which cardiovascular risk factors, metabolic syndrome, and overall mortality are improved is dependent upon percentage of weight lost.

**Weight Regain Post-Surgery**

Despite the fact that bariatric surgery has been shown to be an effective treatment option for morbidly obese individuals in regards to weight loss, cardiovascular risk
reduction, and mortality⁴,22, weight regain postoperatively still exists⁴²,⁴⁴,⁴⁵. Sjostrom et al⁴,⁴⁶ published their research from the Swedish Obese Participants (SOS) Study, which evaluated surgically treated obese participants (RYGB, vertical banded gastroplasty, banding) and matched, conventionally treated control participants aged 37-60 years who had completed at least 2 years of the SOS study intervention (n = 4047). Participants of the control group received non-surgical treatments for obesity which were not standardized by the researchers and included anything from an involved lifestyle intervention and behavior modification program to no treatment at all. Further reporting of the non-surgical treatments used was not provided. The purpose of the study was to determine the difference between the bariatric surgery group and non-surgical control group with respect to mortality and a variety of health outcomes including weight change. At baseline, male participants had a mean BMI of ≥34 kg/m² and women participants had a mean BMI ≥38 kg/m². The study intervention began on the day of the surgically treated participant’s bariatric procedure and included a series of clinical and biochemical assessments measured at 0.5, 1.0, 2.0, 3.0, 4.0, 6.0, 8.0, and 10.0 years following the intervention start date. At each visit, participant’s weight, height, waist circumference, and blood pressure were measured and participants were asked to rate their leisure and work time PA on a scale of 1 to 4. A rating above 1 was considered physically active. Fasting blood samples were obtained at baseline and 2.0 and 10.0 years post-intervention start date. In total, 1845 surgically treated participants and 1660 controls completed the 2-year examination with 641 and 627 respectively, completing the 10 year examination. All reported results were based on participants who completed both the 2 and 10 year follow-up. Results did not change when data from all included participants were used and
all missing follow-up data was replaced with baseline data; however, researchers were assuming that those who had dropped out of the study maintained their baseline characteristics including weight. The results showed that the greatest mean weight change was recorded at 6 months (-1.2%) for the control group and 1 year (-25%) for the surgically treated group. The RYGB showed the greatest percentage of weight loss (-38±7%) at all time-points compared to the other surgically treated sub-groups. After 2 years of the intervention, weight did not change in the control group but decreased by 23.4% in the surgically treated group relative to baseline. The difference between the groups was statistically significant. After 10 years of the intervention, weight was 1.6±12% greater than baseline in the control group and 16.1±11% less than baseline in the surgically treated group which was statistically significant between the groups. Although weight was less than baseline at both 2 and 10 years in the surgically treated group, percentage of weight loss 10 years post-surgery was less when compared to the 2 year post-surgery follow-up, indicating a trend toward weight regain. However, these weight regain trends were not significant. Overall, researchers from this study concluded that surgical treatment for obesity leads to significantly greater weight loss long-term compared to non-surgical weight loss treatments. However, due to the lack of standardization for the non-surgical treatments methods, the results of the control group are not generalizable to all non-surgical treatments. It is possible that assessing specific non-surgical treatment methods and comparing them to the surgical group would have elicited more comparable results. Additionally, because there were a large number of participants who withdrew from the study, it is possible that the follow-up results included more motivated individuals with greater weight loss results rather than those
less motivated. By carrying the baseline characteristics forward to replace missing follow-up data, researchers assumed that those who did not complete the study did not change; nevertheless, it is possible that participants who did not complete the study were not only less motivated but had significant changes in their baseline characteristics which may have influenced the results. Further research on the effects of surgical versus non-surgical weight loss outcomes and weight regain was assessed by Bond et al. They concluded that surgically treated participants (n=105) and 2 characteristically matched non-surgical controls (n=210) who had been equally successful in losing (approximately 56 kg) and keeping off a significant amount of weight (≥13.6 kg) for at least 5 years, showed a significant and similar amount of weight regain ≥6 years after beginning their weight loss intervention. The amount of weight regained was not different (P=0.369) between the surgical (1.8±7.5 kg) and non-surgical groups (1.7±7.0 kg). Evidence with respect to weight loss and weight regain have shown that lifestyle behavioral modifications are necessary for successful weight loss and that unsuccessful weight loss and weight regain are a result of poor adherence to postoperative recommendations.

**Behavioral Compliance and Weight Loss Outcomes**

Elkins et al investigated the rate of noncompliance with behavioral recommendations for 100 RYGB patients with a pre-surgery mean weight of 312.6±60.6 pounds. The participants consisted of 81 women and 19 men with a mean age of 43.6 years. All participants reported unsuccessful attempts at non-surgical methods for weight loss and ≥3 attempts at long-term behavioral modification programs. Before bariatric
surgery, participants went through 6 months of nutritional counseling and were encouraged to begin an exercise program. Recommendations were not given related to mode or volume of exercise. At each pre-surgery session patients were weighed and encouraged to ask questions related to the behavior modifications they were being asked to make. After completing the 6 months of counseling and receiving approval from a psychologist, participants had RYGB surgery. While in the hospital participants were given a pamphlet of dietary recommendations and met with a bariatric nurse practitioner for additional dietary counseling. Additionally, participants were encouraged to exercise for 1 hour/day; however, information about whether more specific exercise instructions were given to the participants was not provided by the researchers. Post-surgery participants were given the option of attending a support group bi-monthly for up to 12 months after surgery and were required to attend meetings with the surgeon and follow-up team 1 week, 2 weeks, 1 month, and every 3 months for up to 12 months. Dietary counseling was provided and exercise was reinforced by a surgeon or bariatric nurse practitioner at all of these visits. Specific information related to how and what dietary and exercise counseling was provided was not reported by the researchers. Participants were weighed and asked to report compliance with all dietary and exercise recommendations. Additionally, each participant’s charts were reviewed at 6 and 12 months for compliance related to diet and exercise. Complete data was available for 100 study participants at 6 months and for 92 study participants at 12 months. Of the 100 study participants 21% reported not attending support group at 6 months and 25% at 12 months post-surgery. Participants had a 15.6±5.3 kg/m² decrease in BMI with a 92.4±26.0 pound weight loss by 6 months and an 18.6±5.3 kg/m² decrease in BMI with
an 116.6±39.2 pound weight loss by 12 months. Despite the participant’s decrease in BMI 1 year post-surgery, approximately 40% of the participants reported not exercising at 6 and 12 months. Because the researchers were not clear about what the exercise recommendations were and what signified “non-compliance” it is difficult to simplify the results to all RYGB patients. It is possible that non-compliance with exercise represented complete lack of exercise without considering the current PA guidelines. Perhaps a higher percentage of participants were not meeting the PA guidelines at 6 and 12 months. Based on their results it appears that the general guideline researchers gave participants of exercising 1 hour/day was not effective in changing exercise behavior in at least 40% of the participants. It is unknown whether the 60% of participants assumed to be compliant with exercise recommendations increased their exercise throughout the study or were meeting the PA guidelines. Knowing this would have allowed the researchers to draw better conclusions about whether their exercise recommendations promoted behavior change. The degree to which exercise noncompliance would have affected weight loss long-term in these study participants is unknown. Previous research by Sjostrom et al has shown that patients reach their lowest weight 1 year after surgery and then experience a gradual, non-significant weight regain up to 10 years post-surgery. Perhaps the trend toward weight regain found by Sjorstrom et al could be due to continual noncompliance beyond the 1 year post-surgery date.

Toussi et al completed a retrospective chart review of 112 RYGB (time of surgery mean age of 44.5±10.9 years mean BMI of 48.8±7.9 kg/m²) patients who had surgery between 1997 and 2002. Researchers investigated the relationship between
weight loss and compliance with physician recommendations from patient’s data, which was available for 1 year before surgery (n=112) and up to 2 years after surgery (n=67). All patients included in this study met with the same medical treatment team 3 times prior to surgery and 1, 3, 6, 12, 18 and 24 months post-surgery to report exercise and dietary behaviors. Additionally, patients were required to participate in a 6 month pre-surgery supervised weight loss program of their choice which included: behavior modification, medication, exercise, Overeaters Anonymous, Weight Watchers, Jenny Craig, Atkins, or another staff approved dietary/nutritional program. Researchers designed a method for coding compliance that was not shared in the research manuscript; researchers confirmed that the coding system was used consistently between all study participants. At each appointment (before and after surgery) a detailed progress note was written regarding patient’s adherence which was used to identify noncompliance. Reasons for noncompliance were broken into 5 main categories including exercise adherence, weight loss plan adherence, medication adherence, missed appointments, and poor food choices. Complete information for each compliance category was only available for 57 patients pre-surgery and 53 patients post-surgery. Of the 112 patients used for pre-surgery descriptive statistics, 67 patients (60%) had descriptive statistics available 24 months post-surgery. Based on this information, patients with 1 year post-surgery data had a mean BMI of 49.9±8.5 kg/m² at the time of surgery and were more likely to have a psychiatric disorder (P=0.04), more likely to be women (P=0.025), and less likely to have a metabolic disorder such as diabetes (P=0.015) than participants without descriptive data at 24 months post-surgery. A description of compliance categories and frequency with which they occurred in medical charts was available for 57
patients before surgery and 53 patients after surgery. Toussi et al.\textsuperscript{48} concluded that overall noncompliance was greater post-surgery than pre-surgery and that the most frequent compliance issue was missed appointments with 65\% (n=37) of pre-surgery patients reporting $\geq1$ missed appointment before surgery and 72\% (n=41) of post-surgery patients reporting $\geq1$ missed appointment after surgery. Patients who reported $\geq1$ 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 patients and 51\% (n=27) of 24 month post-surgery patients, which was similar to the 1 year post-surgery exercise compliance data found by Elkins et al.\textsuperscript{9} in 2005 (43\% not exercising 1 year post-surgery). According to Toussi et al.\textsuperscript{48}, the most common reasons for not exercising were pain, gout, injury, no access, social factors, asthma, cold/illness, too low intensity, and not liking to exercise. Post-surgery participants reported similar reasons for exercise noncompliance at 24 months but included foot problems, too much, no time, and other surgeries as other reasons.\textsuperscript{48} A limitation of this study was the large number of patients lost at follow-up (40\%) and the percentage of patients that were white (79\%) and female (85\%). It is likely that patients with follow-up data were more compliant and had better access to the medical services provided. Therefore, these results are not generalizable to all populations. Additionally, because the pre- and post-surgery compliance data was dependent upon the progress notes of the medical professional performing the required assessments, detailed and consistent information may not have been provided for each patient resulting in inaccurate descriptions of compliance. Researchers were not clear whether the patients with compliance information pre-surgery were the same patients
with compliance information post-surgery. Assuming patients were the same pre- and post-surgery, results showed that the absolute number of compliance issues reported increased from 97 issues pre-surgery to 120 issues post-surgery, despite decreases in number of patients assessed (57 patients pre-surgery to 53 patients 24 months post-surgery). Overall, 90% of patients reported at least 1 area of noncompliance pre-surgery compared to 94% post-surgery. Further research studies need to be done to collect detailed compliance information and its impact on long-term weight loss so that more accurate conclusions can be made regarding the effect on noncompliance on long-term weight loss.

A study by Welch et al. investigated the effect of patient reported post-surgical self-management behaviors (eating style, fluid intake, macronutrient intake, dumping syndrome management, supplement intake, and PA, etc.) on weight loss. Weight loss outcomes (weight, percent of excess weight, and BMI) and lifestyle behaviors including PA were collected at the time of (baseline, n=100) and follow-up (2-3 years post-laparoscopic gastric bypass (LGB) surgery, n=75). PA was assessed at using a modified interview from the Nurses’ Health Study II. Participants were asked to report participation in weekly exercise including walking, jogging, running, bicycling, aerobics/dance/rowing machine, tennis/racket sports, and swimming with response categories available from 0 to >11 hours/week. MET scores were assigned to each activity using an accepted method by Ainsworth et al. Participants were considered compliant if they were meeting the current national PA guidelines of ≥150 min/week of moderate PA. Moderate PA was defined as activities that received a MET score of 3.5.
Comparisons of participants who completed the follow-up intervention (n=75) to those who did not (n=25) showed that participants were not different in both baseline weight and BMI. At follow-up, %EWL was 59.1±4.1% which represented an average weight loss of 96.5 pounds (<.001) from baseline. Mean BMI improved from 49.8±1.6 kg/m\(^2\) at baseline to 34.1±1.5 kg/m\(^2\) 2-3 years after surgery, moving the majority of patients from the morbidly obese category to the obese category. At follow-up, 51.4% of patients reported meeting the national PA guidelines compared to 7.3% at baseline. Predictors of percentage excess weight loss at follow-up were calculated using a regression analysis. Researchers concluded that post-surgical PA (2-3 years post-surgery) and pre-surgical patient weight were positively associated with weight loss at 2-3 years post-surgery and when combined, accounted for 13% of total weight loss variance between participants. It is not surprising that participants who were more physically active achieved better weight loss outcomes. What is surprising is that dietary behaviors were not correlated with post-surgery weight loss. Given that self-report methods for assessing PA are often inaccurate, objective measurements of PA would have strengthened the results of this study.

A large portion of bariatric patients remain noncompliant with PA and other physician recommendations \(^9, 47, 48\). Previous research, evaluating PA compliance, has used primarily self-report methods to measure PA \(^9, 47, 48\). Bond et al \(^51\) concluded that bariatric patients tend to over-report their PA levels after bariatric surgery and that the use of objective measurements like an accelerometer provides a more accurate
representation of PA. This may suggest that noncompliance with PA is more severe than previously reported.

**Physical Activity**

According to the 2008 PA Guidelines for Americans all adults should participate in at least 150 minutes of moderate intensity PA or 75 minutes of vigorous intensity PA/week or an equivalent combination of both to achieve health benefits. Specifically, some evidence supports that meeting these guidelines promotes weight loss maintenance and leads to decreased abdominal fat while strong evidence supports that meeting these guidelines will lead to lower risk of early death, heart disease, stroke, type 2 diabetes, high blood pressure, adverse blood lipid profile, metabolic syndrome, certain cancers, prevention of weight gain, weight loss when combined with diet, and reduced depression. For greater health benefits and specifically, weight loss/maintenance, adults should aim for 300 minutes of moderate-intensity PA or 150 minutes of vigorous-intensity PA/week or an equivalent combination of both. Although all PA is beneficial, PA minutes should only be included in a weekly total if performed in ≥10 minute bouts. Tudor-Locke and Bassett have equated 30 minutes of moderate intensity activity to between 3000 and 4000 steps. Research data from the 2005-2006 National Health and Nutrition Examination Survey (NHANES), a periodic health survey that combines interviews and physical examinations annually published by Tudor-Locket et al, provided objectively measured step data and activity counts/minute for normal, overweight, and obese U.S men and women (n=3522). They concluded that as BMI increases, PA volume, moderate/vigorous activity, and steps/day significantly decrease.
U.S obese adults (n=1242) average 5784 measured steps/day and after calculating non-wear time, spend approximately 57.6% of the day sedentary, 24.0% in low intensity, 16.2% in light intensity, 2.1% in moderate intensity and 0.4% in vigorous intensity. Based on these results, only 2% of the obese population is meeting the recommended PA guidelines. For the purposes of defining accelerometer variables, researchers included time indicators (activity counts/minute) and step-defined activity levels to describe intensity thresholds. These ranges are found in the table below:

**Table 2.1 Accelerometer PA/inactivity indicator variables for**

<table>
<thead>
<tr>
<th>Accelerometer variable</th>
<th>Defined</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time indicators (minutes)</strong></td>
<td></td>
</tr>
<tr>
<td>Time in sedentary intensity</td>
<td>Total time &lt; 100 activity counts/minute$^{-1}$</td>
</tr>
<tr>
<td>Time in low intensity</td>
<td>Total time 100-499 activity counts/minute$^{-1}$</td>
</tr>
<tr>
<td>Time in light intensity</td>
<td>Total time 500-2,019 activity counts/minute$^{-1}$</td>
</tr>
<tr>
<td>Time in moderate intensity</td>
<td>Total time 2,020-5,999 activity counts/minute$^{-1}$</td>
</tr>
<tr>
<td>Time in vigorous intensity</td>
<td>Total time &gt; 5,999 activity counts/minute$^{-1}$</td>
</tr>
<tr>
<td><strong>Step-defined activity levels (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Basal activity</td>
<td>&lt; 2,500 steps/day</td>
</tr>
<tr>
<td>Limited activity</td>
<td>2,500 to 4,999 steps/day</td>
</tr>
<tr>
<td>Low active</td>
<td>5,000-7,499 steps/day</td>
</tr>
<tr>
<td>Somewhat active</td>
<td>7,500-9,999 steps/day</td>
</tr>
<tr>
<td>Active</td>
<td>10,000-12,499 steps/day</td>
</tr>
<tr>
<td>Highly Active</td>
<td>≥12,500 steps/day</td>
</tr>
</tbody>
</table>
Freedson et al\textsuperscript{55} has established accelerometer count ranges for each intensity range correlating to MET values representing light, moderate, and vigorous activity. These were obtained from a treadmill experiment in which 50 normal weight (mean BMI 22.8 kg/m\textsuperscript{2}) young adults (mean age 22.9 ± 3.8 years) walked at various speeds representing light (≤2.99 METs), moderate (3.0-5.99 METs), hard (6.0-8.99 METs) and very hard (≥ 9.0 METs) activity intensities typically used by the literature. The table below contains the defined activity counts/min\textsuperscript{-1} for each of the intensity ranges:

<table>
<thead>
<tr>
<th>Activity Counts</th>
<th>MET Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-wear time</td>
<td>1,440 minutes minus wear time</td>
</tr>
<tr>
<td>Light intensity</td>
<td>&lt; 1952 activity counts/minute\textsuperscript{-1}</td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>1952-5724 activity counts/minute\textsuperscript{-1}</td>
</tr>
<tr>
<td>Hard intensity</td>
<td>5725-9498 activity counts/minute\textsuperscript{-1}</td>
</tr>
<tr>
<td>Very hard intensity</td>
<td>&gt;9498 activity counts/minute\textsuperscript{-1}</td>
</tr>
</tbody>
</table>

The threshold ranges between Freedson et al\textsuperscript{55} and Tudor-Locke\textsuperscript{54} contain slight differences. Tudor-Locke and colleagues\textsuperscript{54} used the activity count categories previously used to analyze NAHNES data in a study done by Troiano et al\textsuperscript{56} and generally provided slightly higher activity counts/minute for each of the activity intensity categories when compared to the ranges defined by Freedson et al\textsuperscript{55}. Tudor-Locke\textsuperscript{54} defined intensity threshold ranges after studying a wide range of BMIs and Freedson\textsuperscript{55} defined intensity threshold ranges after studying a normal to overweight population. Lopes et al\textsuperscript{23}
investigated appropriate activity count thresholds for each of the intensity categories for the overweight/obese (mean BMI 30.2 kg/m²) population (mean age 62.6 years). Below is a table comparing the activity counts between Freedson ⁵⁵ and Lopes ²³.

### Table 2.3 Accelerometer PA/inactivity indicator variables

<table>
<thead>
<tr>
<th>Accelerometer variable</th>
<th>Activity counts/minute¹</th>
<th>Lopes et al ²³</th>
<th>Freedson et al ⁵⁵</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light intensity</td>
<td>&lt;1240</td>
<td>&lt;1952</td>
<td></td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>1240-2400</td>
<td>1952-5724</td>
<td></td>
</tr>
<tr>
<td>Hard intensity</td>
<td>≥2400</td>
<td>&gt;5725</td>
<td></td>
</tr>
</tbody>
</table>

Lopes et al ²³ determined that the 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 ⁵⁵. However like Freedson ⁵⁵, Lopes et al ²³ concluded that the threshold ranges they calculated were highly correlated with the MET scores used to define light (<3 METs), moderate (3-5.99 METs), and vigorous (≥6 METs) activity and that the Actigraph accelerometer was a valid and useful way to measure PA in this population. The variance in threshold ranges between these studies suggests that overweight/obese adults reach a higher MET level with less relative effort (defined by activity counts) compared to normal weight adults. Due to these differences and in order to more accurately compare intensity levels between overweight/obese individuals and normal weight individuals, relative intensity markers should be used. Therefore, threshold ranges defined by Lopes et al ²³ may be most appropriate for
defining exercise intensity when using the Actigraph to assess an overweight/obese population.

**PA Post-Bariatric Surgery**

The majority of bariatric patients are not meeting the current PA guidelines of moderate-to-vigorous (MVPA) after surgery. Research by Bond et al. reported that of the 31 obese participants (mean BMI ≥35 kg/m², aged 18-65 years) studied, 5% were meeting the current PA guidelines of 150 minutes/week of MVPA 6 months after surgery. PA was measured objectively using the RT3 (Stayhealthy, Monrovia, CA) waist-mounted accelerometer. The RT3 accelerometer had been previously validated in men with a mean BMI of 22.5 kg/m² but not in the obese population; therefore, the validity of using this device to measure MVPA in the obese participants studied by Bond et al. is uncertain. Previous research has shown that relative intensity, based on activity counts, is greater for a given absolute intensity in the obese population when compared to normal weight individuals. Assuming this to be correct, the results reported by Bond et al. may actually underestimate the number of obese participants meeting the MVPA guidelines. Meeting the recommended levels of MVPA leads to greater long-term weight loss and health-related quality-of-life and is more effective for weight loss than dietary changes alone.

Josbeno et al. objectively measured PA levels in 40 bariatric participants (BMI 32.6±7.9 kg/m²), 2-5 years after their RYGB surgery, using the previously validated BodyMedia SenseWear® PRO armband. Their results showed that participants spent an average of 49.3±68.9 min/week performing sustained bouts (≥10 minutes in duration)
of MVPA, with only 10% meeting the MVPA guidelines of ≥150 minutes/week of sustained MVPA. MVPA was defined as any activity with a MET value of ≥3.0 including activities such as cycling, fast walking, and running. Although 32% of the study participants did not participate in any sustained bouts of MVPA, participants who met the recommended 150 minutes/week of sustained MVPA had a greater %EWL (68.2±19.0) independent of age, BMI, daily caloric intake, and reported physical function.

Bond et al. examined self-reported PA participation in 1585 morbidly obese RYGB patients (BMI 34-70 kg/m²). The patient’s PA was assessed pre-surgery and examined in relation to patient’s 2 year post-surgery %EWL and BMI. Like Josbeno et al., RYGB participants who reported being physically active had greater %EWL and decreased BMI compared to those patients who reported staying inactive. Participants with the highest pre-surgery BMI (50-70 kg/m²) showed significant increases in %EWL post-surgery only when they also reported participating in post-surgical PA. Researchers concluded that post-surgical PA was effective in increasing %EWL and decreasing BMI at 2 years post-surgery. Additionally, patients with a higher pre-surgery BMI required post-surgery PA in order to see significant increases in %EWL at 2 years post-surgery. As before, many of these studies use self-report methods to measure PA which may have led to over-reporting by some participants and add strength to the results found by Josbeno et al. Regardless, the self-reported PA correlated with weight loss.
PA Pre-Bariatric Surgery

PA before surgery has been shown to be a predictor of post-surgery weight loss \(^{60,61}\) and a factor in improving overall health risk profile. The limited research that has assessed pre-surgery PA data in bariatric patients \(^{51,57}\) has shown that 90-95% of bariatric patients are not meeting the PA recommendations \(^{26,47}\). A study done by Dixon et al. in 2002 \(^{60}\) analyzed the data of 440 bariatric patients 1 year after Lap-Band surgery to investigate potential predictors of outcomes and to determine associations with weight loss. They found that patients who reported a poor PA score on the SF-36 quality of life measure before surgery had less weight loss 1 year after Lap-Band surgery \(^{60}\). Similar results were found in a study done by Hatoum et al. \(^{61}\) which analyzed the data of 300 Roux-en-Y Gastric Bypass (RYGB) patients to determine potential predictors, including PA status, of weight loss 1 year post-surgery. The status of each patient’s PA was determined by a physician and included review of the patient’s PA history. Patients were determined physically inactive if they were unable to climb 2 flights of stairs or walk 2 city blocks, or unsuccessfully completed an exercise tolerance test and did not participating in regular PA. Weight loss was calculated as a %EWL with optimal BMI defined as BMI ≤25 kg/m\(^2\). Their results showed that 1 year after RYGB surgery, patients lost an average of 64.8%±20.5% of their excess weight with initial BMI and level of PA having the greatest effect on %EWL. Participants who were physically inactive had a 17.2% less decrease in excess weight loss compared to those who were physically active 1 year after surgery.
Bond et al. investigated the effect of PA on weight loss outcomes according to when participants become physically active (either before or after bariatric surgery). PA was reported by 199 RYGB participants prior to and 1 year after their bariatric surgery using the International PA Questionnaire short form (IPAQ-short). The IPAQ-short is a self-report tool that assesses walking and other activities of moderate and vigorous intensity performed continuously for at least 10 minutes. In this study, the total reported minutes of walking and participation in MVPA were summated for each participant. Participants were categorized into 3 groups (active/active, inactive/active, or inactive/inactive) based on their baseline and 1 year post-surgery reported PA minutes. Participants that achieved ≥200 minutes/week of PA were considered active and those who achieved <200 minutes/week were considered inactive. According to their results, 38% (n=68) of RYGB participants reported achieving at least 200 minutes of PA at baseline and up to 1 year after surgery. Of the participants who were categorized as inactive at baseline, 68% (n=83) became active 1 year post-surgery and 32% (n=39) remained inactive. The RYGB participants that reported becoming more active after surgery lost an additional 8% excess weight than participants who reported staying inactive post-surgery. Interestingly, there was no difference in pre-surgery age, sex, ethnicity, weight, BMI, or PA between participants who became active and those who remained inactive. Therefore, it is unclear of what factor(s) determined whether the participants changed their PA behavior from pre to post-surgery within this study. Additionally, those who reported being physically active at baseline showed a similar
%EWL to those who became physically active after surgery indicating that the timing of when someone becomes active relative to their bariatric surgery is unimportant in regards to the long-term weight loss outcome. Researchers cautioned against the use of self-report methods for measuring PA after completing a follow-up study that showed over-reporting of PA through the use of self-report methods when compared to objectively-measured MVPA.

With the increasing body of research suggesting patient’s noncompliance to PA behavioral recommendations and the effect this has on long-term surgery success, it’s possible that current behavioral modification programs are ineffective. Currently, few studies have investigated the effectiveness of different PA behavior change interventions in the bariatric population and therefore, further research is needed to determine what factors predict or influence compliance, in order to develop an effective behavioral modification program that motivates patients to change.

**Theories of Behavior Change**

Several social and psychological theories have been used to predict and promote PA behavior change in individuals including the health belief model, social cognitive theory, Transtheoretical Model, and the theory of reasoned action and planned behavior. Doshi et al determined that the social cognitive theory and the Transtheoretical Model for behavior change are the most commonly used behavior change theories by Web based PA interventions and that interventions based on these theories are successful in promoting PA behavior change.
The social cognitive theory is based on the idea that PA behavior change and maintenance is dependent on a combination of personal, behavioral and environmental factors. Within this idea, the social cognitive theory focuses on examining cognitive processes, particularly, perception of physical and social environment, personal experiences with PA, perceptions and attitudes toward PA, knowledge about PA, skills, and beliefs. This theory, developed by Albert Bandura in the 1980s, emphasizes that individuals have the ability to self-regulate their behaviors by setting goals and strategically altering their environment to support these goals. Bandura suggests that self-regulation of behavior change depends upon how a person perceives the behavior change will affect them (consequences of the behavior) and whether they have the ability to make that change (self-efficacy); observational learning and modeling by others influence these factors. Dzewaltowski suggests that a strong sense of self-efficacy, dissatisfaction with past substandard attainment, and strong challenging goals are effective cognitions for motivation and should be evaluated within Bandura’s social cognitive theory.

The Transtheoretical Model was developed by James Prochaska and DiClemente who studied the process of behavior change in smokers. Through their research, they determined that as people attempt to quit smoking they move through a series of behavior change stages. Based on this idea, they created 5 specific stages of change: 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 >6 months)\textsuperscript{13, 67}. These stages have been applied to many health behaviors including PA\textsuperscript{67}. In addition to the stages, the Transtheoretical Model has developed 10 processes of change or strategies that people use to progress from one stage to the next\textsuperscript{68}. The Transtheoretical Model has been applied to behavioral change interventions in order to better individualize programs and address patient’s specific barriers and needs based on their current stage of change.

PA interventions based on the Transtheoretical Model have been shown to be successful in changing PA behavior in overweight and obese adults\textsuperscript{20, 64, 65, 68}. For example, a randomized control trial by Dallow and Anderson\textsuperscript{68} assessed the effectiveness of applying the Transtheoretical Model and self-efficacy theory to a 24 week PA intervention for obese, sedentary women between the ages of 25 and 60 with a mean BMI of 36.1 kg/m\textsuperscript{2}. Motivational readiness, processes of change, exercise confidence, energy expenditure, and cardiorespiratory fitness were measured at baseline, 24 weeks, and 48 weeks. Energy expenditure was assessed over the phone by a trained interviewer using the PAR, which is a 6-item instrument that estimates energy expenditure for PA in a 7-day period. The assessment tool includes questions related to participation in moderate, hard, and very hard physical activities and sleep time during the previous week. This information is converted to kcs/kg 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. Participants were randomly assigned to either a theory-based, lifestyle group (n=29) or a standard, usual care, exercise group (n=29). Each
group was given the PA goal of 30 minutes of moderate-intensity PA on most days of the week and was encouraged to gradually increase their PA in order to meet this goal by 24 weeks. The theory-based intervention group met for 90 minutes a week for the first 16 weeks of the intervention and then once every other week for the remaining 8 weeks. Meetings were facilitated by the same health care professional who discussed a variety of topics including integrating shorter bouts of PA into daily life, current PA guidelines, and physiological responses to exercise. Additionally, participants identified potential barriers to PA, discussed ways to overcome barriers, discussed relapse prevention, set personal goals, heard from other previously sedentary overweight/obese women, and went on field trips to a health center, water aerobics class, and a local bike path. The usual care group was provided with an individualized exercise prescription based on the ACSM guidelines and was given a 24 week free membership to a local fitness facility. They were provided 4 educational sessions on how to start and maintain an exercise program and were encouraged to find an exercise partner to exercise with them. Although the use of the fitness facility was highly recommended, participants were given the option completing their exercise at home. Nineteen lifestyle (66%) and 14 usual care (48%) participants completed the 24 week assessments. At baseline 26 (89%) of the lifestyle participants were in the contemplation stage and 3 (11%) were the in the preparation stage for PA. At 24 weeks, 3 (16%) had moved into the action stage and 9 (47%) into the maintenance stage. In the usual care group, 21 (71%) of the participants were in the contemplation stage at baseline and 1 (7%) and 5 (50%) were in the action and maintenance stage, respectively, at 24 weeks. Participant reported daily energy expenditure increased in the lifestyle group at 24 (32.9±0.3 to 33.9±0.4 kcal/kg) and 48
(32.9±0.3 to 34.7±0.4 kcal/kg) weeks and was significantly greater at both assessment points than the usual care group. For cardiorespiratory fitness, the lifestyle group had a significant increase from baseline to 24 (23.3±1.0 to 26.3±0.9 ml/kg/min) and 48 (23.3±1.0 to 25.8±1.0 ml/kg/min) weeks. The usual care group showed no change in energy expenditure or cardiorespiratory fitness throughout the study intervention however, their cardiorespiratory fitness level was significantly greater at baseline than the lifestyle group (28.1±1.0 ml/kg/min versus 23.3±1.0 ml/kg/min). At 24 and 48 weeks there was no difference in cardiorespiratory fitness between the groups. Therefore, the lifestyle group improved their fitness level while the usual care group remained the same, but both groups had the same relative cardiorespiratory fitness level at 24 and 48 weeks. Similar results were seen with self-efficacy. The usual care group had a significantly higher self-efficacy compared to the lifestyle group at baseline and showed no change throughout the study intervention. The lifestyle group had a significant increase in self-efficacy at 24 and 48 weeks relative to baseline. Significant improvements were also observed in 8 of the 10 processes of change in the lifestyle group and 2 of the 10 in the control group after 24 weeks. A limitation of this study is the significant differences seen between the groups for cardiorespiratory fitness and self-efficacy. It is unclear if participants with a higher baseline cardiorespiratory fitness, like in the control group, would have improved their fitness level to the same magnitude as those less fit. Additionally, because of the larger number of participants that dropped out of the study, the follow-up results may be bias to those participants who were more motivated to change compared to those who did not complete the study. Because of this, it may be difficult to generalize these results to all overweight/obese women. Nevertheless, this PA
intervention based on the Transtheoretical Model and self-efficacy theory was effective in changing PA behavior for those who actively participated in the program. These results confirmed the findings from Project Active, a randomized controlled clinical trial that compared a Transtheoretical Model based lifestyle PA intervention with traditional structured exercise intervention, by Dunn et al.\textsuperscript{20} The participants of Project Active were healthy, sedentary (mean self-reported energy expenditure of <35 kcals/kg/day) men (n=116) and women (n=119) with a mean age of 46.0±6.7 years and BMI 28.2±4.0 kg/m\textsuperscript{2}. They were randomly assigned to either a 6-month lifestyle intervention group based on the Transtheoretical Model or a 6-month gymnasium-based structured program group. Both the lifestyle and structured exercise groups were advised to participate in 30 minutes of moderate-intensity exercise on most days of the week. The lifestyle group met with a facilitator for 60 minutes once a week for the first 16 weeks and then once every other week for the final 8 weeks to discuss cognitive and behavioral strategies appropriate for their level of readiness for change. Participants were assessed monthly on their PA readiness for change and were given a tailored manual accordingly. Home assignments were given each week related to the weekly discussion topic. The structured exercise group was asked to attend 3 to 5 structured exercise classes at a local fitness center where group leaders helped participants to set realistic PA goals, monitored their PA, and provided verbal feedback. After 3 weeks of group leader instruction, the participants in the structured exercise group created their own exercise program which included anything offered by the fitness facility. They were encouraged to become self-directed and plan exercise when they would be minimally supervised. The goal was to have the participants act as a normal member of the fitness facility. Cholesterol, blood
pressure, body composition, cardiopulmonary fitness level and behavioral processes of change were assessed at baseline and 6 months. The results showed that both interventions were effective in improving cholesterol, increasing physical fitness, decreasing blood pressure, and decreasing body fat percentage. Additionally, significant improvements were seen in self-efficacy, motivational readiness, and processes of change (3 of the 10 for the lifestyle group and 4 out of 10 for the structure exercise group) similar to Dallow’s results 68. Overall, the researchers concluded that the lifestyle intervention based on the Transtheoretical Model was just as effective as the structured gymnasiumbased program in changing PA behavior. This study indicates that sedentary adults can make significant improvements in their health without having to participate in an on-site exercise program.

**PA and Weight Loss Interventions**

Very few studies have been done to assess the efficacy of PA and dietary lifestyle interventions in bariatric patients on weight loss outcomes. However, research has been done to evaluate the effectiveness of intensive lifestyle interventions on weight loss in the overweight and obese population 69. A study by Goodpaster et al 70 investigated the effectiveness of a 1 year weight loss and PA intervention on the adverse health risks and weight loss in morbidly obese individuals. Specifically, researchers evaluated whether the addition of a PA component to a dietary lifestyle intervention program would be effective in promoting further weight loss. Participants (n=130), between the ages of 30 and 55 years with a BMI between 35.0 and 39.9 kg/m², were randomized into 1 of 2 blinded groups. The first group received a dietary and PA intervention for the entire 12 months
(initial PA group). The second group received an identical dietary intervention to the first group but was not given a PA intervention until 6 months into the intervention (delayed PA group). Both participant groups participated in a behavioral lifestyle intervention which included 3 group sessions and 1 individual contact/month for the first 6 months, and 2 group sessions and telephone contacts/month for the last 6 months. The initial PA group was prescribed a progressive PA program at the onset of the intervention and the delayed PA group was given the same progressive PA program 6 months after the onset of the intervention. After receiving the PA intervention participants gradually increased their PA to 60 minutes of accumulated (≥10 minutes each bout) moderate-intensity PA/day, 5 days/week. Participants were also provided a pedometer and step goal of >10,000 steps/day, and were instructed to keep track of their PA in a journal. A pedometer, exercise videos, and occasional financial incentives were provided for motivational and program adherence purposes. The results showed that both groups lost a significant amount of weight at 6 months (10.9 kg for the initial PA group vs. 8.2 kg for the delayed PA group) and at 12 months (12.1 kg for the initial PA group vs. 9.9 kg for the delayed PA group). The initial PA group lost significantly more weight and had greater reductions in body fat and waist circumference at 6 months compared to the delayed PA group. The magnitude of weight loss, body fat, and waist circumference did not differ between groups at 12 months. At 6 months, the initial PA group had significantly increased their steps/day from 7048 to 8475 and was engaged in approximately twice the amount of vigorous activity compared to the delayed PA group (71 versus 36 minutes/week, respectively). The initial PA group maintained their steps/day and minutes of vigorous activity/week between month 6 and month 12 of the
intervention while the delayed PA group significantly increased their PA (7047 to 7991 steps/day; 36 to 53 minutes of vigorous activity/week). Researchers concluded that this non-surgical lifestyle intervention program was effective in promoting weight loss and that the addition of PA, regardless of whether initiated early or later in the program, promoted additional weight loss independent of a dietary intervention. Based on these results it was suggested that intensive lifestyle interventions use a behavior-based approach and include PA in addition to a dietary component. Jakicic et al \textsuperscript{71} investigated the amount of PA required to maintain weight loss in the overweight population through a 24-month PA intervention. After providing study participants a home treadmill and a specific PA program, they concluded that participants who performed at least 275 minutes/week of PA (1835 kcal/wk), in combination with decreased caloric intake, sustained a weight loss $>$10\%. The results from this study provided further evidence that PA is effective for the maintenance of weight loss in the morbidly obese population \textsuperscript{71, 72} and that non-surgical intensive lifestyle interventions are effective for weight loss \textsuperscript{70, 73, 74}.

\textit{Internet based PA interventions}

Doshi et al \textsuperscript{63}, offer an excellent review of PA Web sites for the use of behavior change theories. Researchers assessed Web sites for their use of the a variety of behavior change theories including constructs of health belief model, Transtheoretical Model, social cognitive theory, and theory of reasoned action and planned behavior. Twenty-four various Web sites were scored on a 100 point scale based on content validity and reliability. Most often Web sites used the Transtheoretical Model or the social cognitive theory. Overall, the Web site that scored the highest in using the health promotion
theories was www.justmove.org from the American Heart Association. Researchers concluded that the PA intervention Web sites studied were successful at providing knowledge-based information and most demonstrated the capabilities to be able to offer knowledge and guidance about PA behavior change. Nevertheless, they suggested that improvement was needed in the areas of feedback provided, Web site interaction, and manipulation of information provided based on a person’s differing stage of change.

Since this study, research has been done evaluating other Web site programs as tools for PA behavior change. Napolitano et al. investigated the effectiveness of an internet-based PA program in 65 participants with a mean BMI of 26.6±4.3 kg/m² and moderate PA level of 75.4±69.3 minutes/week. Participants were randomized to either the control group (n=35) or the intervention group (n=35). The study time period was 3 months and participants of both groups were assessed similarly at 1 and 3 months throughout the study. Participants in the control group were told they had to wait 3 months to access the PA intervention while the participants in the intervention group were given immediate access to the Web site, which included information based on the social cognitive theory and Transtheoretical Model. Targeted information and links to other Web sites were provided for each of the stages of motivational readiness (pre-contemplation, contemplation, preparation, action, and maintenance). For example, the precontemplation page contained suggested links to teach participants about PA. These included the PA guidelines, examples of PA, benefits of PA, tips to get started, and overcoming barriers. The contemplation page included links to help participants think about how to get started with being physically active. Links and information included a
walking program and activity planner, preparing for PA, choosing activities, a walking test, and tips to get started. The preparation stage included links related to measuring heart rate, measuring body circumference, and recording daily activity with the goal of preparing participants to begin PA. The action phase was focused on motivating participants to continue being physically active and contained links related to exercise safety, measuring progress and relapse prevention. For the maintenance stage, participants were provided the same links and information as the action stage. The intervention Web site also included the following main sections: Activity Quiz, Safety Tips, Becoming Active, PA and Health, Overcoming Barriers, Planning Activity, and Benefits of Activity. Emails were sent to the intervention group containing PA behavior change tips and a link back to the original intervention Web site. Each time the intervention group logged into the Web site they were asked to complete a readiness for change quiz. The questions from this quiz were not provided by the researchers in their manuscript. Based on the results from this quiz, participants were led to a stage-of-change section, targeting their current motivational readiness for change. Participants from the intervention group were encouraged to engage in moderate-intensity activity on at least 5 days/week. The PA stages of change and the Behavioral Risk Factor Surveillance System (BRFSS) were assessed and used as the primary outcomes. The BRFSS had previously demonstrated test-retest reliability for days/week, min/week, and metabolic equivalent min/week of PA and when compared to self-report PA logs, validity for days/week and min/week. The PA stages of change were analyzed on the basis of whether participants progressed (moved up ≥1 stage) or regressed (moved down a stage or stayed the same). The BRFSS results were reported for moderate minutes of PA and
walking minutes. Of the participants who began the study, 88% completed the 1 month assessment. At the 1 month time point, intervention participants were significantly more likely to have progressed to a higher stage of motivational readiness for change than the control group and reported a higher number of minutes/week of moderate intensity PA (112±75.7 versus 82±87.3) and minutes of walking (99.75±68.3 versus 68.39±85.2). At 3 months, 80% of the initial participant group completed the assessment. Researchers reported that there were no differences on stage of motivational readiness from month 1 to month 3, suggesting that movement of motivational readiness for change takes place early on in an intervention. Walking minutes was statistically different between the groups (p<.05) at 3 months with the intervention group walking 99.75±68.3 minutes/week and the control group walking 68.39±85.2 minutes/week. No difference was seen at month one between the groups. Based on the results from this study researchers concluded that sedentary individuals who participate in a theoretically-based Web site PA program may see significant changes in their readiness for PA behavior change a short time after beginning the program. Because the study intervention was only 3 months in length it cannot be assumed that the sedentary participants from this study would have 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 the Web site based intervention was effective in promoting long-term behavior change. In addition to significant changes in readiness for PA behavior change, progress through the stages of readiness for change (movement up ≥1 stages) lead to increased amounts of moderate intensity PA, time spent walking and motivation to become more physically active. Moderate intensity activity and progress through the stages of readiness for
change did not change beyond the first month of the intervention. Participants reported that after 1 month of the study intervention, they no longer used the Web site due to the stagnancy of the information. This may explain why the intervention group did not continue to improve their motivational readiness at 3 months. However, no information was provided regarding the number of actual hits to the Web site or whether the e-mails sent to the participants were received, making it difficult to determine the dose of intervention that each of the participants received and to assume that the initial changes in reported activity level and stage of change were due to the Web site/email information. Another limitation of the study is that PA and walking time was assessed using a self-report method which may have led to inaccuracies in the actual amount of time participants were engaging in PA. Objective measurements, such as a pedometer, may have provided a more objective and reliable method of assessing the participant’s PA, allowing the researchers to validate changes in motivational readiness for PA by changes in measured PA. Due to the variety of possible influences on behavior change (weekly emails, theory-based Web site, or a combination of the two) it is unclear as to which part of the program was most effective in motivating change. Additionally, due to the small sample size, the results from this study are less generalizable. Nevertheless, the internet may have the potential to be an effective way to stimulate behavior change through the use of an interactive Web site that provides varying information and individualized feedback based on the stages of motivational readiness for change. Future research assessing the long-term effects of a Web based PA intervention would be beneficial.
Marcus et al \(^{64}\) investigated the efficacy of an internet-based, individually tailored, PA intervention relative to a print-based, individually tailored, PA intervention. Secondly, they investigated the efficacy of an individually tailored internet-based program relative to a standard internet-based PA intervention. Participants assigned to the individually tailored internet-based intervention (n=81) were provided weekly email reminders to access the internet site which contained PA education and motivational information, goal setting functions, and links to other informative Web sites. Participants were also asked to complete a monthly questionnaire in which they were provided with immediate feedback individualized to their specific stage of readiness to change based on the Transtheoretical Model and level of confidence (social cognitive theory). They were also asked to set PA goals and keep track of their daily PA online. Participants were rewarded a $10/month compensation for completing the monthly questionnaires. Participants assigned to the individually tailored print-based intervention (n=86) received all of the same material as the internet-based intervention, but all information was provided through the mail rather than the internet. Participants assigned to the standard internet-based intervention (n=82) were given the option of participating in any of the following 6 publically available PA Web sites: The American Heart Association’s Just Move, Shape Up America, May Clinic Fitness and Sports Medicine Center, American Academy of Family Physicians’ PA section, and American Council on Exercise, and American College of Sports Medicine health and fitness information. Marcus et al \(^{64}\) determined that the American Heart Association’s Just Move program incorporated the Transtheoretical Model and social cognitive theory the most, which was also found by Doshi et al \(^{63}\). Baseline characteristics were not significantly different between groups.
Participants reported participating in ≤10 minutes of MVPA/week. Follow-up was completed at 6 months by 89.2% of the participants and at 12 months by 87.1% of participants. There were no differences in reported PA at 6 months with tailored print group reporting 112.5 minutes/week, the internet tailored group reporting 120.0 min/week and the standard internet group reporting 90.0 minutes/week ($P=0.15$). Similarly, there were no differences in PA at 12 months ($P=0.74$) with the tailored internet and tailored print groups reporting 90 minutes of PA/week and the standard internet group reporting 80 minutes/week. At 6 months, those meeting the PA guidelines of 150 minutes/week of moderately intense PA were 37.2%, 44.4%, and 36.6% for the tailored print, internet-tailored, and standard-internet groups, respectively ($P=0.52$). There were differences in reported minutes of moderate intensity PA between the 6 and 12 month assessment for all groups ($P=0.45$). Overall, the most common mode of activity between all groups was walking. Non-significant differences were found in estimated VO$_2$ between baseline and 12 month follow-up for all groups ($P=0.31$) but improvements in baseline VO$_2$ was significantly correlated to changes in the follow-up interview. Marcus et al. $^{64}$ concluded that all of the researched PA interventions were effective in improving PA levels in previously sedentary adults. However, a limitation of the study was that the assessment of PA was based on self-reported PA methods, which may have led to over or under-reporting of PA. Additionally, because the standard-internet group was allowed the option of an internet-based program based on the Transtheoretical Model and social cognitive theory, it cannot be determined whether the development of material based on these methods influenced the effectiveness of the PA intervention. Other research has shown that PA behavior change interventions based on
the Transtheoretical Model and social cognitive theory are successful in changing PA behavior\textsuperscript{65}. This may explain why the groups had similar changes in PA. A study by Spittaels et al\textsuperscript{18} concludes that although tailored advice provided by an online PA program is more appreciated by individuals, it is not more effective than online standard information related to PA. Based on both of these studies, it is unclear whether the delivery method (internet versus print) of educational material or the technique of how the information is presented (tailored versus standard) motivates change.

Carr et al\textsuperscript{75} researched the effectiveness of an internet-delivered theory-based PA behavior change program called the Active Living Every Day (ALED) on increasing PA and improving cardiovascular risk factors in the overweight and obese population. The ALED program is a commercially-available behavior change program based on the Transtheoretical Model\textsuperscript{13} and the social cognitive theory\textsuperscript{78} that was developed by Human Kinetics®\textsuperscript{14}. The ALED program includes a workbook (Human Kinetics®) and a Web site\textsuperscript{79} that is designed to guide participants through a step-by-step process to becoming more physically active. The content was based on Project Active\textsuperscript{20}, a randomized clinical trial that compared a lifestyle PA intervention (based on the Transtheoretical Model) with a traditional structured exercise intervention. The workbook contains 12 chapters (lessons) designed to aid participants in determining and understanding their stage of readiness for change and what steps to take to progress to the next stage\textsuperscript{14}. Some of the topics included in the chapters are: finding ways to become more active, overcoming barriers, setting goals, gaining confidence, enlisting support, avoiding pitfalls, defusing stress, positive planning, and maintaining behavior change. In
addition to the workbook, the ALED Web site offers links to other Web sites that provide further information related to each of the lessons. The book also contains signposts throughout each chapter including: activity alerts (spotlights hands-on activities), myth busters (corrects common misconceptions about PA), real life (offers testimonies by people who have made positive lifestyle changes), did you know (offers facts and information related to PA and the most recent PA research), and weighing in (provides advice for people interested in losing weight). To evaluate the effectiveness of the internet-delivered ALED program in the overweight/obese population, Carr et al. randomized 67 overweight/obese adults (BMI 31.5±0.9) into a control group and an ALED intervention group. Of the control group, 3 participants dropped out of the study prematurely due to medical reasons or non-compliance and 9 participants were dropped from the data analysis due to incomplete data. Of the ALED intervention group, 11 participants dropped out prematurely due to time constraints, medical reasons, or noncompliance and 12 participants were dropped from the final data analysis due to incomplete data. Thirty-two participants were included in the final data analysis with 18 making up the control group and 14 the ALED intervention group. Baseline and follow-up PA (steps/day) was measured using the Yamax Digiwalker® SW-200 pedometer during the first and last week of the 16 week study intervention in both groups. During the intervention time period (between baseline and follow-up assessment) control participants were instructed to maintain their current lifestyle behaviors and were not given a pedometer. The ALED intervention group was issued a pedometer and instructed to keep track of their daily steps in a PA journal. Additionally, the ALED group met with a research professional bi-monthly to increase their weekly step goal by 10%. During the
16-week protocol participants were asked to complete the ALED program at their own pace and were provided the ALED handbook as well as 24 hour/day access to the ALED Web site. Facilitators communicated with the participants once a month and assessed their participation in using the online ALED resource. At baseline the ALED group was older and had higher triglycerides with a higher overall coronary risk ratio. Waist circumference was also greater in the ALED group at baseline. However, baseline average steps/day was not different between groups. Following the study intervention, the control group had a significant increase in body fat percentage (43.1±1.3 to 44.3±1.3) paired with a significant decrease in lean body mass percentage (56.9±1.3 to 55.7±1.3). The control group showed no change in PA level from baseline to follow-up ($P=0.14$), whereas the ALED group had a 17% increase which was statistically significant. After controlling for age, the ALED group showed a reduction in waist circumference and coronary risk ratio that was not found in the control group suggesting a correlation in PA level and overall body composition. Overall, researchers concluded that the ALED intervention was effective in increasing PA and decreasing waist circumference in the overweight/obese population and that the degree of baseline PA predicted the efficacy of the ALED internet delivered program. Previous studies had been done validating the use of the ALED program for increasing self-reported PA in normal/overweight adults through a small group delivery format $^{20}$. This study confirmed that using the internet-delivered ALED program was just as effective as the small group delivery format that was initially studied by Dunn $^{20}$. 
A more recent study by Patrick et al. assessed the effect of a 1-year internet-based weight loss intervention on weight-related behaviors in 441 participants. Of the participants, 69 of them were overweight (BMI 25.0-29.9 kg/m²), 184 were classified as obesity I (BMI 30.0-34.9 kg/m²), 149 classified as obesity II (BMI 35.0-39.9 kg/m²), and 39 classified as obesity III (BMI >40.0 kg/m²). Participants were randomized into a control group and intervention group and were assessed at baseline, 6, and 12 months. Baseline and 12 month assessments took place at the research office and the month 6 assessment was completed online for the participant’s own computer. Participants were compensated $20 for completing the 6-month assessment and $100 for completing the 12-month assessment. Demographic characteristics were similar between the groups.

Participants in the intervention group (n=224) were provided internet-based intervention with Web content created in short, weekly sessions that was based on the social cognitive theory and the behavioral determinants model. More specifically, the program consisted of an individualized behavioral assessment, which was used to tailor recommendations for behavioral targets, weekly Web-based learning activities, and individualized feedback on progress. Frequently, participants were reassessed for health behaviors in order to continue altering the content based on the individual’s needs. Participants set individualized goals for dietary and PA behaviors based on an internet-based assessment. The intervention allowed for participants to choose which behaviors they wanted to work on the most and encouraged them to make small changes along the way. Participants in the intervention group were provided with a Yamax Digiwalker® pedometer and were encouraged to keep track of their activity by inputting their daily steps into the Web site. Researchers also communicated with intervention participants through email or phone to
encourage the use of the Web site when necessary. Participants in the control group (n=217) were given access to an alternative Web site that contained general information of interest to men but not related to diet and PA behavior change. Control participants were given the opportunity to use the weight loss intervention Web site at the completion of the study. Of the participants who began the study, 58% had a complete data set at the end of the study. Patrick et al reported no difference in BMI, weight, or waist circumference between the groups throughout the study time period. Still, researchers saw a significant change in dietary behaviors such as intake of fat, saturated fat, and daily servings of fruits and vegetables in the intervention group compared to the control. No change in body mass was attributed to the nonspecific dietary recommendations which focused on behavior change rather than specific calorie restriction goals. Additionally, researchers reported a significant increase in IPAQ total walking (minutes/day) for the intervention group when compared to the control group. No objective data from the pedometer was reported. Participation in the weight loss intervention was determined by the number of times participants logged-in to complete goal-setting. Participants who logged-in to complete at least 60% (≥31 weeks) of the recommended goal setting sessions (1 time/week) lost more weight, reduced their BMI and waist circumference, and were more likely to lose 5% of their initial body weight than those who logged in <31 weeks. In conclusion Patrick et al concluded that overweight and obese men who actively participate in an internet-based weight loss intervention (>60% of the time) can make positive behavioral changes related to diet and PA that result in weight loss.
Pre-Bariatric Surgery PA Interventions (Internet and PA Devices and other)

There is limited research assessing the effectiveness of pre-bariatric surgery behavior modification programs on objective PA levels pre- and post-surgery. A study done by Brandenburg et al. assessed the effectiveness of a pre-surgery behavior modification program on necessary lifestyle-modifications, including PA, with the use of a self-report questionnaire. The pre-surgery behavior modification program was developed by the McLaren Regional Medical Center in Michigan, aiming to provide a multi-dimensional approach to behavior change in 124 RYGB patients. Patients were enrolled in the program for 6 weeks before their surgery date. The program included a medically-supervised liquid supplement diet combined with weekly behavioral modification group sessions. The purpose of the liquid supplement diet was to train patients to follow the necessary guidelines required of them after RYGB. The behavioral modification group sessions were structured around the following topics: cognitive and emotional components to eating, relapse prevention, setting goals, exercise, stress management, and changing self-talk. In addition to the educational sessions patients were given the opportunity to talk about their successes and obstacles, review their dietary log, use resistance training bands, and meet one-on-one with a dietician. Researchers evaluated the perceived usefulness of the pre-surgery behavioral modification program and its effect on weight loss, PA, and dietary changes. Data was obtained from a self-report questionnaire which participants received approximately 1 year post-surgery. Participants (n=124) were 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. They were also asked to rate their satisfaction with the pre-surgery behavioral modification program and the usefulness of each of the programs specific components. Of those participants who returned the survey (n=70) 99% were Caucasian, 78.6% were female, 68.6% were employed, 80% were married, 54% had a college degree and mean age was 46.2±9.3. At the time of the survey participant’s mean BMI had decreased 19 kg/m² from the initial preoperative BMI of 55.3 kg/m². One year post-surgery, 20% of the study participants reported no current PA, while 45% reported being physically active at least 3 days/week. Eighty percent of participants reported being physically active at least 1 day a week and of those, 31.9% reported engaging in at least 90 min/week. Participants’ satisfaction with the amount of focus on exercise during the 6 week pre-surgery behavior modification was average and many suggested that more emphasis should be placed on this topic. Researchers concluded that future research needs to be done in order to obtain objective evidence about whether pre-surgery programs are effective at changing behaviors.

Summary

As the prevalence of morbid obesity continues to rise, more individuals are choosing bariatric surgery as an effective weight loss intervention. Based on the literature, bariatric surgery does not promote health behavior change in the majority of bariatric patients and as a result, researchers are recognizing the need for new behavioral change strategies to prevent weight regain and future development of cardiovascular risk factors. PA is a vital component to successful weight loss and maintenance and needs to
be a part of these strategies. Researchers must find ways to effectively promote PA behavior change pre- and post-surgery and define what influences PA behavior change in the obese population. The use of internet-based interventions as a supplement to existing programs may be a time and resource efficient way of providing information based on theories of behavior change. Additionally, the effectiveness of PA self-monitoring tools, like pedometers or accelerometers, should be investigated further in this population as a potential behavior change strategy. Additionally, short-term and long-term studies researching the efficacy of pre-surgery and post-surgery behavioral modification programs on bariatric surgery outcomes are needed. With the availability of this information, appropriate guidelines for administering pre- and post-surgery behavioral modification programs can be established.
CHAPTER III

METHODOLOGY

Research has shown that bariatric surgery has a significant effect on short-term weight loss and the incidence of diabetes, hypertension, hypertriglyceridemia, low HDL levels, sleep apnea, and quality-of-life \(^4\)\(^-\)\(^6\); without lifestyle modifications and long-term maintenance of weight reduction, the initial improvement in these risk factors diminishes \(^9\).

PA has been proven to be an effective method to maintaining weight loss and preventing weight re-gain, while improving overall cardiovascular risk \(^2\), \(^8\). Currently, there are no published studies reporting data on the effect of a pre-surgery PA intervention on sedentary behavior in the bariatric patient population and very few studies have evaluated the effect of an internet-based PA intervention prior to bariatric surgery, on PA behavior change. Therefore, the purposes of this study were to: 1) assess whether the ALED PA intervention, a structured 12-week internet-based program, would promote an increase in average steps/day and total time spent in sedentary, light, and moderate/vigorous activity per day relative to device wear time in bariatric patients prior to their bariatric surgery; 2) determine any changes in subject characteristics, cardiovascular disease (CVD) risk factors, and psychological characteristics from pre- to
post-PA intervention; and 3) determine whether total usage of the ALED online step-log was associated with change in average steps/day from pre- to post-PA intervention.

**Methods**

The Institutional Review Boards at both Ball State University and Indiana University Health Ball Memorial Hospital approved this study. Monthly participant recruitment meetings were held at the Indiana University Health Ball Memorial Hospital Bariatric Clinic (IUHBC) with the bariatric surgery candidates and the bariatric surgery staff to explain the procedures and guidelines of the study. Participants were 19 individuals preparing for bariatric surgery at Indiana University Health Ball Memorial Hospital in Muncie, Indiana or Indiana University Health in Indianapolis, IN. Of the 19 participants who consented, 11 (58%) completed the study and were included in the data analysis. Participants ranged from 22-59 years of age and were actively participating in the pre-surgery preparatory requirements at IUHBC which included 4-6 months of required nutritional sessions.

**Study Design**

Participants were recruited by the researchers at the once-per-month seminar meeting held at the IUHBC or by the IUHBC nurse and dietician at the patient’s required pre-surgery monthly nutritional counseling sessions. Following recruitment, participants were scheduled for an individual orientation meeting with an investigator to go over the procedures. After orientation, participants visited the Ball State University Human Performance Laboratory (HPL) for their baseline assessments and after the 12-week PA
intervention for their follow-up visits. Overall each participant was required to meet with the researcher on 5 separate occasions with 4 of the appointments taking place at the HPL (2 at baseline and 2 at follow-up) and the remaining appointment at the IUHBC. Additionally, each participant met with an investigator once-a-month throughout the 12-week intervention to download their PA device.

**Procedures**

**Visit One**

Participants scheduled individual meetings with the investigators at the IUHBC for their first day of testing to receive their PA monitors and log sheet and to complete the necessary paperwork and psychological assessments. During this first visit, study procedures were explained and questions were encouraged and addressed regarding the methodology. Participants read and signed the informed consent and protected health information form. Following consent, the participants were asked to complete the quality-of-life survey, stage of change questionnaire, exercise thoughts questionnaire, exercise barrier questionnaire, and self-efficacy survey (Appendices B-F).

For proper set-up of the Omron pedometer (Omron Healthcare Model HJ-720ITC dual-axis pedometer; Omron Healthcare, Inc., Bannockburn, IL, USA), each participant’s stride length and baseline (pre-PA intervention) weight were measured. To determine stride length, participants walked at a comfortable pace for 10 steps which was counted by the researcher; total distance was measured with a tape measure and divided by 10 to determine approximate stride length in inches. Weight was measured with shoes off;
both weight and stride length measurements were entered into the Omron. Participants were instructed on how to properly wear the pedometer, and accelerometer (Actigraph Model GT3X tri-axial accelerometer; Actigraph, Pensacola, FL, USA), on their waistbands, with the devices placed at the midline of their thigh in an upright position. Each participant was asked to demonstrate proper placement of the devices for the researchers. Participants were asked to put on the PA monitors each morning upon rising, and remove before going to bed at night for a total of 7 consecutive days. The participants were instructed not to wear the devices while bathing/showering or while participating in water activities. Non-wear time was assessed using the Actigraph software (SAS version 5.10; Actigraph, Pensacola, FL, USA) and participants were asked to re-wear the device if they had <4 days of wear time at <8 h/day. In addition, participants were scheduled for their second research visit and were given a health history questionnaire (HHQ) to fill out and bring with to the Human performance Laboratory (HPL) for their next visit.

Visit Two

Participants arrived at the HPL for their second visit 1-2 weeks after their Visit One with their completed HHQ, PA log sheet and PA devices. If the participants wore the PA devices for longer than 7 days, the last 7 days were used for analysis. The research staff reviewed their HHQ while the participant rested in a seated position for 5 minutes. Blood pressure, heart rate, and body composition were measured following standardized lab procedures according the American College of Sports Medicine (ACSM)². Blood pressure measurements were obtained by a trained technician with an
aneroid sphygmomanometer (Baumanometer®; W.A. Baum Co, Inc., Copiague, NY, USA) as the participant sat quietly in a chair with their feet flat on the floor and arm supported at heart level. Two blood pressure measurements were taken at least 1 minute apart on the left arm; the lowest blood pressure measurement was used for analysis. In addition to blood pressure, heart rate was calculated by palpating the radial pulse on the left arm for 30 seconds and doubling; the HR measurement was taken between the 2 blood pressure measurements.

Weight was measured on a calibrated digital scale (Toledo iD1 Multirange, Model KC240; Toledo Scale Corporation, Worthington, Ohio, USA) and height was measured using a calibrated stadiometer (Seca 222; Vogel & Halke GmbH & Co, Hamburg, Germany). Patients were asked to remove their shoes, empty their pockets, and remove any heavy jewelry or extra clothing, including jackets or sweatshirts, to prevent measurement error. In addition to weight and height measurements, circumference measurements were taken of the waist, hip, bicep, calf and thigh using a cloth tape measure with a spring-loaded handle according to the established anatomical landmark guidelines as defined by the ACSM. Measurements were taken on the anatomical right side of the body and were taken at least 2 times; the 2 measurements, falling within 2 centimeters of each other, were used to obtain an average circumference measurement.

Participants underwent a body composition measurement of total body and regional adiposity using a Lunar iDXA™ Dual-energy x-ray absorptiometer (enCORE software, version 13.40.038; GE Healthcare, Madison, WI, USA) (DXA). Prior to the scan, participants were asked to remove their shoes, and any clothing, jewelry or
accessories containing metal. The participant was asked to lie still in the supine position on the DXA platform for 13 minutes while the scan was taken. The scan was performed in “thick mode” for all participants, assuming a body thickness of >25 cm; body thickness is chosen based on a person’s height and weight by the Lunar iDXA™ software. A strap was placed around the participant’s lower legs to help them hold their legs still. Due to body size, all of the participants in this study were unable to completely fit into the measurement box. As a result, the complete right side of the body was positioned inside the measurement box and the body composition for the left side of the body was estimated by the Lunar iDXA™ software.

At the completion of the DXA scan, participants completed a submaximal exercise test on a treadmill consisting of walking at 1.5 mph @ 1% grade (≈2.4 METs) and 2.3 mph @ 4% grade (≈4 METs). Before the test, participants were prepped for the recording of a 12-lead electrocardiogram (Case P2 Series; GE Medical Information Technologies, Milwaukee, WI, USA). This included wiping each appropriate electrode site with alcohol, brushing the skin with an abrasive prep pad, and placing the 10 electrodes in their designated location. Before having the participant walk on the treadmill, they were instructed on the testing procedures and the Borg rating of perceived exertion (RPE) scale (6-20 scale) \(^{81}\) was explained. The participants were encouraged to communicate any symptoms felt during the test. After the initial submaximal test instructions, a blood pressure was taken on the participant’s left arm in the supine and standing position. The headpiece and mouthpiece were placed on their head and in their mouth, and connected to the metabolic measurement system. Participants were given a
60 second warm-up at 1.2 mph. Heart rate (via electrocardiogram) and RPE were recorded each minute and blood pressure was recorded at 4 and 8 minutes during the 8 minute test. Oxygen consumption (VO₂), carbon dioxide production (VCO₂), and respiratory exchange ratio (RER) were measured continuously throughout the exercise test via Parvo Trueone 2400 Metabolic Measurement system (ParvoMedics, Inc., Sandy, UT, USA) and analyzed using 1 minute averages. The session was terminated prior to the completion of the 8 minutes if the participant reached 84% their age predicted maximal heart rate (220-age) for exercise or if the participant experienced any other signs, symptoms, or responses that have been established for termination of an exercise session².

Following the assessments at this visit, the participant’s PA devices were downloaded and analyzed as their baseline PA level. The Omron pedometer was given back to the participant to be used for the remainder of the study. A blood analysis requisition form was given to the participants to take to the LabCorp in Muncie, IN to obtain a fasting blood sample that was analyzed for glucose, insulin, LDL-cholesterol, HDL-cholesterol, and triglycerides. At the completion of the second visit, the third visit to the HPL was scheduled and instructions about how to prepare for this visit were given. Participants were asked to arrive to the HPL well rested on a 4 hour fast without the use of caffeine or tobacco prior to the visit.

Visit Three

Participants arrived to the HPL for their third visit 1 to 2 weeks after Visit Two, fasted and well rested for the resting metabolic rate measurement (RMR) via the dilution
method (ParvoMedics, Inc.), which was confirmed prior to beginning the test. The participants were asked to lie down on a padded surface for 30 minutes, in a quiet room with low lighting. After resting for 30 minutes a clear plastic hood was placed over their head and a steady flow of fresh air was circulating through the hood. The participants were asked to be as still as possible during the measurement and to not fall asleep. Energy expenditure was calculated by analyzing oxygen consumption for 15-30 minutes.

At the conclusion of the third visit, the researcher assisted the participant in creating an online ALED account. Instructions and demonstration were provided to the participant on how to use the online program, how to begin the 12-week PA intervention and how to obtain online/Web site technical support if needed. Participants were told to read 1 chapter/week in the ALED textbook and to record their daily step totals on the ALED website step-log. After demonstration and hands-on practice using the online program by the participant, all questions were addressed by the researcher. Participants were encouraged to contact the researcher by phone or email with any questions about the program throughout the remainder of the study and were reminded of the next time they would need to meet the researcher for the download of their pedometer (1 month from Visit Three date).

Visit Four and Five

Following completion of the 12-week PA intervention program, participants returned to the HPL to repeat the procedures of Visits One, Two, and Three as stated above before their bariatric surgery.
PA Assessment Devices

PA was recorded using the Actigraph Model GT3X tri-axial accelerometer and the Omron Healthcare Model HJ-720ITC dual-axis pedometer as stated above. The Actigraph is worn on the waist at the midline of the thigh and measures activity counts, steps taken, energy expenditure, and activity levels. For the purpose of this study, activity counts from the Actigraph were used for analysis of PA and sedentary, light, and moderate/vigorous activity in the bariatric participants. Lopes et al.\textsuperscript{23} validated activity count cut-points for sedentary (0-199 counts/minute), light (200-1239 counts/minute), and moderate/vigorous (≥1240 counts/minute) activity in the overweight and obese population using the Actigraph. These cut-points were used to define sedentary (<1.5 METs), light (1.5-2.9 METs), moderate/vigorous activity (≥3 METs) in the present study. Each participant’s Actigraph accelerometer dataset in the present study was assessed via Actilife software (SAS version 5.10) for data validation purposes; the Actilife software was used to convert the downloaded Actigraph data into an .agd file and then a .csv file which was opened and analyzed in a Microsoft Excel 2007 spreadsheet (Microsoft Corporation, Redman, Washington, USA) by the researcher. The Actigraph was worn during the pre- and post-intervention analysis; In order for the data to be considered valid, the Actigraph had to be worn for at least 8 h/day and at least 4 days/week.

The Omron pedometer was used to quantify steps/day in this study. The Omron pedometer was worn on the waistband at the midline of the thigh, but has been validated at various mounting positions in overweight adults (7). Each participant’s Omron pedometer was assessed via Omron Health Management Software version 1.3. The
Omron was worn during the pre- and post-intervention analysis and throughout the entire intervention period.

*Active Living Every Day Program*

The ALED program was used as the 12-week PA intervention. This program is designed to help people improve their health and quality of life and is designed based on the following principles: that moderate amounts and intensities of PA have health benefits, that increasing lifestyle PA is an important alternative to formal exercise programs, and that people will be more likely to become and stay active when they are given the tools for lifestyle change based on their readiness to change 14, 82. The ALED intervention was delivered via internet access through a secure Web site and a supplemental textbook given to each participant. 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. Participants were encouraged to use the online pedometer tracking tool (step-log) throughout the intervention to record their daily steps, measured by the Omron pedometer.

*Monthly Downloads*

At the monthly face-to-face meetings, the participant’s pedometer was downloaded and their progress through the ALED program was discussed. Feedback and suggestions were provided when appropriate. These meetings lasted approximately 10 minutes and were necessary in order to clear the 41 day memory capacity of the Omron
pedometer. The meetings took place at a location most convenient for the participant, but most often were held at the IUHBC or HPL.

**Statistical Analysis**

The primary purpose of this study was to determine whether participation in the ALED PA intervention, a structured 12-week internet-based program, would promote an increase in average steps taken/day, a decrease in average sedentary (<1.5 METs) time/day, and an increase in average time spent in light (1.5-2.9 METs) and moderate/vigorous (≥3 METs) activity/day. Sedentary, light, and moderate activity was measured using the Actigraph Model GT3X tri-axial accelerometer (Actigraph, Pensacola, FL, USA). Threshold ranges for each of the intensity levels were reported according to the ranges defined by Lopes et al.\textsuperscript{23} for overweight and obese individuals. Steps/day was measured using the Omron Healthcare Model HJ-720ITC dual-axis pedometer (Omron Healthcare Inc., Bannockburn, IL, USA) as described in the section **PA Assessment Devices.** Separate baseline (pre-PA intervention) and follow-up (post-PA intervention) profiles were created for each of the PA measures (average steps/day, percentage of sedentary, light, and vigorous/moderate activity relative to PA device wear time, and average time spent in sedentary, light and moderate/vigorous activity/day) and consisted of basic descriptive statistics (e.g. mean, standard deviation). Baseline and follow-up PA intervention data were compared using non-parametric Wilcoxon Signed Ranks Test to determine whether differences existed for all PA measures with an alpha value of 0.05.
The second purpose of the study was to determine any changes in subject characteristics (weight, BMI, waist circumference, hip circumference, resting systolic and diastolic blood pressure, peak heart rate, peak RPE, RMR, blood lipids, including LDL and HDL cholesterol and triglycerides, fasting blood glucose, and fasting blood insulin), reported PA, reported regular PA, and psychological characteristics (self-efficacy, perceived exercise barriers, and perceived exercise thoughts) from baseline to follow-up. Basic descriptive statistics (e.g. mean, standard deviation) were provided for each variable and baseline and follow-up PA intervention data were compared using non-parametric Wilcoxon Signed Ranks Test to determine whether differences existed with an alpha value of 0.05.

The third purpose of the study was to compare ALED step-log usage with average baseline sedentary activity and with average follow-up sedentary activity. These comparisons were made between 2 groups: 1) participants with <65 days of step-log usage and 2) participants with ≥65 days of step-log usage. Basic descriptive statistics (e.g. mean, standard deviation) were provided for all variables and comparisons were made using the Mann-Whitney U Test to determine whether differences existed between groups with an alpha value of 0.05.

All statistical procedures were performed using SPSS and IBM company statistics program (Version 19.0, Chicago, IL) for MAC/PC computer.
CHAPTER IV
RESEARCH MANUSCRIPT

Journal Format: Obesity
PRE-BARIATRIC SURGERY PHYSICAL ACTIVITY INTERVENTION

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ABSTRACT

No scientific data exists reporting the effect of a pre-surgery PA intervention on objectively measured pre-surgery sedentary behavior in the bariatric patient population; very few studies have evaluated the effect of an internet-based PA intervention, prior to bariatric surgery, on pre-surgery PA behavior change. To investigate the effect of a 12-week internet-based PA intervention (Active Living Every Day (ALED)) program on average steps/day and daily time spent in sedentary, light, and moderate/vigorous activity/day, PA was objectively measured at baseline and follow-up using the Omron pedometer (steps/day) and the Actigraph GT3X (daily activity level) in 11 bariatric patients (41±12 years) from the IU Health Ball Memorial Hospital Bariatric Clinic. Significant changes (p<.05) were found in weight, BMI, body fat %, waist and hip circumference, submaximal RPE, percentage of individuals reporting PA (walking briskly, jogging, bicycling, swimming, etc) and perceived exercise barriers from baseline to follow-up. No significant differences were found in steps/day or daily activity level from baseline to follow-up. On average, bariatric participants walked approximately 4454 ± 203 steps/day and 74% of their day was spent in sedentary behavior. Based on this data it appears that the 12-week PA intervention was not effective in significantly changing PA behavior in the short-term, despite improvements in other cardiovascular risk factors, RPE and perceived exercise barriers.

Keywords: Bariatric, Physical Activity Intervention, Lifestyle Physical Activity
Introduction

Obesity, the leading preventable cause of death worldwide, affects nearly 33% of the US population and is considered the most serious public health issue. Studies have shown that bariatric surgery, also known as weight-loss surgery, is the most effective weight loss intervention for the treatment of morbid obesity (BMI ≥40 kg/m² or BMI >35 kg/m² paired with serious obesity-related co-morbidities) and its related cardiovascular disease (CVD) risk factors and comorbidities. Bariatric patients who incorporate PA into their daily routine before or after bariatric surgery show greater improvements in weight loss, short-term surgery complications, and quality-of-life compared to those who remain inactive. Despite this, studies using self-report measurements of PA have shown that 90-95% of bariatric patients are not meeting the current PA recommendations and, based on objective PA measurements, spend approximately 80% of their day in sedentary behavior pre-surgery. Noncompliance with PA recommendations pre-surgery has been shown to carry over into post-surgery PA behaviors and result in lower percent excess weight loss (%EWL) long-term; therefore, because the primary goal of bariatric surgery is %EWL, it would make sense that patients should be able to demonstrate their willingness and ability to change PA behavior prior to having bariatric surgery. There is a need to develop PA interventions to determine a successful approach to promote PA behavior change prior to bariatric surgery.

Health behavior change and compliance with behavioral recommendations have been linked to motivation and self-efficacy. As a result, readiness-for-change, as defined by the Transtheoretical Model, has been recommended as one of the backbones...
to effective PA behavior change interventions. Self-monitoring tools such as pedometers and internet-based programs are also effective ways to promote behavior change. Internet-based PA programs that incorporate individualized feedback are successful in promoting weight loss and improving levels of PA. Additionally, PA programs that focus on lifestyle change have proven as successful in changing PA behavior as a structured exercise program taking place in a fitness center setting. Using a combination of these techniques, Blair et al has designed a 12-week internet-based program called Active Living Every Day® (ALED) with the goal of improving people’s health and quality of life through a variety of lifestyle PA recommendations specific to the person’s motivational readiness for change and through the use of self-monitoring tools. Current research evaluating PA compliance in the bariatric population has primarily used self-report methods for collecting PA data. Bond et al has concluded that bariatric patients tend to over-report their PA levels after bariatric surgery and suggests using an objective measurement, like an accelerometer, for a more accurate representation of PA.

Currently, there are no published studies reporting data on the effect of a pre-surgery PA intervention on objectively measured pre-surgery sedentary behavior in the bariatric patient population. Additionally, very few studies have evaluated the effect of an internet-based PA intervention, prior to bariatric surgery, on PA behavior change defined as steps/day. Therefore, the purposes of this study were to: 1) assess whether the ALED PA intervention, a structured 12-week internet-based program, would promote an increase in average steps taken per day, total time spent in sedentary, light,
moderate/vigorous activity/day (h/day), and percentage of sedentary, light, and moderate/vigorous relative to average wear time (the average time the PA device was worn) in bariatric patients prior to their bariatric surgery; 2) determine changes in participant characteristics, CVD risk factors, and psychological characteristics from pre-to post-PA intervention; and 3) determine whether total usage of the online step-log was associated with change in sedentary activity from pre- to post-PA intervention.

**Methods**

**Participants**

The Institutional Review Boards at both Ball State University and Indiana University Health Ball Memorial Hospital (IUHBMH) approved this study. Monthly participant recruitment meetings were held at the Indiana University Health Ball Memorial Hospital Bariatric Clinic (IUHBC) with the bariatric surgery candidates and the bariatric surgery staff to explain the procedures and guidelines of the study. Participants were recruited by the researchers at these monthly seminar meeting or by the IUHBC nurse and dietician at the patient’s required pre-surgery monthly nutritional counseling sessions. Bariatric patients pursuing Roux-en-Y Gastric Bypass (RYGB) or Lap-Band surgery at Indiana University Health (IUH) in Indianapolis or IUHBMH in Muncie, IN, respectively, served as the sample for the current study. The sample represented morbidly obese patients actively participating in 4-6 months of pre-surgical preparatory requirements at the IUHBC. Individuals were included if they met the following criteria: 1) were ambulatory, 2) had weekly access to internet, and 3) anticipated having bariatric surgery no sooner than 4 months after the intervention start.
date. Throughout the recruitment time period (8 months), 104 bariatric patients were spoken with about the current research study; of these, 19 patients consented to participate. Of the 19 bariatric patients who consented to participating, 8 (42%) did not complete the study intervention and were not included in final analysis due to the following reasons: excluded from participation after consent due to extensive health history (2 participants), complications with diabetic neuropathy and rheumatoid arthritis (1 participant), death in the family (1 participant), pregnancy (1 participant), and unspecified personal reasons (3 participants); 7 of the 8 participants who did not complete the study are not pursing bariatric surgery at this time. No cost was required for participation, and all participants who completed the study were allowed to keep the ALED textbook and Omron pedometer.

Visit One

Participants scheduled individual meetings with the investigators at the IUHBC for their first day of testing to complete the necessary paperwork and psychological assessments and to receive their PA monitors. During this first visit, study procedures were explained and questions were encouraged and addressed regarding the methodology. Participants read and signed the informed consent and protected health information form. Following consent, the participants were asked to complete the quality-of-life survey, stage of change questionnaire, exercise thoughts questionnaire, exercise barrier questionnaire, and self-efficacy survey (Appendices B-F).

For proper set-up of the Omron pedometer (Omron Healthcare Model HJ-720ITC dual-axis pedometer; Omron Healthcare, Inc., Bannockburn, IL, USA), each participant’s
stride length and baseline (pre-PA intervention) weight were measured. To determine stride length, participants walked at a comfortable pace for 10 steps which was counted by the researcher; total distance was measured with a tape measure and divided by 10 to determine approximate stride length in inches. Weight was measured with shoes off; both weight and stride length measurements were entered into the Omron. Participants were instructed on how to properly wear the pedometer, and accelerometer (Actigraph Model GT3X tri-axial accelerometer; Actigraph, Pensacola, FL, USA), on their waistbands, with the devices placed at the midline of their thigh in an upright position. Each participant was asked to demonstrate proper placement of the devices for the researchers. Participants were asked to put on the PA monitors each morning upon rising, and remove before going to bed at night for a total of 7 consecutive days. The participants were instructed not to wear the devices while bathing/showering or while participating in water activities. Non-wear time was assessed using the Actigraph software (SAS version 5.10; Actigraph, Pensacola, FL, USA) and participants were asked to re-wear the device if they had <4 days of wear time at <8 h/day. In addition, participants were scheduled for their second research visit and were given a health history questionnaire (HHQ) to fill out and bring with to the Human performance Laboratory (HPL) for their next visit.

Visit Two

Participants arrived at the HPL for their second visit 1-2 weeks after their Visit One with their completed HHQ, PA log sheet and PA devices. If the participants wore the PA devices for longer than 7 days, the last 7 days were used for analysis. The
research staff reviewed their HHQ while the participant rested in a seated position for 5 minutes. Blood pressure, heart rate, and body composition were measured following standardized lab procedures according the American College of Sports Medicine (ACSM)\textsuperscript{1}. Blood pressure measurements were obtained by a trained technician with an aneroid sphygmomanometer (Baumanometer\textsuperscript{®}; W.A. Baum Co, Inc., Copiague, NY, USA) as the participants sat quietly in a chair with their feet flat on the floor and arm supported at heart level. Two blood pressure measurements were taken at least 1 minute apart on the left arm; the lowest blood pressure measurement was used for analysis. In addition to blood pressure, heart rate was calculated by palpating the radial pulse on the left arm for 30 seconds and doubling; the HR measurement was taken between the 2 blood pressure measurements.

Weight was measured on a calibrated digital scale (Toledo iD1 Multirange, Model KC240; Toledo Scale Corporation, Worthington, Ohio, USA) and height was measured using a calibrated stadiometer (Seca 222; Vogel & Halke GmbH & Co, Hamburg, Germany). Participants were asked to remove their shoes, empty their pockets, and remove any heavy jewelry or extra clothing, including jackets or sweatshirts, to prevent measurement error. In addition to weight and height measurements, circumference measurements were taken of the waist, hip, bicep, calf and thigh using a cloth tape measure with a spring-loaded handle according to the established anatomical landmark guidelines as defined by the ACSM\textsuperscript{1}. Measurements were taken on the anatomical right side of the body and were taken at least 2 times; the 2 measurements, falling within 2 centimeters of each other, were used to obtain an average circumference measurement.
Participants underwent a body composition measurement of total body and regional adiposity using a Lunar iDXA™ Dual-energy x-ray absorptiometer (enCORE software, version 13.40.038; GE Healthcare, Madison, WI, USA) (DXA). Prior to the scan, participants were asked to remove their shoes, and any clothing, jewelry or accessories containing metal. The participant was asked to lie still in the supine position on the DXA platform for 13 minutes while the scan was taken. The scan was performed in “thick mode” for all participants, assuming a body thickness of >25 cm; body thickness is chosen based on a person’s height and weight by the Lunar iDXA™ software. A strap was placed around the participants’ lower legs to help them hold their legs still. Due to body size, all of the participants in this study were unable to completely fit into the measurement box. As a result, the complete right side of the body was positioned inside the measurement box and the body composition for the left side of the body was estimated by the Lunar iDXA™ software.

At the completion of the DXA scan, participants completed a submaximal exercise test on a treadmill consisting of walking at 1.5 mph @ 1% grade (≈2.4 METs) and 2.3 mph @ 4% grade (≈4 METs). Before the test, participants were prepped for the recording of a 12-lead electrocardiogram (Case P2 Series; GE Medical Information Technologies, Milwaukee, WI, USA). This included wiping each appropriate electrode site with alcohol, brushing the skin with an abrasive prep pad, and placing the 10 electrodes in their designated location. Before having the participant walk on the treadmill, they were instructed on the testing procedures and the Borg rating of perceived exertion (RPE) scale (6-20 scale) was explained. The participants were encouraged to
communicate any symptoms felt during the test. After the initial submaximal test instructions, a blood pressure was taken on the participant’s left arm in the supine and standing position. The headpiece and mouthpiece were placed on their head and in their mouth, and connected to the metabolic measurement system. Participants were given a 60 second warm-up at 1.2 mph. Heart rate (via electrocardiogram) and RPE were recorded each minute and blood pressure was recorded at 4 and 8 minutes during the 8 minute test. Oxygen consumption (VO₂), carbon dioxide production (VCO₂), and respiratory exchange ratio (RER) were measured continuously throughout the exercise test via Parvo Trueone 2400 Metabolic Measurement system (ParvoMedics, Inc., Sandy, UT, USA) and analyzed using 1 minute averages. The session was terminated prior to the completion of the 8 minutes if the participant reached 84% their age predicted maximal heart rate (220-age) for exercise or if the participant experienced any other signs, symptoms, or responses that have been established for termination of an exercise session.

Following the assessments at this visit, the participants’ PA devices were downloaded and analyzed as their baseline PA level. The Omron pedometer was given back to the participant to be used for the remainder of the study. A blood analysis requisition form was given to the participants to take to the LabCorp in Muncie, IN to obtain a fasting blood sample that was analyzed for glucose, insulin, LDL-cholesterol, HDL-cholesterol, and triglycerides. At the completion of the second visit, the third visit to the HPL was scheduled and instructions about how to prepare for this visit were given.
Participants were asked to arrive to the HPL well rested on a 4 hour fast without the use of caffeine or tobacco prior to the visit.

Visit Three

Participants arrived to the HPL for their third visit 1 to 2 weeks after Visit Two, fasted and well rested for the resting metabolic rate measurement (RMR) via the dilution method (ParvoMedics, Inc.), which was confirmed prior to beginning the test. The participants were asked to lie down on a padded surface for 30 minutes, in a quiet room with low lighting. After resting for 30 minutes a clear plastic hood was placed over their head and a steady flow of fresh air was circulated through the hood. The participants were asked to be as still as possible during the measurement and to not fall asleep. Energy expenditure was calculated by analyzing oxygen consumption for 15-30 minutes.

At the conclusion of the third visit, the researcher assisted the participant in creating an online ALED account. Instructions and demonstration were provided to the on how to use the online program, how to begin the 12-week PA intervention and how to obtain online/Web site technical support if needed. Participants were told to read 1 chapter/week in the ALED textbook and to record their daily step totals on the ALED website step-log. After demonstration and hands-on practice using the online program by the participant, all questions were addressed by the researcher. Participants were encouraged to contact the researcher by phone or email with any questions about the program throughout the remainder of the study and were reminded of the next time they would need to meet the researcher for the download of their pedometer (1 month from Visit Three date).
Visit Four and Five

Following completion of the 12-week PA intervention program, participants returned to the HPL to repeat the procedures of Visits One, Two, and Three as stated above before their bariatric surgery.

PA Assessment Devices

PA was recorded using the Actigraph Model GT3X tri-axial accelerometer and the Omron Healthcare Model HJ-720ITC dual-axis pedometer as stated above. The Actigraph is worn on the waist at the midline of the thigh and measures activity counts, steps taken, energy expenditure, and activity levels. For the purpose of this study, activity counts from the Actigraph were used for analysis of PA and sedentary, light, and moderate/vigorous activity in the bariatric participants. Lopes et al. validated activity count cut-points for sedentary (0-199 counts/minute), light (200-1239 counts/minute), and moderate/vigorous (≥1240 counts/minute) activity in the overweight and obese population using the Actigraph. These cut-points were used to define sedentary (<1.5 METs), light (1.5-2.9 METs), moderate/vigorous activity (≥3 METs) in the present study. Each participant’s Actigraph accelerometer dataset in the present study was assessed via Actilife software (SAS version 5.10) for data validation purposes; the Actilife software was used to convert the downloaded Actigraph data into an .agd file and then a .csv file which was opened and analyzed in a Microsoft Excel 2007 spreadsheet (Microsoft Corporation, Redman, Washington, USA) by the researcher. The Actigraph was worn during the pre- and post-intervention analysis; In order for the data to be considered valid, the Actigraph had to be worn for at least 8 h/day and at least 4 days/week.
The Omron pedometer was used to quantify steps/day in this study. The Omron pedometer was worn on the waistband at the midline of the thigh, but has been validated at various mounting positions in overweight adults\textsuperscript{27}. Each participant’s Omron pedometer was assessed via Omron Health Management Software version 1.3. The Omron was worn during the pre- and post-intervention analysis and throughout the entire intervention period.

*Active Living Every Day Program*

The ALED program was used as the 12-week PA intervention. This program is designed to help people improve their health and quality of life and is designed based on the following principles: a) moderate amounts and intensities of PA have health benefits; b) increasing lifestyle PA is an important alternative to formal exercise programs; and c) people will be more likely to become and stay active when they are given the tools for lifestyle change based on their readiness to change\textsuperscript{17, 28}. The ALED intervention was delivered via internet access through a secure Web site and a supplemental textbook given to each participant. 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. The ALED chapters included information related to the following topics: barriers, goal setting, self-monitoring, social support, self-efficacy, relapse prevention, consequences, and reward. The ALED book also contains signposts throughout each chapter including: activity alerts (spotlights hands-on activities), myth busters (corrects common misconceptions about PA), real life (offers
testimonies by people who have made positive lifestyle changes), did you know (offers facts and information related to PA and the most recent PA research), and weighing in (provides advice for people interested in losing weight). In addition to reading the book, participants were encouraged to use the online pedometer tracking tool (step-log) throughout the intervention to record their daily steps, measured by the Omron pedometer.

**Monthly Downloads**

At the monthly face-to-face meetings, the participants’ pedometers were downloaded and their progress through the ALED program was discussed. Feedback and suggestions were provided when appropriate. These meetings lasted approximately 10 minutes and were necessary in order to clear the 41-day memory capacity of the Omron pedometer. The meetings took place at a location most convenient for the participants, but most often were held at the IUHBC or HPL.

**Statistical Analysis**

The primary purpose of this study was to determine whether participation in the ALED PA intervention, a structured 12-week internet-based program, would promote an increase in average steps taken/day, a decrease in average sedentary (<1.5 METs) time/day, and an increase in average time spent in light (1.5-2.9 METs) and moderate/vigorous (≥3 METs) activity/day. Sedentary, light, and moderate activity was measured using the Actigraph Model GT3X tri-axial accelerometer (Actigraph, Pensacola, FL, USA). Threshold ranges for each of the intensity levels were reported
according to the ranges defined by Lopes et al.\textsuperscript{26} for overweight and obese individuals. Steps/day was measured using the Omron Healthcare Model HJ-720ITC dual-axis pedometer (Omron Healthcare Inc., Bannockburn, IL, USA) as described in the section \textit{PA Assessment Devices}. Separate baseline (pre-PA intervention) and follow-up (post-PA intervention) profiles were created for each of the PA measures (average steps/day, percentage of sedentary, light, and vigorous/moderate activity relative to PA device wear time, and average time spent in sedentary, light and moderate/vigorous activity/day) and consisted of basic descriptive statistics (e.g. mean, standard deviation). Baseline and follow-up PA intervention data were compared using non-parametric Wilcoxon Signed Ranks Test to determine whether differences existed for all PA measures with an alpha value of 0.05.

The second purpose of the study was to determine any changes in participant characteristics (i.e. weight, BMI, waist circumference, hip circumference, resting systolic and diastolic blood pressure, peak heart rate, peak RPE, RMR, blood lipids, including LDL and HDL cholesterol and triglycerides, fasting blood glucose, and fasting blood insulin), reported PA, reported regular PA, and psychological characteristics (i.e. self-efficacy, perceived exercise barriers, and perceived exercise thoughts) from baseline to follow-up. Basic descriptive statistics (e.g. mean, standard deviation) were provided for each variable and baseline and follow-up PA intervention data were compared using non-parametric Wilcoxon Signed Ranks Test to determine whether differences existed, with an alpha value of 0.05.
The third purpose of the study was to compare ALED step-log usage with average baseline sedentary activity and with average follow-up sedentary activity. These comparisons were made between 2 groups: 1) participants with <65 days of step-log usage and 2) participants with ≥65 days of step-log usage. Basic descriptive statistics (e.g. mean, standard deviation) were provided for all variables and comparisons were made using the Mann-Whitney U Test to determine whether differences existed between groups, with an alpha value of 0.05.

All statistical procedures were performed using SPSS and IBM company statistics program (Version 19.0, Chicago, IL) for MAC/PC computer.

Results

The study cohort consisted of 11 participants (mean age, 41.0 ± 12.0 years; 2 male, and 9 female). Descriptive characteristics for baseline and follow-up variables are displayed in Table 4-1. Significant improvements between baseline and follow-up for weight, BMI, body fat %, waist and hip circumference, submaximal RPE, HDL-cholesterol, percentage of individuals reporting PA (walking briskly, jogging, bicycling, swimming, etc) and perceived exercise barriers (P<.05). No significant differences were observed for percentage of participants reporting regular PA (≥30 minutes/day and at least 5 days/week), exercise thoughts, self-efficacy or any of the other measured variables. A large increase in blood insulin from baseline (22.3±8.7 µIU/mL) to follow-up (32.8±23.4 µIU/mL) was noted, but not statistically significant; as suggested by the follow-up SD, the large mean increase was due to one participant, with an increase in blood insulin of 58.7 µIU/mL from baseline to follow-up.
The mean step data for the entire study cohort is presented in Figure 4-1. No differences were observed in mean steps/day from baseline (3903.3±1528.3) to follow-up (4601.9±2624.6) for the Omron pedometer. Table 4-2 shows daily average duration and proportion of mean monitored wear time spent in sedentary, light, and moderate/vigorous activity. Average wear time was 13.5±1.1 h/day at baseline and 13.2±1.3 h/day at follow-up. No significant differences were found between baseline and follow-up for all activity intensities represented or mean wear time. Overall, participants spent approximately 9.9 h/day or 74% of total wear time in sedentary behavior at baseline and follow-up. Six of the participants had a decrease in their sedentary behavior from baseline to follow-up and 5 had an increase in moderate/vigorous PA, although this did not rise to the level of statistical significance. Moderate/vigorous PA was most often represented in bouts of <10 minutes with the entire group averaging approximately one, 10 minute bout of moderate/vigorous activity/week.

Figure 4-2 shows mean sedentary behavior (h/day) at baseline and follow-up according to step-log usage. No significant differences were found in sedentary behavior between groups at baseline ($P=0.088$) and follow-up ($P=0.238$); however, participants who used the step-log $\geq65$ times (N=6) throughout the PA intervention averaged more steps/day (6155±2191 steps/day versus 3014±1958 steps/day) at follow-up.

**Discussion**

Results from the present study demonstrate that after 12-weeks of the ALED PA intervention body weight, BMI, body fat percentage, and waist and hip circumference were significantly lower. Possible explanations for these significant changes are: 1) the
IUHBC required dietary recommendations, and/or 2) the ALED PA intervention. As is standard protocol by the IUHBC, and in addition to the 12-week PA intervention, participants of the current study were encouraged to start a liver reduction diet (avoidance of starchy and sugary foods) within 3 months of their bariatric surgery by the IUHBC dietician; because the implementation of the liver reduction diet was not a part of the PA intervention and was considered usual care for patients at the IUHBC, diet was not assessed in the current study. Previous research has shown that the liver reduction diet significantly changes body mass and composition on its own \(^{29}\). Specifically, a study by Colles et al \(^{29}\) revealed that 12-weeks of the liver reduction diet significantly decreased patient’s weight (10.6%), waist circumference (9.0%), and BMI (10.6%). Participants in the current study saw a weight, waist circumference, and BMI decrease of approximately 3.0% after 12-weeks of the PA intervention and approximately 4-12 weeks after starting the liver reduction diet. Based on results reported by Colles \(^{29}\), it would concur that the changes in body mass/composition in the current study may be due to the addition of the liver reduction diet. Because the consistency and compliance of the liver reduction diet among participants in the current study were not assessed or controlled for, it is unclear to what extent the liver reduction diet may have affected the body mass/composition variables previously mentioned. Possible inconsistency of when participants began the liver reduction diet relative to starting the PA intervention may also explain the decreased percent change in weight, waist circumference, and BMI relative to the changes presented by Colles et al \(^{29}\). Participants from both studies had a similar baseline weight and BMI, but the number of participants was much larger (n=32) in the study by Colles et al \(^{29}\) giving their results more statistical power than the present study.
Another explanation for the significant decreases in body mass measurements is the PA intervention itself. Goodpaster et al\textsuperscript{30} revealed that the addition of a self-monitored and progressive PA program (up to 60 minutes/day of moderate/vigorous PA, 5 days/week) to a dietary weight loss program (energy intake of 1200-2100 kcal/day; 20-30% fat, 50-55% carbohydrate, and 20-25% protein) results in significantly greater weight loss (10.9 kg versus 8.2 kg), larger decreases in body fat percentage (3% versus 1%) and waist circumference (8.6 cm versus 5.2 cm), with a significant increase in PA (7048 ± 2886 to 8475 ± 2927 steps/day) after 6 months. Participants in the current study participated in a 3-month PA intervention, rather than a 6-month PA intervention, and had a higher mean baseline BMI (49.5 ± 8.0 kg/m\textsuperscript{2} versus 43.5 ± 4.8 kg/m\textsuperscript{2}), but similar baseline waist circumference (122.5 ± 16.2 cm versus 124.4 ± 2.9 cm) compared to the participant group studied by Goodpaster et al\textsuperscript{30}. Rather than the specific dietary recommendations provided by Goodpaster and colleagues, the participants in the current study followed a liver reduction diet prescribed by their Registered Dietician. After 3 months of the PA intervention in the current study, weight had decreased an average of 4.2 kg, body fat had decreased 1%, and waist circumference had decreased 3.4 cm; all of these values were approximately 35% of the values reported by Goodpaster et al\textsuperscript{30} after a 6 month intervention. An increase in PA (3903 ± 1528 to 4602 ± 2625 steps/day) in the current study was not significant; additionally, both baseline and change in steps/day were much lower than the average steps/day recorded by Goodpaster et al\textsuperscript{30}. In the present study, all participants were categorized as “sedentary” at baseline and follow-up with a step average of <5000 steps/day\textsuperscript{31}. Participants did not significantly increase in
average steps/day from baseline to follow-up; resultantly, the liver reduction diet may have influenced the body mass/composition changes more than the PA intervention.

The current study revealed no significant differences from baseline average steps/day to follow-up average steps/day ($P=0.328$); however, a significant increase was found in reported PA ($P=0.046$), which was measured using a PA questionnaire. The PA questionnaire asked patients to answer yes or no to the following statement: “I am currently physically active (walking briskly, jogging, bicycling, swimming, or any other activity in which the exertion is at least as intense as these activities)”. Bond et al $^{24}$ previously reported that bariatric patients tend to over-report their PA and that objective measurement of PA should be used; therefore, this is consistent with the current study.

Mean steps/day at baseline and follow-up (3903±1528.3 and 4602±2625, respectively) were less than those reported by Tudor-Locke et al $^{31}$, which found an objectively measured average step count (Actigraph AM-7164) of 5784 steps/day for 1242 U.S obese adult men and women (BMI $\geq$35.0 kg/m$^2$); Goodpaster et al $^{30}$ has reported an even higher baseline step average of 7048±2886 steps/day for 67 obese participants (BMI 43.5±4.8). One difference between these studies is the method of how steps/day was measured; steps in the current study were measured using the Omron pedometer; Tudor-Locke et al $^{31}$ used the Actigraph AM-7164 accelerometer; Goodpaster et al $^{30}$ utilized the Sensewear Pro3 armband. The Actigraph accelerometer $^{26}$ and the Omron pedometer $^{27, 32}$ have been previously validated in the obese/overweight adult population. The Sensewear Pro3 Armband has been validated in obese children, but it’s validity in the obese adult population is more uncertain, often overestimating values $^{33}$. 
To the author’s knowledge, no studies have been done to validate a PA device in the bariatric population specifically. Because the Omron has been validated in the overweight/obese population it is possible that the step averages reported in the current study represent the PA behavior of most bariatric patients; however, because the study cohort was so small and did not focus on PA device validation specifically, further PA device validation should be done with this population.

As a part of the ALED program, participants were asked to record their daily steps from their Omron pedometer onto the online ALED step-log; although not significant, the use of the online step-log appeared to be related to average steps/day and sedentary behavior. The online step-log was used an average of 65 days (77% of study intervention days) by the participants in the current study. A meta-analysis of 103 articles (65 publications) by Kang et al reported that pedometer based PA interventions are effective in positively influencing PA across all age groups and PA intervention time period; additionally, motivational feedback provided by a pedometer and step-log has shown to be successful in promoting PA in the overweight/obese population. On Figure 4.3 it appears that all 6 participants who used the step-log ≥65 times improved their daily step average from baseline to follow-up and that 3 of the 4 participants who used the step-log <65 times decreased their daily step average from baseline to follow-up. One participant was not included in the final step data analysis due to non-compliance with wearing the PA device at follow-up. Observational assessment of the individual step-data suggests that the participant who appeared to have the greatest percent increase in average steps/day from baseline to follow-up (32%) also had the highest baseline
(6554 steps/day) and follow-up (9684 steps/day) step averages, and used the step-log the
greatest number of times (106 times). Based on observational assessment, participants
who used the step-log <65 days (n=4) appeared to be less active at baseline (3155±1792
steps/day) and follow-up (3014±1958 steps/day) than participants who used the step-log
≥65 days (n=6; 4547±1284 steps/day and 6155±2191 steps/day, respectively) and spend
less time on the ALED Web site (13.9±5.6 minutes versus 31.4±12.6 minutes). The
average sedentary behavior (h/day) was not statistically significant between the step-log
groups at baseline (≥65 days: 9.4±0.5 and <65 days: 10.9±0.6; \( P=0.088 \)) and follow-up
(>65 days: ≥9.4±0.5 and <65 days: 10.1±0.6; \( P=0.238 \)); however, a possible trend was
noted at baseline (\( P=0.088 \)) suggesting the possibility that the bariatric participants who
were more active at baseline were also more likely to comply with the ALED PA-
intervention recommendations (using the step-log). With a larger cohort, it is possible
that a more distinct pattern may have emerged and that significant differences in average
steps/day and sedentary behavior may have been found between individuals who used the
step-log ≥65 times and those who used the step-log <65 times. It is possible that other
factors could have played a role in whether participants used the online step-log including
internet access and understanding of how to locate and use the step-log. However, based
on observations and conversations with participants, the author would suggest that these
results are an accurate depiction of motivation level for each of the individual participants
toward the PA intervention. Anecdotally, participants reported that the one-on-one
monthly pedometer download meetings with the research team were the most
beneficial/motivating component of the PA intervention; therefore, it is possible that this
patient population would see greater changes in PA behavior with more frequent and structured meetings with a PA counselor.

Results of the present study revealed bariatric patients spend approximately 74% of their time in sedentary behavior, 21% of their time in light activity, and 5% in moderate/vigorous activity. Bond et al \(^ {11}\) reported from their research that bariatric patients spend approximately 81% of the day in sedentary behavior, 15% of the time in light activity, and 4% of the time in moderate/vigorous activity prior to bariatric surgery through the use of SenseWear Pro2 Armband. The participant group in the study by Bond et al\(^ {11}\) was larger (n=42) than the current study; however, age (44.8±9.2 years), BMI (49.5±7.9 kg/m\(^2\)), body weight (135.9±24.5 kg), and PA validation criteria (8 h/day, 4 days/week) were comparable. As previously stated the SenseWear Pro2 Armband has been shown to overestimate PA in the obese population \(^ {32}\); assuming this to be true, the results of the present study appear to be consistent with Bond et al \(^ {11}\). Compared to normal weight individuals (BMI <25 kg/m\(^2\)), bariatric patients are much less active than normal weight individuals spending 54% of their time in sedentary behavior, 41% in light activity, and 5% in moderate/vigorous activity \(^ {31}\).

Percent time spent in sedentary, light, and moderate/vigorous PA did not change in the present study which may suggest that the pre-surgery 12-week ALED PA intervention was not effective in positively changing PA behavior in the bariatric participants. The ALED PA-intervention protocol resembles the internet-based ALED group in the study by Carr et al \(^ {36}\). Carr’s results show the internet-delivered ALED PA significantly increases PA and significantly decreases CVD risk factors in sedentary,
overweight adults (n=14; BMI=32.3±1.3 kg/m²; age=49.4±1.7 years) \(^{36}\). Compared to the present study, participants in the study by Carr et al \(^{36}\) had a much smaller BMI (17.2 kg/m² less), were slightly older (8 years), and a higher baseline step average (3312 steps/day); resembling the current study, participants using the internet-based ALED PA program were given the ALED textbook and access to the ALED supplemental Web-site, and were encouraged to work through the material at their own pace. A major difference between the 2 studies is the amount of time participants had to complete the PA intervention. The participants in Carr’s \(^{36}\) research study had 4 additional weeks, which may have influenced the magnitude to which average steps/day increased. Not surprisingly, the participants in the current study, with a much higher mean BMI (49.5±8.0 kg/m²), had a lower baseline step average than the participants included in Carr’s research \(^{36}\). Through the use of a Yamax Digiwalker pedometer, Carr et al \(^{36}\) saw a significant increase in steps/day from 6614±388 to 7999±439, a gain of approximately 17%, after 16-weeks of the ALED intervention. This percent gain, reported by Carr, was similar to the percent gain found in the present study (15%; \(P=0.328\)) as measured by the Omron pedometer. Although no significance was found for the percent change in steps/day in the current study, it is possible that because the participants had a higher BMI and were much less active initially, an increase of steps/day by 15% is more considerable than the 17% reported by Carr et al \(^{36}\). Other research has shown an additional 2000 steps/day results in significantly greater improvements in waist circumference for obese adults walking 2000 steps/day compared to obese adults walking 10,000 steps/day \(^{37}\); this researcher is suggesting that less active obese adults will see greater improvements in body mass for a given amount of PA when compared to more
active obese adults. The ALED program used in the present study is designed based on the principle that moderate amounts and intensities of PA have health benefits. Therefore, although the mean increase in steps/day was not significant in the current study, the increase from baseline to follow-up still represents beneficial lifestyle change.

A significant decrease was found in RPE during the submaximal exercise test and is reported in Table 4.1; this difference indicates that participants perceived the maximal absolute workload (4 METs) to be less intense at follow-up than baseline. It is possible that a decrease in RPE during the submaximal exercise test would translate into a decreased RPE for home activities of the same intensity level (4 METs); this change could potentially give participants confidence to engage in more lifestyle PA at home, leading to significant changes in PA long-term. In this short-duration study, perceived self-efficacy, a measure of confidence, did not change significantly (P=0.113) but increased from baseline (39.1±9.0) to follow-up (43.2±7.1); perceived exercise barriers decreased significantly. Due to the significant decrease in RPE and perceived exercise barriers and non-significant improvements in self-efficacy and measured PA, it seems likely that a longer-duration study of participants using the ALED PA intervention would result in significant increases in self-efficacy and PA long-term. Therefore, it appears the ALED PA intervention was at least effective in promoting some positive lifestyle change in these bariatric patients.

The present study was able to descriptively report the PA profile for morbidly obese, bariatric patients before bariatric surgery and provide valuable information about how a pre-bariatric surgery PA intervention affects various CVD risk factors and PA.
behavior. Researchers found that bariatric patients participate in “limited activity” most of the time \(^{31}\), spending approximately 74\% of their day being sedentary (20\% higher than the normal weight population \(^{31}\)). The ALED PA intervention was effective in significantly decreasing perceived exercise barriers and submaximal RPE at a moderate intensity of 4 METs; these results suggest that after the PA intervention, participants felt more capable and confident in their ability to do moderate PA. Based on observation evidence, it appears that participants of the current study who were most involved in the PA intervention (defined by use of the step-log and time spent on the ALED Web site) were more physically active and showed the most improvement in overall PA (steps/day and sedentary behavior) from baseline to follow-up; therefore, it is suggested that initial motivation is a factor in determining short-term PA behavior change. Because of the small sample size, the results are not generalizable to the entire bariatric population; however, the results may help to characterize patients who are more likely to successfully change pre-surgery PA behavior long-term. A longer-duration study with a larger participant group would be beneficial to determine the effects of decreased exercise barriers and submaximal RPE on long-term self-efficacy and PA.
**Figure Legend**

*Figure 4.1:* Average steps/day for the Omron and Actigraph PA devices for baseline and follow-up. * Significant differences between baseline and follow-up (P < 0.05).

*Figure 4.2:* Mean sedentary activity (h/day) at baseline and follow-up time-points for participants who had used the online ALED step-log <65 times and for participants who had used the online ALED step-log ≥65 times throughout the study intervention.

*Figure 4.3:* Individual mean steps/day at baseline, 1 month, 2 months, 3 months, and follow-up for participants who had used the online ALED step-log <65 times and for participants who had used the online ALED step-log ≥65 times throughout the study intervention.
Table 4.1: Descriptive Characteristics of Subjects (mean ± SD)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline (n=11)</th>
<th>Follow-up (n=11)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>138.7 ± 26.1</td>
<td>134.5 ± 24.7</td>
<td>0.033*</td>
</tr>
<tr>
<td>BMI (kg·m²)</td>
<td>49.5 ± 8.0</td>
<td>48.8 ± 6.9</td>
<td>0.050*</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>52.6 ± 6.6</td>
<td>51.6 ± 7.2</td>
<td>0.047*</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>122.5 ± 16.2</td>
<td>119.1 ± 14.8</td>
<td>0.008*</td>
</tr>
<tr>
<td>Hip (cm)</td>
<td>150.9 ± 12.5</td>
<td>148.0 ± 11.8</td>
<td>0.018*</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>121.4 ± 16.3</td>
<td>119.6 ± 15.0</td>
<td>0.722</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>75.6 ± 7.1</td>
<td>74.7 ± 7.8</td>
<td>0.439</td>
</tr>
<tr>
<td>Submax Peak HR (bpm)</td>
<td>141.9 ± 22.6</td>
<td>137.0 ± 20.4</td>
<td>0.306</td>
</tr>
<tr>
<td>Submax RPE</td>
<td>11.7 ± 2.1</td>
<td>9.9 ± 2.5</td>
<td>0.021*</td>
</tr>
<tr>
<td>RMR (kcal/D)</td>
<td>2044.9 ± 471.7</td>
<td>2005.2 ± 410.3</td>
<td>0.333</td>
</tr>
<tr>
<td>LDL-C (mg·dL⁻¹)</td>
<td>103.5 ± 16.7</td>
<td>99.6 ± 17.9</td>
<td>0.894</td>
</tr>
<tr>
<td>HDL-C (mg·dL⁻¹)</td>
<td>48.7 ± 11.8</td>
<td>44.5 ± 8.4</td>
<td>0.041*</td>
</tr>
<tr>
<td>Triglycerides (mg·dL⁻¹)</td>
<td>128.0 ± 61.1</td>
<td>146.5 ± 91.0</td>
<td>0.130</td>
</tr>
<tr>
<td>Blood Glucose (mg·dL⁻¹)</td>
<td>95.7 ± 13.6</td>
<td>99.1 ± 12.0</td>
<td>0.759</td>
</tr>
<tr>
<td>Blood Insulin (µIU/mL)</td>
<td>22.3 ± 8.7</td>
<td>32.8 ± 23.4</td>
<td>0.155</td>
</tr>
<tr>
<td>Physically Active, N (%)</td>
<td>4 (36.4)</td>
<td>8 (72.7)</td>
<td>0.046*</td>
</tr>
<tr>
<td>Regular Exercise N, (%)</td>
<td>1 (9.1)</td>
<td>2 (18.2)</td>
<td>0.564</td>
</tr>
<tr>
<td>Self-efficacy (score)</td>
<td>39.1 ± 9.0</td>
<td>43.2 ± 7.1</td>
<td>0.113</td>
</tr>
<tr>
<td>Exercise Barriers (score)</td>
<td>20.4 ± 3.9</td>
<td>17.5 ± 4.8</td>
<td>0.012*</td>
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<tr>
<td>Exercise Thoughts (score)</td>
<td>62.5 ± 18.0</td>
<td>51.3 ± 15.6</td>
<td>0.100</td>
</tr>
</tbody>
</table>

BMI, body mass index; BP, blood pressure; Submax, submaximal; HR, heart rate; RPE, rate of perceived exertion; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; Physically Active, engaging in activities such as: walking briskly, jogging, bicycling, swimming, or any other activity in which the exertion is at least as intense as these activities; Regular Exercise, ≥ 30 minutes/day, 5 days per week of physical activity; Score, Self-efficacy, exercise thoughts, and exercise barriers are all represented as a total score; * Significant differences between baseline and follow-up (P < 0.05).
Figure 4.1

Average Steps/Day

Baseline        Follow-up
Measurement Time Point
Figure 4.2

Time Sedentary (h/day)

Measurement Time Point

Baseline

Follow-up

> 65 Log ins

< 65 Log ins
Figure 4.3

Individual Average Steps/Day

Measurement Time Point

- > 65 Log ins
- < 65 Log ins
<table>
<thead>
<tr>
<th></th>
<th>Sedentary activity (&lt;1.5 METs)</th>
<th>Light physical activity (1.5-2.9 METs)</th>
<th>Moderate-to-Vigorous physical activity (≥3 METs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Sample (n=10)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time (h/day)</td>
<td>10.0 ± 1.4</td>
<td>2.8 ± 1.0</td>
<td>0.7 ± 0.3</td>
</tr>
<tr>
<td>% Wear Time</td>
<td>74.4 ± 8.7</td>
<td>20.6 ± 6.8</td>
<td>5.0 ± 2.5</td>
</tr>
<tr>
<td><strong>Follow-up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time (h/day)</td>
<td>9.7 ± 1.2</td>
<td>2.8 ± 1.0</td>
<td>0.6 ± 0.4</td>
</tr>
<tr>
<td>% Wear Time</td>
<td>73.6 ± 8.5</td>
<td>21.3 ± 6.3</td>
<td>4.9 ± 3.0</td>
</tr>
<tr>
<td>*P Value</td>
<td>0.44</td>
<td>1.00</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Daily average duration (h/day) and proportion of mean monitored wear time (%) spent in sedentary, light, and moderate/vigorous activity. (n=10), one subject was not included in analysis due to not wearing the accelerometer at follow-up. *P value represents comparisons between baseline and follow-up average duration (h/day) of sedentary, light, and moderate/vigorous activity.
REFERENCES

CHAPTER V

SUMMARY AND CONCLUSIONS

Studies have shown that bariatric surgery, also known as weight-loss surgery, is the most effective weight loss intervention for the treatment of morbid obesity (BMI $\geq 40.0$ kg/m$^2$ or BMI $>35.0$ kg/m$^2$ paired with serious obesity-related co-morbidities) and its related cardiovascular disease (CVD) risk factors and comorbidities. Bariatric patients who incorporate PA into their daily routine before or after bariatric surgery show greater improvements in weight loss, short-term surgery complications, and quality-of-life compared to those who remain inactive. Despite this, studies using self-report measurements of PA have shown that 90-95% of bariatric patients are not meeting the current PA recommendations and, based on objective PA measurements, spend approximately 80% of their day in sedentary behavior pre-surgery. Noncompliance with PA recommendations pre-surgery has been shown to carry over into post-surgery PA behaviors and result in lower percent excess weight loss (%EWL) long-term; therefore, because the primary goal of bariatric surgery is %EWL, it would make sense that patients should be able to demonstrate their willingness and ability to change PA behavior prior to having bariatric surgery. PA programs that focus on lifestyle change have proven as successful in changing PA behavior as a structured exercise program taking place in a fitness center setting. Using a combination of these
techniques, Blair et al \(^{14}\) has designed a 12-week internet-based program called Active Living Every Day® (ALED) with the goal of improving people’s health and quality of life through a variety of lifestyle PA recommendations specific to the person’s motivational readiness for change and through the use of self-monitoring tools \(^{14}\). Current research evaluating PA compliance in the bariatric population has primarily used self-report methods for collecting PA data \(^9,47,48\). Bond et al \((12)\) has concluded that bariatric patients tend to over-report their PA levels after bariatric surgery and suggests using an objective measurement, like an accelerometer, for a more accurate representation of PA \((12)\). To the author’s knowledge, there are no published studies reporting data on the effect of a pre-surgery PA intervention on objectively measured pre-surgery sedentary behavior in the bariatric patient population. Additionally, very few studies have evaluated the effect of a pre-bariatric surgery internet-based PA intervention on average steps/day.

Therefore, the purposes of this study were to: 1) objectively assess whether the ALED PA intervention, a structured 12-week internet-based program, would promote an increase in average steps taken/day, total time spent in sedentary, light, moderate/vigorous activity/day (h/day), and percentage of sedentary, light, and moderate/vigorous relative to average wear time (the average time the PA device was worn) in bariatric patients prior to their bariatric surgery using the Actigraph GT3X accelerometer and Omron pedometer; 2) determine changes in participant characteristics, CVD risk factors, and psychological characteristics from pre- to post-PA intervention; and 3) determine whether total usage of the online step-log was associated with change in
sedentary activity from pre- to post-PA intervention. Eleven bariatric patients (2 male, and 9 female; mean age, 41.0 ± 12.0 years) preparing to have bariatric surgery within 4-6 months participated in the study.

Results from the study indicated that participants did not significantly increase their average steps/day after 12 weeks of the ALED PA intervention; however, non-significant improvements from baseline to follow-up were found. Despite no statistical differences in overall average steps/day, individual data suggests that participants who recorded their daily steps from their Omron pedometer onto the online ALED step-log ≥65 times (N=6) had higher baseline (4547±1284 versus 3155±1792 steps/day) and follow-up (6155±2191 versus 3014±1958 steps/day) step averages and showed better improvements in average steps/day from baseline to follow-up (26% versus -5%); participants who used the step-log <65 times decreased their average steps/day from baseline to follow-up. Carr et al \(^7\) has previously reported that baseline PA predicts efficacy of the ALED internet delivered program.

In addition to non-significant changes in overall average steps/day, participants in the current study showed a non-significant decrease (1%) in sedentary behavior after 12 weeks of the ALED PA intervention. Despite no statistical differences in sedentary behavior between baseline and follow-up for the entire study cohort, a non-parametric t-test between participants who used the online step-log <65 (N=4) and those who used the step-log ≥65 days (N=6) revealed a possible trend in sedentary behavior at baseline (\(P=0.088\)): participants who recorded their daily steps onto the online ALED step-log ≥65 times averaged less sedentary behavior at baseline (10.9±1.5 h/day) than those who
used the step-log <65 times (9.4±1.1 h/day). Due to the small sample size, the ability to reach conclusions is limited; however, based on the results of this small pilot study, it is possible that a larger sample size would reveal a statistically significant difference in PA behaviors at baseline in participants who used the step-log more than 77% (≥65 days) of the time. Overall, the results of this study were consistent with other research reporting that obese individuals are sedentary most of the time and spend very little time in moderate/vigorous activity.

Because the ALED PA intervention is based on the Transtheoretical Model, with its chapters structured around moving individuals to a higher stage of change, it is possible that the non-significant improvements found in the current PA data represent the beginning of behavior change in these participants; additionally, because participants who used the step-log ≥65 times averaged less sedentary behavior at baseline (4547±1284 versus 3155±1792), they were likely in a higher stage of change at baseline than those who used the step-log <65 times. The entire participant group had a significant decrease in submaximal RPE and perceived exercise barriers from baseline to follow-up; it is possible, then, that the ALED intervention was successful in improving participant’s stage of change by helping them realize the feasibility of including PA into their daily life. Participants who used the step-log ≥65 times may have been in the preparation or action stage of the Transtheoretical Model at baseline, already making small or large changes toward behavior change; participants who used the step-log <65 times were more likely in the contemplation or preparation stage of the Transtheoretical Model at baseline, recognizing the need for behavior change and/or beginning to gather resources to start
making changes. Based on the significant changes in RPE and perceived exercise barriers, it appears that on average, participants moved to the next stage of change, taking the first step toward making a permanent PA lifestyle change; research supports that PA interventions based on the Transtheoretical Model lead to PA behavior change \textsuperscript{20, 64, 65, 68} and that forward progress through the stages of readiness for change (≥1 stages) leads to increased moderate intensity PA, time spent walking, and motivation to become more physically active \textsuperscript{65}.

The biggest challenge in the current study was keeping participants accountable to reading the chapters without much interaction with the researcher. Individual meetings with researchers to set specific step-goals \textsuperscript{65, 75} and structured ways of assessing progress through the ALED PA intervention \textsuperscript{75} may be helpful for optimizing PA behavior change in this specific population; Carr et al \textsuperscript{75} found that meeting with participants (N=67, BMI=31.5±0.9) bi-monthly to increase step-goals and asking participants to report progress through the ALED chapters, led to a mean increase in PA of 17%, which was statistically significant. In addition to a pre-surgery PA intervention \textsuperscript{80}, a follow-up post-surgery PA intervention may be beneficial for further progressing PA behavior change in the bariatric population \textsuperscript{85}.

Despite no significant changes in overall PA, body weight, BMI, body fat percentage, and waist and hip circumference, all decreased significantly throughout the study intervention. Without significant changes in PA, the changes in body mass/composition were most likely due to dietary changes that the participants were required to make as a part of the “normal” pre-bariatric surgery protocol at the IUHBC \textsuperscript{86}.
Because the dietary changes were not standardized for all participants, it is difficult to know to what magnitude these changes affected overall body mass/composition results.

Due to the small sample size and not having a control group, the ability to reach conclusions is limited; nevertheless, non-significant improvements in PA paired with significant decreases in submaximal RPE and perceived exercise barriers seen in this study are encouraging and should be explored further. Hopefully with further study, components of the ALED PA intervention that worked can be implemented into a more formal pre- and/or post-bariatric surgery regimen.

**Recommendations for further study**

Researchers should consider repeating the current study with a larger sample size and a standard care control group; additionally, dietary changes, required of bariatric patients prior to surgery, should be assessed. This would allow for further exploration of the present study’s results and determination of differences in PA outcomes between standard pre-surgery PA advice and a structured pre-surgery PA intervention, with greater statistical power.

Bariatric research needs to compare both the short-term (pre-surgery) and long term (6-12 months post-surgery) effects of a pre-surgery PA intervention on self-efficacy, exercise barriers, stage of change, and physical activity habits; a 6-12 month post-surgery follow-up study with participants from the current study would accomplish this. This comparison would allow healthcare professionals to better predict what pre-surgery PA
behaviors and characteristics lead to a successful bariatric patient long-term (post-surgery).

Further research should aim to determine the appropriate timing (pre- or post-surgery) and format (Web based, one-on-one coaching, support groups, etc.) of PA interventions for optimizing PA behavior change in the bariatric population; based on anecdotal evidence from the current study, the value of a one-on-one, individualized PA intervention should be studied further.
REFERENCES


48 Toussi R, Fujioka K, Coleman KJ. Pre- and postsurgery behavioral compliance, patient health, and postbariatric surgical weight loss. Obesity (Silver Spring) 2009;17:996-1002.


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 setbacks, 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
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>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sure I could NOT do it</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.g. moving, a divorce, a death in the family, etc.) ____
APPENDIX E

EXERCISE THOUGHTS QUESTIONNAIRE
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. Not at all
2. Sometimes
3. Moderately Often
4. Often
5. 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
Subject Name:_________________________________

**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