EFFECT OF MINDFULNESS MEDITATION AND HOME-BASED RESISTANCE EXERCISE ON WEIGHT LOSS, WEIGHT LOSS BEHAVIORS, AND PSYCHOSOCIAL CORRELATES IN OVERWEIGHT ADULTS

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Submitted to the Graduate Faculty of

The Department of Health and Physical Activity in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh

2008

UNIVERSITY OF PITTSBURGH

SCHOOL OF EDUCATION

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[EFFECT OF MINDFULNESS MEDITATION AND HOME-BASED RESISTANCE EXERCISE ON WEIGHT LOSS, WEIGHT LOSS BEHAVIORS, AND PSYCHOSOCIAL CORRELATES IN OVERWEIGHT ADULTS.

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Behavioral weight loss programs typically result in short-term weight loss of approximately 7-10%. However, it is important to continue to develop innovative weight loss treatments for the overweight and obese to improve upon this weight loss and related outcomes. **PURPOSE:** To examine the effect of mindfulness meditation and home-based resistance exercise on weight loss, weight loss behaviors, and various psychosocial correlates in overweight adults across a 6-month behavioral weight loss intervention. **METHODS:** Seventy-one subjects (BMI = 32.9±3.7 kg/m^2; age = 45.1±8.3 years) participated in a 6-month behavioral weight loss intervention. Subjects were randomly assigned to one of three treatment groups: standard behavioral weight loss program (SBWL, n=24), SBWL plus resistance exercise (RT, n=23), or SBWL plus mindfulness training (MD, n=24). All participants were instructed to decrease energy intake to 1200-1500 kcal/d and dietary fat intake to 20-30% of total energy intake, increase physical activity to 300 min/wk, and attend weekly group meetings. SBWL+RT consisted of the addition a resistance training component using resistance tubing and exercise balls. SBWL+MD consisted of mindfulness training using meditation, yoga, and mindful eating techniques. Body weight, process measures of weight loss (physical activity, energy intake, eating behavior inventory), and psychosocial correlates of weight loss (eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint

and disinhibition, and body image) were measured at 0, 3, and 6 months. **RESULTS:** Weight significantly decreased in all groups at 6 months ($p<0.05$), but did not differ between groups (SBWL= -6.1±2.4 kg; SBWL+RT= -8.8±1.9 kg, SBWL+MD= -8.0±0.2 kg). Physical activity significantly increased in all groups at 3 months (average increase = 833±439 kcal/wk) ($p<0.05$), but did not differ between groups. Adoption of weight loss eating behaviors increased in all groups ($p<0.05$) with no significant difference between groups. Physical activity and eating self-efficacy, dietary restraint, and most subscales of body image increased over the 6-month intervention, while dietary disinhibition, perceived hunger, and overall exercise barriers decreased significantly over time, with no difference between the groups. Significant decreases in body weight were correlated with improvements in physical activity and weight loss eating behaviors ($p<.05$), but not with decreases in energy intake. Significant correlates of physical activity included perceived barriers to physical activity (negative), physical activity self-efficacy (positive), and some subscales of body image (positive). Significant correlates of weight loss eating behaviors included body image (positive), eating self-efficacy (positive), dietary restraint (positive), dietary disinhibition (negative), and perceived hunger (negative). **CONCLUSIONS:** The behavioral weight loss intervention resulted in significant weight loss and improvements in physical activity and eating behaviors. However, the addition of resistance exercise or mindfulness training did not improve these short-term outcomes. It remains important that alternative behavioral approaches be examined over a longer duration to improve weight-related outcomes in overweight adults.

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INTRODUCTION

The epidemic of overweight and obesity in the United States and worldwide continues to be a serious public health concern, and has proven to be a multi-faceted crisis with considerable economic, social, psychological, and medical consequences. The prevalence of overweight (body mass index (BMI) > 25kg/m^2) and obesity (BMI > 30kg/m^2) in the United States is currently 65% and 32%, respectively.[87] These estimates represent more than a doubling in the rates of obesity since 1980.[88] Consequently, obesity-related co-morbidities, including cardiovascular disease, dyslipidemia, type II diabetes, hypertension, sleep apnea, some forms of cancer, and various musculoskeletal problems, have also increased.[88, 94, 95]

These obesity-related morbidities increase the health care costs attributed to obesity. A staggering 5.7 to 9.1% of the annual national health care costs (~$92.6 to $117 billion dollars) is attributed directly (e.g., medical care, hospital time, physician services, medications) to obesity,[139] while an additional 64 billion dollars are spent on the indirect costs (e.g., decreased productivity, increased absenteeism, lost work output) of obesity.[39, 139] Americans are also spending billions on obesity treatment. Not only do overweight and obese adults have health care costs that are 37% higher than normal weight adults,[107] there also exists a more than $40 billion-per-year diet industry which serves nearly 55 million Americans who attempt to lose weight each year.[39] Although not included in these estimates, the psychological costs for these individuals must also be considered, including decreased self-esteem, increased rates of clinical depression, increased severity of binge-eating disorders, and discrimination.[42, 129] Clearly the continued treatment of overweight and obesity remains critical in that even a modest reduction of 5-10% of initial body weight improves these health outcomes [30, 69] and allays the economic burden of obesity.

Treatment of Overweight and Obesity

The current treatment for overweight and obesity varies according to the intensity of treatment, cost, type of intervention employed, strategies used, and involvement of health-care providers, which can range from self programs to pharmacotherapy and obesity surgery. Regardless of the treatment selected, however, most include some form of lifestyle modification that incorporates diet, exercise, and behavior change.[125, 126] In fact, the Clinical Guidelines for the Identification, Evaluation, and Treatment of Overweight and Obesity published by The National Heart, Lung, and Blood Institute (NHLBI) suggests that behavioral weight control interventions which combine caloric restriction, physical activity, and behavior therapy are the most effective for weight loss and weight loss maintenance.[1]

Diet modification is naturally the foundation of most standard behavioral weight loss programs. Participants are typically instructed to consume a conventional high carbohydrate, low-fat (less than 30% of calories from fat) diet with a reduction in energy intake of approximately 500 to 1000kcal/day.[14, 31] A caloric deficit of this magnitude should produce a weight loss of about 1-2 pounds per week. In addition, engaging in increasing levels of physical activity has been shown to improve weight loss beyond that produced by diet alone,[1, 58] and is likely to be even more essential in the prevention of weight regain following the program.[62, 136] Current guidelines suggest that at least 60 minutes of moderate-intensity physical activity per day is needed to maximize weight loss. [58, 59] Lastly, these types of interventions also employ a variety of behavioral therapies, including self-monitoring, problem solving, stimulus control, relapse prevention, goal setting, social support, and cognitive restructuring.[76] These principles and techniques are taught in order to assist participants in modifying their eating and physical activity behaviors to an extent that the

fundamental goal of weight loss is achieved.

This type of comprehensive approach which combines diet, exercise, and behavior therapy, has been shown to produce an average weight loss of approximately 10.7kg, or 11% of initial body weight at the end of treatment.[126] Although this degree of weight loss would be considered a "success" by current standards,[64, 137] it has been shown that patients treated with behavioral lifestyle modification generally regain 30% to 35% of their lost weight in the year after treatment, and will have regained the majority if not all of the lost weight by five years. [6, 62, 93]

Many studies have also demonstrated that there is a large discrepancy in participants who are successful and nonsuccessful during a standard behavioral program. It is not only common for approximately 20% of subjects to drop out of a study before it ends,[127] but among those who do complete the study, there is a large amount of variability in actual weight loss. For example, results from a 16-week lifestyle weight loss program with a 1 year follow-up showed that even after accounting for the 30% of subjects who were considered noncompleters, there remained a large variability in individual weight change (range of 37.2 kg) among those that completed the study.[120] In addition, unpublished data from our research center shows that approximately 70% of individuals lose at least 7% of their baseline body weight during the initial 6 months of an intervention, indicating that at least 30% of individuals do not reach a clinically significant weight loss. Thus it remains imperative that research continues to examine alternative techniques and related psychosocial factors that encourage adoption of the behaviors that lead to weight loss among those who may not be responsive to current interventions.

Clinical Rationale

It is well accepted that when a participant alters their eating and physical activity behaviors by decreasing the amount of calories consumed and increasing the amount of calories expended, weight loss will occur. Research has also shown that by training participants in theory-based behavior change strategies that encourage desired eating and physical activity modifications, weight loss can improve.[135] However, given the large variability in success of these behavioral interventions in both the short- and long-term, identifying strategies and predictors which explain why some participants achieve a clinically significant weight loss and other do not remains essential.

Results from previous behavioral treatment programs have shown that there are many factors which contribute to weight loss success among participants. One underlying feature of most standard behavioral weight loss programs is that participants are typically required to attend individual or group meetings weekly or bi-weekly, at least in the initial stages of treatment. This not only facilitates the delivery of the behavioral lessons, but also allows for group and therapist support throughout treatment. Frequent therapist contact has been shown to improve weight loss outcomes initially. For example, Jeffrey et al. found that in a standard 6-week behavioral weight loss program, the frequency of therapist-contact (3 times per week vs. 1 time per week) did increase weight loss.[61] In addition to frequent contact, Teixeira et al. reported that dieting history, dietary intake, outcome evaluations, exercise self-efficacy, and quality of life, may all be useful pretreatment predictors of success and/or attrition in behavioral weight loss programs for overweight or obese women.[120]

When examining physical activity participation, the most consistent correlates have been exercise self-efficacy, perceived barriers, use of behavioral strategies, and enjoyment. [44, 77, 119] Likewise, when specifically examining eating behaviors, research has shown that

increased dietary restraint, decreased dietary disinhibition, body image, and eating self-efficacy are all positive correlates of eating behaviors that lead to weight loss.[119, 121, 137] Therefore these have been recommended as potential targets for behavioral weight loss treatments, and thus are examined in this study.

Theoretical Rationale

Alternative behavioral and physical activity approaches to weight loss and their potential effect on related psychosocial parameters continues to be an area of research that demands attention. Therefore, a standard behavioral weight loss intervention was supplemented in this study with one of two additional intervention strategies: mindfulness meditation training or resistance exercise. A theoretical construct was developed to illustrate the rationale behind why these alternative treatment approaches may differentially affect weight loss and/or physical activity. (See Figures 1 and 2.)

Mindfulness involves bringing ones' attention to the internal and external experiences occurring in the present moment in a nonjudgmental way, and is typically developed through regular meditation training.[12] This concept was applied directly to eating and physical activity behaviors in this investigation, in which participants were taught techniques of mindfulness meditation such as breathing exercises, yoga, progressive relaxation, and focused visualization. Frequently employed was a hunger meditation, in which participants were asked to bring awareness to their experience of food, hunger, feeling full, thoughts about food and eating, and emotions. Figure 1 illustrates our proposed theory of how this type of focused meditation training may impact outcomes. We have theorized that this type of alternative training will impact self-regulation of eating and exercise behaviors through improvement in eating self-efficacy, the increased therapist contact time, decreased barriers, decreased dietary disinhibition, and increased dietary restraint. These variables have previously been shown to

impact eating and physical activity behaviors, and thus improve weight loss.

Although increasing physical activity has long been a major component of standard behavioral weight loss programs, resistance exercise has often been overlooked as a potential means to improve overall physical activity and weight loss in overweight and obese adults. Reduced physical function and health-related quality of life is a major barrier to being physically active in the overweight and obese population, and should therefore be targeted in our interventions. It has been shown that resistance exercise using resistance tubing and exercise balls improves strength and physical functioning in the elderly[83], and so we proposed to examine this type of training in overweight and obese individuals. Figure 2 illustrates our proposed theory of how this type of resistance exercise training may impact outcomes. We have theorized that this type of alternative training will impact eating and exercise behaviors through improvement in physical activity self-efficacy, increased therapist contact time, increased physical strength, function, physical capacity, and improved body image. These variables have also previously been shown to impact eating and physical activity behaviors, and thus improve weight loss.

Development of innovative, alternative approaches to a standard behavioral weight loss program is critical to effectively combat the obesity epidemic. It is not currently known how the addition of a mindfulness meditation component or a home-based resistance exercise component using elastic tubing will impact weight loss, physical activity, and related factors. Therefore this study aimed to examine the potential impact of these strategies on psychosocial parameters, eating and physical activity behaviors, and weight loss.

Figure 1. Proposed theoretical construct for how mindfulness meditation training may impact eating and physical activity behaviors and weight loss.

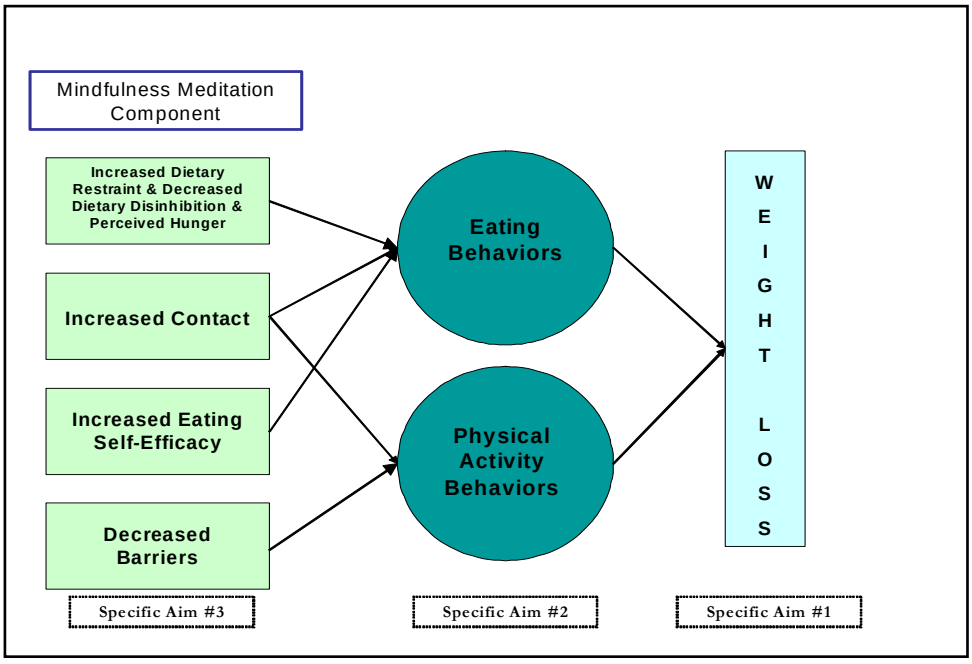
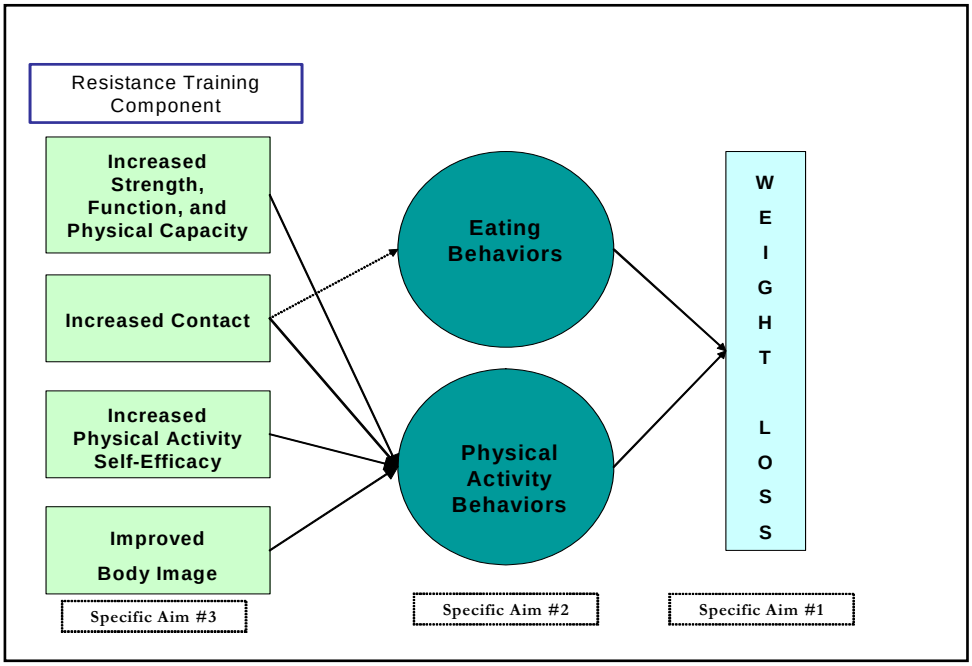


Figure 2. Proposed theoretical construct for how resistance exercise training may impact eating and physical activity behaviors and weight loss.



Specific Aims

The specific aims of this study (refer to Figures 1 and 2) included:

1. To examine changes in body weight between three intervention groups: standard behavioral weight loss (SBWL), standard behavioral weight loss plus resistance exercise training (SBWL + RT), and standard behavioral weight loss plus mindfulness meditation training (SBWL + MD), during a 24-week behavioral weight loss intervention.
2. To examine changes in process measures of eating and physical activity behaviors between three intervention groups: standard behavioral weight loss (SBWL), standard behavioral weight loss plus resistance exercise training (SBWL + RT), and standard behavioral weight loss plus mindfulness meditation training (SBWL + MD), during a 24-week behavioral weight loss intervention.
3. To examine changes in various psychosocial correlates of weight loss and physical activity, such as eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image between three intervention groups: standard behavioral weight loss (SBWL), standard behavioral weight loss plus resistance exercise training (SBWL + RT), and standard behavioral weight loss plus mindfulness meditation training (SBWL + MD), during a 24-week behavioral weight loss intervention.

The secondary specific aims of this study included:

4. To examine if various psychosocial factors (eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image) are associated with body weight and physical

activity across the three intervention groups: SBWL, SBWL + RT, and SBWL + MD, during a 24-week behavioral weight loss intervention.

5. To examine if process measures of eating and physical activity behaviors are associated with weight loss across the intervention groups: SBWL, SBWL + RT, and SBWL + MD, during a 24-week behavioral weight loss intervention.
6. To examine if various psychosocial factors (eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image) are associated with process measures of eating and physical activity behaviors across the three intervention groups: SBWL, SBWL + RT, and SBWL + MD, during a 24-week behavioral weight loss intervention.

Research Hypotheses:

The study proposed the following hypotheses:

1. There will be a greater weight loss in the SBWL + RT group and in the SBWL + MD group when compared to the SBWL group.
2. There will be a greater improvement in process measures of eating and physical activity behaviors in the SBWL + RT group and in the SBWL + MD group, when compared to the SBWL group.
3. There will be an improvement in eating self-efficacy, dietary restraint and disinhibition, outcome expectations (benefits) and perceived barriers in the SBWL + MD group, when compared to the SBWL group or the SBWL + RT. In addition, there will be a greater improvement in physical activity self-efficacy and body image in the SBWL + RT group when compared to the SBWL group or the SBWL + MD group.

4. The psychosocial factors of eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image will be significantly associated with body weight in three intervention groups: SBWL, SBWL + RT, and SBWL + MD.
5. The process measures of eating and physical activity behaviors will be significantly positively associated with weight loss across the intervention groups: SBWL, SBWL + RT, and SBWL + MD.
6. The psychosocial factors of eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image will be significantly associated with the process measures eating and physical activity behaviors in the intervention groups: SBWL, SBWL + RT, and SBWL + MD.

Significance

Behavioral weight loss interventions have been shown to effectively treat overweight and obesity, producing an average loss of 10.7kg (11% of initial weight), [126] with maximal weight loss usually occurring around 6 months[62]. In the year following behavioral weight loss treatments, weight regain averages approximately 30% to 50% of lost weight,[74] indicating that the successful maintenance of long-term weight loss following treatment remains a significant challenge. Yet, despite the ineffectiveness of our current interventions long-term, the continued treatment of obesity is warranted in that even a modest weight loss of 5-10% of initial body weight results in beneficial health effects, and possibly decreased morbidity and mortality from cardiovascular disease, diabetes, musculoskeletal problems, and some forms of cancer[1, 69]. Thus it is important to continue to develop innovative and cost-effective interventions that address the challenges of weight loss both in the short- and long-term.

This study examined a distinct and unique approach to the management of the obesity epidemic through the use of alternative behavioral and physical activity methods that may influence eating and physical activity behaviors that lead to weight loss. In addition, these alternative methods may theoretically influence psychosocial variables that have the potential to produce desired outcomes. If it is shown that the addition of these alternative methods to a standard behavioral weight loss program leads to improved psychosocial parameters, eating and physical activity behaviors, and ultimately greater weight loss, then researchers and clinicians could use this information to tailor future behavioral weight loss interventions. Ultimately this could lead to the application of targeted, cost-effective, and successful treatments for the overweight and obese and potentially alleviate this public health burden.

REVIEW OF THE LITERATURE

Introduction

Obesity is a chronic disease with the prevalence reaching epidemic proportions, affecting both adults and children in the United States and around the world. The vast social, economic, and public health consequences demand that serious attention be given to the development and implementation of strategies to address obesity. In the 2001 Surgeon-General issued a call to action to prevent an increase in overweight and obesity, which recommended that a key strategy to address the problem is to increase research examining the behavioral and biological causes of obesity.[33] Although considerable progress had been made in trying to understand obesity and its' causes and consequences, much remains unknown. Therefore without a complete knowledge of the genetic and cultural influences on body weight, the vast majority of obesity treatment continues to center on current behaviors that can be changed through the use of behavioral modification techniques.[14, 76]

Treatments available for overweight and obese individuals include a combination of behavioral, dietary, and exercise therapies, pharmacotherapy, and weight loss surgery. Currently, the best non-surgical treatments available produce an average weight loss of approximately 10% of initial body weight, which although is considered clinically significant, is likely not enough to stop the upward trend.[76] In addition, unpublished findings from our laboratory have shown that approximately 30% of individuals do not achieve at least 7% weight loss within the initial 6 months of these standard behavioral treatments. Therefore innovative and alternative approaches to a standard behavioral weight loss program must continually be developed and studied to effectively combat the obesity epidemic. It is not currently known how the addition of a mindfulness meditation component or a home-based resistance exercise component will impact weight loss, physical activity, and related factors.

Therefore this study explored alternative approaches to the management of the obesity epidemic through the addition of a mindfulness meditation and resistance exercise component to a standard behavioral program, and examined the potential impact of these strategies on psychosocial parameters, eating and physical activity behaviors, and weight loss.

Obesity: Definition & Prevalence

The prevalence of overweight and obesity in the United States has risen dramatically over the past two decades, with rates nearly doubling in the last 25 years.[39] Overweight and obesity are characterized by an excess in body weight or body fat, and are defined based on the classifications of body mass index (BMI), calculated as weight in kilograms divided by the squared height in meters.[1] A person would be considered overweight if the BMI is between 25.0 and 29.9 kg/m^2 , and obese if the BMI is greater than or equal to 30 kg/m^2.[1, 139] The definition of obesity can be further divided in classes, with a BMI of 30 to 34.9 kg/m^2 being Class I obesity, a BMI of 35 to 39.9 kg/m^2 as Class II Obesity, and a BMI greater than or equal to 40 kg/m^2 as Class III obesity.[139] It is now estimated that more than 65% of American adults are considered overweight, with 32% classified as obese.[87] The high prevalence rates are found across all regions of the nation, among all racial and ethnic groups, among all socioeconomic groups, in both genders, and among all age groups.[88, 89, 139]

Causes and Contributing Factors to Overweight and Obesity

It is not known whether the epidemic of overweight and obesity is primarily caused by an increase in energy intake (caloric consumption), a decline in energy expenditure (physical activity), or a combination of both, but it is clear that it is fundamentally a result of energy imbalance.[71] An individual will gain weight when the amount of calories consumed exceeds the amount of calories expended.[39] Although this is a seemingly simple explanation, the disparity on either side of the energy balance equation has proven to be a result of the

complex interaction of biologic, genetic, cultural, social, and environmental factors.[139]

Increased energy intake is the result of eating and drinking behaviors, which are influenced by hunger, satiety, and thoughts.[139] Decreased energy expenditure is the result of physical activity and exercise behaviors that are less than ideal. These behaviors, however, are influenced by genetic, physiological, cultural, social, and environmental factors and so must be considered in context. Although more than 20 genes have been discovered which may be linked to body fat storage[139], and there are some genetic components to the ability to store fat in the presence of food excess or lose fat in the presence of starvation, it is unlikely that genetics and biology completely explain this epidemic.[78, 88] Rather this may be a result of a gene-environment interaction, in which genetically predisposed individuals may respond to the overwhelming presence of energy-dense foods and an increase in energy-saving devices that encourage sedentary behaviors.[88, 139] There also appears to be a disconnect between thoughts and behavior in that although more than 60% of adults who are overweight and obese report using physical activities to lose weight, only 20% of them are meeting the physical activity guidelines.[139] Clearly the dose of physical activity required to compensate for these eating behaviors is not being met, and thus is not enough to promote energy balance.

Consequences of Overweight and Obesity

The negative effects of obesity extend into many aspects of our society, with far-reaching medical, economic, and psychosocial consequences. Medically, it has been well-reported that a higher body weight, or higher BMI, is associated with an increased morbidity and mortality of numerous conditions, such as diabetes mellitus, cardiovascular disease, hypertension, sleep apnea, dyslipidemia, stroke, musculoskeletal disorders, and certain types of cancers.[1, 33, 88] Central adiposity, or the amount of abdominal fat, is of particular concern because it has been shown to be an independent risk factor for morbidity associated with

overweight and obesity. [1] Although the exact number of deaths *directly* attributable to obesity is difficult to determine, the current estimates range from 110,000 to 300,000 annually in the United States.[41, 89, 139]

The economic impact of overweight and obesity is equally overwhelming. Obesity imposes costs on an individual level by limiting personal opportunities[39, 107] and by incurring annual medical expenditures that are 36% higher than normal-weight individuals.[39] These expenditures extend into the workplace, where employers who offer health insurance absorb many of these additional costs, along with the indirect costs of increased absenteeism, reduced productivity, and lost work output.[39, 107] Ultimately these individual and workplace costs translate into government costs. Treatment of obesity-related diseases is estimated to account for $92.6 to $117 billion dollars, which is approximately 5.7% to 9.1% of the total US health care expenditures.[139] Medicare (~$17 billion) and Medicaid (~$21.3 billion) pay for more than half of these costs through public funds[107], costing the average taxpayer approximately $175 per year to finance obesity-related expenses among recipients of these government programs.[39] Lastly, an estimated $36.5 billion of these costs is paid for by private insurance.[139]

Although potential psychosocial consequences involve a complex interaction of gender, personality, level of education, socioeconomic status, poverty, cultural beliefs, and family environment, it is important to examine how these issues adversely affect quality of life in the overweight and obese.[139] Numerous reports show that these individuals experience significant impairments in quality of life as a result of their obesity[40, 67], with greater impairments associated with greater degrees of obesity.[63, 70] In addition, the stigma of being overweight or obese may contribute to higher rates of anxiety, depression[115], low self-esteem, and increased rates of binge-eating disorder (BED).[24, 67, 71, 139]

Obesity has proven to be an extremely complex condition of which prevention and treatment are challenging, yet crucial. The deleterious medical and psychosocial effects experienced by overweight or obese individuals extend beyond the personal level into vast economic, social, and public health consequences. Thus to combat the epidemic in the long-term, a multi-faceted approach may be necessary.

Obesity Treatment

The National Institutes of Health have recommended that obese individuals should aim to lose approximately 10% of their initial body weight, and large clinical intervention trials have aimed to lose at least 7% of initial body weight.[2, 131] A goal of 7 to 10% was chosen because a reduction of initial body at these levels has been shown to elicit health benefits,[1, 3, 96] and there are a few different treatment options available to help individuals accomplish this goal. Bariatric surgery, pharmacotherapy, and lifestyle modification approaches which include diet, physical activity, and behavior therapy components are the most current treatments available.[100, 106] A recent review of the efficacy of these treatments for promoting sustained reductions in body weight ($\geq$2 years) reported that both lifestyle and drug interventions consistently produced a weight loss of approximately 7 pounds sustained across a 2 year period, which was associated with improvements in diabetes, blood pressure, and other cardiovascular risk factors.[100] Surgical approaches showed larger initial weight losses (50 to 80 pounds) that were sustained for two years. However, upon consideration of the more significant short-term side-effects and questions about the sustainability of this loss beyond the 2 year point, the authors of the review conclude it is still unclear whether the benefits of surgery outweigh the potential risks.[100]

Regardless of which treatment is selected by an individual, it is recommended that an approach (or combination of approaches) that includes lifestyle or behavior modification

should be used to promote long-term weight loss and sustainable health benefits in this population.[14, 76, 100, 106, 126, 135] In addition, this approach has been shown to be efficacious and cost-effective. An economic evaluation concluded that an approach which included diet, exercise, and behavior modification was effective for weight loss and cost-effective when compared to other weight loss approaches.[106]

Standard Behavioral Weight Loss Interventions

The evidence-based Clinical Guidelines for the Identification, Evaluation, and Treatment of Overweight and Obesity published by The National Heart, Lung, and Blood Institute (NHLBI) suggests that behavioral weight control interventions which combine caloric restriction, physical activity, and behavior therapy are the most effective for weight loss and weight loss maintenance.[1] These types of standard behavioral weight loss interventions are typically conducted on a weekly basis across an initial period of 16 to 26 weeks[126, 127] and treatment is usually provided in 30 to 60 minutes of group and/or individual sessions lead by registered dieticians, exercise specialists, behavioral psychologists, or other healthcare specialists.[126, 135] These group sessions allow for the delivery of the behavioral therapy lessons, and also for group and therapist support throughout treatment. This type of frequent therapist contact and group therapy has been shown to improve initial weight loss outcomes.[103, 126] These group sessions typically occur and include assessment of body weight, followed by the delivery and discussion of a behavioral lesson, which include topics such as self-monitoring, problem solving, nutrition, physical activity, stimulus control, relapse prevention, goal setting, social support, and cognitive restructuring.[14, 76, 127] The primary goal of this type of approach is to assist participants in restructuring their lifestyle and environment to reduce behaviors thought to contribute to obesity, and to closely monitor those behaviors.[14]

To achieve the recommended weight loss of 1 to 2 pounds of weight loss per week,

participants are typically given specific calorie, fat gram, and physical activity goals that are to be self-monitored throughout the intervention. A conventional high carbohydrate, low-fat (less than 30% of calories from fat) diet is usually encouraged, with a reduction in energy intake of approximately 500 to 1000 kcal/day.[14, 31] Other diet modifications such as very low calorie diets (VLCD), meal replacements, portion-control, low glycemic index, and low-carb, high-fat diets have been used as well, either alone or in combination with the standard recommendation.[126 32, 53, 124]

Most studies of short-term interventions show that the most significant weight loss occurs when a combination of diet and exercise is used, yet the weight loss is only a little higher than diet alone.[1, 27, 54, 58, 60] A meta-analysis by Miller et al.[85] reported that in comparison of 493 studies, diet alone (-10.7kg) and diet plus exercise (-11kg) were superior to exercise alone (-2.9kg) in reducing weight, with no significant differences between the diet and diet plus exercise group.[85] However most evidence suggests that physical activity does play a significant role in energy expenditure and long-term weight control,[57, 59, 62, 136] and thus is a vital part of any behavioral weight loss program. The 2005 Dietary Guidelines for Americans and the current American College of Sports Medicine/American Heart Association Recommendations both suggest that to promote and maintain health, adults aged 18 to 65 years need moderate-intensity aerobic physical activity for at least 30 minutes per day on five days each week.[31, 50] However, in order to achieve weight loss or prevent weight regain, more is likely needed.[50] Current guidelines suggest that *at least* 60 minutes of moderate-intensity physical activity per day is needed to maximize weight loss. [31, 58, 59, 109] Therefore to achieve the optimal dose of physical activity for weight control, Jakicic and Otto[59] recommend that current standard behavioral weight loss programs should aim to prescribe physical activity beyond what is needed to achieve health benefits, which is closer to 200-300min/wk or the

equivalent of ≥ 2000kcal/wk across the intervention period and beyond.[59, 109, 136]

Short-Term Results of Treatment

Standard behavioral weight loss programs that include a comprehensive approach of diet, exercise, and behavioral changes typically result in short-term weight losses of approximately 10.7kg, or 11% of initial body weight at the end of treatment.[126] This has been a significant improvement over results from behavioral programs from 20 to 30 years ago. Whereas in 1974, the average participant lost 3.8kg in 8.4 weeks of treatment, by 1996-2002, this rate more than doubled to 10.7kg in 31.4 weeks of treatment.[126, 135] Although this may appear to reflect an improvement in treatment efficacy, the increase in the average weight loss resulting from behavioral interventions appears to be most likely due to the longer duration of treatment, as the average rate of weight loss has actually remained constant at about 0.4 to 0.5 kg per week.[126]

Despite advancements in behavioral weight loss interventions, there is still much that can be improved upon. There still remains a large amount of variability in those who adhere to the recommendations, stay committed to the intervention, and in those who respond to the treatment strategy. For example, in a review of behavior therapy for obesity treatment by Wadden et al. (2007) it was shown that approximately 80% of participants complete the treatment program,[126] leaving a mean attrition rate of 20%. In addition, internal data from our research center shows that approximately 70% of individuals lose at least 7% of their baseline body weight during the initial 6 months of an intervention, indicating that at least 30% of individuals do not reach a clinically significant weight loss.

Thus it is important to not only understand what had been shown to be effective aspects of behavioral weight loss interventions, but also what techniques and factors lead to weight loss among those who may not be responsive to current interventions.

Long-Term Results of Treatment

The average weight loss of approximately 10-11% of initial weight that is seen in most standard behavioral programs would be considered a "success" by current standards.[64, 137] However, it has been shown that patients treated with behavioral lifestyle modification generally regain 30% to 35% of their lost weight in the year after treatment, and will have regained the majority if not all of the lost weight by five years. [6, 62, 93] Regardless of method used to lose weight in the short-term, long-term weight loss and maintenance remains a significant challenge.[62]

However, there is some evidence that extended treatment involving prolonged therapist contact and proactive approaches that encourage continued use of learned behavioral strategies can be successful for up to 5 years time. The efficacy of this type of long-term lifestyle intervention was shown by the success of the Diabetes Prevention Program (DPP), which was a multi-center randomized clinical trial in over 3000 overweight and obese individuals with impaired glucose tolerance.[2] This trial included a no treatment (placebo) group, a medication group in which participants were prescribed metformin, and a lifestyle group in which intensive behavioral methods were taught. Although the initial treatment phase was 16 to 24 weeks and involved weekly or bi-weekly meetings, there was ongoing contact at least every 2 months for the remainder of the study. The promising result was that participants in the lifestyle group lost significantly more weight at all assessment periods when compared to the other two treatment groups. The average weight loss in this group at 6 months was a modest but clinically significant 7% of baseline weight, which was maintained at 12 months, but then was slowly regained for a mean weight loss of 4% at the end of treatment. Although modest, these results were considered very successful when compared to the metformin group, who lost 2.5% within the first year, and then regained weight during the

subsequent 2 years. However, the main and most significant finding of the DPP was that the lifestyle intervention reduced the risk of diabetes by 58%, and was twice as effective as the medication group. In addition, self-reported physical activity was 224 minutes at 6 months and 227 minutes at the end of the study.[2, 76, 101, 126, 135] In addition, a recent randomized controlled trial by Wing et al.[138] reported that an 18-month intervention of daily self-weighing and face-to-face counseling sessions in a group of individuals who had lost weight reduced the amount of weight regain by 50% when compared to the control group.[138]

Therefore the success of long-term interventions is likely attributed to the continued therapist contact, high levels of physical activity, and continued self-monitoring. However, it is important to continue to develop innovative weight loss treatments in both the short- and long-term for the overweight and obese to improve upon this weight loss and related outcomes. Even in highly successful trials such as the Diabetes Prevention Program, weight regain still occurred in the long-term, suggesting that more needs to be done. There is also a growing need to expand the current definition of success to include other health related quality of life outcomes (i.e., physical functioning, pain) in addition to the traditional risk factor and outcome evaluation.

Alternative Treatments for Overweight and Obesity

Mindfulness Meditation

Recent findings from a random-digit-dialed survey of United States adults in 2002 found that approximately 3.3% of people surveyed had used some form of complementary or alternative medicine for weight control in the previous 12 months, with the most widely reported therapies being yoga (57.4%) and mediation (8.2%).[112] Despite the use of these therapies for weight control by some, little is really known about the efficacy of using these

types of treatments for weight loss or as part of an overall behavioral weight loss intervention.[5, 98]

Description of Mindfulness Meditation Training

Examination of and interest in mindfulness meditation training techniques and the potential health benefits has grown tremendously since the introduction of a Mindfulness-Based Stress Reduction (MBSR) clinical program, developed to help chronic pain patients more than 25 years ago by John Kabat-Zinn.[65] The primary goal of this program and others like it is to provide participants training in meditation techniques to cultivate the quality of "mindfulness."[15] Mindfulness involves bringing ones' attention to the internal and external experiences occurring in the present moment in a nonjudgmental way, without getting caught up in the thoughts or emotional reactions to these experiences.[12, 15] It aims to teach people to approach stressful situations "mindfully" so they may respond in an appropriate and thoughtful way instead of automatically reacting to it as they may have previously.[15, 65]

Mindfulness can be cultivated using a variety of techniques, all which have some form of meditative component. In addition to formal mindfulness meditation (a sitting or lying meditation period), there are mindful movement techniques (incorporating yoga or 'mindful walking'), and brief periods of being mindful or meditative throughout the day. The techniques also include the aim of being mindful while doing daily activities, such as being aware and present in the moment even when doing habitual tasks such as eating or getting a shower.[4]

Health Benefits of Mindfulness Meditation

A number of studies have shown beneficial effects of mindfulness on physical health and psychological well-being.[20, 25, 36, 66, 84, 113] A meta-analysis by Grossman et al.[48] examined approximately 20 studies that covered a wide variety of clinical populations (pain, cancer,

heart disease, depression, and anxiety, and stressed nonclinical groups) and found overall effect sizes of approximately 0.5 ($p<.0001$), suggesting that mindfulness-based techniques, and specifically MBSR, may help a broad range of individuals with their myriad of health problems.[48] For example, one randomized trial examining the use of mindfulness and acceptance techniques to improve diabetes self-management compared to an education control group, found that after 3 months those that used the mindfulness-based therapies were more likely to use coping strategies to deal with their diabetes, reported better diabetes self-care, and had better glycated hemoglobin levels.[47] Another randomized controlled trial examining 10-year risk of coronary heart disease (CHD) compared usual care (UC) to the use of a personalized health plan (PHP) that included mindfulness meditation training and relaxation techniques.[36] Research results showed that the PHP group had a reduced risk of CHD (7.8%) over the 10-month intervention, possibly due to the increased days of exercise per week and greater weight loss in the PHP group compared to the UC group, although these differences were not statistically significant.[36]

Mindfulness Meditation and Weight Loss

In relation to weight loss, one of the most important effects of a mindfulness intervention may be on the regulation of health behaviors, such as eating behaviors. Of these poor eating behaviors, binge eating is one that is particularly harmful because it may lead to weight gain and obesity.[140] For example, binge eating, defined as a repeated, uncontrolled consumption of a large amount of food, may represent a failure to self-regulate eating behaviors.[140] Poor eating behaviors may also encompass "emotional eating" or eating in response to one's emotions rather than hunger cues.[82] Emotional eating is a commonly described occurrence by participants of weight loss programs, and may result from either a lack of ability or awareness to distinguish between emotional distress and hunger, or from the

use of food as a way to reduce emotional distress.[82, 97] It has been theorized that mindfulness meditation may be effective for producing changes relative to binge eating and other negative eating behaviors such as emotional eating through changes in self-regulation, values clarification, cognitive-behavioral flexibility, and exposure.[111] Additional plausible mechanisms by which mindfulness meditation training may influence eating behaviors have been suggested and include the following: 1) it provides an alternative means for relief from distress, 2) provides a sense of perceived control[28] 3) provides a heightened ability to resist impulsive urges,[80] and 4) provides a "deconditioning" of habits.[20, 28, 111] In one of the few studies examining mindfulness mediation techniques and eating behaviors, Kristeller and colleagues conducted a pilot study on the effects of MBSR on 18 women diagnosed with Binge Eating Disorder (BED) and found a statistically significant reduction in mean frequency of binge episodes from a mean of 4 per week to 1.6 per week. The authors suggest that the self-observation skills developed through MBSR training might lead to improved recognition of satiety cues in binge eaters, as well as an increased ability to resist urges when they appear.[73]

Mindfulness training has been shown to be useful as part of clinical interventions that utilize cognitive-behavioral therapy, and may improve behaviors that relate to a variety of physical and mental health problems.[12] A review of studies utilizing mindfulness training as a clinical intervention also suggests that not only will many participants who enroll in mindfulness-based programs complete them in spite of the time and homework requirements, they will also continue to practice the skills long after treatment completion.[11] In addition, a study which examined the effects of mindfulness on the intention-behavior relationship demonstrated that individuals acting mindfully and not habitually are more likely to act on their intentions than are individuals acting habitually and not mindfully,[20, 28] which may prove

useful in lifestyle modification for obesity treatment.

To date, the systematic evaluation of mindfulness meditation training to specifically treat overweight and obese individuals as part of a behavioral weight loss intervention has yet to be done. In addition, the influence of this type of alternative intervention strategy on self-regulation of eating and exercise behaviors through improvement in specific measures such as eating self-efficacy, decreased barriers, decreased dietary disinhibition, and increased dietary restraint has yet to be examined. These variables have previously been shown to impact eating and physical activity behaviors, and thus improve weight loss. Therefore, given the increasing popularity of mindfulness training and its' potential impact on self-regulatory and eating behaviors, it is critically important to continue to study this innovative strategy.

Resistance Training

Although increasing physical activity has long been a major component of standard behavioral weight loss programs, the addition of exercise to food restriction only produces an overall average increase in weight loss of about 1.5 kg.[85] However, exercise has been shown to be a crucial element in long-term weight maintenance, and therefore should be a part of a comprehensive behavioral weight loss program.[137] The majority of interventions have focused on endurance exercise for weight loss, and resistance exercise has often been overlooked as a potential means to improve overall physical activity and weight loss in overweight and obese adults. A recent review of physical activity and weight loss in 17 randomized controlled trials identified 7 that included a resistance-training arm. Unfortunately, this type of exercise training also did not lead to any improvements in weight loss compared to the control, at least in the short-term.[27] Data on the long-term effects of resistance training on weight loss are limited as well. A 48-week study examining exercise as a treatment for obesity compared diet alone, diet plus aerobic training, diet plus strength

training, or diet combined with both aerobic and strength training in 128 obese women enrolled in a standard behavioral weight loss program.[128] The women in the study had a mean weight loss of 16.5 $\pm$ 6.8 kg at Week 24, but no significant differences were found among any of the conditions at any time in body weight or body composition. And although resistance exercise has been theorized to help preserve resting energy expenditure (REE) to a greater extent than aerobic exercise, the women who received aerobic training had smaller reductions in REE than the strength training group at Week 24.[128] In another randomized controlled trial that compared walking to resistance training across a 6 month weight maintenance program and a 23-month follow-up, following a 20-month energy restriction, found that although exercise training did not improve short or long-term weight maintenance compared to the control, resistance training did attenuate the regain of body fat mass during weight maintenance, although this effect disappeared at the 23-month follow-up.[18]

Despite the lack of strong evidence that resistance training improves weight loss[35], the addition of resistance training has other clear advantages. Fat-free mass normally decreases following diet-induced weight loss by approximately $\geq$ 7kg, which typically results in concurrent decrease in resting energy expenditure (REE).[45] Yet it has been shown that resistance training is a potent stimulus for increasing fat-free mass (FFM), and may help to preserve FFM while maximizing fat loss during a period of weight loss.[35, 55, 58, 72, 99, 122] For example, Sweeny et al.[118] found that following a 3-month diet and exercise intervention, obese patients had a smaller decline in fat-free mass following a combined endurance and resistance training program when compared to endurance training alone.[118] A recent review of 12 studies that combined resistance exercise and diet (with or without endurance training) by Hansen et al.[49] concluded that resistance training does not modulate fat-mass loss, but it does prevent the decline in fat-free mass and resting metabolic rate (or REE) secondary to dietary

restriction. Donnelly et al.[34] also reported that even during a period of severe energy restriction that induced weight loss and a decline in FFM, weight training was able to elicit muscle fiber hypertrophy and a significant increase in overall strength (~37% from baseline) when compared to the sedentary controls.

Reduced physical function and health-related quality of life is also a major barrier to being physically active in the overweight and obese population[49], and the preservation of FFM may potentially lead to increased strength, physical functioning, and improvement in the ability to carry out activities of daily living.[35, 59, 99] It has already been shown that resistance exercise using resistance tubing and exercise balls improves strength and physical functioning in the elderly population,[56, 83, 99] but examination of this type of training in overweight and obese individuals has yet to be studied extensively. For example, a recent study examining the effects of 12-week home-based resistance training program using body weight and rubber tubing as a load in elderly adults demonstrated that in the absence of weight loss, this type of training induced a significantly greater decrease in waist circumference, visceral and thigh fat thickness, and increase in thigh muscle thickness when compared to the control group.[122] In addition to these beneficial effects, home-based exercise programs have been shown to be superior to clinic-based interventions in promoting adherence,[68] as was also demonstrated by the fact that there were no dropouts in the previously mentioned study.[122] Thus, although data are lacking for the overweight and obese population, a combination of home-based resistance training utilizing resistance tubing and exercise balls may provide an effective and practical way to incorporate resistance exercise into a behavioral weight loss intervention.

In addition to the potential physical benefits of resistance exercise training for the overweight and obese population, a potential psychosocial advantage that has been shown to improve with this type of training is body image, physical self-concept, and physical activity

self-efficacy.[8, 81, 102, 134] A recent meta-analysis based on 35 studies examining the effect of physical activity on body concerns found an overall effect of .45, which suggests that exercise does have a positive effect on body image. It was also noted that, overall, anaerobic exercise such as weight training, generated a stronger effect on body concerns (d=.64) than aerobic exercises such as jogging (d=.40). [102] A general limitation of these studies, however, is that the majority of participants were young adults, usually university students, of normal body weight. Therefore, although resistance training and effects on body image have been studied in both sedentary men and women, [7, 8, 81, 123] it has yet to be studied in the overweight and obese population.

Certain variables such as physical activity self-efficacy, increased therapist contact time, increased physical strength, function, physical capacity, and improved body image have previously been shown to impact eating and physical activity behaviors, and thus improve weight loss. However, the extent to which a home-based resistance exercise program will affect these variables in the overweight and obese population has yet to be determined and thus requires further examination.

Psychosocial Factors

The large variability in success among participants of behavioral weight loss programs continues in spite of advancement in research and evolvement of treatment. Obesity has proved to be a multi-faceted condition which requires equally diverse treatment options, which specifically target individual psychological, biological, and environmental differences.[121] There has been some attempt at predicting who will be successful at weight loss at the beginning of a program, or at explaining retrospectively behavioral and psychological correlates associated with successful or unsuccessful weight loss following a

program.[23] However, a 2005 review by Teixeira et al.[121] reported that only 20-35% of the variance in subsequent weight loss following a treatment program has been predicted from baseline variables.[121] An adequate explanation as to why some people adopt and maintain attitudes and behaviors necessary for weight loss and weight maintenance has yet to be determined, and clearly remains a research priority.

Psychosocial and behavioral variables have been identified that appear to contribute to weight loss success among participants of behavioral weight loss programs. These variables are frequently grouped as a part of choice health behavior models, such as the Theory of Planned Behavior (TPB), the Transtheoretical Model (TTM), the Social-Cognitive Theory (SCT), and Self-Determination Theory (SDT) in an attempt to explain or predict behavior.[92] For example, in addition to frequent therapist contact, Teixeira et al. reported that dieting history, dietary intake, outcome evaluations, exercise self-efficacy, and quality of life, may all be useful pretreatment predictors of success and/or attrition in behavioral weight loss programs for overweight or obese women in the long-term (12-month follow-up).[120] However, other variables appeared to be important when examining short-term weight loss in the same study. Following the 4-month lifestyle weight reduction program, in which participants lost $6.2 \pm 4.6\%$ of initial body weight, changes in variables such as eating restraint, disinhibition, and hunger, exercise, self-efficacy, and body shape concerns, were associated with weight change at 4-months ($p<0.05$).[119] Another study examining psychosocial variables in a short-term weight loss intervention found that weight change was significantly predicted by various health behavior change theories (SCT, TTM, TPB, SDT), particularly those that included self-efficacy as part of the model.[92]

Other psychosocial variables related specifically to physical activity and eating behaviors that likely lead to and/or predict individual weight loss success should also be

explored. Past research suggests that the most consistent correlates of physical activity participation have been exercise self-efficacy, perceived barriers, use of behavioral strategies, and enjoyment. [13, 44, 77, 119] For example, following a 6-month behavioral weight loss intervention, 165 overweight or obese women with ≥ 10% weight loss reported higher levels of physical activity self-efficacy and fewer barriers to physical activity compared to those with less weight loss ($p<0.05$). In addition, these same psychosocial variables were related to higher levels of physical activity.[44]

Likewise, research has shown that increased dietary restraint, decreased dietary disinhibition, body image, and eating self-efficacy are all positive correlates of eating behaviors that lead to weight loss.[119, 121, 137] In particular, the eating behavior termed "disinhibition" has been shown to be strongly associated with weight gain over time and obesity in adult life.[51, 52] In addition, a short-term (12-week) intervention study in overweight young adults found that as eating self-efficacy improved, eating habits improved and thus weight loss was greater.[104] Long-term studies show similar results, as seen in the PREFER study.[132] Results from this 18-month behavioral weight loss trial also demonstrate that eating self-efficacy does appear to be significantly associated with weight loss ($p=0.02$), even after controlling for dietary adherence.[132]

If behavioral weight loss interventions are to become progressively more effective, they will need to specifically target true causal mechanisms of behavior and lifestyle modification. For example, evidence currently suggests that the knowledge of the health benefits of weight loss (and related physical activity and eating behaviors) do not appear to change over time for participants in these types of interventions, and do not appear to be associated with better outcomes.[13, 77] Therefore to spend time educating participants about the health benefits would likely not be the best use of time and resources. If, however, it was

known specifically which psychosocial and behavioral factors largely affect weight loss and related behaviors, and the time course by which changes in these variables occur, interventions could be designed to target these defined factors at precisely the right time. The implications of this knowledge would likely be the development of cost-effective and increasingly successful behavioral treatment programs to help alleviate some of this public health burden.

Conclusion

Obesity is recognized as one of the most significant public health burdens with increasing prevalence rates and inadequate progress in the development of viable treatment options that maintain weight loss long-term. Therefore development of innovative, alternative approaches to a standard behavioral weight loss program and understanding the interaction of individual psychosocial factors is critical to effectively combat this epidemic. Although previous research findings and plausible mechanisms have been reviewed here, it is not currently known how the addition of a mindfulness meditation component or a home-based resistance exercise component using elastic tubing to a standard behavioral weight loss program will impact weight loss, physical activity, and related factors. Therefore this study aimed to examine the potential impact of these strategies on psychosocial parameters, eating and physical activity behaviors, and weight loss.

METHODS

Current estimates show that more than 65% of American adults are considered overweight (body mass index (BMI) > 25 kg/m^2), with 32% classified as obese (BMI > 30 kg/m^2),[87] indicating serious attention must be given to this public health crisis as it is linked to many serious negative health outcomes.[94] Standard behavioral weight loss programs that include diet, exercise, and behavioral changes typically result in short-term weight losses of approximately 8-11% of initial body weight.[126] However, it is important to continue to develop innovative weight loss treatments for the overweight and obese to improve upon this weight loss and related outcomes.

This study examined alternative approaches to the management of the obesity epidemic through the addition of mindfulness meditation and resistance exercise component to a standard behavioral program. These additional methods may influence eating and physical activity behaviors that lead to improved weight loss.

Subjects

The subjects in the current investigation were seventy-two (72) sedentary, overweight and obese adult men and women who were recruited to participate in a behavioral weight loss study at the University of Pittsburgh Physical Activity and Weight Management Research Center. In order to be considered eligible for this study, participants were to be 18 to 55 years of age, with a BMI ranging from of 25 to 39.9 kg/m^2. Inclusion and exclusion criteria for participation in this study are listed in Table 1.

Table 1. Study Eligibility Requirements

Inclusion Criteria:
▪ Male or Female ▪ 18 to 55 years of age ▪ Body Mass Index (BMI) between 25.0 to 39.9 kg/m^2 ▪ Ability to provide informed consent
Exclusion Criteria:
▪ Regular exercise participation of at least 20 minutes per day on at least 3 days per week during the previous six months. ▪ Participation in a previous physical activity or weight management research project in the previous 6 months. ▪ Weight loss of > 5% of current body weight in the previous 6 months. ▪ For women, those currently pregnant, pregnant during the previous 6 months, or plan on becoming pregnant in the next 6 months. ▪ History of myocardial infarction, heart bypasses surgery, angioplasty, or other heart-related surgeries. ▪ History of orthopedic complications that would prevent optimal participation in the exercise component of the intervention. ▪ Currently taking any prescription medication that may affect metabolism and/or body weight (e.g., synthroid). ▪ Currently being treated for any condition that could affect body weight, such as coronary heart disease, diabetes mellitus, hypertension, cancer, depression, and anxiety. ▪ Currently being treated for any psychological issues or problems, taking any psychotropic medications, or receiving treatment with psychotropic medications within the previous 6 months. ▪ Non-medicated resting systolic blood pressure $\geq$ 160mmHg or non-medicated diastolic blood pressure $\geq$ 100mmHg, or taking medication that would affect blood pressure or heart rate at rest or in response to exercise (e.g., beta blockers).

Recruitment and Screening Procedures

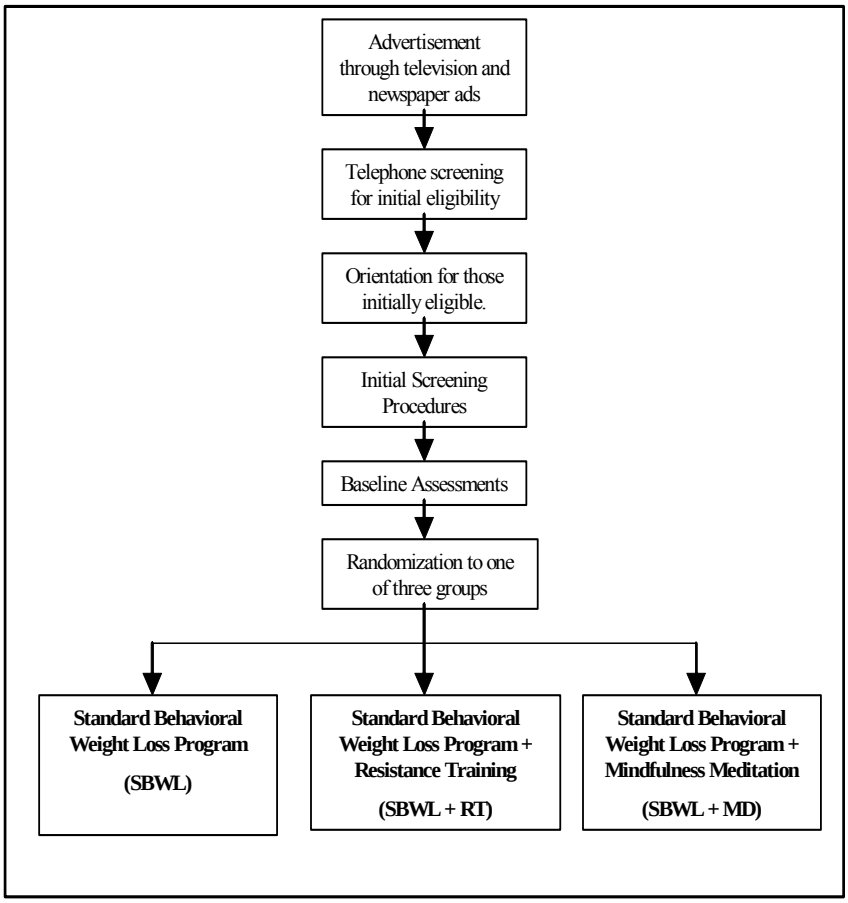
Subjects for this study were recruited through various media outlets, such as local newspaper advertisements, newsletters, television and radio advertisements, and other techniques approved by the Institutional Review Board at the University of Pittsburgh. Interested individuals were instructed to call the University of Pittsburgh Physical Activity and Weight Management Research Center via the telephone number provided in the advertisements. Individuals participated in a brief phone screen interview to assess initial eligibility and were provided a brief explanation of the study and its' potential risks and benefits. This interview was conducted by staff and graduate students at the University of Pittsburgh Physical Activity and Weight Management Research Center.

If determined eligible, individuals were sent a letter inviting them to attend a sixty minute orientation session of 20-30 individuals at a time at which a detailed description of the study was provided and questions concerning the study were answered. Prior to completing baseline assessments, eligible individuals were asked to provide a written informed consent document and complete a physical activity readiness questionnaire (PAR-Q) and a detailed medical history. All subjects were required to provide written clearance from their primary care physician prior to participation in this study. The cost of obtaining this physician clearance was the responsibility of the subject.

Eligible subjects participated in a series of baseline assessments that included measures of height, weight, body composition, cardiorespiratory fitness, muscular strength, physical function, health-related quality of life, physical activity, eating behaviors, and questionnaires to assess potential psychosocial correlates of weight loss. Assessment procedures will be described in detail below. Eligible participants who completed baseline assessments were then randomized to one of three groups (see Figure 1 below). All

procedures were reviewed and approved by the Institutional Review Board (IRB) at the University of Pittsburgh prior to the initiation of the study.

Figure 3. Study enrollment and randomization.

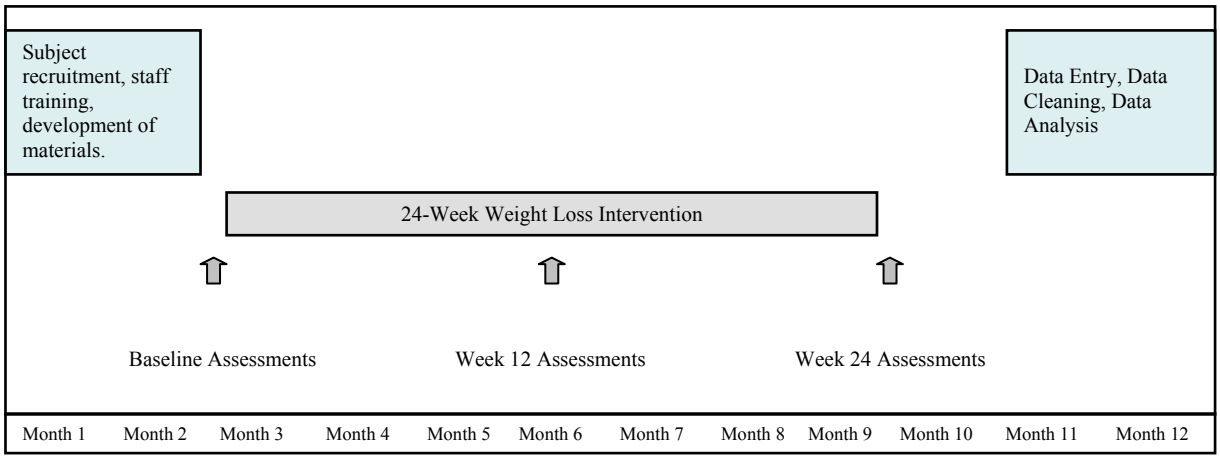


Experimental Design

This investigation was a 24-week clinical behavioral weight loss intervention conducted at the University of Pittsburgh Physical Activity and Weight Management Research Center. Eligible participants who completed baseline assessments were randomized (as shown above in Figure 1) to one of the following treatment conditions: 1) Standard behavioral weight loss program (SBWL) 2) Standard behavioral weight loss program plus resistance exercise training (SBWL + RT), and 3) Standard behavioral weight loss plus

mindfulness meditation training (SBWL + MD). Assessments were performed at 0, 12, and 24 weeks of participation. A summary of the study timeline is illustrated in Figure 2 below.

Figure 4. Study timeline.



Weight Loss Interventions:

Standard Behavioral Weight Loss Intervention (SBWL)

All subjects, regardless of group assignment, participated in a comprehensive 24-week behavioral weight loss intervention that included diet, exercise, and behavior modifications. To facilitate the intervention, subjects attended group meetings weekly for 6 months at the University of Pittsburgh's Physical Activity and Weight Management Research Center. Group meetings were approximately 30 minutes in length and consisted of structured didactic behavioral lessons and facilitated group discussions led by a qualified nutritionist, exercise physiologist, or health educator with experience conducting weight loss intervention groups. The behavioral lesson topics were based primarily on social cognitive theory and included strategies for adopting and maintaining positive eating and exercise behaviors. All topics of the 24-week standard behavioral intervention are listed in Table 2. Weekly recipes and supplemental written materials, many which included worksheets and home activities, were also provided to subjects.

To assist with counseling subjects and setting goals, subjects were weighed each week prior to their group meeting. Participants who were unable to attend the weekly group meetings were called by phone and were re-scheduled for an individual weigh-in and make-up session with a staff interventionist prior to the next group meeting. If an individual session could not be scheduled, an interventionist would provide a brief counseling session by phone and mailed written materials.

Table 2. Standard Behavioral Lesson Topics

Week	Lesson Topic
1	The Behavioral Approach to Changing Your Eating and Exercise Habits
2	Healthy Food Choices
3	Motivation for Weight Loss
4	Developing and Implementing Your Exercise Program
5	Barriers to Exercise
6	The Role of Thoughts in Weight Management
7	Stimulus Control: Cues in Your Physical Environment for Eating & Exercise
8	Strategies for Becoming a Skillful Supermarket Shopper
9	Consuming the Foods You Like: Modifications in Food Preparation
10	The Art of Positive Thinking and Planning: Taking Responsibility
11	Build a Better Breakfast
12	Eating Out In Restaurants
13	Evaluating Your Progress: Where have you been? Where are you going?
14	My Pyramid: Steps to a Healthier You
15	My Time, My Values
16	Urge Surfing: Wanting to Eat When You Are Not Hungry
17	Laughter: It Does More Than Improve Your Mood
18	Smart Snacking
19	Energy Balance Revisited: The Impact on Body Weight
20	Problem Solving
21	3 Month Assessment Feedback
22	Looking Forward: Charting Your Future
23	Holiday-Proofing Your Home
24	Life After Get Firm

Dietary Intervention:

The goal of the dietary intervention was to employ a balanced-deficit diet with a macronutrient composition consisting of approximately 55% carbohydrate, 20-25%

fat, and 10-25% protein. Subjects were therefore instructed to reduce total energy intake to approximately 1200-1800 calories per day depending on initial body weight (see Table 3) and total fat intake to no more than 20% of total caloric intake. These dietary recommendations are consistent with those typically used in behavioral weight loss programs,[2, 124] and with the 2005 Dietary Guidelines for Americans.[64]

Table 3. Recommended Daily Caloric and Fat Intake by Body Weight

Body Weight	Prescribed Energy Intake	Fat Intake
≤ 200 pounds	**1200 kcal/day**	**26 grams**
201 to 250 pounds	**1500 kcal/day**	**33 grams**
> 250 pounds	**1800 kcal/day**	**40 grams**

Subjects were provided sample meal plans, menus, and recipes developed by registered dieticians in order to assist them with making appropriate food selections. In addition, a copy of The Calorie King® Calorie, Fat, and Carbohydrate Counter book (2007 Edition) was given to each participant as an additional reference. Dietary recommendations were based on eating a diet composed of a wide variety of food groups, weighing and measuring foods to control portion sizes, limiting the amount of meals eaten out, and self-monitoring daily intake. Additional lessons were taught on the Food Guide Pyramid, label reading, and healthful eating.

To facilitate this, subjects were asked to record their eating behaviors (including all calorie and fat content of food) in a weekly food diary that would be reviewed weekly by the designated interventionist. Diaries were reviewed to determine if subjects were adherent to the guidelines, accomplishing set goals, and eating appropriately. If a participant demonstrated eating behaviors that were not consistent with the study recommendations, they were counseled by a staff dietician.

Exercise Intervention:

Subjects were instructed to gradually increase their exercise over the course of the intervention. The exercise prescribed was primarily aerobic in nature, with walking being the standard mode recommended. Exercise was initiated at 100 minutes of exercise per week (20 minutes per day, 5 days per week) and progressively increased by 10 minutes per day at 4-week intervals to 300 minutes per week (60 minutes per day, 5 days per week) by the end of the 6 months. The exercise was to be of moderate intensity (60 to 70% of age-predicated maximal heart rate), which is equivalent to brisk walking for most individuals. This intensity corresponds to a subjective rating of perceived exertion of approximately 11 to 13 on the Borg Perceived Exertion Scale of 6 to 20,[46] and subjects were taught how to monitor their exercise intensity using this scale. Table 4 illustrates the progressive exercise prescription.

Table 4. Progressive Aerobic Exercise Prescription

	Prescribed Exercise Duration			Intensity
Weeks	Minutes/Week	Minutes/Day	Days/Week	(RPE*)
1-4	100 min/wk	20 min/d	5 d/wk	11-13
5-8	150 min/wk	30 min/d	5 d/wk	11-13
9-12	200 min/wk	40 min/d	5 d/wk	11-13
13-16	250 min/wk	50 min/d	5 d/wk	11-13
17-24	300 min/wk	60 min/d	5 d/wk	11-13
*RPE –Rating of Perceived Exertion				

Subjects were instructed to record their exercise behaviors (including the time, type, duration, and RPE) in a weekly diary that would be reviewed weekly by the designated interventionist. If a participant demonstrated exercise behaviors that were

not consistent with study recommendations they were counseled by a staff exercise physiologist.

In addition, subjects were instructed to participate in a thirty minute supervised exercise session either before or after their group behavioral session at the University of Pittsburgh's Physical Activity and Weight Management Research Center where treadmills and stationary bicycles were available for use. If a participant was unable to attend in the supervised exercise session, the session was able to be made up later in the week at the center. An eight week "Step Campaign" was also initiated for all groups in week 9 of the intervention, in which participants were given pedometers and tracking cards to record the number of steps done daily. A goal of 10,000 steps per day or 60,000 steps per week was chosen as the target for participants. To provide motivation for participation, a weekly raffle was conducted and prizes (e.g., gift cards) were awarded to those who achieved the step goals for the week.

Table 5 below illustrates the standard diet, exercise, and behavior components common to all three of the randomized groups, plus the additional treatment components received by the SBWL + RT and SBWL + MD groups. These additional components are described in detail below following Table 5.

Table 5. Treatment components for SBWL, SBWL + RT, and SBWL + MD groups

	STANDARD	RESISTANCE TRAINING	MINDFULNESS/ MEDITATION
Standard Treatment Contact			
• 30 minute weekly meetings (Weeks 1-24)	☑	☑	☑
Additional Treatment Contact			
• 30 minute Resistance Training instruction & practice.		☑	
• 30 minute mindfulness/meditation instruction & practice			☑
Diet Component			
• 1200-1800 calories a day • Fat intake at 20-30% of total intake • Record diet in a food diary	☑	☑	☑
Exercise Component			
• Progress to 300 min/wk	☑	☑	☑
• Supervised Exercise weekly for 30 minutes.	☑	☑	☑
• Record exercise in diary	☑	☑	☑
• Exercise Campaigns	☑	☑	☑
• Resistance training at home 4 X/wk		☑	
Additional Component			
• Mindfulness/Meditation Practice at home • Yoga at home			☑

Mindfulness Meditation Intervention (SBWL + MD)

Subjects randomized to the mindfulness meditation group received the same 24-week standard weight loss intervention as described above, which included the same diet, exercise, and group behavioral lessons. They also received an additional 15 to 30 minute treatment component which was mindfulness meditation training as described below.

Subjects in the SBWL + MD group attended an additional 15 to 30 minute group session immediately following the standard behavioral group session each week of the intervention. Mindfulness involves bringing ones' attention to the internal and external experiences occurring in the present moment in a nonjudgmental way, and is typically developed through regular meditation training.[12] These sessions were taught by a graduate student with expertise in mindfulness mediation practice and techniques, and were geared specifically toward improving eating and physical activity behaviors. The lessons taught included topics such as breathing exercises, visualization, focused eating and walking meditations, progressive relaxation, yoga, and personal awareness. Table 6 outlines the mindfulness meditation topics for each week during the intervention.

Table 6. Mindfulness Meditation Lesson Topics

Week	Lesson Topic
1	Introduction to Group Assignment and Plan
2	Introduction to Mindfulness & Steps to Mindful Eating/Raisin Meditation
3	Sitting Medication – Mastering the Mindful Meal & Mindful Eating
4	Body Scan Meditation – Stress and the "Monkey Mind"
5	Conscious Eating & Hunger Meditation
6	Yoga Standing Meditation (CD)
7	Awareness of Satiety/Fullness Meditation & Hunger/Taste Meditation
8	Review Mediation Progress- Recommitment
9	Mindful Lying Yoga Session (CD)
10	Lake Meditation and Eating Triggers
11	Mindful Yoga for Weight Management I – Yoga DVD
12	Managing Emotional Eating – Taste, Portions, and Emotions
13	Health-e-Weight: Understanding Your Inner Voice/Negative Thinking
14	Mindful Yoga for Weight Management II – Yoga DVD
15	The Principles of Mindful Eating Review and Mindfulness Scales
16	Principles of Mindful Exercise
17	Mindful Yoga for Weight Management III – Yoga DVD
18	Seven Mindfulness Qualities
19	Meditation on Forgiveness
20	Practicing Walking Meditations
21	Mindful Walking Meditation- 2 mile walk
22	Inner Wisdom Meditation
23	What is Normal Eating? Mindful Relapse Prevention
24	Integrating Mindfulness Into Everyday Life

Subjects discussed and performed the components if mindfulness mediation during each in-person session, and were then instructed to practice these techniques and incorporate them into their daily lives the remaining days of the week. In order to facilitate the use of mindfulness meditation in their every day lives, subjects were provided either handouts recounting the weekly lesson/meditation, or a CD/DVD that guided them through the various breathing and yoga exercises taught during the in-person session. Subjects were also instructed to monitor and record their daily participation in mindfulness meditation techniques in their exercise diary, and a Mindfulness Mediation participation recall questionnaire was collected at the beginning of each weekly group session. This questionnaire asked if they participated in mindfulness meditation and yoga each week, and if so, how approximately how much time was spent in these activities.

Resistance Exercise Intervention (SBWL + RT)

Subjects randomized to the resistance exercise group received the same 24-week standard weight loss intervention as described above, which included the same diet, exercise, and group behavioral lessons. They also received an additional 15 to 30 minute treatment component which was resistance exercise training as described below.

Subjects in the SBWL + RT group attended an additional 15 to 30 minute group session immediately following the standard behavioral group session each week of the intervention. Subjects in this group were provided with rubber exercise resistance tubing, exercise resistance balls, and laminated exercise cards complete with color pictures and written descriptions of each resistance training exercise that was to be completed. In addition, they were provided with exercise logs to record the days completed, duration, sets, reps, RPE, and color tubing used during their resistance exercise when at home. The resistance tubing was available in four different resistance levels ranging from easy to difficult. Intervention

staff that led the resistance training group session initially provided bands to each individual participant in order to ensure safety and that the appropriate level tubing was provided. This was determined by encouraging subjects to use the elastic tubing that forced the specific muscle group being worked to be at a rating of perceived exertion (RPE) between 6 and 8 on the OMNI 1-10 scale upon completion of the recommended sets and repetitions (typically 3 sets of 10 repetitions).

Each week the intervention staff led the subjects in an in-person resistance training session in which all exercises were taught and then monitored for proper execution. They were then instructed to engage in the resistance training routine taught in the group session an additional 4 days per week, totaling 5 days per week of resistance training exercises. Exercises were changed and/or altered approximately every 4 weeks throughout the intervention in order to ensure a safe and effective progression of exercises. In addition, a resistance training "Lift-a-Ton" campaign was implemented at week 16 to enhance participant motivation and adherence to the resistance training exercises. Subjects were instructed to log the amount of repetitions and sets done at home and these numbers were converted into weight in pounds. The goal was to lift a "ton" by the end of the campaign and prizes were awarded to those achieving predetermined levels.

Subjects were instructed to monitor and record their resistance exercise in their exercise diaries and on the logs provided. The diaries were reviewed by the interventionists each week and feedback was provided when necessary to ensure achievement of goals, proper use of tubing and progression when necessary, and participation. Subjects were instructed to progress to the next resistance level in the elastic tubing when reporting an RPE of less than 6 for the active muscle involved on 2 separate occasions when the prescribed amount of sets

and repetitions were completed. The goal of this progression was to minimize the risk of injury while allowing for continued strength development.

Assessment Procedures

Assessments were conducted at the University of Pittsburgh Physical Activity and Weight Management Research Center weekdays between the hours of 7:00AM and 11:00AM. Each assessment took approximately one and a half hours to complete, and subjects were each paid a stipend of $25.00 upon completion of the baseline, 3, and 6 month assessment. In addition, a packet of questionnaires were given to participants upon scheduling to complete at home. The following measurements were taken at baseline, 12 weeks, and 24 weeks of the intervention.

Height, Weight, and Body Mass Index:

Height was assessed to the nearest 0.1cm at the baseline visit using a wall-mounted stadiometer (Perspective Enterprises, Portage, MI) with subjects removing their shoes for this measurement. Weight was measured at 0, 12, and 24 weeks on a balance beam scale recorded to the nearest 0.25kg (Healthometer Inc., Bridgeview, IL) with subjects in a lightweight hospital gown. BMI was then computed using these measurements of height and weight (kg/m^2).

Body Composition:

Body composition, or an estimate of the total amount of fat mass and lean mass, was analyzed using bioelectrical impedance analysis (BIA) at 0, 12, and 24 weeks. Resistance and reactance were measured using a tetrapolar impedance analyzer (Quantum II Bioelectrical Body Composition Analyzer, Clinton Township, MI) while subjects were supine with arms and legs abducted. Following cleaning of the skin surface with alcohol, disposable electrodes were placed on the following four

sites: 1). Midpoint of the right styloid processes of the ulna and radius, 2). Distal end of the second and third metacarpals, 3). Between the lateral malleolus and the medial malleolus, and 4). The distal end of the first and second metatarsals. Fat and lean mass will be estimated from regression equations predicting lean mass as measured with DEXA validated by Segal and colleagues.[110]

Anthropometric Measurements:

Waist and hip circumferences were obtained with a Gulick measuring tape recorded to the nearest 0.1 centimeter. Waist circumference was measured in the horizontal plan directly over the umbilicus. A sternum/umbilicus measurement was also recorded as 2/3 the distance between the xyphoid process and the umbilicus in the horizontal plane. Hip circumference was measured at the largest part of the hips above the gluteal fold. The waist measurement will be divided by the hip measurement to obtain the waist-to-hip ratio (WHR).

Cardiorespiratory Fitness:

In order to determine functional capacity and aerobic fitness, subjects performed a submaximal graded exercise test on a treadmill using a modified Bruce protocol. All exercise testing was conducted by an American College of Sports Medicine certified Exercise Specialist. Prior to each test, the metabolic cart, mass flow sensor, and mouthpieces were sterilized. The metabolic cart was calibrated according to the procedures recommended by the manufacturer.

The exercise test was done according the following protocol: The treadmill began at a speed of 3.0mph and was kept constant throughout the test. The grade began at 0% and increased 2.5% every 3 minutes until 85% of age-predicated max was reached, or until any ACSM test termination criteria are met. During the

test, subjects were breathing through a mass flow sensor with expired gas volumes and concentrations being measured continuously using the SensorMedics V-max Metabolic Cart. In addition, heart rate and a 12-lead EKG (GE Medical) were monitored continuously, with measures recorded at one-minute intervals and at test termination. Blood pressure was taken in the final minute of each 3 minute stage and at test termination, and ratings of perceived exertion (RPE) were assessed during the last fifteen seconds of each stage and at test termination. Test-termination was at 85% of subjects' age-predicted maximal heart rate unless otherwise noted (see above).

Following the test termination, subjects will undergo a 5 minute recovery period, in which 3 minutes are active and 2 are passive in the seated position. Heart rate, EKG, and blood pressure will continue to be monitored throughout recovery, at minute 3 and minute 5. If heart rate and blood pressure are not at pre-exercise levels after 5 minutes, the subject may be monitored an additional 5 minutes to insure that they are. Results of each exercise test will be reviewed by a physician certified in EKG interpretation to insure there are no contraindications to exercise training. Due to the fact that the subject's in this study are considered low-to-moderate risk, are performing a submaximal test (vs. a maximal test), and receive physician clearance before the test, a physician is not required to be present during the test based on the ACSM risk stratification criteria and testing recommendations. In addition, all staff are certified in CPR and AED use, and safety equipment is immediately available for use in the testing room.

Dietary Intake:

Macronutrient composition of the diet was measured at 0, 12, and 24 weeks using the Block Food Frequency Questionnaire (FFQ) (Block-98 Dietary Data Systems, Berkeley, CA).[117] This questionnaire has been used in past studies and has been shown to be sensitive to change in energy intake and eating behaviors resulting from a behavioral intervention.[16] It provides data for energy intake and macronutrient composition by asking subjects about routinely eaten food items and usual portion sizes.

Physical Activity:

Physical activity was assessed using the Paffenbarger Physical Activity Questionnaire[90, 91] (Exercise Habits) at weeks 0, 12, and 24. This self-report questionnaire assessed exercise and physical activity patterns among all groups. The Exercise Habits questionnaire reports the average number of flights of stairs climbed and the number of city blocks walked each day for each of the past seven days. These values were converted into kilocalorie scores as defined by Paffenbarger and colleagues. In addition, this questionnaire reported the time spent in sports, recreational, or fitness activities over the previous week. This questionnaire has shown to be not only easy to administer, but sensitive to change, and has a high correlation to the 7-day Physical Activity Recall (0.88). [90, 91]

Eating Behaviors:

Adoption of weight loss eating behaviors was assessed using the Eating Behavior Inventory (EBI) at weeks 0, 12, and 24. This 26-item self-report questionnaire assesses behaviors that have been theoretically implicated in weight loss, such self-monitoring of food intake and of weight, refusing offers to food, eating

at only one place, eating in response to emotions, etc; The EBI has been shown to be consistently sensitive to behavioral weight management interventions.[86]

Muscular Strength:

Upper and lower body muscular strength was determined at 0, 12, and 24 weeks using a plate-loaded universal strength-training machine (Pacific Fitness "Zuma") located at the University of Pittsburgh's Physical Activity and Weight Management Research Center. Lower body strength was assessed using the quadriceps extension, and upper body strength was assessed using the vertical chest press. A one repetition maximum (1-RM) protocol obtained through the American College of Sports Medicine (ACSM) was used to determine the maximal amount of weight (lbs.) a subject was able to lift just one time. The 1-RM test was determined to be a reliable measure for untrained middle-aged adults (ICC > 0.99).[75]

The subject first performed an initial warm-up of 5-10 repetitions at 40-60% of their perceived maximum and were asked to rate their exertion level using the OMNI perceived exertion scale for resistance exercise.[105] After a brief one minute rest period, subjects then performed a second warm-up of 5-10 repetitions at 60-80% of their perceived maximum. Once again, subjects were asked to rate their exertion level using the OMNI perceived exertion scale (RPE) for resistance exercise.[105] One or two plates (15 pounds each) were added; the number chosen using a pre-determined protocol dependent on the subject's rating of exertion during the warm-up trial. A 1-RM lift was attempted, and if the subject was successful, a rating of perceived exertion was obtained and another weight plate was added. A rest period of 30 seconds to 1 minute was taken in between each trial. These procedures were repeated until a lift

could not successfully be completed. The final weight lifted (# of plates), and RPE using the OMNI scale were recorded.

Physical Function:

Physical function was determined by using a modified version of the Physical Performance Test (PPT) that has been previously used to study disability specifically caused by obesity in women.[9, 10] This physical function assessment was done at 0, 12, and 24 weeks and included 5 standardized, timed tests that took approximately 10 minutes to administer. Prior to testing, the Borg (6-20) rating of perceived exertion scale (RPE), the perceived difficulty scale (1-4), and the pain scale (0-10) were introduced and explained to each subject. The following timed tests were included: 1) The time required to complete a 50 foot walk while carrying 2 shopping bags weighing approximately 10 pounds each, 2) the time required to sit down and get out of a chair 5 consecutive times, 3) the length of time the participant could balance on their left leg for up to 60 seconds, 4) The length of time the participant could balance on their right leg for up to 60 seconds, and 5). The length of time it took to step up and down two times on a step that was approximately 20 inches high. Following the completion of the first two tasks listed above, the participants' rating of perceived exertion (RPE) and rating of pain were recorded. Following the completion of the final three tasks listed above, the participants' rating of perceived difficulty and rating of pain were recorded.

Correlates of Weight Loss and Behavior Change (Questionnaires):

In addition to the primary outcome measures, we are also were interested in various psychosocial parameters associated with weight loss. Questionnaires that assess possible psychosocial correlates of eating and physical activity behaviors, and

ultimately body weight, were sent home with participants for each assessment at 0, 12, and 24 weeks of participation. It has been estimated that these questionnaires take approximately 60-90 minutes to complete and included the following:

1). *Self-Efficacy for Physical Activity and Weight Loss*: Self-efficacy is a central construct of behavior change theory, specifically Social Cognitive Theory, and has been shown to be related to success in weight loss and physical activity. Self-efficacy for exercise was assessed using the questionnaire by Marcus et al.,[79] which has been shown to have a high test-retest reliability of 0.90 over a 2-week time period. The five-item scale used in this questionnaire rates the participant' confidence regarding the ability to be physically active in various situations (0= not at all confident to 5=extremely confident). Self-efficacy for weight loss was assessed using the 20-item Weight Efficacy Lifestyle Questionnaire (WEL) developed by Clark et al.[29] that consists of five situational factors: Negative Emotions, Availability, Social Pressure, Physical Discomfort, and Positive Activities.

2). *Eating Inventory (EI)*: Eating (cognitive) restraint, eating disinhibition, and perceived hunger were assessed with this 51-item eating inventory[116] developed to assess behaviors conducive to weight management. Cognitive dietary restraint, defined as conscious attempts to monitor and regulate food intake, is assessed from 21 items. Eating disinhibition, defined as dysregulation of eating in response to cognitive or emotional cues, is assessed from 16 items. Hunger, or perceptions of hunger, is assessed from 14 items on this questionnaire. Changes in EI scores over time in obesity treatments have been shown to have a significant relationship with weight loss.[43]

3). *Exercise Beliefs (Barriers and Expected Outcomes)*: The Exercise Beliefs Questionnaire developed and validated by Steinhardt and Dishman[114] was used to assess outcome expectations (psychologic, body image, and health) and perceived barriers (time, effort, and obstacles) for physical activity. Participants rated their agreement with statements related to benefits and barriers on a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. Internal consistency coefficients for this measure range from .47 to .78, with test-retest reliability stability correlations ranging from .66 to .89.

4). *Body Image*: Body Image was measured using the Multidimensional Body-Self Relations Questionnaire (MBSRQ) which provided a validated multidimensional, attitudinal assessment of body image and weight-related variables.[21] Participants rated their agreement with statements related to three domains: physical appearance, physical fitness, and health on a 5-point Likert scale ranging from (1) definitely disagree to (5) definitely agree. Within each of these domains are items comprising two subscales: 1) evaluation – extent of liking, attainment, and satisfaction and 2) orientation – investment, attention, or degree of cognitive importance related to maintaining or improving factors related to the domain.[21]

5). *Mindfulness*: Mindfulness was measured using the Mindfulness Attention Awareness Scale (MAAS) which is a 15-item questionnaire measured on a 6-point Likert scale ranging from 1 (almost always) to 6 (almost never) to assess present moment attention and awareness by Brown and Ryan (2003).[20]

Statistical Analyses

Statistical analyses were conducted using SPSS for Windows (SPSS, Inc., Chicago, IL). Statistical significance was accepted at the $p<0.05$ level of confidence. The data was

double-entered and verified by different staff members in order to compare discrepancies and ensure accuracy. Initially, analyses were performed to examine normality and appropriate transformations were used for data that was not normally distributed. The specific analyses that were performed are:

1. Descriptive analyses were performed on subject characteristics (age, body weight, BMI) energy intake, energy expenditure, physical activity, retention rates, and specific adherence measures, such as group attendance.
2. To examine specific aims 1 through 3, change from baseline to six months in body weight, physical activity, eating and physical activity behaviors, and psychosocial variables were assessed using two-factor (group X time) repeated measures analysis of variance (ANOVA) to determine if there are significant group main effects, time main effects, or group X time interaction effects based on the randomized group assignment for this study. The time main effect was based on assessment data collected at 0, 3, and 6 months. The group main effect was based on the randomized group intervention.
3. To examine specific aims 4 through 6, correlation coefficients were computed to determine the relationship between weight loss, physical activity, and eating and physical activity behaviors, and psychosocial variables at both baseline, 3, and 6 months using Pearson Product Moment correlations. If the data were skewed, Spearman Rank Order correlations were computed.

Power Analyses

The primary aim of this study was to examine if either SBWL+RT or SBWL+MM would improve weight loss compared to SBWL. However, there is limited data in the literature to provide an estimate of the effect of either SBWL+RT or SBWL+MM on weight

loss compared to SBWL. Therefore, this study served as a pilot study and will provide data that will be useful for estimating sample sizes for these groups in a larger study should these data demonstrate a reasonable effect. Thus, this investigation provided the initial data to allow for variance estimates to power a larger clinical trial. Assuming that the variance estimates from other weight loss studies are representative of what we would observe in this study (standard deviation= 4.8 kg in a recent study conducted in our laboratory), we would need to observe that either SBWL+MM or SBWL+RT would improve weight loss by 2.4 kg compared to the SBWL to achieve an effect size of 0.50 in this study, by 2.9 kg to achieve an effect size of 0.60, and 3.4 kg to achieve an effect size of 0.70. This study randomized approximately 25 subjects per group, which would provide sufficient sample to detect an effect size of 0.65 with a type I error rate of 0.05 at 70% power. This is a reasonable sample size to obtain variance estimates on the effectiveness of these interventions (SBWL+MM and SBWL+RT) compared to SBWL that can be use determine appropriate sample sizes for a future full-scale clinical study of these intervention strategies.

RESULTS

The purpose of this study was to examine the effect of the addition of a mindfulness meditation and home-based resistance exercise component on psychosocial parameters, eating and physical activity behaviors, and weight loss in overweight and obese adults across a 6-month standard behavioral weight loss intervention. The study was a pretest-midtest-posttest design with assessments performed at 0, 3, and 6 months of participation. The results from this study are presented in the following sections.

Subject Characteristics

The subjects in the current investigation were seventy-one (71) sedentary, overweight and obese adult men (N=8) and women (N=63) who participated in a behavioral weight loss study at the University of Pittsburgh Physical Activity and Weight Management Research Center. All of the participants were between 18 to 55 years of age, with a BMI ranging from 25 to 39.9 kg/m^2 at the start of the study, with a mean age of 45.1$\pm$8.3 years, mean BMI of 32.9$\pm$3.7kg/m^2, and a mean body weight of 93.0$\pm$12.0 kg. Descriptive statistics (mean $\pm$ standard deviation) for all subjects in this study are shown in Table 7. A one-way analysis of variance (ANOVA) revealed no significant baseline differences between randomized groups for all variables (age, weight, body mass index, lean body mass, gender, ethnicity, energy intake, percent dietary fat, percent dietary carbohydrate, percent dietary protein, and physical activity). Data by group are shown in Table 8.

Table 7. Baseline Characteristics of Subjects (Total, Completers, and Non-Completers)

Characteristics	Total (N=71) (mean ± s.d.)	Completers (N=51) (mean ± s.d.)	Non-Completers (N=20) (mean ± s.d.)
Age (years)	45.1 ± 8.3	45.0 ± 8.7	45.5 ± 7.4
Weight (kg)	93.0 ± 12.9	92.7 ± 13.0	93.9 ± 12.9
Body Mass Index (kg/m^2)	32.9 ± 3.7	32.7 ± 3.8	33.3 ± 3.3
Lean Body Mass (kg)	54.6 ± 6.8	54.6 ± 6.6	54.8 ± 7.3
Gender			
% Males	11.3% (N=8)	11.8% (N=6)	10% (N=2)
% Females	88.7% (N=63)	88.2% (N=45)	90% (N=18)
Ethnicity			
% African-American	25.4% (N=18)	23.5% (N=12)	30% (N=6)
% Caucasian	73.2% (N=52)	76.5% (N=39)	65% (N=13)
% Other	1.4% (N=1)	-------	5% (N=1)
Energy Intake (kcal/day)	2118.9 ± 976.3	2158.4 ± 977.7	2018.1 ± 990.5
Percent Dietary Fat Intake (%)	40.5 ± 6.8	40.1 ± 6.4	41.5 ± 7.9
Percent Carbohydrate Intake (%)	45.2 ± 7.1	45.4 ± 6.7	44.8 ± 8.1
Percent Protein Intake (%)	15.1 ± 2.9	15.4 ± 2.6	14.4 ± 3.4
Physical Activity (kcal/wk)	776.0 ± 648.6	802.2 ± 670.9	709.2 ± 598.9

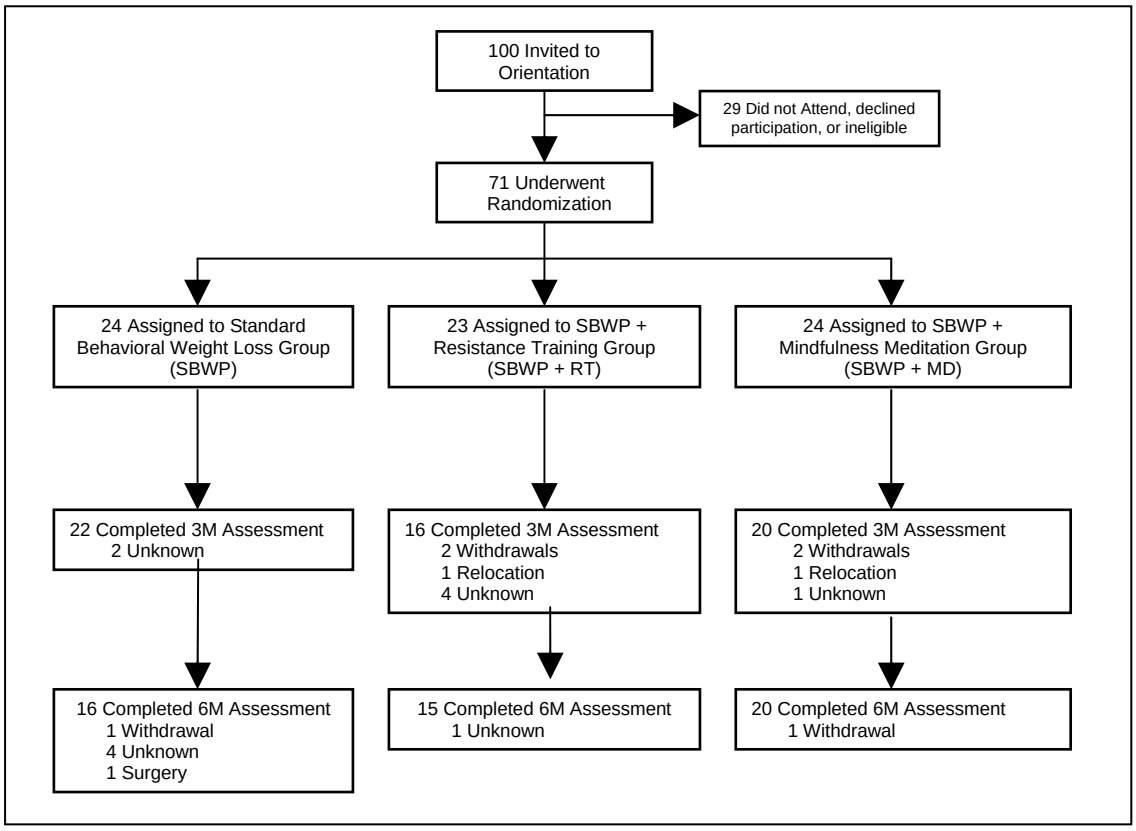
s.d. = standard deviation
Note: No statistically significant difference between baseline characteristics of completers and non-completers.

Retention Rates

Seventy-one subjects were randomized to one of three intervention groups. Retention of participants who provided assessments at both baseline and at 6 months (N=51) was 72% and these individuals are referred to as "completers". Participants who failed to complete the 6-month assessment (N=20, 28%) are referred to as "non-completers." A one-way ANOVA revealed no significant differences between completers and non-completers across intervention groups (see Table 8). Figure 3 illustrates the study enrollment and retention across the three intervention groups, and the explanation for dropout. Reasons for withdrawal included work schedule changes, personal/family problems, dissatisfaction with the program, and health limitations. The retention rates for the three individual groups were 66% for the

SBWL group, 65% for the SBWP + RT group, and 83% for the SBWL + MD group, and chi square analyses revealed these were not significantly different (p=.43). Baseline characteristics of completers versus non-completers across the three intervention groups (SBWL, SBWL + RT, and SBWL + MD) are presented in Table 8.

Figure 5. Study Enrollment and Retention



Adherence Measures

Attendance and diary completion percentages were calculated as the total number of sessions attended or diaries completed divided by the total number of possible group sessions or diaries over the 6-month period. Attendance at the weekly group sessions was 63.7±30.2%. Comparison of the three groups reveal no significant differences in attendance to the intervention sessions (p=.34), with group attendance at 62.3±26.7% (13.7±5.9 sessions)

for the SBWL group, 57.9±36.3% (12.7± 8.0 sessions) for the SBWL ± RT group, and 70.1+27.7% (16.8±6.6 sessions) for the SBWL + MD group. Percentage of food diaries turned in was 52.4±31.7%. Comparison of the three groups reveal no significant differences in percentage of food diaries turned in (p=.47), with 51.6±29.9% for the SBWL group, 47.1±36.7% for the SBWL ± RT group, and 58.5±28.5% for the SBWL + MD group. In addition, the SBWL + RT group was to attend an additional 15-30 minute resistance training group session each week, with a possible total of 21 sessions over the 6-month intervention. Attendance for these resistance training sessions was 49.1±35.7% (10.3±7.5 sessions). SBWL + RT was also prescribed an additional 4 days per week of resistance training at home, and examination of self-reported dairy information revealed that subjects reported participating in 40.3±33.9% of prescribed days of resistance training exercise. The SBWL + MD group was to attend an additional 15-30 minute mindfulness meditation training group session each week, with a possible total of 23 sessions over the 6-month intervention. Attendance for these mindfulness sessions was 62.3±31.4% (14.3±7.2 sessions). The SBWL + MD group was also prescribed home-based mindfulness meditation practice, and examination of self-reported mindfulness recall information revealed that subjects reported participating in approximately 5.29±2.9 practices per week. .

Table 8. Baseline Characteristics of Completers, and Non-Completers Across the Intervention Groups

Characteristics	SBWL Completers vs. Non-Completers (mean ± standard deviation)		SBWL + RT Completers vs. Non-Completers (mean ± standard deviation)		SBWL + MD Completers vs. Non-Completers (mean ± standard deviation)	
	(N=16)	(N=8)	(N=15)	(N=8)	(N=20)	(N=4)
Age (years)	43.4±9.8	47.6±7.1	46.2±9.1	42.4±8.4	45.5±7.7	47.5±4.2
Weight (kg)	92.9±11.0	93.7±14.2	98.2±13.8	90.5±12.3	88.4±12.8	101.0±11.7
Body Mass Index (kg/m^2)	32.8±3.5	33.5±3.6	34.4±3.5	32.3±3.8	31.5±3.9	34.9±.76
Lean Body Mass (kg)	55.2±7.1	54.5±8.4	56.1±7.4	53.2±4.6	52.9±5.5	58.5±10.0
Gender						
% Males	18.8% (N=3)	12.5% (N=1)	13.3% (N=2)	0% (N=0)	5% (N=1)	25% (N=1)
% Females	81.3% (N=13)	87.5% (N=7)	86.7% (N=13)	100% (N=8)	95% (N=19)	75% (N=3)
Energy Intake (kcal/day)	2231.1±1170.6	2303.2±952.3	1909.6±959.5	1616.9±836.5	2286.8±827.5	2250.2±1321.9
Percent Dietary Fat Intake (%)	40.7±6.0	45.4±7.9	40.1±7.1	37.9±6.9	39.7±6.5	40.9±7.7
Percent Carbohydrate Intake (%)	44.5±4.6	40.8±9.6	45.3±6.9	47.9±6.9	46.1±8.1	46.4±4.5
Percent Protein Intake (%)	15.7±2.7	14.5±4.5	15.8±2.4	14.4±2.3	14.8±2.8	14.3±3.7
Physical Activity (kcal/wk)	702.4±620.1	607.8±608.9	957.7±652.1	783.7±613.1	765.6±734.0	763.0±695.4

s.d. = standard deviation
Note: No statistically significant difference between baseline characteristics of completers and non-completers across the intervention groups

Change in Body Weight, BMI, and Body Composition

A two-factor repeated measures (group X time) ANOVA was performed to compare changes in body weight, body mass index, and body composition between the three groups (see Table 9). Results revealed a significant decrease in body weight from 0 to 6 months for the completers in the SBWL group (-6.1±2.4 kg), the SBWL + RT group (-8.8±1.9 kg), and the SBWL + MD group (-8.0±0.2 kg) ($p<.001$), with no significant difference between the groups ($p=.41$). Likewise, body mass index (BMI) significantly decreased over time for all three groups ($p<.001$), with no significant difference between groups ($p=.47$). Changes in body composition were examined by both lean body mass (LBM) and body fat percent (%).

Table 9. Differences in Main Outcome Measures for Completers Across the 6-month Behavioral Intervention by Group

Outcome Measure	Intervention Group	Assessments			p-Values		
		Week 0	Week 12	Week 24	Group Effect	Time Effect	Group X Time Interaction
Body Weight (kg)	SBWL (n=16)	92.9±10.9	87.9±11.9	86.8±13.3	.091	<.001	.411
	SBWL + RT (n=14)	99.0±13.8	92.3±14.4	90.3±15.7			
	SBWL + MD (n=19)	88.3±13.1	82.5±12.5	80.3±12.9			
Body Mass Index (kg/m^2)	SBWL (n=16)	32.8±3.5	30.9±3.6	30.6±4.0	.097	<.001	.474
	SBWL + RT (n=14)	34.6±3.5	32.2±4.1	31.5±4.4			
	SBWL + MD (n=19)	31.5±4.0	29.4±4.0	29.4±3.9			
Lean Body Mass (kg)	SBWL (n=14)	53.7±5.9	53.2±6.3	52.7±6.4	.328	<.001	.562
	SBWL + RT (n=14)	56.5±7.5	55.6±7.6	55.3±7.5			
	SBWL + MD (n=18)	53.3±5.6	52.2±5.7	51.9±5.7			
Body Fat (%)	SBWL (n=14)	40.7±6.4	37.9±6.6	37.5±6.1	.582	<.001	.388
	SBWL + RT (n=14)	42.5±6.9	39.0±8.6	37.8±9.2			
	SBWL + MD (n=18)	39.9±4.6	37.0±5.6	35.1±6.4			
Physical Activity (kcal/wk)	SBWL (n=16)	702±620	1612±962	1169±1361	.227	<.001	.373
	SBWL + RT (n=14)	930±667	1897±741	2029±1173			
	SBWL + MD (n=19)	767±754	1822±885	1700±825			
Energy Intake (kcal/day)	SBWL (n=13)	1956.1±910	1329.1±471	1171.6±488	.389	<.001	.013
	SBWL + RT (n=12)	1664.1±732	1298.0±464	1362.6±690			
	SBWL + MD (n=19)	2357.1±786	1356.6±490	1346.3±399			
Percent Fat Intake (%)	SBWL (n=13)	39.8±6.3	32.3±5.1	34.1±8.0	.671	<.001	.543
	SBWL + RT (n=12)	40.4±7.9	30.5±8.2	30.5±6.9			
	SBWL + MD (n=19)	40.5±5.8	30.7±4.4	31.1±4.4			
Percent Carbohydrate Intake (%)	SBWL (n=13)	45.1±4.7	53.0±3.9	51.1±7.5	.697	<.001	.515
	SBWL + RT (n=12)	44.8±7.7	53.1±6.9	53.9±5.8			
	SBWL + MD (n=19)	45.2±7.1	50.4±6.3	51.4±6.9			
Percent Protein Intake (%)	SBWL (n=13)	15.8±2.9	16.1±2.2	15.5±2.3	.305	<.001	.011
	SBWL + RT (n=12)	16.1±2.6	17.7±2.5	17.5±2.9			
	SBWL + MD (n=19)	14.9±2.8	18.6±3.0	17.0±3.0			
Eating Behavior Inventory	SBWL (n=16)	68.0±8.9	79.0±9.9	80.9±12.4	.146	<.001	.120
	SBWL + RT (n=13)	70.4±10.1	85.5±12.7	88.2±12.4			
	SBWL + MD (n=18)	67.8±7.3	86.6±7.9	88.3±7.9			

Results revealed that all three groups showed similar changes in both lean body mass and body fat % with weight loss. Lean body mass ($p<.001$) and body fat % ($p<.001$) significantly decreased from 0 to 6 months for all three groups, with no significant difference between groups for either measure ($p=.56$ and $p=.39$, respectively). Data for all main outcome

measures were also analyzed with an intent-to-treat (ITT) analysis, whereby the baseline data is carried forward for missing post-evaluation data at 3- and 6 months. Results from these analyses can be seen in Appendix A and reveal no differences in the pattern of results shown in Table 9 for completers for body weight, BMI, or body composition.

Process Measures

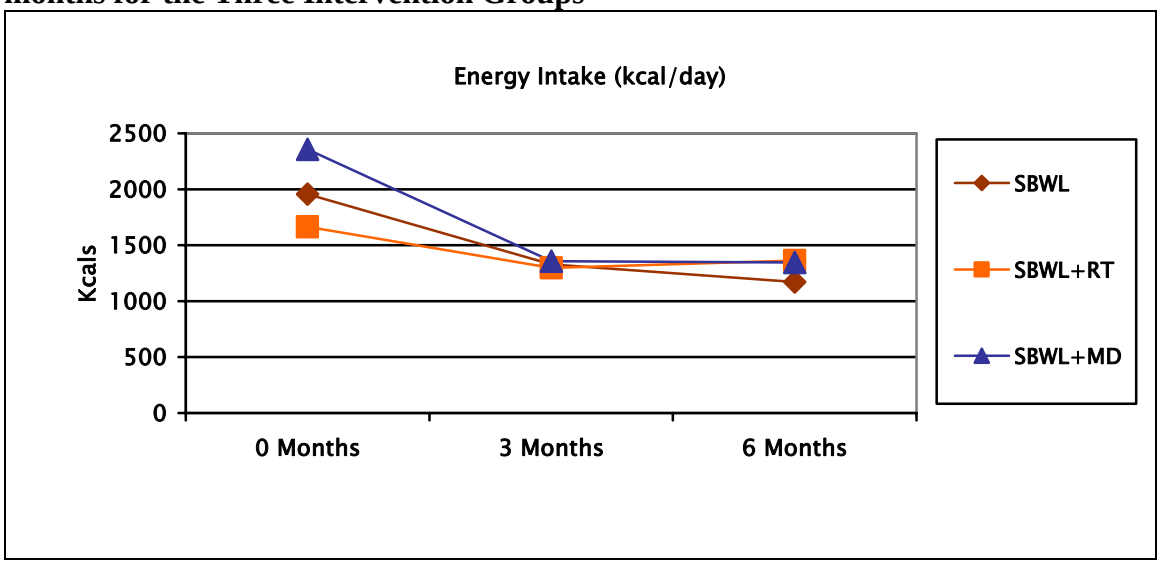
Physical Activity

Physical activity energy expenditure (kcal/wk) increased significantly from baseline to 6 months ($p<.001$) for the SBWL group (mean difference = 467±741 kcal/wk), SBWL + RT group (mean difference =1099±506 kcal/wk), and SBWL + MD group (mean difference = 933±71 kcal/wk), with no significant difference between the groups ($p=.37$) (see Table 9). However, the intent-to-treat analysis revealed a different result in that a significant group x time interaction ($p=.02$) was found for physical activity energy expenditure (see Appendix A). This analysis revealed that physical activity energy expenditure increased for all three treatment groups (SBWL, SBWL +RT, SBWL+MD) from 0 to 3 months, but then decreased from 3- to 6 months for both the SBWL (1913±982 to 982±1181 kcal/wk, respectively) and the SBWL +MD (1712±930 to 1507±862 kcal/wk, respectively) groups only. However, the SBWL +RT group continued to increase from 3- to 6 months (1516±831 to 1566±1138 kcal/wk, respectively). Thus, the pattern of physical activity energy expenditure over the course of the intervention was different between the groups. Despite the decrease in physical activity from 3- to 6 months in these groups, physical activity energy expenditure still remained significantly higher than baseline as revealed by the significant time main effect ($p<.001$).

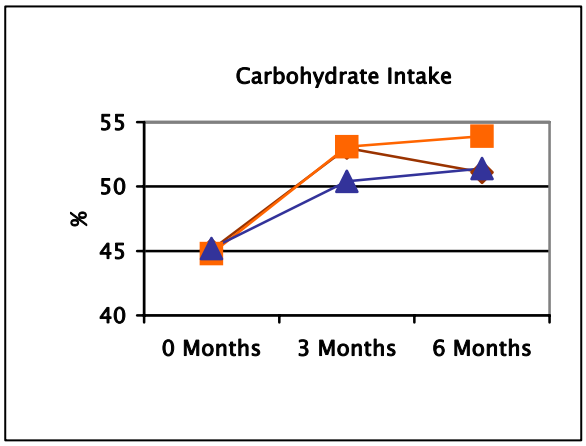
Energy Intake

Results from a repeated measures two-way (group X time) ANOVA revealed a significant decrease in energy intake from 0 to 6 months for the completers in the SBWL group (-784±422 kcal/day), the SBWL + RT group (-302±42 kcal/day), and the SBWL + MD group (-1011±387 kcal/day) ($p<.001$), with a significant group x time interaction ($p=.01$). This interaction reveals that the pattern in energy intake in the three intervention groups differed over time, in that all three groups decreased energy intake from baseline to 3 months, but from 3 months to 6 months the SBWL+RT group increased slightly (1298±464 to 1362±690, respectively) while the SBWL (1329±471 to 1172±488, respectively) and SBWL + MD (1357±490 to 1346±399, respectively) groups continued to decrease (see Figure 6). Percentage of fat significantly decreased from baseline to 6 months ($p<.001$) in the SBWL group (39.8±6.3% vs. 34.1±8.0%), the SBWL + RT group (40.4±7.9% vs.30.5±6.9%), and the SBWL+MD group (40.5±5.8% vs. 31.1±4.4%). Percentage of carbohydrate significantly increased from baseline to 6 months ($p<.001$) in the SBWL group (45.1±4.7% vs. 51.1±7.5%), the SBWL + RT group (44.8±7.7% vs.53.9±5.8%), and the SBWL+MD group (45.2±7.1% vs. 51.4±6.9%). A non-significant group x time interaction showed the pattern of percentage of fat ($p=.54$) and percentage of carbohydrate intake ($p=.52$) over time for the groups was similar. There was a significant group x time interaction for the percentage of protein ($p=.01$) consumed over the course of the intervention. (see Table 9). Figure 6 illustrates the pattern in energy intake for the three intervention groups, as well as the composition of the dietary intake (percentage of fat, percentage of carbohydrate, and percentage of protein) from baseline to 6 months. The intent-to-treat analysis revealed similar results for all aspects of energy intake.

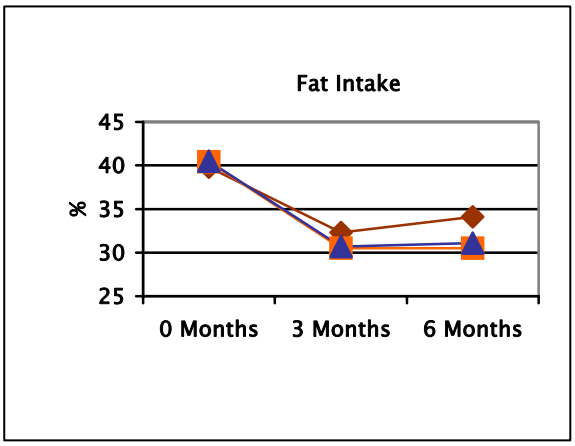
Figure 6. Energy Intake (kcal/day) and Diet Composition (%) from Baseline to 6 months for the Three Intervention Groups



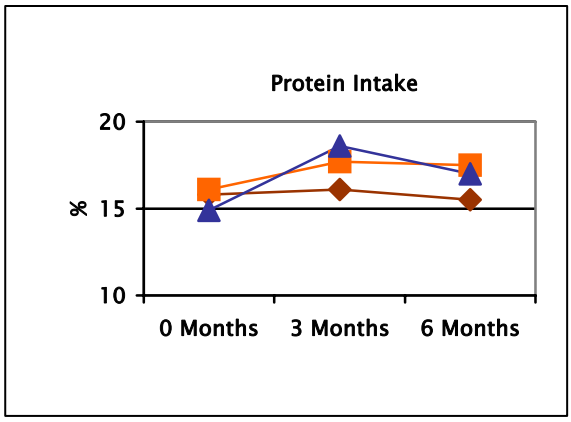
Group Effect (p=.39), Time effect (p<.001), Group X Time interaction (p=.01)



Group Effect (p=.70), Time effect (p<.001)
Group X Time interaction (p=.52)



Group Effect (p=.67), Time effect (p<.001)
Group X Time interaction (p=.54)



Group Effect (p=.31), Time effect (p<.001)
Group X Time interaction (p=.01)

Eating Behavior Inventory

Adoption of weight loss eating behaviors was assessed using the Eating Behavior Inventory (EBI), where higher scores indicate greater adoption of weight loss eating behaviors. Results revealed a significant time main effect (P<.001), with EBI scores increasing from baseline to 6 months (see Table 9), with no significant differences between the groups (p=.12). The intent-to-treat analysis revealed similar results, with a greater trend (p=.08) toward the SBWL + MD group having higher EBI scores when compared to the SBWL group.

Change in Muscular Strength

Muscular strength was measured using the leg extension and chest press exercises. Results from a two-way repeated measures ANOVA show that there were no significant changes in strength over time for the leg extension (p=.33), nor were there any differences between the groups (p=.32). Chest strength did significantly improve over time (p<.05), but there were no significant differences between the groups (p=.25). See Table 10.

Change in Mindfulness

Mindfulness was assessed using the Mindfulness Attention Awareness Scale (MAAS). Results from a two-way repeated measures ANOVA revealed that mindfulness did significantly improve over time (p<.001), but did not differ between the groups (p=.49). See Table 10.

Table 10. Differences in Absolute & Relative Muscular Strength (Leg and Chest) and in a Measure of Mindfulness for Completers Across the 6-Month Behavioral Intervention by Group

		Assessments			p-Values		
Variable	**Intervention Group**	**Week 0**	**Week 12**	**Week 24**	**Group Effect**	**Time Effect**	**Group X Time Interaction**
Absolute Muscular Strength							
Chest Press (kg)	SBWL (n=11)	29.5±13.0	29.3±13.9	30.9±14.1	.248	.002	.675
	SBWL + RT (n=12)	33.2±12.4	31.0±12.2	33.1±11.2			
	SBWL + MD (n=16)	26.0±6.8	24.3±6.5	27.0±7.2			
Leg Extension (kg)	SBWL (n=10)	31.1±6.5	31.9±8.9	31.0±8.4	.323	.337	.075
	SBWL + RT (n=11)	36.3±12.6	35.2±11.9	35.6±12.1			
	SBWL + MD (n=17)	29.4±5.0	30.4±5.1	34.2±6.9			
Relative Muscular Strength (kg/kg body weight)							
Chest Press (kg)	SBWL (n=11)	.32±6.5	.34±.17	.36±.16	.729	<.001	.667
	SBWL + RT (n=12)	.33±12.6	.33±.13	.36±.12			
	SBWL + MD (n=16)	.30±5.0	.30±.10	.34±.07			
Leg Extension (kg)	SBWL (n=10)	.35±.08	.37±.11	.36±.11	.905	<.001	.005
	SBWL + RT (n=11)	.35±.11	.37±.11	.38±1.0			
	SBWL + MD (n=17)	.33±.06	.37±.07	.43±.10			
Mindfulness Scale							
MAAS	SBWL (n=14)	59.6±10.7	63.9±11.4	64.5±11.2	.486	<.001	.332
	SBWL + RT (n=13)	58.9±13.9	65.7±12.6	68.3±15.1			
	SBWL + MD (n=19)	58.5±11.2	60.1±11.7	60.8±10.4			

Psychosocial Variables

Two-factor repeated measures (group X time) ANOVAs were performed to compare changes in psychosocial variables (physical activity and eating self-efficacy, body image, eating inventory, and expected benefits and barriers) between the three intervention groups (see Tables 11-14).

Physical Activity Self-Efficacy and Eating Self-Efficacy

Data from these questionnaires were divided into subscales representing self-efficacy for physical activity or eating in various situations. Analyses revealed no difference in the pattern of change in these variables between intervention groups across the 6-month period, as well as no significant group differences. Self-efficacy for physical activity when tired significantly improved from baseline to 6 months ($p<.05$ for time main effect). A significant time main effect ($P<.05$) was also found for self-efficacy for physical activity when on vacation, where all three groups increased from baseline to 3 months, and then decreased from the 3-month to the 6-month time period. There was no significant interaction effect ($p=.85$). Eating self-efficacy when experiencing negative emotions, when food is available, when under social pressure, and during positive activities all significantly improved from baseline to 6 months ($p<.001$ for time main effect) (See Table 11.)

Table 11. Differences in Self-Efficacy (Physical Activity and Eating) for Completers Across the 6-Month Behavioral Intervention by Group

		Assessments			p-Values		
Psychosocial Variable	**Intervention Group**	**Week 0**	**Week 12**	**Week 24**	**Group Effect**	**Time Effect**	**Group X Time Interaction**
Physical Activity Self-Efficacy							
Tired	SBWL (n=13)	2.54±.88	2.92±.86	2.62±1.2	.10	.021	.433
	SBWL + RT (n=13)	2.31±1.0	2.92±1.3	3.00±1.2			
	SBWL + MD (n=18)	2.56±1.1	2.72±1.1	2.94±1.1			
Bad Mood	SBWL (n=13)	3.46±1.4	3.15±1.2	3.00±1.3	.66	.855	.234
	SBWL + RT (n=13)	3.08±1.2	3.54±1.1	3.38±1.3			
	SBWP + MD (n=18)	3.50±1.1	3.50±.71	3.56±.86			
Low on Time	SBWL (n=13)	2.69±1.0	2.77±1.0	2.69±1.3	.88	.813	.832
	SBWL + RT (n=13)	2.69±.86	2.85±1.1	2.62±1.3			
	SBWL + MD (n=18)	2.44±1.0	2.56±.98	2.78±1.1			
On Vacation	SBWL (n=13)	3.38±1.3	3.62±1.2	3.23±1.4	.89	.023	.852
	SBWL + RT (n=13)	3.31±.95	3.85±1.1	3.31±1.4			
	SBWL + MD (n=18)	3.39±1.1	3.78±.73	3.56±.92			
Bad Weather	SBWL (n =13)	3.23±1.2	3.38±.77	3.31±1.0	.81	.546	.513
	SBWL + RT (n=13)	2.77±1.2	3.31±1.4	3.08±1.4			
	SBWL + MD (n=13)	3.17±1.4	3.00±1.2	3.17±1.3			
Eating Self-Efficacy							
Negative Emotions	SBWL (n=13)	20.4±10.5	23.2±10.7	22.5±11.3	.911	<.001	.281
	SBWL + RT (n=13)	16.8±11.8	22.7±9.4	23.1±9.8			
	SBWL + MD (n=19)	17.6±10.3	23.1±7.9	25.7±6.1			
Availability	SBWL (n=13)	17.1±8.5	20.9±8.9	20.0±9.3	.869	<.001	.392
	SBWL + RT (n=13)	15.2±10.7	23.6±7.9	21.8±8.9			
	SBWL + MD (n=19)	15.2±9.4	19.9±7.2	21.0±7.8			
Social Pressure	SBWL (n=13)	21.1±6.9	25.1±9.6	24.7±9.7	.893	<.001	.402
	SBWL + RT (n=13)	19.0±10.4	27.2±7.4	25.9±7.8			
	SBWL + MD (n=19)	20.0±10.5	23.3±8.1	25.0±6.7			
Physical Discomfort	SBWL (n=13)	26.7±7.5	28.2±9.0	26.8±9.6	.806	.073	.649
	SBWL + RT (n=13)	24.5±8.8	26.3±8.2	27.8±8.4			
	SBWL + MD (n=19)	25.6±9.3	28.5±5.5	29.2±4.4			
Positive Activities	SBWL (n=13)	23.8±6.9	27.7±6.7	26.5±7.0	.733	<.001	.879
	SBWL + RT (n=13)	22.9±9.7	28.5±5.5	27.6±7.1			
	SBWL + MD (n=19)	24.8±9.3	28.4±5.8	29.2±4.3			

Eating Inventory

Data from the 51-item Eating Inventory (EI) questionnaire were divided into three subscales of eating behavior: dietary restraint, dietary disinhibition, and perceived hunger. Dietary restraint significantly increased from baseline to 6 months ($p<.001$) for all three

groups. Dietary disinhibition and perceived hunger significantly decreased from baseline to 6 months ($p<.001$) for all three groups. Examination of these three constructs revealed no differences in the pattern of change in these variables between intervention groups across the 6-month period, as well as no significant group differences. (See Table 12.)

Table 12. Differences in Dietary Restraint, Dietary Disinhibition, and Perceived Hunger for Completers Across the 6-Month Behavioral Intervention by Group

		Assessments			p-Values		
Psychosocial Variable	**Intervention Group**	**Week 0**	**Week 12**	**Week 24**	**Group Effect**	**Time Effect**	**Group X Time Interaction**
Eating Inventory							
Eating Cogntive Restraint	SBWL (n=14)	10.6±4.3	16.1±3.2	15.9±4.5	.344	<.001	.360
	SBWL + RT (n=13)	8.8±4.6	15.5±4.8	16.2±3.9			
	SBWL + MD (n=19)	9.8±3.6	17.2±2.1	17.9±1.8			
Eating Disinhibition	SBWL (n=14)	11.0±3.6	9.1±4.4	8.6±4.4	.102	<.001	.951
	SBWL + RT (n=13)	8.4±2.8	6.3±3.8	5.6±2.9			
	SBWL + MD (n=19)	9.9±4.3	7.8±3.5	6.7±3.1			
Perceived Hunger	SBWL (n=14)	7.6±3.6	6.4±4.6	5.7±3.6	.204	<.001	.422
	SBWL + RT (n=13)	5.9±3.3	4.3+3.5	3.9±3.1			
	SBWL + MD (n=19)	7.6±3.0	5.1±2.5	3.8±2.2			

Body Image

Data from the 69-item MBSRQ were divided into three domains of body image and weight-related variables: physical appearance, physical fitness, and health. They were then further divided in subscales of evaluation and orientation. Additional special multi-item subscales of Body-Areas Satisfaction Scale, Overweight Preoccupation Scale, and Self-Classified Weight Scale were also analyzed. Results from all subscales are presented in Table 13 and reveal no significant group differences. There were significant (time effect) improvements in most of the subscales of body image including appearance evaluation

(p<.001), fitness orientation (p<.001), health evaluation (p<.001), health orientation (p<.001), illness orientation (p<.05), body-areas satisfaction (p<.001), and overweight preoccupation (p<.001). A significant interaction effect was seen only with the health evaluation subscale (p=.03). There was also a significant decrease in self-classified weight over time (p<.001). The only two subscales of body image which did not show a significant effect was appearance orientation (p=.12) and fitness evaluation (p=.37).

Exercise Beliefs (Outcome Expectations and Barriers)

Data from the exercise beliefs questionnaire were divided into an overall outcome expectations (benefits) score, with subscales of psychological, body image, and health benefits, and overall perceived barriers score, with subscales of time, effort, and obstacle barriers (see Table 14). Analyses revealed a significant decrease in the expected barriers for physical activity (p<.05 for time main effect) in all groups across the 6-month intervention period, with no significant difference between the groups in overall (p=.91), time (p=.86), effort (p=.77), or obstacle (p=.53) barriers. There was a significant group x time interaction effect for the time barrier (p=.04).

Analyses of the overall outcome expectations (benefits) revealed a significant group x time effect (p=.04), with post-hoc analyses revealing that the outcome expectations increased for both the SBWL + MD and SBWL + RT groups, and were significantly greater than the SBWL group. Two of the benefits subscales, psychological (P=.03) and body image (p=.02), also reveal significant group differences. Post-hoc analyses of the body image scale show that there were significant group difference between the SBWL group and the SBWL+MD groups, in that the SBWL + MD group has much higher expectations that body image will improve with exercise when compared to the standard group. (See Table 14.)

Table 13. Differences in Body Image for Completers Across the 6-Month Behavioral Intervention by Group

Psychosocial Variable	Intervention Group	Assessments			p-Values		
		Week 0	Week 12	Week 24	Group Effect	Time Effect	Group X Time Interaction
Body Image							
Appearance Evaluation	SBWL (n=14)	2.13±.82	2.58±1.0	2.97±1.2	.606	<.001	.911
	SBWL + RT (n=13)	2.27±.80	2.68±.92	3.02±1.0			
	SBWL + MD (n=19)	2.38±.68	2.93±.80	3.20±.61			
Appearance Orientation	SBWL (n=14)	3.30±.69	3.33±.77	3.46±.90	.741	.122	.972
	SBWL + RT (n=13)	3.32±.63	3.37±.64	3.46±.68			
	SBWL + MD (n=19)	3.47±.45	3.51±.47	3.55±.44			
Fitness Evaluation	SBWL (n=14)	3.45±1.1	3.55±.94	3.55±1.0	.573	.368	.728
	SBWL + RT (n=13)	3.54±.79	3.79±.93	3.61±1.0			
	SBWL + MD (n=19)	3.33±.63	3.33±.98	3.39±.66			
Fitness Orientation	SBWL (n=14)	3.03±.63	3.37±.73	3.30±.79	.630	<.001	.274
	SBWL + RT (n=13)	3.09±.48	3.47±.57	3.72±.62			
	SBWL + MD (n=19)	2.99±.44	3.41±.53	3.47±.56			
Health Evaluation	SBWL (n =14)	3.30±.57	3.74±.48	3.68±.78	.448	<.001	.027
	SBWL + RT (n=13)	3.56±.58	3.65±.58	4.00±.67			
	SBWL + MD (n=19)	3.46±.47	4.03±.51	3.88±.46			
Health Orientation	SBWL (n =14)	3.33±.58	3.69±.66	3.72±.55	.926	<.001	.381
	SBWL + RT (n=13)	3.13±.54	3.80±.51	3.88±.63			
	SBWL + MD (n=19)	3.14±.62	3.70±.52	3.77±.44			
Illness Orientation	SBWL (n =14)	3.07±.93	3.27±.80	3.36±.60	.836	.004	.874
	SBWL + RT (n=13)	3.06±.67	3.32±.75	3.22±.82			
	SBWL + MD (n=19)	2.94±.68	3.15±.74	3.21±.63			
Body-Areas Satisfaction	SBWL (n =14)	2.45±.69	2.72±.87	2.88±.94	.484	<.001	.917
	SBWL + RT (n=13)	2.63±.72	2.82±.92	3.08±.81			
	SBWL + MD (n=19)	2.69±.48	3.03±.57	3.20±.60			
Self-Classified Weight	SBWL (n =24)	4.44±.50	3.92±1.6	2.46±2.0	.234	<.001	.308
	SBWL + RT (n=23)	4.13±.81	2.97±2.1	2.17±2.0			
	SBWL + MD (n=24)	4.25±.44	3.31±1.6	2.93±1.6			
Overweight Preoccupation	SBWL (n =14)	3.25±.90	3.68±.88	3.86±.88	.147	<.001	.230
	SBWL + RT (n=13)	2.42±.76	3.37±1.1	3.33±.95			
	SBWL + MD (n=19)	3.10±.70	3.50±.74	3.59±.68			

Table 14. Differences in Outcome Expectations (Benefits) and Perceieved Barriers for Physical Activity for Completers Across the 6-Month Behavioral Intervention by Group

Psychosocial Variable	Intervention Group	Assessments			p-Values		
		Week 0	Week 12	Week 24	Group Effect	Time Effect	Group X Time Interaction
Exercise Beliefs							
Outcome Expectations (Benefits)	SBWL (n=14)	4.0±.81	4.2±.60	3.9±.68	.031	.071	.035
	SBWL + RT (n=13)	4.3±.57	4.4±.57	4.7±.38			
	SBWL + MD (n=19)	4.4±.43	4.4±.39	4.6±.38			
Psychological	SBWL (n=14)	3.2±1.3	3.6±1.1	3.4±1.1	.034	.032	.513
	SBWL + RT (n=13)	3.9±.75	4.2±.86	4.4±.71			
	SBWL + MD (n=19)	3.7±.84	3.7±.84	4.1±.67			
Body Image	SBWL (n=14)	4.5±.66	4.6±.49	4.2±.94	.019	.654	.013
	SBWL + RT (n=13)	4.5±.59	4.6±.70	4.8±.34			
	SBWL + MD (n=19)	4.9±.19	4.8±.31	4.9±.26			
Health	SBWL (n=14)	4.6±.58	4.6±.57	4.6±.62	.157	.489	.624
	SBWL + RT (n=13)	4.6±.48	4.7±.74	4.9±.28			
	SBWL + MD (n=19)	4.8±.41	4.8±.37	4.9±.25			
Perceived Barriers	SBWL (n=14)	2.9±.58	2.3±.79	2.8±.84	.911	.013	.120
	SBWL + RT (n=13)	2.9±.61	2.6±.95	2.7±.69			
	SBWL + MD (n=19)	2.9±.63	2.8±.72	2.6±.64			
Time	SBWL (n=14)	3.1±1.0	2.6±1.1	3.8±1.1	.860	.059	.035
	SBWL + RT (n=13)	3.2±.79	3.2±1.3	3.6±1.1			
	SBWL + MD (n=19)	3.2±.99	3.5±.96	3.2±1.1			
Effort	SBWL (n =14)	3.2±1.0	2.5±1.3	2.7±1.1	.774	<.001	.385
	SBWL + RT (n=13)	3.0±.91	2.5±1.3	2.6±.71			
	SBWL + MD (n=19)	3.2±.84	2.9±.86	2.6±.71			
Obstacles	SBWL (n =14)	2.2±.56	1.8±.63	2.2±1.1	.530	.166	.793
	SBWL + RT (n=13)	2.4±.73	2.2±.87	2.2±.71			
	SBWL + MD (n=19)	2.2±.66	2.0±.89	2.1±.72			

Correlates of Body Weight Change

Bivariate associations between the process measures of weight loss (physical activity, energy intake, and eating behaviors) and actual body weight change at 3 months and 6 months were examined and results are presented in Table 15. Body weight change was calculated as the 3-month and 6-month body weight minus the baseline body weight, and therefore a negative number for body weight change indicates weight loss.

Physical Activity and Body Weight Change. A significant relationship ($p<.05$) between both baseline measures of physical activity ($r = -.27$) and 3-month measures of physical

activity (r= -.28) and 3-month weight change were found. Similarly, weight change at 6 months was significantly correlated (p<.01) with 3-month (r= -.37) and 6-month physical activity (r= -.37) measures.

Energy Intake and Body Weight Change. The change in energy intake from baseline to 3-months (r= .28) showed a significant relationship (p<.05) to the 3-month weight change. No significant relationships were seen between 6-month energy intake and 6-month weight change.

Eating Behaviors and Body Weight Change. Weight loss eating behaviors measured by the Eating Behavior Inventory at 3 months (r= -.34) and the change in eating behaviors from baseline to 3 months (r= -.45) were both significantly correlated with 3-month weight change (p<.05). In addition, weight loss eating behaviors at both 3 months (r= -.29), 6 months (r= -.41), and the change scores from baseline to 3 months (r= -.30) and baseline to 6 months (r= -.39) were significantly correlated (p<.05) with weight loss at the 6-month time period.

Table 15.Correlations Between 3-and 6-Month Weight Change and Process Measures

	Correlation	
Process Measures	**3-Month Weight Change**	**6-Month Weight Change**
Physical Activity (kcal)		
Baseline	-.273*	-.271
3-Month	-.284*	-.365**
6-Month	-----	-.369**
Change (0-3 months)	-.105	-.146
Change (0-6 months)	-----	-.230
Energy Intake (kcal/day)		
Baseline	-.168	-.084
3-Month	.021	.018
6-Month	-----	.053
Change (0-3 months)	.279*	.148
Change (0-6 months)	-----	.167
Eating Behavior Inventory		
Baseline	.086	-.035
3-Month	-.336*	-.288*
6-Month	-----	-.413**
Change (0-3 months)	-.449**	-.303*
Change (0-6 months)	-----	-.392**

***p< 0.05, **p<0.01**

Psychosocial Correlates of Body Weight Change

Physical Activity and Eating Self-Efficacy. Correlations between 3-month and 6-month weight change and physical activity and eating self-efficacy are presented in Table 16. Body weight change was calculated as the 3-month and 6-month body weight minus the baseline body weight, and therefore a negative number for body weight change indicates weight loss.

At the 3-month time period, self-efficacy for physical activity when tired (r = -.36), in a bad mood (r= -.31), low on time (r= -.30), and on vacation (r= -.37) were significantly correlated with 3-month weight change. Eating self-efficacy did not correlate with 3-month weight change. At the 6-month time period, self-efficacy for physical activity when tired (r= -.35) and in a bad mood (r= -.30) with both significantly correlated ($p<.05$) with 6-month weight change. However, unlike 3 months, all subscales of eating self-efficacy at 6 months, (negative emotions (r= -.36), availability (r= -.45), social pressure (r= -.35), physical discomfort (r= -.34), and positive activities (r= -.50)) were significantly correlated ($p<.05$) with 6-month weight change.

Body Image. Correlations between 3-month and 6-month weight change and body image are presented in Table 17. The two subscales of body image which did not significantly improve during the intervention (appearance orientation and fitness evaluation), also did not significantly correlate with change in body weight at either 3 months or 6 months. Analyses revealed that it was the change in body image subscales from 0 to 3 months (appearance evaluation (r = -.29), fitness orientation (r= -.34), health orientation (r= -.41), body areas satisfaction (r= -.31), and overweight preoccupation (r= -.35)) that significantly correlated ($p<.05$) with the 3-month weight change This same pattern was observed at 6

months, in which it was the change in the body image subscales from 0 to 6 months (appearance evaluation (r = -.41), fitness orientation (r= -.58), health orientation (r= -.47), body areas satisfaction (r= -.44), and overweight preoccupation (r= -.47)) that significantly correlated (P<.01) with 6-month weight change.

Outcome Expectations and Perceived Barriers. Correlations between 3-month and 6-month weight change and outcome expectations (benefits) and perceived barriers for physical activity are presented in Table 18. There were significant relationships (p<.05) between baseline scores for overall benefits (r= -.28), psychological benefits (r= -.26), overall barriers (r= -.27), and effort barriers (r= -.26) and weight loss at 3 months, however these baseline relationships disappeared when compared to 6-month weight change. The weight change at 6 months was inversely associated (p<.05) with the change in overall barriers (r= .35), time barriers (r= .33), and effort barriers (r= .37) from baseline to 6 months.

Table 16.Correlations Between 3-and 6-Month Weight Change and Self-Efficacy (Physical Activity & Eating)

Psychosocial Variable	Correlation	
	3-Month Weight Change	6-Month Weight Change
Physical Activity Self-Efficacy:		
Tired		
Baseline	-.246	-.078
3-Month	-.360**	-.282
6-Month	----	-.347*
Change (0-3 months)	-.163	-.214
Change (0-6 months)	----	-.334*
Bad Mood		
Baseline	-.203	-.071
3-Month	-.310*	-.275
6-Month	----	-.296*
Change (0-3 months)	-.092	-.173
Change (0-6 months)	----	-.210
Low on Time		
Baseline	-.241	-.041
3-Month	-.300*	-.287*
6-Month	----	-.190
Change (0-3 months)	-.117	-.240
Change (0-6 months)	----	-.146
On Vacation		
Baseline	-.074	-.070
3-Month	-.372*	-.362*
6-Month	----	-.207
Change (0-3 months)	-.301*	-.308*
Change (0-6 months)	----	-.184
Bad Weather		
Baseline	-.082	-.042
3-Month	-.107	-.073
6-Month	----	-.197
Change (0-3 months)	-.052	-.060
Change (0-6 months)	----	-.232
Eating Self-Efficacy:		
Negative Emotions		
Baseline	-.220	-.145
3-Month	-.129	-.081
6-Month	----	-.362*
Change (0-3 months)	.142	.063
Change (0-6 months)	----	-.241
Availability		
Baseline	-.090	-.022
3-Month	-.241	-.224
6-Month	----	-.453**
Change (0-3 months)	-.159	-.236
Change (0-6 months)	----	-.440**
Social Pressure		
Baseline	-.084	-.094
3-Month	-.222	-.200
6-Month	----	-.354*
Change (0-3 months)	-.127	-.120
Change (0-6 months)	----	-.156
Physical Discomfort		
Baseline	-.183	-.163
3-Month	-.177	-.086
6-Month	----	-.342*
Change (0-3 months)	.016	.081
Change (0-6 months)	----	-.156
Positive Activities		
Baseline	-.205	-.169
3-Month	-.229	-.143
6-Month	----	-.503**
Change (0-3 months)	.024	.056
Change (0-6 months)	----	-.168

***p< 0.05, **p<0.01**

Table 17.Correlations Between 3-and 6-Month Weight Change and Body Image

Psychosocial Variable	Correlation	
	3-Month Weight Change	6-Month Weight Change
Body Image		
Appearance Evaluation		
Baseline	.189	.142
3-Month	-.004	.037
6-Month	-----	-.145
Change (0-3 months)	-.285*	-.156
Change (0-6 months)	-----	-.414**
Appearance Orientation		
Baseline	.016	-.093
3-Month	-.078	-.174
6-Month	-----	-.265
Change (0-3 months)	-.163	-.133
Change (0-6 months)	-----	-.266
Fitness Evaluation		
Baseline	.177	.276
3-Month	.025	.132
6-Month	-----	.097
Change (0-3 months)	-.217	-.219
Change (0-6 months)	-----	-.285
Fitness Orientation		
Baseline	.165	.280*
3-Month	-.122	-.097
6-Month	-----	-.221
Change (0-3 months)	-.342**	-.460**
Change (0-6 months)	-----	-.580**
Health Evaluation		
Baseline	-.026	-.128
3-Month	.003	-.067
6-Month	-----	-.243
Change (0-3 months)	.018	.067
Change (0-6 months)	-----	-.188
Health Orientation		
Baseline	.218	.136
3-Month	-.152	-.203
6-Month	-----	-.365
Change (0-3 months)	-.406**	-.392**
Change (0-6 months)	-----	-.474**
Illness Orientation		
Baseline	.129	.056
3-Month	.023	.059
6-Month	-----	.068
Change (0-3 months)	-.147	-.064
Change (0-6 months)	-----	.047
Body Areas Satisfaction		
Baseline	.161	.094
3-Month	-.055	-.047
6-Month	-----	-.218
Change (0-3 months)	-.308*	-.200
Change (0-6 months)	-----	-.442**
Self-Classified Weight		
Baseline	-.035	.002
3-Month	-.132	-.056
6-Month	-----	.221
Change (0-3 months)	-.097	-.052
Change (0-6 months)	-----	.185
Overweight Preoccupation		
Baseline	.162	.175
3-Month	-.146	-.096
6-Month	-----	-.268
Change (0-3 months)	-.351**	-.314*
Change (0-6 months)	-----	-.465**

***p< 0.05, **p<0.01**

Table 18.Correlations Between 3-and 6-Month Weight Change and Expected Outcomes and Barriers for Physical Activity

Psychosocial Variable	Correlation	
	3-Month Weight Change	6-Month Weight Change
Exercise Beliefs		
Outcome Expectations (Benefits)		
Baseline	-.276*	-.218
3-Month	-.181	-.124
6-Month	-----	-.247
Change (0-3 months)	.171	.135
Change (0-6 months)	-----	-.032
Psychological		
Baseline	-.259*	-.207
3-Month	-.217	-.099
6-Month	-----	-.120
Change (0-3 months)	.085	.151
Change (0-6 months)	-----	.106
Body Image		
Baseline	-.151	-.150
3-Month	-.139	-.157
6-Month	-----	.299
Change (0-3 months)	.014	-.030
Change (0-6 months)	-.285	-.192
Health		
Baseline	-.297	-.186
3-Month	.066	-.014
6-Month	-----	-.284
Change (0-3 months)	.296*	.122
Change (0-6 months)	-----	-.082
Perceived Barriers		
Baseline	-.265*	-.272
3-Month	-.005	-.005
6-Month	-----	.156
Change (0-3 months)	.220	.243
Change (0-6 months)	-----	.354*
Time		
Baseline	-.073	-.235
3-Month	.110	.087
6-Month	-----	.219
Change (0-3 months)	.189	.285*
Change (0-6 months)	-----	.330*
Effort		
Baseline	-.263*	-.222
3-Month	.036	.054
6-Month	-----	.148
Change (0-3 months)	.287*	.316*
Change (0-6 months)	-----	.369*
Obstacles		
Baseline	-.202	-.126
3-Month	-.208	-.219
6-Month	-----	-.005
Change (0-3 months)	-.029	-.056
Change (0-6 months)	-----	.108

***p< 0.05, **p<0.01**

Eating Inventory. Correlations between 3-month and 6-month weight change and dietary restraint, dietary disinhibition, and perceived hunger are presented in Table 19. Analyses revealed that dietary restraint at 3 months (r= -.31) and the change in dietary restraint from 0- to 3 months (r= -.32) were both significantly correlated (p<.05) with 3-month weight change. Significant inverse relationships with 3-month weight change were also found for dietary disinhibition at 3 months (r= .32), the change in dietary disinhibition from 0-3 months (r= .32), and for perceived hunger at 3 months (r= .26). Similar relationships were shown for 6-month weight change. Dietary restraint at 6 months (r= -.47) and the change in dietary restraint from 0-6 months (r= -.48) were both significantly correlated (p<.05) with 6-month weight change. In addition, significant inverse relationships were found with 6-month weight change and dietary disinhibition at 6 months (r= .39) and the change in dietary disinhibition from 0-6 months (r= .34). Perceived hunger at 6 months was not significantly correlated with 6-month weight change (r= .29), but the 3-month score was (r= .30) (p<.05).

Table 19.Correlations Between 3-and 6-Month Weight Change and Eating Behaviors

	Correlation	
Psychosocial Variable	**3-Month Weight Change**	**6-Month Weight Change**
Eating Inventory		
Eating Cogntive Restraint		
Baseline	.033	.088
3-Month	-.314*	-.299*
6-Month	-----	-.469*
Change (0-3 months)	-.320*	-.364*
Change (0-6 months)	-----	-.483**
Eating Disinhibition		
Baseline	.091	.111
3-Month	.319*	.238
6-Month	-----	.385**
Change (0-3 months)	.322*	.238
Change (0-6 months)	-----	.335*
Perceived Hunger		
Baseline	.111	.101
3-Month	.261*	.302*
6-Month	-----	.286
Change (0-3 months)	.183	.243
Change (0-6 months)	-----	.165

***p< 0.05, **p<0.01**

Correlations between Process Measures and Psychosocial Variables

Correlational analyses were performed to determine the relationships between the process measures of weight loss (physical activity, energy intake, and eating behaviors) and the psychosocial variables (body image, eating inventory, exercise benefits and barriers, and physical activity and eating self-efficacy). All absolute and change variable were compared, and results can be seen in Appendices B – J (Tables 20-28).

Psychosocial Correlates of Physical Activity

Baseline measures of the psychosocial variables did not have any significant relationships to physical activity at 3 months, but three body image subscales at baseline (fitness orientation (r= .31), health evaluation (r=.33), and self-classified weight (r= -.29)) did have a significant relationship with physical activity at 6 months ($p<.05$).

Data from the 3-month and 6-month measures of the psychosocial variables reveal that at 3 months, physical activity was only significantly correlated with the 3-month body image subscale of fitness orientation (r=.28), 3-month effort barriers (r= -.34), and 3-month self-efficacy for physical activity when tired (r= .31) and on vacation (r= .27) (see Appendix B). At 6 months, however, the majority of the psychosocial variables measured showed highly significant relationships with 6-month physical activity. (see Appendix C). The only psychosocial variables (and subscales) that did not have a significant relationship with 6-month physical activity were body image subscales (appearance orientation, fitness evaluation, illness orientation, self-classified weight, and overweight preoccupation), the expected outcome of psychological benefits, and self-efficacy for physical activity when on vacation. Significant positive correlations were seen for body image

subscales (appearance evaluation, fitness orientation, health evaluation, health orientation, body-areas satisfaction), dietary restraint, overall benefits, body image benefits, and health benefits of physical activity. Physical activity self-efficacy when tired, in a bad mood, low on time, and in bad weather, and self-efficacy for eating while having negative emotions, when food is available, when under social pressure, in physical discomfort, and during positive activities were also significantly positively correlated with 6-month physical activity ($p<.05$).

Psychosocial Correlates of Energy Intake

At baseline, the only psychosocial variable significantly ($p<.05$) associated with energy intake at 3 months was perceived hunger ($r= .29$). At the 3-month time period, two subscales of body image (fitness evaluation ($r= -.28$) and health orientation ($r= -.27$)) had a significant inverse relationship ($p<.05$) to 3-month energy intake. Dietary restraint ($r= -.31$), dietary disinhibition ($r= .30$), and self-efficacy for eating while having negative emotions ($r= -.30$), when in physical discomfort ($r= -.27$), and during positive activities ($r= -.43$) at 3 months were also significantly correlated with 3-month energy intake ($p<.05$). (See Appendix D). These relationships were not significant at 6 months. Dietary restraint ($r= -.15$) was significantly and inversely correlated with energy intake at 6 months. (See Appendix E).

Psychosocial Correlates of Eating Behaviors

Baseline measures of the psychosocial variables revealed significant relationships ($p<.05$) between dietary restraint ($r= .28$) and self-efficacy for eating during positive activities ($r= .27$) and 3-month weight-loss eating behaviors.

Weight-loss eating behaviors at 6 months were significantly correlated with baseline appearance orientation (r= .40).

Significant correlations ($p<.05$) between three body image subscales at 3-months (fitness evaluation (r= .28), fitness orientation (r= .40), health orientation (r=.39), and 3-month weight loss eating behaviors emerged. In addition, dietary restraint was positively associated with 3-month eating behaviors (r= .32) ($p<.05$), while dietary disinhibition (r= -.40) and perceived hunger (r= -.44) were negatively associated ($p<.05$) with 3-month weight loss eating behaviors. (See Appendix F).

At 6 months, the majority of measured psychosocial variables were significantly correlated with 6-month weight loss eating behaviors. The significant positive correlations ($p<.05$) were seen for body image subscales (appearance evaluation, appearance orientation, fitness evaluation, fitness orientation, health evaluation, health orientation, body-areas satisfaction), dietary restraint, and body image benefits. Dietary disinhibition and perceived hunger were significantly correlated ($p<.05$) with 6-month eating behaviors. (See Appendix G).

Summary of Findings

The 6-month behavioral weight loss intervention, regardless of group assignment, resulted in significant decreases in body weight (range of weight loss = 6.1 to 8.8 kg), body mass index, body composition (LBM and % body fat), and energy intake. Likewise, physical activity (range of physical activity increase = 467 to 1099 kcal/wk) and weight loss eating behaviors also significantly increased across the 6-month intervention, regardless of group assignment. Other measures such as muscular strength of the chest and qualities of mindfulness also improved significantly, with no significant differences between the groups.

When examining psychosocial measures, most of the subscales of physical activity and eating self-efficacy improved over the 6-month intervention. As expected, dietary restraint increased, while dietary disinhibition and perceived hunger decreased significantly over time, with no difference in the groups. In addition, most of the subscales of body image improved over time, with no difference between the groups. There were mixed results with outcome expectations and perceived barriers for physical activity. There was a significant interaction effect for overall outcome expectations, where they increased over time for the SBWL + RT and SBWL + MD groups, but not for the SBWL group. The overall perceived barriers did change significantly over time, but there was no difference between the groups.

The significant decreases in body weight were correlated with improvements in physical activity and weight loss eating behaviors, but not with decreases in energy intake. Significant correlates of physical activity included perceived barriers to physical activity (negative), physical activity self-efficacy (positive), and some subscales of body image (positive). Significant correlates of weight loss eating behaviors included body image (positive), eating self-efficacy (positive), dietary restraint (positive), dietary disinhibition (negative), and perceived hunger (negative).

DISCUSSION

Introduction

As the prevalence of overweight and obesity continues to increase,[87] there is an increasing need to develop effective intervention strategies. Considering the current standard behavioral weight loss interventions currently produce a weight loss of approximately 10.7kg or 11% of initial body weight,[126] and there is large variability in treatment success, there is still considerable room for advances in the treatment of this population . Innovative, alternative, and effective intervention protocols may need to be developed and implemented if progress is going to continue to be made. In addition, identifying the behaviors that are critical for successful weight loss, and the corresponding psychosocial variables that may partially explain or predict the adoption of these behaviors, should clearly be a primary research objective. If the key behavior changes and related psychosocial variables are identified, future interventions could be tailored to focus on these variables and theoretically produce greater weight loss. Therefore, the purpose of the current investigation was to examine the effect of the addition of alternative techniques including mindfulness meditation and home-based resistance exercise on weight loss, eating and physical activity behaviors, and psychosocial variables in overweight and obese adults.

Summary of Major Findings and Discussion

Effect of the Intervention on Participant Attrition

The attrition rate of this study was 28%, with 51 of the initial 71 randomized subjects completing the 6-month intervention. Past research has suggested that, on average, approximately 20% of subjects who begin treatment in a behavioral weight loss intervention

do not complete it.[126] Therefore the attrition rate seen in this study is higher than is what is typically observed. In addition, a summary of studies in which the length of treatment (approximately 22.2 weeks) was most similar to this study (24 weeks) reported an average attrition rate of 18.5%,[126] which again is much smaller than the attrition seen here.

When examining data by intervention group, attrition was 34% for the SBWL group, 35% for the SBWL + RT group, and 17% for the SBWL + MD group. Although there was no statistically significant differences in these attrition rates, it appears that the SBWL group in this study had a much higher attrition rate than what is normally seen in a standard intervention, while the SBWL + MD group had an attrition rate more closely related to what is typically observed. Due to this higher than usual attrition rate in the SBWL group, it is difficult to determine whether the attrition of the other two groups (SBWL + RT and SBWL + MD) was because of the addition of the alternative techniques or simply representative of the standard intervention.

Upon closer examination of the attrition rates in studies that include resistance exercise as part of the intervention, completion rates range from 0 to 37%.[27] One study which specifically examined four exercise interventions in obese women across 48-weeks, two of which included resistance training on Cybex and Universal gym equipment, found that 18% of the subjects discontinued treatment prematurely.[130] In the same study, attendance at the group treatment sessions declined significantly from weeks 9 to 24, and averaged 86.2%$\pm$14.4% of possible visits.[130] The attendance at the resistance training sessions in this study was much lower at 49.1$\pm$35.7%. It is unclear why adherence to the resistance exercise intervention was lower in this study, but it is important to note that the addition of this alternative technique did not contribute to improved adherence, or to improved outcomes, such as weight loss, physical activity, or strength. One possible explanation is that is the mode

of resistance training in this study (resistance tubing and resistance balls) may not have been acceptable to the subjects. Or perhaps it did not produce substantial strength gains or results that may naturally promote adherence.

When examining the attrition rates of previous intervention studies using mindfulness mediation techniques, completion rates range from 60 to 97%, with a mean of 85±8.9%.[11] One study in particular was a randomized trial of two mind-body interventions for weight loss maintenance. Results from this study showed that 71% and 90% of randomized subjects to the mind-body techniques completed 24-week follow-up, compared to 77.4% in the control group.[37] Another study across 5-months found that participants in a mind-body intervention to improve cardiovascular risk had a 92% retention, compared to 99% in the usual care intervention.[36] These average attrition rates of approximately 15% are comparable to the 17% attrition rate of the current SBWL + MD group. And although only a few mindfulness studies reported the extent to which subjects completed their home-practice assignments, the average number of practices per week reported was 3.25,[11] which is less than the reported 5.29 practices per week in the current study. A possible reason for this slight difference may be in the way in which "practice" at home was defined in each study. Overall, the additional mindfulness mediation intervention did not appear to hinder adherence or retention to the current investigation, and it may have even helped to improve it, given the attrition rates of the SBWL and SBWL + RT groups were much higher than what is typically seen. It is possible that this type of intervention may have helped to promote group cohesion and a personal sense of importance of attendance to the group sessions as there was an additional 15-30 minutes of group time dedicated to sharing of personal experiences and emotions, group meditative experiences, and discussion around emotional aspects of weight loss behaviors.

Effect of the Intervention on Weight Loss

The 6-month intervention resulted in significant ($p<.05$) weight loss for all three intervention groups (SBWL = -6.1 kg, SBWL + RT = -8.8 kg, SBWL+MD = -8.0 kg). This represents an overall weight loss of 8% (-7.6 kg) of initial body weight. These weight losses were slightly less than expected, given that the average weight loss in a standard behavioral intervention as reported by Wadden et al. is approximately 0.4 kg per week, or 9.6 kg across 24-weeks.[126] Not only is the weight loss averaged across the three groups lower (2.0 kg less), but the SBWL group specifically is much lower (3.5 kg lower) than standard groups in other studies.

Past research in which resistance training as been a part of the intervention has shown that this type of training does not add any additional weight loss benefits when compared to a control group,[27] which is in agreement with the current findings. However, while there was not a significant difference between the SBWL+RT group and the SBWL and SBWL+MD groups, the resistance training group did have a 2.7 kg improvement in weight loss above the SBWL group. This may require additional investigations to determine the possible impact of resistance exercise on weight loss. To date, there have not been any randomized clinical trials examining the addition of mindfulness training to a standard behavioral weight loss program, and therefore comparison of weight loss is unqualified. However, in the current study, analyses revealed that there were no significant differences between the three groups, indicating that although the intervention was effective in producing weight loss, the additional techniques of resistance exercise and mindfulness did not improve on this.

Effect of the Intervention on Processes Measures of Weight Loss

Physical Activity

The results from this study showed that self-reported physical activity (kcal/wk) was significantly higher at 6 months than at baseline, with an overall average increase in physical activity energy expenditure of 833±439 kcal/wk. The comparison of the three intervention groups revealed no significant group differences, although the SBWL + RT group had the largest increase in physical activity (mean difference = 1099±506 kcal/wk) from baseline to 6 months amongst the three groups, which is to be expected given the exercise prescription included an additional 30 minutes each week of group exercise and 4 days/wk of prescribed resistance exercise at home. Therefore, the behavioral intervention did result in an overall increase in physical activity when compared to baseline, but neither the resistance training nor the mindfulness training improved this outcome when compared to the standard group. The lack of a significant difference in physical activity energy expenditure between groups is possibly due to lack of adherence to the resistance training protocol in the SBWL +RT group, and because the primary focus in the SBWL + MD group was on eating behaviors and not physical activity per se.

As shown in Appendices B and C (Tables 20 and 21), significant positive correlates of increased physical activity participation in this study were physical activity self-efficacy, subscales of body image, and outcome expectations. As has been previously shown, barriers to physical activity were the most consistent negative correlate of physical activity participation. Therefore continued focus on improving physical activity participation in weight loss interventions, should place considerable attention on increasing physical activity self-efficacy by providing mastery experiences, and reducing barriers to being physically active through strategies such as problem-solving, planning, and environmental restructuring.

Energy Intake

Energy intake (kcal/day) significantly decreased over the course of the 6-month intervention for all three groups, decreasing from an average of 1992±809 kcal/d at baseline to an average of 1293±526 kcal/d at 6 months. Therefore, the intervention did result in significant decreases in energy intake over time. However, the pattern of energy intake was different from 3 months to 6 months in that both the SBWL and SBWL + MD groups continued to decrease their energy intake, while the SBWL + RT group increased their energy intake from 3- to 6 months. This difference could possibly be due to compensation for the slight increase in physical activity energy expenditure reported above for the SBWL + RT group, although a review of the research has shown that only 19% of intervention studies reported an increase in energy intake after exercise.[17] Additional research to understand the influence of resistance training on energy intake may be warranted.

As shown in Appendices C and E (Tables 22 and 23), a consistent negative correlate to energy intake at both 3- and 6 months was dietary restraint, which is defined as conscious attempts to monitor and regulate food intake. There was some relationship seen at 3 months for eating self-efficacy as well, but this relationship was not present at 6 months. These results confirm previous findings that some form of self-monitoring of food intake is crucial to energy intake[19, 126], and must continue to be an essential element to any behavioral weight loss program.

Eating Behaviors

Results from the eating behavior inventory (EBI), which examines the role of specific eating and weight loss behaviors in weight loss, revealed that these behaviors increased over the 6-month intervention as expected. However, there was no significant difference between the groups. It was theorized that the SBWL + RT and the SBWL + MD would have a greater

improvement in weight loss eating behaviors when compared to the SBWL group, and although this was not the case, the intent-to-treat analysis revealed that a trend (p=.08) began to emerge in which the SBWL + MD group had higher EBI scores when compared to the SBWL group. Given that a large portion of the mindfulness training was centered on hunger awareness, eating mindfully, and learning to listen to the body's cues before, during, and after eating, it is not surprising that this trend emerged. Considering the amount of time it may take to fully incorporate mindful eating as part of one's lifestyle, perhaps a study of longer duration would reveal significant differences in weight-loss eating behaviors in a group that receives this type of training.

As shown in Appendices F and G (Tables 24 and 250, significant correlates of improved weight loss eating behaviors in this study were higher levels of eating self-efficacy, higher dietary restraint, and improvements in some of the subscales of body image. As previously shown, higher levels of dietary disinhibition and perceived hunger were the most consistent negative correlates of weight loss eating behaviors.[22, 52, 119]

Effect of the Intervention on Psychosocial Variables

As seen in Tables 11-14, the behavioral intervention resulted in significant improvements in many of the psychosocial variables measured in this study including physical activity self-efficacy when tired and on vacation, eating self-efficacy, dietary restraint, dietary disinhibition, perceived hunger, and most subscales of body image. These results are in agreement with other studies that have also reported improvements in physical activity self-efficacy, eating self-efficacy, dietary restraint and disinhibition, perceived hunger, and body image over the course of an intervention.[44, 104, 119, 120, 132] The addition of the

alternative methods of resistance training or mindfulness training did not have any additional effect on these variables.

Results from this study also showed that over the course of the behavioral intervention, there was a significant decrease in the overall barriers and the effort barriers to physical activity, with no difference between the three groups. Other studies have also shown that exercise barriers decrease over the course of an intervention.[44, 119] However, except for the psychological benefits, the outcome expectations did not significantly improve over time. This was also observed by Gallagher et al. in which psychological benefits increased over the course of the intervention.[44]

This study also revealed differences between the three groups, in that the overall outcome expectations for physical activity increased over the course of the intervention for both the SBWL+RT and SBWL+MD groups, but increased at 3 months and then decreased at 6 months for the SBWL group. In addition, the SBWL +MD group had higher expectations that body image would improve with exercise when compared to the SBWL group. This is interesting in that past studies of the treatment of binge eating disorder using mindfulness-based stress reduction found that most subjects reported an increased sense of self-concept and self-awareness following treatment.[73] A similar effect may be seen here in that mindfulness training improves self-concept and self-awareness as the subjects relate to exercise behaviors, and therefore expectations that body image will improve is also greater.

Effect of the Intervention on Correlates of Weight Loss and Process Measures

The correlates of body weight change over the course of the intervention are shown in Tables 15-19. The primary process measures associated with body weight change at 3 months was baseline and 3-month physical activity, the change in energy intake from baseline to 3

months, and the improvement in eating behaviors at 3 months. The weight loss at 6 months was also correlated with the process measures of physical activity and eating behaviors, but here it was the 3-month and 6-month physical activity and the 3-month and 6-month eating behaviors that significantly correlated. There was no relationship between energy intake at 6 months and 6-month weight loss, which may have been due to the measure of energy intake, the Block Food Frequency Questionnaire. These relationships affirm past studies which show that an increase in physical activity and an improvement in eating behaviors are associated with the greatest weight losses.

The study also found various psychosocial variables to be related to weight loss across the intervention. At 3 months, weight loss was related to physical activity self-efficacy (when tired, in a bad mood, low on time, on vacation), but not eating self-efficacy. At 6 months physical activity self-efficacy when tired and in a bad mood were still related to 6-month weight change, but the other subscales were not. It was also interesting to note that all subscales of 6-month eating self-efficacy were now correlated with weight change, even when these relationships were not seen at 3 months suggesting that eating self-efficacy becomes more critical at the 6-month time period. And although a review of psychosocial predictors of weight control by Teixeira et al.[121] suggested that it is more the changes in both eating and exercise self-efficacy that are most consistently associated with weight loss, this was not the case in this study.

As shown in Table 17, it was the change in body image subscales of appearance orientation, fitness orientation, health orientation, body areas satisfaction, and overweight preoccupation from 0-to 3 months and from 0-to 6 months that correlated with weight loss at 3 months and 6 months, respectively. It is interesting to note that it was the change in body image subscales that showed a relationship to weight loss rather than the absolute body image

scores. When comparing these absolute body image scores of the overweight sample in this study to those of the general population, even with the positive changes in body image over the course of the intervention, the 6-month scores (except for the health subscales) are still somewhat less than that of the general population.[26]

The results revealed that it was the overall outcome expectations and psychological benefits of exercise, and the overall and effort barriers to exercise at baseline that were related to weight loss at 3 months. However, at 6 months it was primarily the decrease in barriers (overall, time, and effort) from baseline to 6 months that was associated with weight loss, which is in agreement with other studies[44, 119] and show that it is primarily the barriers to exercise rather than the benefits that need to be addressed in a behavioral intervention.

Previous studies have shown that weight loss eating behaviors such as high levels of dietary restraint and low levels of disinhibition are associated with weight loss.[38, 119] Results from the current investigation support these findings, in that 3-month weight change was associated with greater dietary restraint, and lower disinhibition and hunger at 3 months. Weight loss at 6 months was also associated with greater dietary restraint at both 3- and 6 months, as well as the change from baseline to both 3-and 6 months. In addition, decreases in eating disinhibition at 6-month was also related to weight loss at 6 months. The strongest relationship with weight loss was dietary restraint in particular, as has been shown consistently in other investigations.[43, 119]

Limitations and Recommendations for Future Research

There were several limitations to this study which may have contributed to the observed outcomes. Therefore the current findings need to be considered in context with these limitations, and future investigations should take into account the following suggestions:

1. Although the sample size at the start of the study was sufficient to provide 70% power to the investigation, the small sample size by the end of the study may be one factor in the failure to detect significant group differences, and/or significant relationships between weight loss, physical activity and eating behaviors, and psychosocial variables. Therefore future interventions which examine resistance training and/or mindfulness should be conducted with larger sample sizes.
2. This study was 6 months in duration, and therefore may not have been significantly long enough see the differential effects of the resistance training or mindfulness training components of the study. It is unclear whether a study longer in duration would have an effect on the measured outcomes, yet some trends shown here suggest that future investigations longer in duration may be needed to elicit differences.
3. The standard group in this study had a much higher attrition rate (34%) than what is typically seen in most standard behavioral interventions (20%). In addition, the weight loss was lower than expected for a standard behavioral intervention group. This may have made accurate comparison between groups difficult.
4. The resistance exercise group (SBWL +RT) in the current study a high attrition rate (35%) as well as a low adherence rate, in which subjects self-reported participating in only 40.3% of the prescribed resistance exercise sessions. It is unclear why adherence was so low, but may have been due to the likeability of the resistance tubing and resistance balls, the volume of exercise was overwhelming, or the training did not

provide adequate stimulus to produce results. For example, sufficient overload is required for strength gains to occur, and it is possible that either the resistance tubing cannot produce this type of intensity in this population or that the RPE scale used by the subjects to subjectively rate their exertion did not accurately represent the true intensity. Future investigations should consider the use of a more potent, yet still portable, strength stimulus such as free weights, and provide adequate training to produce results which may provide further motivation to continue training protocols.

5. There was a lack of any significant relationships between energy intake and weight loss, which may reflect the method used to assess energy intake.[108] Future investigations may consider other options for measurement of energy intake such as the 24-hr dietary recall, or use other reference methods to verify results such as resting metabolic and physical activity or doubly labelled water.[133]

6. Physical activity energy expenditure was assessed using the Paffenbarger Exercise Habits questionnaire, which although has been shown to be consistent with results from the 7-day physical activity recall, may not have provided the most accurate assessment of physical activity. Future investigation should consider objective measures of physical activity, such as a portable electronic armband device or accelerometers.

Proposed Research Hypotheses and Conclusions

1. **Hypothesis 1:** There will be a greater weight loss in the SBWL + RT group and in the SBWL + MD group when compared to the SBWL group. **Conclusion:** All groups had a significant weight loss across the 6-month intervention, but there was no difference between the groups, therefore this hypotheses was rejected.
2. **Hypothesis 2:**There will be a greater improvement in process measures of eating and physical activity behaviors in the SBWL + RT group and in the SBWL + MD group, when compared to the SBWL group. **Conclusion:**All groups had similar increases in physical activity and eating behaviors, and similar decreases in energy intake over time, with the energy intake for the SBWL + RT increasing slightly from month 3 to month 6. Therefore this hypothesis was rejected.
3. **Hypothesis 3:**There will be an improvement in eating self-efficacy, dietary restraint and disinhibition, outcome expectations (benefits) and perceived barriers in the SBWL + MD group, when compared to the SBWL group or the SBWL + RT. In addition, there will be a greater improvement in physical activity self-efficacy and body image in the SBWL + RT group when compared to the SBWL group or the SBWL + MD group. **Conclusion:**All groups had similar improvements in eating and physical activity self-efficacy, dietary restraint and disinhibition, outcome expectations and perceived barriers, and body image, therefore these hypotheses are rejected.
4. **Hypothesis 4:**The psychosocial factors of eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image will be significantly associated with body weight in three intervention groups: SBWL, SBWL + RT, and SBWL + MD. **Conclusion:**Body weight change was significantly associated with eating and physical activity self-

efficacy, perceived barriers to exercise, dietary restraint and disinhibition, and body image, but not with outcome expectations. Therefore this hypothesis was accepted for the psychosocial factors listed above, but was rejected for outcome expectations.

5. **Hypothesis 5:** The process measures of eating and physical activity behaviors will be significantly positively associated with weight loss across the intervention groups: SBWL, SBWL + RT, and SBWL + MD. **Conclusion:** Both physical activity and eating behaviors were significantly positively associated with weight loss, but energy intake was not. Therefore the hypothesis is accepted for two of the process measures examined, and rejected for the process measure of energy intake.

6. **Hypothesis 6:** The psychosocial factors of eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image will be significantly associated with the process measures eating and physical activity behaviors in the intervention groups: SBWL, SBWL + RT, and SBWL + MD. **Conclusion:** The psychosocial factors of eating and physical activity self-efficacy, outcome expectations (benefits) and barriers to exercise, dietary restraint and disinhibition, and body image were significantly associated with the process measures eating and physical activity behaviors and therefore this hypothesis is accepted.

Conclusion

In conclusion, although the intervention was successful in producing favorable changes in body weight, physical activity, and weight loss eating behaviors, the present study did not demonstrate that the addition of alternative techniques of home-based resistance exercise or mindfulness meditation to a standard behavioral weight loss intervention produced greater weight losses, greater improvements in physical activity, or greater improvements in

weight loss eating behaviors. In addition, the intervention did have an impact on psychosocial factors that seem to influence physical activity and eating behaviors, which have been shown to ultimately influence weight loss.

The study did show that overall, the process measures of weight loss (physical activity, energy intake, and eating behaviors) and the psychosocial variables (self-efficacy, outcome expectations and barriers, body image, and dietary restraint, dietary disinhibition, and hunger) were positively affected by the standard behavioral intervention. Weight loss was most strongly associated with improvements in physical activity and eating behaviors, and there were many correlates of weight loss and those behaviors that seem to enhance success. If the aim is to improve weight loss success, there needs to be improvement in physical activity energy expenditure and in weight-loss eating behaviors. This study suggests that to improve physical activity, interventions should focus on decreasing barriers to physical activity, improving self-efficacy for physical activity, and improving body image. It also suggests that to improve eating behaviors, interventions should focus on increasing eating self-efficacy and dietary restraint, and decreasing disinhibition tendencies, which would likely improve overall body image. Ultimately, if interventions continue to focus on teaching individuals how to adopt these behaviors, and instill confidence in their ability to maintain them, weight loss outcomes may be improved.

APPENDIX A

Differences in Main Outcome Measures (Intent-to-Treat) Across the 6-month Behavioral Intervention by Group

Outcome Measure	Intervention Group	Assessments			p-Values		
		Week 0	Week 12	Week 24	Group Effect	Time Effect	Group X Time Interaction
Body Weight (kg)	SBWL (n=24)	93.2±11.9	88.1±12.1	89.1±13.7	.359	<.001	.112
	SBWL + RT (n=23)	95.5±13.5	91.2±12.9	89.7±14.3			
	SBWL + MD (n=24)	90.5±12.9	85.9±13.8	83.7±14.5			
Body Mass Index (kg/m^2)	SBWL (n=24)	33.0±3.5	31.2±3.5	31.6±4.1	.259	<.001	.120
	SBWL + RT (n=23)	33.6±3.6	32.1±3.7	31.6±4.1			
	SBWL + MD (n=24)	32.1±3.8	30.4±4.0	29.6±4.2			
Lean Body Mass (kg)	SBWL (n=24)	54.9±7.4	54.2±7.4	54.3±7.6	.717	<.001	.553
	SBWL + RT (n=23)	55.1±6.6	54.6±6.5	54.4±6.4			
	SBWL + MD (n=24)	53.8±6.5	52.9±6.7	52.8±6.7			
Body Fat (%)	SBWL (n=24)	40.8±6.5	38.2±6.9	38.7±6.9	.566	<.001	.197
	SBWL + RT (n=23)	41.8±6.0	39.6±7.1	38.9±7.7			
	SBWL + MD (n=24)	40.1±4.9	37.8±5.9	36.5±6.7			
Physical Activity (kcal)	SBWL (n=24)	670±605	1913±1364	982±1181	.752	<.001	.024
	SBWL + RT (n=23)	897±630	1516±831	1566±1138			
	SBWL + MD (n=24)	765±713	1712±930	1507±862			
Energy Intake (kcal/day)	SBWL (n=24)	2255.1±1082	1722.2±1049	1767.6±968	.561	<.001	.007
	SBWL + RT (n=23)	1807.8±910	1479.3±813	1671.2±937			
	SBWL + MD (n=24)	2280.7±891	1508.8±752	1480.5±695			
Percent Fat Intake (%)	SBWL (n=24)	42.3±6.9	35.0±6.8	39.1±9.2	.071	<.001	.122
	SBWL + RT (n=23)	39.3±6.9	33.8±8.2	33.9±7.4			
	SBWL + MD (n=24)	39.9±6.5	32.1±6.3	32.5±6.2			
Percent Carbohydrate Intake (%)	SBWL (n=24)	43.2±6.7	49.9±7.1	46.7±9.2	.220	<.001	.303
	SBWL + RT (n=23)	46.1±6.9	50.8±7.0	51.1±6.5			
	SBWL + MD (n=24)	46.2±7.6	50.4±6.7	51.1±7.2			
Percent Protein Intake (%)	SBWL (n=24)	15.3±3.4	16.2±3.1	15.2±3.1	.714	<.001	.013
	SBWL + RT (n=23)	15.3±2.4	16.0±2.8	16.3±3.0			
	SBWL + MD (n=24)	14.7±2.9	17.6±3.6	16.4±3.2			
Eating Behavior Inventory	SBWL (n=24)	66.9±9.9	78.8±13.0	75.5±14.3	.075	<.001	.101
	SBWL + RT (n=23)	71.2±9.3	80.5±12.4	81.2±13.4			
	SBWL + MD (n=24)	69.9±9.0	84.2±9.5	86.1±10.6			

APPENDIX B

Table20. Correlations between 3-month Physical Activity (kcal/wk) and Baseline, 3-Month, and Change (0-3M) in Psychosocial Variables

	Correlation		
Psychosocial Variable	**Baseline Psychosocial Variable & 3-Month Physical Activity**	**3-Month Psychosocial Variable & 3-Month Physical Activity**	**Change (0-3 M) & 3-Month Physical Activity**
Body Image			
Appearance Evaluation	.045	-.066	-.181
Appearance Orientation	-.112	-.127	-.039
Fitness Evaluation	-.005	-.131	-.188
Fitness Orientation	.034	.276*	.315*
Health Evaluation	.203	.116	-.115
Health Orientation	-.060	.206	.280*
Illness Orientation	-.236	-.132	.136
Body Areas Satisfaction	-.020	.077	.135
Self-Classified Weight	.137	-.026	-.130
Overweight Preoccupation	.004	.133	.159
Eating Inventory			
Eating Cogntive Restraint	.081	.038	-.061
Eating Disinhibition	.045	-.140	-.244
Perceived Hunger	.186	-.228	-.416**
Exercise Beliefs			
Outcome Expectations (Benefits)	.066	.241	.181
Psychological	.101	.247	.174
Body Image	.006	.012	-.019
Health	-.010	.236	.196
Perceived Barriers	.244	-.148	-.349**
Time	.222	.011	-.179
Effort	.119	-.335*	-.501**
Obstacles	.246	.193	.006
Physical Activity Self-Efficacy:			
Tired	.091	.314*	.206
Bad Mood	.094	.228	.100
Low on Time	.101	.215	.085
On Vacation	.081	.269*	.151
Bad Weather	-.056	.142	.169
Eating Self-Efficacy:			
Negative Emotions	-.012	.053	.069
Availability	-.056	.062	.143
Social Pressure	-.078	.131	.197
Physical Discomfort	-.174	.072	.249
Positive Activities	-.016	.147	.118

***p< 0.05, **p<0.01**

APPENDIX C

Table 21. Correlations between 6-month Physical Activity (kcal/wk) and Baseline, 6-Month, and Change (0-6M) in Psychosocial Variables

	Correlation		
Psychosocial Variable	**Baseline Psychosocial Variable & 6-Month Physical Activity**	**6-Month Psychosocial Variable & 6-Month Physical Activity**	**Change (0-6 M) & 6-Month Physical Activity**
Body Image			
Appearance Evaluation	.085	.317*	.410**
Appearance Orientation	.032	.205	.237
Fitness Evaluation	.007	.181	.261
Fitness Orientation	.306*	.567**	.430**
Health Evaluation	.330*	.489**	.360*
Health Orientation	.223	.562**	.263
Illness Orientation	-.030	.112	.110
Body Areas Satisfaction	.221	.488**	.483**
Self-Classified Weight	-.294*	.058	.186
Overweight Preoccupation	-.065	.094	.141
Eating Inventory			
Eating Cogntive Restraint	-.116	.330*	.381**
Eating Disinhibition	-.095	-.400**	-.344*
Perceived Hunger	.055	-.429**	-.418**
Exercise Beliefs			
Outcome Expectations (Benefits)	.171	.353*	.219
Psychological	.175	.243	.040
Body Image	.131	.322*	.234
Health	.083	.368*	.265
Perceived Barriers	-.012	-.548**	-.458**
Time	.058	-.315*	-.307*
Effort	-.184	-.546**	-.343*
Obstacles	.238	.374**	-.434**
Physical Activity Self-Efficacy:			
Tired	.246	.462**	.231
Bad Mood	.171	.459**	.273
Low on Time	.133	.378**	.175
On Vacation	.272	.252	.045
Bad Weather	.100	.332*	.279
Eating Self-Efficacy:			
Negative Emotions	.080	.489**	.344*
Availability	.063	.409**	.315*
Social Pressure	-.041	.366*	.339*
Physical Discomfort	-.021	.357*	.418**
Positive Activities	.022	.398**	.343*

***p< 0.05, **p<0.01**

APPENDIX D

Table 22. Correlations between 3-Month Energy Intake (kcal/wk) and Baseline, 3-Month, and Change (0-3M) in Psychosocial Variables

	Correlation		
Psychosocial Variable	**Baseline Psychosocial Variable And 3-Month Energy Intake**	**3-Month Psychosocial Variable and 3-Month Energy Intake**	**Change (0-3 M) and 3-Month Energy Intake**
Body Image			
Appearance Evaluation	-.081	-.119	-.101
Appearance Orientation	-.119	-.088	.048
Fitness Evaluation	-.150	-.281*	-.213
Fitness Orientation	-.064	-.254	-.265*
Health Evaluation	-.210	-.156	.064
Health Orientation	.075	-.270*	-.372**
Illness Orientation	.079	-.019	-.134
Body Areas Satisfaction	.052	-.064	-.168
Self-Classified Weight	.175	.103	-.082
Overweight Preoccupation	.158	-.138	-.336*
Eating Inventory			
Eating Cogntive Restraint	-.035	-.311*	-.232
Eating Disinhibition	.175	.300*	.192
Perceived Hunger	.291*	.249	-.013
Exercise Beliefs			
Outcome Expectations (Benefits)	-.154	-.096	.101
Psychological	-.047	-.075	-.031
Body Image	-.261	-.042	.282*
Health	-.250	-.116	.101
Perceived Barriers	.061	.173	.135
Time	.038	.105	.080
Effort	.011	.139	.151
Obstacles	.116	.156	.057
Physical Activity Self-Efficacy:			
Tired	-.049	-.175	-.120
Bad Mood	-.054	-.145	-.075
Low on Time	.054	- .091	-.135
On Vacation	.046	.081	.032
Bad Weather	.047	.081	.043
Eating Self-Efficacy:			
Negative Emotions	-.098	-.302*	-.227
Availability	.037	-.262	-.344**
Social Pressure	.122	.162	-.280*
Physical Discomfort	-.099	-.271*	-.161
Positive Activities	-.002	-.431**	-.351**

***p< 0.05, **p<0.01**

APPENDIX E

Table 23. Correlations between 6-Month Energy Intake (kcal/wk) and Baseline, 6-Month, and Change (0-6M) in Psychosocial Variables

	Correlation		
Psychosocial Variable	**Baseline Psychosocial Variable And 6-Month Energy Intake**	**6-Month Psychosocial Variable and 6-Month Energy Intake**	**Change (0-6 M) and 6-Month Energy Intake**
Body Image			
Appearance Evaluation	.157	.122	-.011
Appearance Orientation	-.111	-.043	.083
Fitness Evaluation	.079	.001	-.115
Fitness Orientation	.224	.001	-.200
Health Evaluation	-.024	.045	.088
Health Orientation	-.078	-.043	.038
Illness Orientation	-.079	-.080	.008
Body Areas Satisfaction	.090	.086	.022
Self-Classified Weight	.006	-.091	-.071
Overweight Preoccupation	.031	-.061	-.091
Eating Inventory			
Eating Cogntive Restraint	-.151	-.145**	-.191
Eating Disinhibition	.087	.136	.055
Perceived Hunger	.240	.270	.010
Exercise Beliefs			
Outcome Expectations (Benefits)	-.024	-.074	-.065
Psychological	.101	-.040	-.170
Body Image	-.185	-.002	.161
Health	-.197	-.233	-.025
Perceived Barriers	.255	-.042	-.225
Time	.322*	-.050	-258
Effort	.085	-.005	-.085
Obstacles	.257	-.060	-.220
Physical Activity Self-Efficacy:			
Tired	-.083	-.045	.032
Bad Mood	-.085	.013	.117
Low on Time	.005	.068	.065
On Vacation	-.067	.131	.222
Bad Weather	-.078	.132	.264
Eating Self-Efficacy:			
Negative Emotions	-.019	-.045	.027
Availability	-.034	.003	.057
Social Pressure	-.022	-.017	-.039
Physical Discomfort	-.059	.042	.044
Positive Activities	-.112	-.050	-.015

***p< 0.05, **p<0.01**

APPENDIX F

Table 24. Correlations between 3-Month Eating Behavior Inventory and Baseline, 3-Month, and Change (0-3M) in Psychosocial Variables

	Correlation		
Psychosocial Variable	**Baseline Psychosocial Variable And 3-Month EBI**	**3-Month Psychosocial Variable and 3-Month EBI**	**Change (0–3 M) and 3-Month EBI**
Body Image			
Appearance Evaluation	.083	.223	.267*
Appearance Orientation	.034	.188	.264*
Fitness Evaluation	.115	.280*	.245
Fitness Orientation	.156	.397**	.341*
Health Evaluation	.195	.074	-.112
Health Orientation	.125	.389**	.293*
Illness Orientation	.159	.089	-.089
Body Areas Satisfaction	.053	.230	.313*
Self-Classified Weight	-.208	-.078	.085
Overweight Preoccupation	-.127	.019	.157
Eating Inventory			
Eating Cogntive Restraint	.277*	.321*	.038
Eating Disinhibition	-.255	-.404**	-228
Perceived Hunger	-.308	-.441**	-.194
Exercise Beliefs			
Outcome Expectations (Benefits)	.206	.176	-.060
Psychological	.151	.174	.023
Body Image	.229	.063	-.198
Health	.194	.125	-.038
Perceived Barriers	-.171	-.229	-.398**
Time	-.060	-.205	-.189
Effort	.135	-.223	-.391**
Obstacles	.299*	-.054	-.283*
Physical Activity Self-Efficacy:			
Tired	.263	.361**	.124
Bad Mood	.264*	.345**	.048
Low on Time	.246	.320*	.106
On Vacation	.239	.354**	.103
Bad Weather	.039	.039	.031
Eating Self-Efficacy:			
Negative Emotions	.218	.275*	.043
Availability	.251	.303*	.016
Social Pressure	.161	.226	.055
Physical Discomfort	.198	.310*	.111
Positive Activities	.269*	.511**	.144

***p< 0.05, **p<0.01**

APPENDIX G

Table 25. Correlations between 6-Month Eating Behavior Inventory and Baseline, 6-Month, and Change (0-6M) in Psychosocial Variables

	Correlation		
Psychosocial Variable	**Baseline Psychosocial Variable And 6-Month EBI**	**6-Month Psychosocial Variable and 6-Month EBI**	**Change (0–6 M) and 6-Month EBI**
Body Image			
Appearance Evaluation	.071	.310*	.428**
Appearance Orientation	.400**	.590**	.368*
Fitness Evaluation	.143	.313*	.333*
Fitness Orientation	.182	.465**	.445**
Health Evaluation	.151	.459**	.440**
Health Orientation	.218	.636**	.362*
Illness Orientation	.146	.194	.008
Body Areas Satisfaction	.000	.314*	.389**
Self-Classified Weight	.074	-.057	-.060
Overweight Preoccupation	.049	.219	.167
Eating Inventory			
Eating Cogntive Restraint	.255	.551**	.232
Eating Disinhibition	-.125	-.497**	-.453**
Perceived Hunger	-.132	- .451**	-.299*
Exercise Beliefs			
Outcome Expectations (Benefits)	.282*	.247	-.037
Psychological	.226	.045	-.217
Body Image	.231	.344*	.189
Health	.312*	.441**	.135
Perceived Barriers	.175	-.216	-.326*
Time	.103	-.141	-.183
Effort	.079	-.146	-.223
Obstacles	.253	-.233	-.372**
Physical Activity Self-Efficacy:			
Tired	.028	.345*	.335*
Bad Mood	.166	.430**	.229
Low on Time	.080	.263	.109
On Vacation	.096	.071	.064
Bad Weather	.175	.338*	.176
Eating Self-Efficacy:			
Negative Emotions	.121	.491**	.351*
Availability	.013	.488**	.451**
Social Pressure	-.030	.483**	.446*
Physical Discomfort	.091	.441**	.371*
Positive Activities	.159	.648**	.391**

***p< 0.05, **p<0.01**

APPENDIX H

Table 26. Correlations Between 3-and 6-Month Change in Physical Activity and Body Image

Psychosocial Variable	Correlation	
	3-Month Change in Physical Activity	6-Month Change in Physical Activity
Body Image		
Appearance Evaluation		
Baseline	-.007	.052
3-Month	-.103	.093
6-Month	-----	.234
Change (0-3 months)	-.194	.081
Change (0-6 months)	-----	.305*
Appearance Orientation		
Baseline	-.087	.062
3-Month	-.158	-.030
6-Month	-----	.208
Change (0-3 months)	-.127	-.131
Change (0-6 months)	-----	.212
Fitness Evaluation		
Baseline	-.157	-.195
3-Month	-.287*	-.182
6-Month	-----	-.029
Change (0-3 months)	-.203	-.004
Change (0-6 months)	-----	.229
Fitness Orientation		
Baseline	-.143	.127
3-Month	.032	-.267
6-Month	-----	.362*
Change (0-3 months)	-.007	.210
Change (0-6 months)	-----	.337*
Health Evaluation		
Baseline	.092	.250
3-Month	-.029	.154
6-Month	-----	.359*
Change (0-3 months)	-.140	-.095
Change (0-6 months)	-----	.258
Health Orientation		
Baseline	-.117	.163
3-Month	-.063	.300*
6-Month	-----	.356*
Change (0-3 months)	-.052	.142
Change (0-6 months)	-----	.142
Illness Orientation		
Baseline	-.231	-.048
3-Month	-.145	.041
6-Month	-----	.036
Change (0-3 months)	.111	.116
Change (0-6 months)	-----	.069
Body Areas Satisfaction		
Baseline	-.037	.116
3-Month	-.208	.239
6-Month	-----	.412**
Change (0-3 months)	.073	.254
Change (0-6 months)	-----	.495**
Self-Classified Weight		
Baseline	.229	-.196
3-Month	.915	.045
6-Month	-----	.033
Change (0-3 months)	-.189	.153
Change (0-6 months)	-----	.120
Overweight Preoccupation		
Baseline	.038	-.021
3-Month	.084	-.028
6-Month	-----	-.037
Change (0-3 months)	.061	-.023
Change (0-6 months)	-----	-.031

***p< 0.05, **p<0.01**

APPENDIX I

Table 27. Correlations Between 3-and 6-Month Change in Physical Activity and Outcome Expectations and Barriers for Physical Activity

Psychosocial Variable	Correlation	
	3-Month Change in Physical Activity	6-Month Change in Physical Activity
Exercise Beliefs		
Outcome Expectations (Benefits)		
Baseline	-.034	.069
3-Month	.115	.110
6-Month	-----	-.298*
Change (0-3 months)	.176	.046
Change (0-6 months)	-----	.281
Psychological		
Baseline	-.003	.061
3-Month	.128	.107
6-Month	-----	.209
Change (0-3 months)	.170	.060
Change (0-6 months)	-----	.147
Body Image		
Baseline	-.055	.091
3-Month	-.016	.004
6-Month	-----	.260
Change (0-3 months)	.033	-.107
Change (0-6 months)	-----	.192
Health		
Baseline	-.075	.013
3-Month	.113	.124
6-Month	-----	.317*
Change (0-3 months)	.147	.105
Change (0-6 months)	-----	.264
Perceived Barriers		
Baseline	.350**	.161
3-Month	.098	-.139
6-Month	-----	-.430**
Change (0-3 months)	-.173	-.285*
Change (0-6 months)	-----	-.487**
Time		
Baseline	.260*	.148
3-Month	.117	.000
6-Month	-----	-.331*
Change (0-3 months)	-.100	-.134
Change (0-6 months)	-----	-.377**
Effort		
Baseline	.254	.006
3-Month	-.074	-.265
6-Month	-----	-.391**
Change (0-3 months)	-.317*	-.362*
Change (0-6 months)	-----	-.377**
Obstacles		
Baseline	.262*	.297*
3-Month	.333*	.097
6-Month	-----	-.269
Change (0-3 months)	.120	-.128
Change (0-6 months)	-----	-.395**

***p< 0.05, **p<0.01**

APPENDIX J

Table 28. Correlations Between 3-and 6-Month Change in Physical Activity and Physical Activity Self-Efficacy

Psychosocial Variable	Correlation	
	3-Month Change in Physical Activity	6-Month Change in Physical Activity
Physical Activity Self-Efficacy:		
Tired		
Baseline	-.066	.109
3-Month	.056	.191
6-Month	-----	345*
Change (0-3 months)	.196	.061
Change (0-6 months)	-----	.238
Bad Mood		
Baseline	-.023	.074
3-Month	.015	.332*
6-Month	-----	.339*
Change (0-3 months)	.135	.278
Change (0-6 months)	-----	.263
Low on Time		
Baseline	-.001	.022
3-Month	.035	.230
6-Month	-----	.361*
Change (0-3 months)	.169	.183
Change (0-6 months)	-----	.246
On Vacation		
Baseline	.008	.203
3-Month	.133	.239
6-Month	-----	.230
Change (0-3 months)	.075	.005
Change (0-6 months)	-----	.065
Bad Weather		
Baseline	-.157	.016
3-Month	.012	.239
6-Month	-----	.295*
Change (0-3 months)	.038	.203*
Change (0-6 months)	-----	-.308

***p< 0.05, **p<0.01**

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