

PSYCHOLOGICAL CONSTRUCTS, DIET QUALITY, AND INTENTIONAL WEIGHT
LOSS AMONG POST-MENOPAUSAL MIDDLE-AGED AND OLDER WOMEN

by

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(Under the Direction of Mary Ann Johnson)

ABSTRACT

Older women are one of the subgroups of the United States population in which the prevalence of obesity is still rising (Ogden et al 2014). Therefore, research is warranted to determine effective methods for and predictors of weight loss in middle-aged and older women. This dissertation explored the relationship of age and psychological variables with intentional weight loss and change in diet quality in middle-aged and older women enrolled in a weight loss intervention. Two studies were conducted to: 1) determine the relationship of age and change in self-motivation, vitality, and satisfaction with life on intentional weight loss and the likelihood of achieving weight loss goals (10% weight loss) and 2) determine change in diet quality from baseline to post-intervention and the relationship of age and change in self-motivation, vitality, and satisfaction with life with change in diet quality in middle-aged and older women enrolled in a 6-month intentional weight loss intervention who are following an energy restricted (~ -500 kcal/day) higher protein (~30 energy) or conventional protein (~18% energy) diet and with or without exercise. Major findings were that participants were successful in achieving weight loss ($-9.3 \pm 4.8\%$ initial body weight), but the relationship of age with weight loss was not consistent. An increase in satisfaction with life was significantly associated with achieving weight loss

goals. Following the intervention, diet quality improved, but room for additional improvement was found at post-intervention. Older women made a larger number of nutritionally beneficial improvements in diet quality compared to middle-aged women, and higher baseline self-motivation was related to improvements in Healthy Eating Index-2010 total and several component scores. These findings contribute to the understanding of weight loss in middle-aged and older women and the relationship of age and psychological variables with weight loss and change in diet quality.

INDEX WORDS: Obesity, older adults, weight loss, protein, diet quality, beef, self-motivation, vitality, satisfaction with life, Healthy Eating Index

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DEDICATION

This dissertation is dedicated to the women who participated in the DIVAS intervention.

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I would like to thank the people who believed in me, provided support, and helped me reach this point. Dr. Mary Ann Johnson, I appreciate all of the guidance, assistance, and opportunities for growth you have provided me during my years at the University of Georgia. Thank you to my family for encouraging me, believing in me, and making sacrifices to help me reach this point.

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CHAPTER I

INTRODUCTION

Obesity prevalence is high in the United States, and older women are one of the few subgroups in which obesity prevalence is still increasing. Research suggests that weight loss interventions in older adults are effective and result in favorable changes in health, quality of life, and physical function (Felix & West 2013, Johnson 2013, Porter Starr, McDonald, & Bales 2014). Identifying predictors of successful weight loss has been cited as an important area of research to better understand the needs of individuals engaging in weight loss (National Institutes of Health National Heart, Lung, and Blood Institute 2000; Teixeira et al 2005). Research suggests that older adults may be more effective at losing weight than middle-aged adults (The Diabetes Prevention Program Research Group 2006; Wadden et al 2009). Self-motivation has been identified as a predictor of weight loss (Teixeira et al 2002; Teixeira et al 2004a; Teixeira et al 2004b; Teixeira, Going, Sardinha, & Lohman 2005). Feelings of fatigue, or low energy (vitality), and low levels of life satisfaction have been associated with higher body weight (Korkeila et al 1998; Resnick et al 2006; Strine et al 2008; Valentine et al 2009; Wadsworth & Pendergrast 2014). Higher protein diets (~ 1.2-1.6 g/kg body weight) have shown effectiveness for producing weight loss and fat mass loss, while preserving lean mass, but little is known about the effects of following an energy restricted higher protein diet on diet quality (Leidy et al 2015). Therefore, the purpose of this dissertation was to conduct studies in middle-aged and older women enrolled in a 6-month intentional weight loss intervention who are following an energy

restricted (~ -500 kcal/day) higher protein (~30% energy) or conventional protein (~18% energy) diet and with or without exercise to determine:

1) the relationship of age and change in self-motivation, vitality, and satisfaction with life with intentional weight loss and the likelihood of achieving weight loss goals (10% weight loss), and

2) changes in diet quality from baseline to post-intervention and the relationship of age and change in self-motivation, vitality, and satisfaction with life with change in diet quality.

Chapter II is a review of the literature relevant to this dissertation, and includes information on the growing population of older adults in the United States, obesity and weight loss in older adults, and higher protein diets for weight loss. Information on psychological variables including self-motivation, vitality and fatigue, and satisfaction with life and their relationship with age, higher body weight and/or weight loss, diet, and physical activity is included. Literature on the Health Eating Index-2010 is included and information on the relationship of the Healthy Eating Index with age, higher body weight and/or weight loss, physical activity, and change in diet quality as a result of dietary intervention. This dissertation was conducted within a larger parent project funded, in part, by a grant from the National Cattlemen's Beef Association, entitled Effects of a Higher Protein Diet and Exercise on Body Composition, Physical Function, and Fatigue in Overweight Older Women (Principal Investigator: Ellen M. Evans, PhD, Co-investigators: Mary Ann Johnson, PhD, Kevin M. McCully, PhD, Patrick J. O'Connor, PhD).

Chapter III is a manuscript to be submitted to a peer-reviewed journal, which assessed the relationship of age and change in self-motivation, vitality, and satisfaction with life with weight loss and achieving weight loss goals (defined as 10% weight loss). Self-motivation was assessed

with the Self-Motivation Inventory (SMI), vitality was assessed with the vitality scale of the Medical Outcomes Survey Short Form-36 (SF-36), and satisfaction with life was assessed with the Satisfaction with Life Scale (SWLS).

Chapter IV is a manuscript to be submitted to a peer-reviewed journal, which assessed change in diet quality from baseline to post-intervention in middle-aged and older women following a reduced energy (~ -500 kcal/day) and higher protein (~30% energy) or conventional protein (~ 18% energy) diet and with or without exercise and the relationship of age and change in self-motivation, vitality, and satisfaction with life with change in diet quality. Diet quality was assessed with Health Eating Index-2010 scores. Self-motivation was assessed with the Self-Motivation Inventory (SMI), vitality was assessed with the vitality scale of the Medical Outcomes Survey Short Form-36 (SF-36), and satisfaction with life was assessed with the Satisfaction with Life Scale (SWLS).

Chapter V summarizes the findings in chapter III and IV and provides reflections on the current study, conclusions, and areas for future research. Major findings are that middle-aged and older women succeeded in achieving weight loss. Older age versus middle-age was negatively associated with percent weight loss and achieving 10% weight loss, but the relationship of age with weight loss was no longer significant when age was included in regression models as a continuous variable. Therefore, the relationship of age and weight loss was inconsistent. Research is warranted to determine the relationship of age and weight loss. Change in self-motivation and vitality were not associated with weight loss, while an increase in satisfaction with life was associated with achieving weight loss goals. Additional research is warranted to determine the causal pathway, e.g., does increased weight loss lead to increased life satisfaction, or does increased life satisfaction lead to weight loss. Following the intervention, diet quality

improved, but room for additional improvement in diet quality was found at post-intervention. Compared to middle-aged women, older women made a larger number of nutritional improvements as evidenced by improved HEI-2010 total fruit, whole fruit, and fatty acids component scores. Higher baseline self-motivation was related to improvements in HEI-2010 total score and total fruit, total vegetables, and refined grains scores. Thus, low self-motivation, but not age, may be a barrier to making improvements in diet quality during weight loss interventions.

CHAPTER II

LITERATURE REVIEW

Introduction

The number of older adults age 65 and older in the United States is increasing, and is expected to account for 21.7% of the population by the year 2040 (Administration on Aging 2013). Although the prevalence of obesity in the United States has not significantly increased overall in adults from 2003-2004 to 2011-2012, the prevalence remains high at 34.9% in 2011-2012 (Ogden et al 2014). Obesity is associated with chronic conditions, including type 2 diabetes, heart disease, and some types of cancer as well as function limitations, physical and cognitive disabilities, and increased risk for institutionalization in older adults (CDC 2014; Houston et al 2009; Jensen et al 2010; Johnson 2013). Behavioral weight loss interventions in older adults are effective and safe (Felix & West 2013; Johnson 2013). A growing body of research suggests that older adults may be more effective at losing weight than middle-aged adults (The Diabetes Prevention Program Research Group 2006; Wadden et al 2009); however, further research is necessary.

In addition to being associated with physiological benefits, intentional weight loss is also associated with psychological benefits including improvements in self-esteem, body image, and health-related quality of life (Lasikiewicz, Myrissa, Hoyland, & Lawton 2014). Self-motivation has been identified as a predictor of weight loss (Teixeira et al 2002; Teixeira et al 2004a; Teixeira et al 2004b; Teixeira, Going, Sardinha, & Lohman 2005), but few studies have evaluated the relationship of self-motivation in older women and with making favorable changes

in diet quality. Fatigue has been identified as a prevalent problem for older adults, and has been associated with increased body weight; however, the literature regarding fatigue and diet is limited (Resnick et al 2006; Valentine et al 2009; Yu, Lee, & Man 2010). The relationship of life satisfaction with age remains unclear; however, longitudinal studies have suggested that life satisfaction can and does change in some adults with varying rates of change among individuals (Pavot & Diener 2008; Diener, Lucas, & Scollon 2006). Low levels of life satisfaction have been associated with increased body weight and weight gain; however, few studies have evaluated the relationship of life satisfaction and diet quality (Korkeila et al 1998; Strine et al 2008; Wadsworth & Pendergrast 2014).

The Healthy Eating Index is a measure of diet quality in accordance to the Dietary Guidelines for Americans, and higher scores (indicating better diet quality) are associated with older age in adults, while lower scores have been seen in overweight and obese adults (Drenowatz et al 2014; Guenther et al 2014; Guo et al 2004; Hiza et al 2013; McCabe-Sellers et al 2007; USDA 2008b). However, little is known about the effects of a reduced energy diet with higher protein intake (~30% energy) on diet quality in middle-aged and older adult women undergoing intentional weight loss. This dissertation will contribute to the field of research examining the efficacy of weight loss interventions in older adults, the differences in middle-aged compared to older women in achieving weight loss goals, the effects of energy restricted diets on diet quality, and will provide further insight into the relationship of age, self-motivation, life satisfaction, and fatigue, with diet quality and intentional weight loss.

Older adults

The number of older adults living in the United States is increasing as the “baby boom” generation begins to turn 65 years of age. In 2012, 43.1 million people (13.7% of the U.S.

population) living in the United States were aged 65 years or older, a 21% increase from 2002. The percentage of the population aged 65 years and older is expected to continue to increase with 21.7% of the United States population projected to be aged 65 years and older in the year 2040, and the number of adults 85 years of age and older is expected to triple from 6 million in 2013 to 14.6 million in 2040 (Administration on Aging 2013). In Georgia, 12% of the population were aged 65 years and older in 2013, which is a 44.4% increase from the year 2003 (Administration on Aging 2015). In the United States, a larger proportion of older adults are female (25.1 million female vs. 19.6 million male). Older adult males are more likely to be married than older adult females (72% males vs. 46% females), and 46% of females 75 years of age and older live alone (Administration on Aging 2014)

Obesity

Obesity prevalence is high in the United States as 34.9% of adults in the United States were categorized as obese in 2011-2012 with the highest prevalence of obesity among those aged 40-59 years (39.5%) compared to those 20-39 years (30.3%) and 60+ years (35.4%) (Ogden et al 2014). Obesity prevalence among adults living in the United States has not significantly changed from 2003-2004 to 2011-2012; however, when researchers examined these trends by age a significant 4.4 percentage point increase in adults 60+ years of age was noted ($p < 0.004$) (Ogden et al 2014). When these results were examined by gender, only a significant increase in obesity prevalence was found for women 60+ years of age (6.6% increase in females, $p = 0.006$ vs. males, $p = 0.25$) (Ogden et al 2014). Thus older adults, particularly women, appear to be an at-risk population for developing obesity and its co-morbidities.

Obesity is associated with an increased risk for chronic diseases such as type 2 diabetes, heart disease, stroke, and certain types of cancer as well as increased health care costs, long-term

care placement, and functional limitation in older adults (CDC 2014; Johnson 2013). Obesity places older adults at increased risk for physical and cognitive disabilities (Houston et al 2009; Jensen et al 2010). Physical and cognitive disabilities are risk factors for dependency, institutionalization, and mortality (Houston et al 2009). Obesity-related disability may be due in part to comorbidities as well as inflammation, sarcopenia, and loss of muscle function associated with obesity (Johnson et al 2011).

Weight loss in older adults

When assessing weight loss in older adults, it is important to distinguish between intentional and unintentional weight loss. Intentional weight loss in older adults has been associated with reduced mortality rates in people with diabetes, improved glucose tolerance, and improved physical function (Felix & West 2013; Villareal et al 2005). In a review by Porter Starr, McDonald, & Bales (2014) intentional weight loss interventions resulted in improvements in physical function in older adults (60 + years of age) with the most beneficial effects seen with a combination of weight loss and physical activity consisting of aerobic, strength, flexibility, and balance activities. Unintentional weight loss is often a result of underlying disease, and has been associated with frailty, physical decline, and mortality (Felix & West 2013).

Recommendations for intentional weight loss in older adults are controversial due to the potential for negative effects on muscle and bone. This may be due to the association of unintentional weight loss with mortality; however, when intentional and unintentional weight loss was evaluated separately this relationship with mortality was not seen with intentional weight loss (Houston et al 2009). In the 1998 Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults report, the NIH recommends weight loss for obese and overweight older adults and those with a high waist circumference

with one or more risk factors, while taking care to minimize bone and muscle loss (NIH 1998). The American Society for Nutrition and The Obesity Society recommend weight loss for obese older adults with metabolic complications or functional impairment (Villareal et al 2005). The most recent report from NIH, which is supported by The Obesity Society, states that older adults respond well to behavioral weight loss interventions and experience improvements in CVD risk factors as a result of weight loss; however, the safety of weight loss in older adults remains controversial, and there is a need for additional research regarding weight loss in older adult populations, particularly in assessing the effect of weight loss on risk for CVD, longevity, and osteoporosis (NIH 2013; Obesity Society 2014).

Evidence suggests that weight loss interventions are effective in facilitating weight loss in older adults, and result in favorable changes in health and quality of life (Felix & West 2013, Johnson 2013). Recommendations for weight loss interventions in older adults include focusing on a low-energy diet (energy reduction of 500-750 kcal/day), while ensuring adequate intake of protein, vitamin D, vitamin B12, fiber, and fluid; physical activity; and behavior modification (Houston et al 2009). Research indicates that older adults may be more successful with weight loss compared to middle-aged adults. Older adult participants enrolled in the Diabetes Prevention Program experienced greater weight loss (25-44 y: -4.1 kg; 45-59 y: -5.0 kg; 60-85 y: -6.4kg; $p < 0.001$) and reduction in waist circumference (25-44 y: -4.3 cm; 45-59 y: -4.7 cm; 60-85 y: -6.7 cm; $p < 0.001$) and had a higher percentage of participants achieving weight loss goals (25-44 y: 33%, 45-59 y: 39%, 65-80y: 55%; $p < 0.001$) compared to middle-aged adult and young adult participants (The Diabetes Prevention Program Research Group 2006). Older adult participants in the Look AHEAD study experienced higher amounts of weight loss (1-year

weight loss: 45-54 y: 7.9%, 55-64 y: 8.5%, 65-74 y: 9.4%; $p = 0.04$) and higher treatment adherence at 1 year compared to middle-aged participants (Wadden et al 2009).

Higher protein diets and intentional weight loss in older adults

Researchers are increasingly evaluating the role of higher protein diets in older adults undergoing intentional weight loss. Currently, the Recommended Daily Allowance (RDA) for protein (0.8 g/kg body weight) is the same for healthy younger adults and older adults, and a position paper by the Academy of Nutrition and Dietetics states this amount is adequate to meet minimum protein needs for most older adults; however, slightly higher protein intake may be beneficial for protein muscle anabolism and to prevent loss of muscle mass (Bernstein & Munoz 2012). Current research suggests that protein intake above the RDA (1.0-1.5 g/kg body weight) may provide additional benefits for all older adults, including those attempting intentional weight loss (Paddon-Jones et al 2015).

Despite benefits of increased protein consumption, some older adults may not achieve current recommendations for protein intake with approximately 1/3 of older adults 50 years of age and older consuming protein below the RDA and 10% of older women consuming protein below the Estimated Average Requirement (EAR) of 0.66 g/kg body weight (Paddon-Jones et al 2015). An overarching hypothesis generated at the Protein Summit 2.0 suggests that for all adults, consuming adequate amounts of high-quality protein at each meal coupled with physical activity may delay the onset of sarcopenia, slow the progression of sarcopenia, and/or reduce the magnitude of functional impairment as a result of sarcopenia (Paddon-Jones et al 2015).

Protein intake of 1.2-1.6 g/kg body weight has been investigated as a means to facilitate intentional weight loss through loss of fat mass and preservation of lean body mass (Leidy et al 2015). An overview of the literature on higher protein diets and intentional weight suggests that

higher protein diets (~1.2-1.6 g/kg body weight), which potentially include protein intake of 25-30 g/meal, are more effective in facilitating weight loss and fat mass loss, while preserving lean mass versus lower protein diets through the potential mechanisms of thermogenesis and satiety. Discrepancies in the literature are proposed to be due to compliance to higher protein diets (Leidy et al 2015). Examples of studies evaluating the effects of higher protein diets on weight loss in middle-aged and older adults follow.

Lasker, Evans, & Layman (2008) evaluated the effects of a higher protein diet on intentional weight loss in a sample of 50 overweight adults (mean age = 47 +/- 7 years) during a 4-month weight loss intervention. Participants were randomized to follow a high carbohydrate, low protein diet, which contributed 15% energy from protein, 55% energy from carbohydrates, and 30% energy from fat, or a moderate protein, moderate carbohydrate diet, which contributed 30% energy from protein, 40% energy from carbohydrates, and 30% energy from fat. Both diets provided ~ 1,700 kcal/d for females and ~ 1,900 kcal/d for males and ~ 14 g/1,000 kcal/d dietary fiber. Participants received a weekly menu plan, completed 3-day weighed food records weekly, and attended a weekly 1-hour meeting conducted by research dietitians. Participation in physical activity was voluntary, and participants received guidelines to participate in at least 30 minutes of walking 5 d/week. Results indicated that caloric intake was similar among groups, and protein intake was higher in participants following the moderate protein, moderate carbohydrate diet versus the high carbohydrate, low protein diet (1.4 g/kg vs. 0.7 g/kg). Participants in both diet groups lost body weight, and had decreases in BMI and fat mass. A trend was seen for more body weight loss in participants following the moderate carbohydrate, moderate protein diet versus the high carbohydrate, low protein diet (-9.1 +/- 0.9 kg vs. -6.9 +/- 0.3 kg/m²; p < 0.07). A similar trend was seen with reduction in BMI (protein diet: 3.1 +/- 0.3 kg/m²;

carbohydrate diet: $2.4 \pm 0.3 \text{ kg/m}^2$; $p < 0.07$). A significant decrease in percent fat mass was seen in participants following the moderate carbohydrate, moderate protein diet (-8.7%) compared to participants following the high carbohydrate, low protein diet (-5.7%; $p < 0.03$) (Lasker, Evans, & Layman 2008).

Mojtahedi et al (2011) examined the effects of higher protein intake during intentional weight loss in older women during a double-blinded randomized clinical trial. Thirty-one overweight or obese participants (mean age = 65.2 ± 4.6 years) were randomized to a higher protein (PRO) or conventional protein (CARB) treatment group. Participants in the PRO treatment group received 50 g/day of 90% whey protein isolate and participants in the CARB group received 50 g/day of maltodextrin. All participants were advised to consume half of the supplement in the morning with breakfast and the other half in the afternoon or evening. All participants were advised to follow a meal plan designed to decrease energy intake by 500 kcal/day to result in 10% weight loss over 6 months. With the addition of the protein supplement, the PRO diet provided 30% energy from protein, 40% energy from carbohydrate, and 30% energy from fat. The CARB diet provided 18% energy from protein, 52% energy from carbohydrate, and 30% energy from fat plus the maltodextrin supplement of 50 g/day. All participants were required to attend 2-3 supervised exercise sessions consisting of 20 minutes flexibility exercises and 20-30 minutes of low-moderate intensity walking. Upon completion of the 6 month intervention, participants randomized to the PRO treatment group consumed more protein than participants randomized to the CARB treatment group (PRO: $1.2 \pm 0.14 \text{ g/kg/day}$, CARB: $0.86 \pm 0.2 \text{ g/kg/day}$; $p < 0.001$). A trend for a greater weight loss was seen for the PRO treatment group versus CARB treatment group (PRO: $-8.0\% \pm 6.2\%$, CARB: $-4.1\% \pm 3.6\%$; $p = 0.51$). Participants in the PRO treatment group experienced a 5.8% greater increase in muscle

mass, relative to thigh volume changes, versus participants in the CARB treatment group ($p = 0.049$). In the complete sample, changes in muscle mass in relation to thigh volume and loss of subcutaneous adipose tissue predicted physical performance. Overall, these findings provide evidence that higher protein diets help maintain muscle mass, which improves physical function in older adult women undergoing intentional weight loss (Mojtahedi et al 2011).

Recent meta-analyses and systematic reviews reflect the benefits of higher protein diets on weight loss, reductions in fat mass, preservation of lean mass, and improvements in cardiovascular risk factors (Liedy et al 2015; Santesso et al 2012; Wycherly et al 2012). Given the growing body of evidence suggesting beneficial effects of higher protein diets in older adults undergoing intentional weight loss, future research is warranted to determine the effects of following a higher protein diet on diet quality in older adults. This dissertation will examine the effects of a higher protein diet (~30% energy from protein) on diet quality in postmenopausal middle-aged and older adult women.

Self-motivation inventory

This dissertation explores the associations of self-motivation with age, intentional weight loss, and diet. The self-motivation inventory (SMI) is a 40-item scale designed to measure self-motivation, which is defined as a behavioral tendency to persevere independent of situational reinforcements (Dishman & Ickes 1981). The SMI was developed in sample of undergraduate students enrolled in an introductory psychology course, resulting in high internal consistency ($\alpha = 0.91$), and was correlated with self-report of exercise (Dishman & Ickes 1981). The SMI further predicted engagement in exercise behavior in a variety of settings such as preventive medicine and training programs (Dishman, Ickes, & Morgan 1980). Convergent validity was evidenced by a significant correlation with the Thomas-Zander Ego-Strength Scale ($r = 0.63$; $p <$

0.05), while divergent validity was evidenced by minimal correlation with social desirability ($r = 0.31$; $p < 0.05$) and health locus of control ($r = 0.12$; $p > 0.05$) (Dishman & Ickes 1981). The SMI has been used in older adult populations, and psychometric properties of the SMI were assessed utilizing a shortened version of the SMI (SMI-10) in a French older adult sample. The 1 factor structure of the SMI was replicated in French older adults with internal consistency values ranging from $\alpha = 0.87$ - 0.84 (Andre & Dishman 2012).

Self-motivation and age

Few studies have examined the relationship among self-motivation and age, particularly within older age groups. Wilcox and Storandt (1996) concluded that self-motivation, as assessed by the self-motivation inventory, was unrelated to age in a community sample of women ages 20-85 years. In a clinical application, Brewer et al (2003) determined self-motivation was positively associated with completion of at-home rehabilitation for anterior cruciate ligament reconstruction in older (34 years) but not younger participants (18 years). Further research is needed to determine the relationship of self-motivation and age.

Self-motivation and body weight

Self-motivation has been associated with intentional weight loss (Teixeira et al 2002; Teixeira et al 2004a; Teixeira et al 2004b; Teixeira, Going, Sardinha, & Lohman 2005). A review of psychological predictors of weight loss cites self-motivation as a consistent predictor of weight loss (Lazzeretti et al 2015). Self-motivation was identified as a significant predictor of intentional weight loss in middle-aged women (average age 48.5 years) enrolled in a 4-month weight loss intervention, and significantly predicted group membership as successful participants (weight loss of ≥ 6.4 kg or at least 90% of targeted weight loss) or unsuccessful participants (weight loss of ≤ 1.9 kg or 25% of targeted weight loss) (Teixeira et al 2002). In a similar study

Teixeira et al (2004a) revealed participants in the highest tertile of intentional weight loss had higher self-motivation scores compared with participants in the lowest tertile of weight loss. Higher self-motivation is also identified as a component of successful weight loss maintenance (Elfhag & Rossner 2005). Given the high prevalence of obesity in older adults, additional research is needed regarding self-motivation and intentional weight loss in this age group.

Self-motivation and diet

Few studies have examined the relationship of self-motivation with dietary variables. A longitudinal study by Pelletier et al (2004) examined the relationship of general motivation and motivation towards dietary regulation with total fat and saturated fat intake in a sample of 111 participants whose primary care physicians thought them to be candidates for dietary change as a result of blood lipid results and other cardiovascular disease risk factors. Participants were counseled by a dietitian on healthy eating once, at baseline, and dietary intake was assessed by 24-hour recall and 3-day food records at baseline and 26 weeks. In this sample, baseline general motivation, assessed by the general self-determination scale, predicted motivation for regulating dietary behaviors, measured by the regulation of eating behaviors scale, at 13 weeks. Motivation for regulating dietary behavior was significantly related to a decrease in percent calories from total fat and percent calories from saturated fat from baseline to 26 weeks (total fat: $r = -0.32$, $p < 0.01$; saturated fat: $r = -0.18$, $p < 0.05$) (Pelletier et al 2004).

A cross-sectional study by Pelletier et al (2004) with a sample of 339 female students enrolled at the University of Ottawa revealed that, autonomous motivation (defined as a sum of the intrinsic motivation, integrated regulation, and identified regulation subscales of the Regulation of Eating Behaviors Scale) was positively related to healthy eating behaviors, assessed by the Healthy Eating Behavior Scale, which was designed to assess adherence to

recommendations by the Canadian Food Guide such as eating vegetables, fruits, and grain products and eating foods that are low in fat, saturated fat, and cholesterol (Pelletier et al 2004). The relationship of fruit and vegetable intake with motivation was assessed in a cross-sectional study utilizing data from the Washington State Cancer Risk Behavior Survey (1995-1996). In this sample, intrinsic motivation was related to increased intake of fruits and vegetables with stronger associations found with intrinsic motivation and increased fruit intake than vegetable intake (Trudeau et al 1998).

Shaikh et al (2011) evaluated the relationship of fruit and vegetable intake with psychosocial variables, including motivation, in the Healthy Body Healthy Spirit Trial. At baseline 1,021 African American adults were recruited from health fairs at 16 churches in the Metropolitan Atlanta region, and churches were randomized to 1 of 3 treatment groups. Group 1 was a comparison group in which participants received educational materials targeting self-efficacy and social support for increasing fruit and vegetable consumption from government sources and commercial vendors, Group 2 received culturally targeted materials similar to materials received by Group 1, and Group 3 received the same culturally targeted materials received by group 2 as well as 4 motivational interviewing phone calls by master's- or doctoral-level psychologists. Motivational interviewing phone counseling focused on increasing autonomous motivation for consuming more fruits and vegetables. At the 1-year follow up assessment, 965 participants (94.5%), completed post-intervention surveys. Fruit and vegetable intake, excluding fried potatoes and French fries, was assessed with a 19-item fruit and vegetable intake screener developed by the National Cancer Institute, a 2-item measure, and a 36-item food frequency questionnaire. For use in structural equation modeling, baseline and post-intervention fruit and vegetable intake were operationalized as a latent construct with these 3 measures of

fruit and vegetable intake used as indicators. Motivation was assessed by a revised version of the 15-item Treatment Self-Regulation Questionnaire. Using structural equation modeling, researchers found that only the intervention incorporating motivational interviewing (Group 3) had a statistically significant effect on increased fruit and vegetable intake, and that autonomous motivation for increasing fruit and vegetable consumption partially mediated the effects of the motivational interviewing intervention (Group 3) on fruit and vegetable intake. These findings suggest that participants with low autonomous motivation for increasing fruit and vegetable intake may be more receptive to a motivational interviewing intervention targeting increased fruit and vegetable consumption (Shaikh et al 2011).

Although few studies have evaluated the relationship of motivation with dietary intake and diet quality, some research has evaluated the relationship of motivation with eating behaviors. Bjorvell et al (1994) evaluated the relationship of self-motivation with eating behaviors, measured by the three factor eating questionnaire, in severely obese participants enrolled in a behavioral treatment program. Higher baseline self-motivation was associated with higher dietary restraint, less disinhibition, and less hunger (Bjorvell et al 1994).

Teixiera, Patrick, & Mata (2011) suggest that motivation determines an individual's ability to adopt and maintain a healthy diet, and that health professionals can foster environments that elicit autonomous motivation. Interventions that help a person feel a sense of ownership over their eating habits and routine, value and identify with the goals related to their eating choices, and become genuinely interested in the experiences of selecting and preparing meals are most likely to help participants succeed over the long-term. Examples of techniques that can improve intrinsic motivation include allowing participants to make his/her choices about how to pursue goals, limiting social pressure and control, creating challenges that are difficult but not

overwhelming, and fostering a warm and accepting environment such that participants feel accepted regardless of achieving or not achieving their goals (Teixiera, Patrick, & Mata 2011). Given the important role of self-motivation identified in studies of intentional weight loss, research is needed to examine the relationship of self-motivation with diet in older adults undergoing intentional weight loss.

Self-motivation and physical activity

Although not the main focus of this dissertation, the relationship of self-motivation with physical activity is discussed briefly here. The relationship of self-motivation with adherence to physical activity has been examined in a variety of settings (Dishman & Ickes 1981). Self-motivation was related to adherence to a crew training program in undergraduate women. Women who completed the training had higher SMI scores versus women who dropped out of the training program (Dishman, Ickes, & Morgan 1980). Self-motivation was also related to exercise adherence ($r = 0.44$; $p < 0.05$) in a sample of adult males including healthy non-risk participants and participants who were either at risk or symptomatic for coronary heart disease and who were enrolled in programs of habitual physical activity (Dishman, Ickes, & Morgan 1980). Self-motivation and exercise adherence was analyzed in a sample of adults newly enrolled at a large fitness center in which participants were advised to attend 3 or more exercise sessions per week (Anesi 2002). In this sample, self-motivation was correlated with exercise attendance ($r = 0.22$, p -value not provided), and when entered in regression models, along with a positive pattern of after-exercise feeling state changes, explained 10% of the variance in exercise attendance ($p < 0.03$) (Annesi 2002). Self-motivation was directly related and indirectly related to attendance through a positive relationship with behavioral change processes (counter conditioning, helping relationships, reinforcement management, and stimulus control) in the

Training Interventions and Genetics of Exercise (TIGER) study (Dishman, Jackson, & Bray 2014). In a review by Trost et al (2002) examining factors associated with physical activity in adults, self-motivation was cited as having a repeatedly documented positive association with physical activity.

Medical outcomes survey short form (SF-36)

This dissertation will assess the relationships of fatigue and vitality with age, intentional weight loss, and diet quality. Fatigue will be assessed with the Medical Outcomes Survey Short Form-36 (SF-36) vitality scale, which consists of 4 items. Low scores indicate feeling tired and worn out all the time, while high scores indicate feeling full of pep and energy all the time (Ware, Kosinski, & Gandek, 2005). The 4 vitality scale items were adapted from the Mental Health Inventory (Ware, Kosinski, & Gandek, 2005). Internal consistency for the SF-36 vitality scales has been estimated at 0.85-0.87 and test-retest reliability estimated at 0.80 over 2 weeks (O'Connor 2004). The SF-36 vitality scale has revealed lower vitality scores in samples of people with depression and chronic fatigue syndrome versus population norms and higher scores in physically active versus sedentary people (O'Connor 2004).

Fatigue and age

Fatigue is conceptualized as a mood in which a person has a reduced capacity to complete mental and/or physical activities (O'Connor 2004). Fatigue is a prevalent problem in older adults, with prevalence estimated at 27-50% in community dwelling older adults (Yu, Lee, & Man 2010). Fatigue has been linked to an increased risk for mortality and decreased physical function and cognitive function (Hardy & Studenski 2008; Lin et al 2013; Vestergaard et al 2009). Research suggests that fatigue increases with age. In a longitudinal study by Lin et al (2013) participants classified as having persistent fatigue were significantly older than

participants classified as having persistent energy. Older participants in the Georgia Centenarian study were more likely to report increases in fatigue versus younger participants, and age was a significant predictor of fatigue at time 2 (5-year follow-up for non-centenarians; 18 month follow-up for centenarians) (Martin et al 2006). When examining the role of fatigue in studies of obesity and intentional weight loss, it will be important to control for the effects of age.

Fatigue and body weight

Fatigue has been associated with increased body weight. NHANES data (1988-1994) indicated a U-shaped pattern of BMI and waist circumference across fatigue categories (energetic, fresh, average, tired, and exhausted) with an increase in BMI of 2.3 kg/m² and in waist circumference of 6.3 cm found in exhausted participants versus participants who reported feeling fresh (Resnick et al 2006). In a study by Anandacoomarasmy et al (2009) fatigue, measured by the multidimensional assessment of fatigue, and vitality, measured by the SF-36, were evaluated in obese participants who were enrolled in either a non-surgical or surgical weight loss program. Obese participants reported lower vitality scores versus age-matched scores for the general population. Although age-matched norms are not available for the multidimensional fatigue inventory, mean global fatigue index (GFI) for these obese participants (24.9) was more similar to GFI reported by adults with rheumatoid arthritis (GFI = 29.2) than controls (GFI = 17), suggesting that these obese participants experience a high burden from fatigue (Anandacoomarsamy et al 2009).

Valentine et al (2009) revealed associations with BMI and body composition with fatigue among older adult females. A significant positive association of percent body fat ($r = 0.44$; $p < 0.05$) and BMI ($r = 0.50$; $p < 0.05$) with fatigue was found in older adult females, but not for older adult males (Valentine et al 2009). In a review by Lasikiewicz et al (2014) improvements

in health-related quality of life (HRQOL) is cited as a benefit of weight loss with vitality being the most responsive domain of HRQOL resulting from weight loss. Vitality increased with weight loss in numerous behavioral interventions, and an increase in vitality was maintained at 1 year with maintenance of weight loss (Lasikiewicz et al 2014). Future research is warranted to further examine the relationship of fatigue and intentional weight loss.

Fatigue and diet

Little research has evaluated the relationship of diet and fatigue. The effect of following a DASH-type diet on overall mood in postmenopausal women was evaluated by Torres & Nowson (2012) in which participants were instructed to follow either a vitality diet (VD), which was a DASH-type diet rich in fruits in vegetables with moderate sodium and red meat intake of 1 serving/day, or a healthy diet (HD), which focused on general recommendations to decrease fat, increase complex carbohydrate, and limit red meat consumption for 14 weeks. At the end of the 14 week intervention participants in both the VD and HD treatment groups had significant improvements in mood as measured by the POMS global score as well as improvements in the POMS fatigue score, and change in mood was not significantly different among diet groups (VD: -2.0 +/-0.7, HD: -1.3 +/-0.4; $p < 0.01$) (Torres & Nowson 2012).

McMillan, Kras, & Scholey (2011) evaluated the effects of following a Mediterranean diet for 10 days in young adult females, and determined that participants assigned to follow the Mediterranean diet had significant improvements in vigor as measured by the POMS versus participants with no dietary change. NHANES data 1988-1994 evaluated fatigue by asking, “right now would you say that you are feeling energetic, fresh, average, tired, or exhausted?” (Resnick et al 2006). No significant differences in macronutrient intake were identified across fatigue categories (Resnick et al 2006). Nutrition risk has also been associated with fatigue in

older adults as participants in the Georgia Centenarian Study with higher nutrition risk reported higher fatigue (Martin, Bishop, Poon, & Johnson 2006). Given the important relationship of fatigue and increased body weight, research is needed to examine the relationship of fatigue and diet in middle-aged and older individuals attempting weight loss.

Fatigue and physical activity

Although not a focus of this dissertation a brief review of the relationship of fatigue with physical activity will be discussed. A review of epidemiological evidence suggests that active adults experience a 40% risk reduction for feelings of fatigue and low energy when compared to sedentary adults (Puetz 2006). A review by Puetz, O'Connor, and Dishman (2006) suggest that chronic exercise may be more effective than cognitive-behavioral therapy and medications in decreasing feelings of fatigue and increasing feelings of energy.

A randomized controlled trial by Martin et al (2009) evaluated the effects of a physical activity intervention to examine health benefits of engaging in 50%, 100%, and 150% of the NIH Consensus Panel physical activity recommendation on quality of life, measured by the SF-36, in overweight or obese postmenopausal females 45 to 75 years of age. A significant dose-dependent relationship of physical activity with quality of life was found for all components of the SF-36 except bodily pain. In these postmenopausal females, vitality increased with increasing physical activity even after controlling for weight change (Martin et al 2009). In a cross-sectional analysis of postmenopausal females Ward-Ritacco et al (2015) found that vitality was higher in participants with more steps per day and higher minutes of moderate to vigorous physical activity per day. A cross-sectional study of Australian women determined that an increase in vitality scores was associated with an increase in self-reported physical activity in young, middle-aged and older adult Australian women (Brown et al 2000).

Satisfaction with life scale

In this dissertation the relationship of life satisfaction with age, intentional weight loss, and diet quality will be assessed. The Satisfaction with Life Scale (SWLS) is a 5-item scale measuring global life satisfaction (Diener et al 1985). Life satisfaction is conceptualized as a cognitive evaluation of one's life, and is 1 of 3 components comprising subjective wellbeing (life satisfaction, positive affect, and negative affect) (Pavot & Diener 2008). Judgment of life satisfaction is based upon information that is chronically accessible, such as life domain satisfaction and a person's mood and emotions, which are influenced by temperament (Pavot & Diener 2008). Pavot & Diener (2008) suggest that satisfaction with life is affected by "noise" variables, such as item-order effects and transient mood states; however, these influences are minimal and do not eliminate the "signal" of an individual's life satisfaction judgment.

The SWLS was developed in a sample of undergraduate students enrolled in an introductory psychology class revealing a 1 factor structure with internal consistency of $\alpha = 0.87$ and 2 month test-retest correlation of $r = 0.82$ (Diener et al 1985). The SWLS was not related to the Marlow-Crowne scale of social desirability (0.02) and exhibited moderately strong correlations with measures of subjective well-being, such as the Bradburn Positive Affect Scale (0.50; 0.51) (Diener et al 1985). The SWLS was further evaluated in a sample of older adults (mean age = 75 years). The SWLS correlated 0.46 with the Life Satisfaction Index and 0.43 with SWLS scores rated by trained interviewers, providing evidence of convergent validity for the SWLS. Item-total correlations for the SWLS in the older adult sample were 0.81, 0.63, 0.61, 0.75, and 0.66 (Diener et al 1985).

Pavot & Diener (2008) suggest that the SWLS can be a complement to objective health assessment, and has sufficient sensitivity to change such that this scale can be a useful indicator

for the effectiveness of interventions. Future research is warranted to better understand the cognitive processes involved in formulating judgements of life satisfaction assessed by the Satisfaction with Life Scale, such as research to provide insight as to whether life satisfaction judgements represent an individual's satisfaction with their current life or an individual's satisfaction with their life as a whole (Pavot & Diener (2008).

Life satisfaction and age

Life satisfaction refers to a cognitive and global evaluation of the quality of one's life as a whole (Pavot & Diener 2008). The question of whether or not life satisfaction changes with age is unclear. One theory, the hedonic treadmill, suggests that life satisfaction does not change with age. Rather, life events may affect life satisfaction for short periods of time, but life satisfaction ultimately returns to a stable set point (Pavot & Diener 2008; Diener, Lucas, & Scollon 2006). Others have suggested that life satisfaction can change over time and certain events such as widowhood and unemployment can have lasting impacts on life satisfaction (Pavot & Diener 2008). Fujita & Diener (2005) analyzed data from the German Socio-Economic Panel over 7 years, and recommend a "soft" baseline score for life satisfaction after demonstrating that 24% of participants exhibited significant change in life satisfaction from the first 5 years to the last 5 years of their study.

The direction of change in life satisfaction remains unclear as some longitudinal studies indicate an increase in life satisfaction over time (Gana et al 2012) and some indicate a decrease over time (Berg et al 2009; Baird, Lucas, & Donnellan 2010). Mroczek & Spiro (2005) identified a U-shaped curve utilizing data from the Veterans Affairs Normative Aging Study in which life satisfaction increased until the age of 65 at which time life satisfaction began to decrease. Baird, Lucas, & Donnellan (2010) evaluated life satisfaction in 2 nationally

representative panel studies: The German Socio Economic Panel Study and the British Household Panel Study. Their findings revealed that life satisfaction was stable over most of adulthood, but began to steeply decline in individuals over the age of 70. Results from the British Household Panel Study revealed a large increase in life satisfaction between 40 and 70 years of age (Baird, Lucas, & Donnellan 2010). Koivumaa-Honkanen et al (2005) determined that life satisfaction was relatively stable over a period of 15 years in a nationwide sample of adult Finnish twins aged 18-45 years of age. Gana et al (2012) found an increase in life satisfaction among a sample of older adults aged 62-95 years who were followed over a period of 8 years. Much research has indicated that the rate and degree of change in life satisfaction among individuals is variable (Berg et al 2009; Gana et al 2012; Fujita & Diener 2005). A cross-sectional study by Hamarat et al (2002) evaluated differences in life satisfaction among the middle-aged (45-64 years), young-old (65-74 years) and oldest old (75+ years), and found no significant differences across age groups.

Siedlecki et al (2008) evaluated determinants of life satisfaction among participants aged 18-94 years of age, and found that the determinants of life satisfaction (negative affect as represented by neuroticism, trait anxiety, depression, and positive and negative affect scales) were similar across the life span, while self-reported health was not related to life satisfaction across age groups. Berg et al (2009) evaluated life satisfaction over 6 years in a sample of twins 80 years and older enrolled in the Swedish-OCTO-Twin study. An overall decrease in life satisfaction was observed, and predictors of life satisfaction were identified (Berg et al 2009) including a) widowhood was related to lower life satisfaction, particularly for men, b) higher initial financial satisfaction was related to higher initial life satisfaction, c) greater initial quality of social networks was related to higher initial life satisfaction, but a steeper decline in life

satisfaction over 6 years, d) greater initial depression was related to lower life satisfaction, e) better self-rated health and more internal locus of self-control were related to higher life satisfaction, and f) individuals with more extraversion and less neuroticism experienced higher life satisfaction (Berg et al 2009). Future research is warranted to determine the influence of age on life satisfaction.

Life satisfaction and body weight

Strine et al (2008) evaluated the relationship of life satisfaction with health behaviors in a community dwelling sample of adults living in the United States utilizing BRFSS data from 2005. Life satisfaction was measured by asking, “In general, how satisfied are you with your life?” Participants who were dissatisfied/very dissatisfied with their life were 1.5 times more likely to be obese, 2.0 times more likely to report arthritis, 1.8 times more likely to report diabetes, and 2.2 times more likely to report heart disease than those who were very satisfied with their life (Strine et al 2008). BRFSS data from 2005-2008 indicated that obese participants had a 5% reduced odds and severely obese participants had a 29% reduced odds of reporting being very satisfied with their life versus non-obese participants with the negative effect of life satisfaction on obesity being stronger in females versus males (Wadsworth & Pendergast 2014).

Darling, Coccia, & Senatore (2012) evaluated the relationship of stress, health, and BMI in a sample of midlife women. These researchers found a significant negative correlation of life satisfaction with BMI ($-0.253, p < 0.05$), and in this sample of middle aged women those women who had more stressful life changes, had higher BMIs, slept fewer hours, and had higher health stress had lower life satisfaction (Darling, Coccia, & Senatore 2012). The prevalence of obesity by geographical area influences the relationship of life satisfaction and obesity, such that in areas with a high prevalence of obesity, the difference in life satisfaction between the obese and non-

obese is smaller than in geographical areas with low prevalence of obesity (Wadsworth & Pendergrast 2014).

Life satisfaction has also been identified as a risk factor for weight gain. Low life satisfaction, as measured by Allardt's 4-item scale, was a risk factor for major weight gain (> 10 kg) over 6 years in Finnish women ages 30-54 years (OR = 2.21; $p = 0.043$) (Korkeila et al 1998). Given the high prevalence of obesity in older adults, research is warranted to determine the effect of life satisfaction on intentional weight loss in older adults.

Life satisfaction and diet

Grant, Wardle & Steptoe (2009) evaluated the relationship of life satisfaction, measured by asking, "All things considered, how satisfied are you with your life as a whole?" with health behaviors, in an international sample of university students. These researchers revealed a positive association between fruit intake and life satisfaction in the overall sample (high life satisfaction OR: 1.7 (95% CI: 1.20-2.44); moderate life satisfaction OR: 1.41 (95% CI: 1.08-1.84); neutral OR: 1.12 (95% CI: 0.90-1.40); however, when analyses were conducted by region this relationship was no longer significant for Western Europe and the USA ($p = 0.556$) versus Eastern Europe ($p = 0.026$) and Pacific Asia ($p = 0.008$) (Grant, Wardle, & Steptoe 2009). Fat avoidance, measured by asking "do you make a conscious effort to avoid foods that contain fat and cholesterol?" was related to life satisfaction in the overall sample (high life satisfaction OR: 1.39 (95% CI: 1.04-1.86); moderate life satisfaction OR: 1.30 (95% CI: 1.03-1.63); neutral OR: 1.16 (95% CI: 0.93-1.53); however, when analyzed by region, this relationship was only significant in Central Europe and Eastern Europe ($p = 0.049$) (Grant, Wardle & Steptoe 2009). No significant relationships were seen with fiber intake and alcohol consumption and life

satisfaction (Grant, Wardle & Steptoe 2009). Research is necessary to determine the relationship of life satisfaction with dietary change as part of an intentional weight loss intervention.

Life satisfaction and physical activity

Although not a focus of this dissertation, a brief discussion of life satisfaction and physical activity follows. A review by Rejeski & Mihalko (2001) evaluated the association with life satisfaction, conceptualized as an overall conscious cognitive judgement of one's life, and physical activity in older adults. Three of 6 randomized controlled trials assessing physical activity on life satisfaction found that older adults who engaged in physical activity had an increase in life satisfaction; however, 3 studies did not find an increase in life satisfaction in older adults engaging in physical activity. These contradictory results may be explained by differences in exercise prescription and/or the methods to measure life satisfaction. For example, older adults who engaged in low-intensity seated exercises did not significantly increase life satisfaction, measured with the Life Satisfaction Index (LSI), versus older adults who did not participated in exercise (McMurdo & Rennie 1993; Rejeski & Mihalko 2001), while Mihalko & McAuley (1996) found that older adults who participated in high-intensity upper body strength training experienced an increase in life satisfaction, measured with the SWLS, versus the control group. Cross-sectional studies evaluating the relationship of physical activity with life satisfaction support the relationship of higher life satisfaction in active versus sedentary older adults (Rejeski & Mihalko 2001).

Rejeski & Mihalko (2001) propose that increases in life satisfaction as a result of physical activity may be mediated by engaging in pleasurable experiences, facilitating favorable effects on self-efficacy, providing an opportunity for a person to feel good about a task he/she has completed and thus providing an opportunity to further define one's self, they further propose

that an increase in life satisfaction, as a result of physical activity, may be moderated by the value or importance that an individual places on specific domains of physical function and/or engaging in physical activity.

Elavsky & McAuley (2005) analyzed the relationship of physical activity and satisfaction with life in a sample of 133 women who varied in menopausal status. These researchers revealed a significant relationship of physical activity with satisfaction with life, which was mediated through physical activity's association with physical self-worth and menopausal symptoms (Elvasky & McAuley 2005).

Healthy eating index

This dissertation assessed the relationship of diet quality, measured by the Healthy Eating Index (HEI-2010), with age and psychometric variables including self-motivation, life satisfaction, and fatigue. This research explored the impact of a diet that is energy restricted (~ - 500 kcal/day) and higher in protein (~30% energy) on diet quality. The Healthy Eating Index (HEI) measures quality of diet in accordance with the Dietary Guidelines for Americans on a scale ranging from 0-100 with higher scores indicating higher diet quality (Guenther et al 2013). The HEI was developed to incorporate nutrient needs and dietary guidelines into one measure of diet quality (Kennedy et al 1995). The HEI originally included 10 components. Components 1-5 reflect adherence to the USDA Food Guide Pyramid (grains, vegetables, fruits, milk, and meats), components 6 and 7 reflect percentage of calories from total fat and saturated fat, respectively, component 8 reflects cholesterol intake, component 9 reflects sodium intake, and component 10 reflects dietary variety (Kennedy et al 1995). The HEI-2005 was developed to align with the Dietary Guidelines for Americans 2005. The HEI-2005 is comprised of 12 components. Components 1-9 (total fruit, whole fruit, total vegetables, dark green and orange

vegetables and legumes, total grains, whole grains, milk, meat and beans, and oils) are adequacy components for which consumption should be increased. Components 10-12 (saturated fat, sodium, and calories from solid fats, alcoholic beverages, and added sugars) are moderation components for which consumption should be decreased (Guenther et al 2008).

The HEI-2010 reflects recommendations in the Dietary Guidelines for Americans 2010, and this dissertation will focus on the HEI-2010. The HEI-2010 is in alignment with the omnivore, vegetarian, and vegan versions of the USDA food patterns, and is applicable to all individuals in the United States for which the USDA food patterns apply (Guenther et al 2013). The HEI-2010 does not apply to children 2 years of age or younger and children over the age of 2 years who are consuming breast milk or infant formula (Guenther et al 2013). Similar to the HEI-2005, the HEI-2010 is comprised of 12 components, 9 of which are adequacy components (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids) and 3 of which are moderation components (refined grains, sodium, and empty calories) (Guenther et al 2013). HEI-2010 scores are assigned using a density-based approach in which HEI-2010 scores are independent of energy intake, allowing for the measurement of diet quality versus quantity (Guenther et al 2013). A least-restrictive approach is used to assign maximum scores for components that vary by energy level, age and/or sex, which allows for the assignment of the highest possible score. A least-restrictive approach eases interpretation of scores because the potential error is in the same direction for all people. The likelihood of achieving high scores for many HEI-2010 components, except for total protein, is low for most individuals in the United States; therefore, this approach allows scores to be sensitive to improvement (Guenther et al 2013).

The HEI-2010 can be considered as a set of scores, which measure a unique aspect of the Dietary Guidelines for Americans as well as a total score, which is a sum of all component scores (Guenther et al 2013). Construct validity of the HEI-2010 was confirmed by comparing HEI-2010 scores to 4 menus developed by health professionals: the 7-day 2,000 kcal USDA food pattern menu, the 7-day Dietary Approaches to Stop Hypertension menu, the 1-week sample menus for Harvard Medical School's Healthy Eating Pyramid, and the 1-day sample menus from the American Heart Association's No-Fad Diet. HEI-2010 total scores for these sample menus were high ranging from 87-100 (Guenther et al 2014).

The HEI-2010 predicted differences in diet quality among groups whose diet quality is expected to differ: HEI-2010 total scores were higher in females versus males (female: 52.7; males: 49.8; $p < 0.01$), older age versus younger age (≥ 51 years: 56.1, 20-30 years: 49.6; $p < 0.01$), and non-smokers versus smokers (non-smokers: 53.3, smokers: 45.7; $p < 0.01$) using NHANES 2003-04 data (Guenther et al 2014). HEI-2010 scores derived from analysis of NHANES 2003-04 data indicated that the range of HEI-2010 scores were large enough to allow for the detection of differences among individuals and groups, and allow for the detection of changes over time (HEI-2010 total score: 26.2-78.5) (Guenther et al 2010). HEI-2010 total scores and component scores were shown to be independent of total energy intake as correlation coefficients between HEI-2010 total and component scores with energy intake were low ($r = -0.21$ to -0.01) (Guenther et al 2014). The Cronbach's alpha coefficient of 0.68 suggests adequate reliability of the HEI-2010 (Guenther et al 2014).

HEI-2010 scores derived from 2001-02 and 2007-08 NHANES data indicate need for improvement and little overall change in diet quality (USDA 2013). Total HEI-2010 scores in 2001-02 were 51.9 and were 53.9 in 2007-08, and all of the HEI-2010 component scores, except

for total protein, were below maximum values (USDA 2013). Analysis from 2007-08 NHANES data indicate that HEI-2010 component scores for greens and beans, whole grains, fatty acids, sodium, and empty calories were below 50% of their maximum possible values, and scores on the remaining components were generally low (57-72% of maximum possible value) (USDA 2013). From the years 2001-02 to 2007-08, 3 HEI-2010 component scores significantly changed: HEI-2010 sodium component scores decreased, while HEI-2010 whole fruits and empty calories component scores increased. These findings reflect that intake of sodium and whole fruit increased, while intake of empty calories decreased (USDA 2013).

Data from 2003-04 NHANES indicate that in the United States, the average HEI-2010 total score was 49.9 with significantly higher total HEI-2010 total scores found in females versus males (females: 52.7, males: 49.8; $p < 0.01$) (Guenther et al 2014). Some HEI-2010 component scores were higher in females versus males with higher scores seen for total fruit, whole fruit, total vegetables, greens and beans, and dairy HEI-2010 component scores in females versus males (all $p < 0.01$) (Guenther et al 2014).

HEI-2005 scores were analyzed in low-income (at or below 130% of the poverty level) versus high-income Americans from 2003-04 NHANES data. Low-income Americans had significantly lower component scores for total vegetables, dark green and orange vegetables and legumes, and whole grains and higher component scores for sodium versus high-income Americans (all $p < 0.05$); however there was no significant difference in HEI-2005 total score (USDA 2008a).

Hiza et al (2013) found associations with HEI-2005 scores, derived from 2003-04 NHANES data, with age (discussed below), gender, race, education, and income. Females had higher HEI-2005 total scores versus males (females: 59, males: 54; $p \leq 0.05$), adults with higher

income had higher HEI-2005 total scores versus adults with lower income ($\geq 500\%$ poverty level: 58, $\leq 130\%$ poverty level: 55; $p \leq 0.05$), and adults with higher education had higher HEI-2005 total scores versus adults with lower education (college diploma: 62, less than high school: 55; $p \leq 0.05$) (Hiza et al 2013). HEI-2005 total scores were higher in Hispanics versus blacks ($p \leq 0.05$), but differences were not statistically significant among Hispanics and whites (Hispanic: 59, Black: 53, White: 56) (Hiza et al 2013).

Diet quality of adults living in a rural area of Mississippi was assessed with HEI scores calculated from 1999-2000 NHANES data, and associations with age (discussed below), BMI (discussed below), race, self-reported health, and income were found (McCabe-Sellers et al 2007). Total HEI scores for adults living in rural Mississippi were 60.0, which is lower than the HEI total score from a nationally representative sample of adults derived from NHANES 1999-2000 data of 63.6 (McCabe-Sellers et al 2007). HEI scores of adults living in rural Mississippi did not significantly differ by gender (McCabe-Sellers et al 2007). African American adults had lower total HEI scores versus white adults (Whites: 61.0, African Americans: 58.7; $p < 0.03$). Although total HEI scores did not significantly differ by income, higher component scores for variety were seen in adults with incomes $\geq \$30,000$ versus adults with incomes $< \$15,000$, and component scores for vegetables was higher in adults with incomes of $\geq \$30,000$ versus adults with lower incomes (McCabe-Sellers et al 2007). Adults with a college degree had higher total HEI scores (college degree: 64.5, less than high school: 59.3; $p < 0.03$) as well as higher component scores for variety, fruit, and vegetables versus those with lower education (McCabe-Sellers et al 2007). Total HEI scores did not significantly differ by self-reported health status (poor vs. excellent); however, adults who had been told by a doctor that they have a disease had

higher HEI scores and were more likely to be classified as having a good diet (HEI total scores 81+) (McCabe-Sellers et al 2007).

Healthy eating index and age

Research suggests that diet quality, as determined by HEI scores, increases with increasing age. HEI-2005 scores for older adults, aged 65 years and older, were calculated from the 1994-96 Continuing Survey of Food Intake by Individuals and the 2001-02 NHANES survey and HEI-2005 total scores in 1994-96 were 65.4 and in 2001-02 were 67.6 (USDA 2008b). From 1994-96 to 2001-02, the oils and sodium HEI-2005 component scores significantly increased, while the total vegetables HEI-2005 component scores decreased (USDA 2008b) in older adults. In 2001-2002, HEI-2005 component scores were lowest for whole grains, dark green and orange vegetables and legumes, milk, sodium, and calories from solid fats, added sugars, and alcoholic beverages in older adults (USDA 2008b). Guenther et al (2014) analyzed NHANES data from 2003-2004, and found higher HEI-2010 total scores and total fruit, whole fruit, total vegetables, greens and beans, whole grains, seafood and plant proteins, refined grains, and empty calorie HEI-2010 component scores in adults 51 years of age and older versus adults 20-30 years of age (all $p < 0.01$). Loprinzi, Smit, & Mahoney (2014) determined that each 1-year increase in age was related to a significant increase in the odds of consuming a healthy diet, defined as HEI-2005 scores at or above the 60th percentile, using NHANES data from 2003-06 (OR: 1.028; 95% CI: 1.023-1.032)

HEI-2005 scores calculated from 2003-04 NHANES data indicate that older adults 65 years and older had higher HEI-2005 total scores versus adults less than 65 years of age (65 y+: 65, <65 y: 56, p - value not provided), while older adults 75 years and older had higher HEI-2005 total scores versus older adults 65-74 years of age (65-74 y: 63, 75 y+: 69; $p \leq 0.05$) (Hiza et al

2013). Adults 55-64 years of age had higher HEI-2005 component scores for total fruit, whole fruit, total vegetables, dark green and orange vegetables and legumes, whole grains, oils, and calories from solid fats, alcoholic beverages, and added sugars versus participants 18-30 years of age (all $p \leq 0.05$) (Hiza et al 2013).

Analysis of HEI-2005 component scores among older adults indicate that older adults 75 years of age and older had higher component scores for total fruit, whole grains, milk, and calories from solid fats, alcoholic beverages, and added sugars versus older adults 65-74 years of age ($p \leq 0.05$) (Hiza et al 2013). Hispanic older adults had higher component scores for dark green and orange vegetables and legumes versus whites, while whites had higher component scores for milk versus blacks ($p \leq 0.05$) (Hiza et al 2013).

Similarly, analysis of NHANES III data revealed higher total HEI scores in older adults 61-74 years of age versus adults 41-60 years of age and 20-40 years of age (61-74 y: 68.3, 41-60 y: 63.6, 20-40 y: 61.5; $p < 0.01$) (Guo et al 2004). A higher percentage of adults 61-74 years of age were considered to have good quality diets (HEI scores 81 and above) versus adults 41-60 and 20-40 years of age (61-74 y: 21.2%, 41-60 y: 12.2%, 20-40 y: 6.5%; $p < 0.01$) (Guo et al 2004). An analysis of adults living in a rural area of Mississippi revealed higher HEI scores, calculated from 24-hour recall, in older versus younger adults (60+ y: 64, 40-59 y: 58.9, 18-39 y: 58.6; $p < 0.03$) (McCabe-Sellers et al 2007). HEI component scores for milk, fruit, and variety were also higher in older versus younger participants (McCabe-Sellers et al 2007).

Research suggests that older adults living in rural areas have poor diet quality. Older adults living in the lower Mississippi delta had lower HEI scores than adults in the 1999-2000 NHANES sample (Mississippi: 60.1, NHANES: 63.4; $p < 0.0001$), and more adults in the lower Mississippi delta were classified as having a poor quality diet, defined as a total HEI score < 51 ,

(Mississippi: 24.8%, NHANES: 18.3%; $p < 0.001$) (McCabe-Sellers et al 2007). Vitolins et al (2007) evaluated diet quality in a sample of community dwelling older adults (65 y+) in North Carolina with HEI scores derived from the mean of 6, 24-hour recalls. The overall HEI score in this sample of older adults was 60.5, which is 7 points lower than the national HEI total scores for older adults living in the United States derived from 1999-2000 NHANES data and 1989-1990 Continuing Survey of Intakes by Individuals (Vitolins et al 2007). Additionally, a larger percentage of these older adults residing in rural North Carolina were categorized as needing improvement in their diet quality (20% more than national average) (Vitolins et al 2007). Lower than average diet quality in this sample is hypothesized to be due to low socioeconomic status and low income (Vitolins et al 2007).

Savoca et al (2009) evaluated diet quality in a sample of older adults living in a rural area of North Carolina with HEI-2005 scores derived from food frequency questionnaires. Similar to findings by Vitolins et al (2007) and McCabe-Sellers et al (2007), diet quality in this sample of rural older adults was lower than diet quality assessed in a nationally representative sample of adults living in the United States. Total HEI-2005 scores in this sample were 61.87, which is 5 points lower than HEI-2005 scores of older adults residing in the United States calculated from 2001-02 NHANES data, and less than 2% of the sample residing in North Carolina had HEI-2005 total scores of 80 and above (Savoca et al 2009). Total HEI-2005 scores varied with ethnicity as African American older adults had higher HEI-2005 total scores versus American Indian and Non-Hispanic White older adults (African American: 64.46, American Indian: 60.06, Non-Hispanic White: 61.11; $p = 0.01$). As the number of older adults in the United States is increasing, research on the relationship of diet quality and age is warranted.

Healthy eating index and body weight

Research suggests that diet quality may be lower in individuals who are overweight or obese. The association of excess body weight and diet quality was analyzed with HEI scores calculated from NHANES III data, and obese individuals had lower HEI values after adjusting for sociodemographic variables versus normal weight participants (obese: 62.3, normal weight: 63.6; $p = 0.04$) (Guo et al 2004). Fewer obese participants were classified as having good diet quality (HEI scores 81 and above) versus normal weight participants (obese: 9.2%, normal weight: 11.7%; $p < 0.01$) (Guo et al 2004). Participants with poor diet quality, defined as an HEI score of 50 or below, had increased odds of obesity (OR: 1.8; 95% CI: 1.4-2.5).

McCabe-Sellers et al (2007) evaluated the relationship of HEI components with the odds of being overweight in a sample of adults living in rural Mississippi, and found a decrease in odds of being overweight with consumption of grains (OR: 0.93; 95% CI: 0.88-0.98) and vegetables (OR: 0.92; 95% CI: 0.88-0.97), while the odds of being overweight were increased with consumption of meat (OR: 1.07; 1.03-1.13), saturated fat (OR: 1.06; 95% CI: 1.01-1.11), and cholesterol (OR: 1.05; 1.01-1.09) (McCabe-Sellers et al 2007).

Pate et al (2014) analyzed NHANES 2003-04 and 2005-06 data to determine the relationship of HEI-2005 scores with age, sex, physical activity, BMI, and waist circumference. Diet quality was inversely related to BMI and waist circumference for males 30-39, 40-49, and 50-59 years of age and for females 50-59 years of age (all $p < 0.05$) (Pate et al 2014). The relationship of diet quality and body composition was analyzed by Drenowatz et al (2014) in a sample of adults 21-35 years of age. Diet quality was assessed by HEI-2010 scores derived from 2, 24-hour recalls and body composition was assessed by DXA. Total HEI-2010 scores were 60.3 with 12 participants classified as having a good quality diet (HEI 2010 scores > 80) and 85

participants classified as having poor quality diets (HEI scores < 51) (Drenowatz et al 2014). In the overall sample total HEI-2010 scores were negatively correlated with percent total body fat for the total sample ($r = -0.177$; $p < 0.01$) as well as in males ($r = -0.204$; $p = 0.004$) and in females ($r = -0.154$; $p = 0.027$) (Drenowatz et al 2014).

Total HEI-2010 scores were significant predictors of percent body fat in linear regression analyses for the total sample and in males after controlling for gender (in analyses including the total sample), age, race/ethnicity, and education (Drenowatz et al 2014). In logistic regression analyses predicting overweight/obesity higher HEI-2010 total scores were related to decreased odds of overweight/obesity in the total sample (OR: 0.97; 95% CI: 0.95-0.99) and in males (OR: 0.97; 95% CI: 0.94-0.99) after controlling for gender (in analyses including the total sample), age, race/ethnicity, and time spent in moderate to vigorous physical activity (Drenowatz et al 2014). When moderate-vigorous physical activity was included in regression models HEI-2010 scores remained significant for men only. Logistic analyses of HEI-2010 component scores revealed a decreased odds of overweight/obesity with lower intake of sodium and empty calories (sodium OR: 0.78; 95% CI: 0.66-0.93; empty calories OR: 0.84; 95% CI: 0.73-0.97), while higher intake of protein was associated with higher odds of overweight/obesity (OR: 4.66; 95% CI: 2.10-10.33) in males. In females lower sodium intake was associated with a decreased odds of overweight/obesity (OR: 0.86; 95% CI: 0.74-0.99) (Drenowatz et al 2014).

Higher diet quality is associated with decreased risk of health outcomes associated with obesity, such as type 2 diabetes and cardiovascular disease. A systematic review and meta-analysis by Schwingshackl & Hoffmann (2015) assessed the relationship of diet quality, measured by the HEI, Alternate Healthy Eating Index (AHEI), and the Dietary Approaches to Stop Hypertension (DASH) score, with all-cause mortality, cardiovascular mortality/incidence,

cancer mortality/incidence, type 2 diabetes mellitus, and neurodegenerative diseases. Significant reductions in the risk for all-cause mortality, cardiovascular disease incidence/mortality, cancer incidence/mortality, and type 2 diabetes were found for highest quality diets; however, a significant relationship with higher quality diet and neurodegenerative diseases were not seen (Schwingshackl & Hoffmann 2015). Given the high prevalence of overweight and obesity, research on the relationship of diet quality with body weight and intentional weight loss is warranted.

Healthy eating index and dietary intervention

Research suggests dietary interventions result in improvements in diet quality. A study by Ptomey et al (2015) evaluated the effects of a weight loss intervention utilizing portion controlled meals on diet quality in overweight and obese adults. In this sample diet quality, assessed by HEI-2010 scores, significantly improved throughout the weight loss intervention. HEI-2010 total scores at baseline were 46.6 ± 8.9 and 66.6 ± 9.4 ($p < 0.001$) at the end of the 6-month weight loss intervention. HEI-2010 total scores remained higher than baseline throughout the weight loss maintenance period with total scores estimated at 58.0 ± 10.1 at 12-months and 57.7 ± 10.6 at 18-months. The whole fruits, total vegetables, refined grains, fatty acid, and empty calorie HEI-2010 component scores were significantly higher throughout the 18-month intervention compared to baseline values (Ptomey et al 2015). Glanz et al (2012) evaluated change in HEI-2005 scores in adults 25-50 years of age enrolled in an 8-week intervention designed to educate participants on the Nutrient Rich Foods (NRF) concept. Participants enrolled in the NRF intervention attended an education session led by a registered dietitian on the NRF, had access to a website with information on NRF food scores and a toll-free number to speak with a registered dietitian, and received weekly email and bi-weekly mailings with

motivational messages (Glanz et al 2012). Control subjects attended a 1-hour education session on general nutrition led by a registered dietitian and received two nutrition education mailings. Improvements in HEI-2005 scores were higher in the NRF group versus the control group (NRF group HEI-2005 total score change: 5.0, 9.3%, Control group HEI-2005 total score change: 2.0, 3.6%; $p = 0.039$). Analysis of change in HEI-2005 component scores revealed significant increases within the NRF group for the total fruit, whole fruit, whole grains, saturated fat, and energy from solid fats, alcohol, and added sugars HEI-2005 component scores; however, the only significant difference between the NRF and control groups was found for the saturated fat component score (NRF: 0.732, Control: -0.364; $p = 0.033$) (Glanz et al 2012).

Changes in diet quality were assessed in post-menopausal 55-65 year old Greek women enrolled in a 5-month nutrition intervention (Manios et al 2007). Participants enrolled in the intervention group received education every 2 weeks designed to focus on increasing awareness of health issues, osteoporosis, and increasing self-efficacy in engaging in healthy lifestyle behaviors and following healthy dietary patterns (Manios et al 2007). The intervention group had significant increases for the milk and fat HEI component scores versus the control group, and although both groups exhibited a decrease in total HEI and grain component scores the decrease was lower in the intervention group versus the control group (Manios et al 2007). Although total HEI scores decreased in both groups this is suggested to be due to a decrease in meat component scores, thus lowering total HEI score. These findings are suggested to be a result of follow-up testing occurring during the fasting period of Easter, which is a time when many Greek middle-aged women are refraining from consuming meats (Manios et al 2007).

Carpenter et al (2004) assessed diet quality in men and women aged 29-71 years enrolled in a 6-month cognitive and behavioral skills building intervention. Modified healthy eating

index scores (MHEI) were calculated with 9 of the 10 original components of the HEI. The HEI variety component score was excluded from analysis, resulting in a MHEI score with a range of 0-90 points (Carpenter et al 2004). Participants were randomized to one of three groups: usual care (UC), weekly meeting (WM), and correspondent (CR) groups. All groups received The American Dietetic Association's Complete Food and Nutrition Guide and instructed to contact staff if needed. In addition the WM group met weekly for 16 weeks and biweekly for 8 weeks with study staff and the CR group received educational mailing biweekly, weekly emails from study staff, and had access to a website for weekly online chats, posting questions, and obtaining information on recipes and restaurant reviews (Campbell et al 2004). The WM group significantly improved total MHEI scores by 7.65 (95% CI: 3.8-11.5) points, fruit by 2.2 (95% CI: 1.22-3.18) points, total fat by 2.0 points (95% CI: 0.68-3.23), cholesterol by 1.1 (95% CI: 0.01-2.22) points, and sodium by 1.2 (95% CI: 0.17-2.2) points. The CR group significantly increased sodium scores by 1.4 (95% CI: 0.41-2.32) points, but there were no significant improvements in total or component scores for participants enrolled in the UC group (Campbell et al 2004). The WM group had significantly higher increases in total MHEI scores versus the CR group and the UC group (WM: 7.6, CR: 2.27, UC: -1.23; WM vs. UC $p = 0.002$; WM vs. CR $p = 0.04$). Increases in total fruit component scores were higher in WM versus CR and UC groups (WM: 2.2, CR: -0.18, UC: -0.54; WM vs. UC $p = 0.0001$; WM vs. CR $p = 0.0006$). The WM group significantly increased saturated fat versus the UC group (WM: 1.24, UC: -0.59; $p = 0.04$). No significant differences were found between the CR in UC groups in MHEI total and component scores change (Campbell et al 2004). Future research is warranted to determine the influence of intentional weight loss interventions, which include diet and physical activity, on diet quality in postmenopausal middle-aged and older adult women.

Healthy eating index and physical activity

Although not a main focus of this dissertation, a short review of the limited research on the relationship of diet quality, as measured by the Healthy Eating Index, and physical activity, physical function, and disability follows. A review by Pearson & Biddle (2011) examined the relationship of sedentary behavior, defined as very low levels of energy expenditure through sitting and lying, and dietary intake. In this review, data from mostly cross-sectional studies reveals that sedentary behavior was associated with unhealthy dietary behaviors in children, adolescents, and adults. In adults, sedentary behavior was associated with consumption of energy-dense snacks in 4 of 4 samples, fast food in 3 of 3 samples, and energy-dense drinks in 2 of 2 samples. Sedentary behavior was positively associated with total energy intake in 5 of 7 samples, percent energy from fat in 1 of 4 samples, and total fat in 3 of 4 samples and inversely associated with intake of dietary fiber in 3 of 3 samples (Pearson & Biddle 2011).

Loprinzi, Smit, & Mahoney (2014) evaluated the relationship of physical activity with dietary behavior and health using NHANES data from 2003-2006. In this sample, participants who met physical activity guidelines of 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity or a combination of the two per week, were more likely to consume a healthy diet, defined as at or above 60th percentile for HEI-2005 scores. Participants were 32% more likely to consume a healthy diet if they met physical activity guidelines after controlling for age, sex, BMI, PIR (poverty to income ratio), cotinine level (a marker of active or passive smoking), and comorbidities ($p = 0.004$).

Xu et al (2012) examined the relationship of HEI-2005 total scores with physical function using 1999-02 NHANES data. Participants were categorized in quartiles based on HEI-2005 total scores with quartile 1 representing those with lowest HEI-2005 total scores and

quartile 4 representing those with highest HEI-2005 total scores. HEI-2005 total scores were positively related to gait speed ($p = 0.03$) and knee extensor power ($p = 0.05$) after controlling for age, gender, race/ethnicity, education, and smoking status, cognitive function, comorbidities, BMI, and medication use, but these relationships were no longer significant after controlling for physical activity (Xu et al 2012). Older adults with high HEI-2005 total score (quartiles 3 and 4) had faster gait speed versus those with lowest HEI-2005 total scores (quartile 1) ($p = 0.03$), and older adults in quartile 4 had greater knee extensor power versus those in quartile 1 ($p = 0.04$).

Individuals who met recommendations for total fruit, whole fruit, and dark green and orange vegetables and legumes had faster gait speed and those who met recommendations for total fruit and whole fruit had greater knee extensor power versus those who did not meet recommendations after controlling for age, gender, race/ethnicity, education, and smoking status (Xu et al 2012). After further controlling for number of comorbidities, medications, cognitive function, and BMI (gait speed only), participants meeting the recommendations for dark green and orange vegetables and legumes had faster gait speed and those meeting recommendations for total fruit and whole fruit had greater knee extensor power versus those who did not meet recommendations for these HEI-2005 component scores (Xu et al 2012).

Xu et al (2011) examined the relationship of HEI-2005 scores and self-reported disability in adults 60 years of older in the NHANES 1999-2004 survey. Older adults with higher HEI-2005 total scores were less likely to experience difficulty with lower extremity mobility disability (walking a quarter of a mile and walking up 10 steps; $p = 0.001$) and difficulty with general physical activities (stooping, crouching, kneeling, lifting or carrying, standing up from an armless chair, standing for long periods, sitting for long periods, reaching up over head, and grasping/holding small objects; $p < 0.001$) after adjusting for age, gender, race/ethnicity,

education, smoking status, marital status, availability of emotional help, availability of financial help, ≥ 2 people living in a household, and ≥ 5 close friends versus those with lower HEI-2005 total scores. Older adults with higher HEI-2005 total scores (quartiles 2, 3, and 4) were less likely to report difficulties with instrumental activities of daily living (IADLs) ($p = 0.051$). Participants meeting recommendations for total fruit, whole fruit, and dark green and orange vegetables and legumes reported fewer difficulties with instrumental activities of daily living (managing money, household chores, and preparing meals). Participants meeting recommendations for total fruit, whole fruit, and solid fats and added sugars were less likely to report difficulties with lower extremity mobility and general physical activities. Research is warranted to determine the relationship of physical activity, physical function, and disability with diet quality

CHAPTER III

CHANGES IN SATISFACTION WITH LIFE ARE ASSOCIATED WITH MEETING
WEIGHT LOSS GOALS AMONG POST-MENOPAUSAL MIDDLE-AGED AND OLDER
WOMEN FOLLOWING INTENTIONAL WEIGHT LOSS

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Abstract

Background: Older women are one of the few subgroups of the population in which the prevalence of obesity is still increasing; therefore, research is warranted to determine effective methods for and predictors of intentional weight loss in this population. Older adults may be more successful at achieving weight loss than younger adults. Psychological factors such as low satisfaction with life and low vitality have been associated with increased body weight, and self-motivation has been associated with weight loss. This study examines the relationship of age, and change in self-motivation, vitality, and satisfaction with life with intentional weight loss.

Methods: Eighty middle-aged and older women completed a 6-month weight loss intervention. Women 65-80 years were randomized to follow a higher protein or conventional protein diet (30% and 18% energy, respectively) and with or without exercise, and women 50-64 years of age followed an energy restricted higher protein diet (30% energy) with exercise. Assessments of diet (3-day diet records), self-motivation (Self-Motivation Inventory; SMI), satisfaction with life (Satisfaction with Life Scale; SWLS), and vitality (SF-36) were completed at baseline and 6-months. *Results:* Average weight loss was $9.3 \pm 4.8\%$ of initial body weight, and 44% of participants achieved 10% weight loss. In regression analysis, weight loss did not significantly differ among treatment groups that differed in protein or exercise. Older age was negatively associated with weight loss, but this relationship was no longer significant when age was a continuous variable. Change in self-motivation, vitality, and satisfaction with life were not related to percent weight loss, while an increase in satisfaction with life was associated with achieving 10% weight loss. *Conclusion:* Participants were successful at achieving weight loss, but the relationship of age with weight loss was not consistent. Additional research is warranted

to determine the causal pathway of the relationship of increased satisfaction with life with weight loss, as well as the association of age with successful weight loss.

Introduction

The prevalence of obesity in the United States was estimated at 34.9% in 2011-2012, and older women are one of the few subgroups of the population in which the prevalence of obesity is still increasing (Ogden et al 2014). Research suggests that intentional weight loss interventions in older adults are effective in facilitating weight loss, improving physical function, and fostering favorable changes in health and quality of life (Felix & West 2013; Johnson 2013; Porter Starr, McDonald, & Bales 2014). Higher protein diets with protein intake of ~ 1.2 - 1.6 g/kg body weight have been effective in facilitating weight loss and loss of fat mass, while preserving lean mass (Leidy et al 2015). Mojtahedi et al (2011) examined the effects of a higher protein diet in older women undergoing intentional weight loss, and found that higher protein diets helped maintain muscle mass, which improved physical function. Given the prevalence of obesity in the United States, research is warranted to determine safe and effective methods to facilitate intentional weight loss.

Some research suggests older adults may be more successful with weight loss compared to middle-aged adults. Older adult participants enrolled in the Diabetes Prevention Program experienced greater weight loss and reduction in waist circumference and had a higher percentage of participants achieving weight loss goals compared to middle-aged adult and young adult participants (The Diabetes Prevention Program Research Group 2006). Older adult participants in the Look AHEAD study experienced higher amounts of weight loss and higher treatment adherence at 1 year compared to middle-aged participants (Wadden et al 2009).

Intentional weight loss is associated with psychological benefits including improvements in self-esteem, body image, and health-related quality of life (Lasikiewicz, Myrissa, Hoyland, & Lawton 2014). Self-motivation, defined as a behavioral tendency to persevere independent of

situational reinforcements, has been identified as a predictor of weight loss (Teixeira et al 2002; Teixeira et al 2004a; Teixeira et al 2004b; Teixeira, Going, Sardinha, & Lohman 2005). Feelings of fatigue, or low energy (vitality), and low levels of life satisfaction have been associated with higher body weight (Korkeila et al 1998; Resnick et al 2006; Strine et al 2008; Valentine et al 2009; Wadsworth & Pendergrast 2014). Identifying predictors of successful weight loss has been cited as an important area of research to better understand the needs of individuals engaging in weight loss (National Institutes of Health National Heart, Lung, and Blood Institute 2000; Teixeira et al 2005). Thus, research is warranted to determine the relationship of psychological factors with intentional weight loss in middle-aged and older adult women.

The purpose of this study was to determine the relationship of age and changes in self-motivation, vitality, and satisfaction with life on intentional weight loss and the likelihood of achieving weight loss goals (10% weight loss) in post-menopausal middle-aged and older adult women enrolled in a 6-month weight loss intervention following a conventional protein (~18% energy) or higher protein diet (~30% energy) and with or without exercise. We hypothesized that older age and increased self-motivation, satisfaction with life, and vitality are related to higher loss of body weight and increased likelihood of achieving weight loss goals.

Methods

This section was written in collaboration with Alison C. Berg, and was adapted from her dissertation (Berg 2015).

Participants

Female participants aged 50-64 years of age (n = 25) and 65-80 years (n = 75) were recruited from the community in and surrounding Athens, Georgia through word of mouth,

flyers, email to listservs, and paid newspaper advertisement. Inclusion criteria included having a BMI of $\geq 25 \text{ kg/m}^2$, weight stable (within 2 kg) for 6 months, postmenopausal status (self-reported and defined as the absence of a menstrual cycle within the past 12 months), sedentary (less than 1 hour/week of planned physical activity and a sedentary job), and physician clearance. Exclusion criteria included tobacco use, normal weight, dietary restrictions that do not allow for beef consumption, weight loss surgery and/or current weight loss medication usage, history of and/or current balance disorders, cancer treatment within the last 5 years or active cancer, recent history or current unstable cardiovascular disease, history of lung disease, mini-mental state exam score less than 25, and any medical condition that precludes ability to exercise at levels specified by the study. In addition, participation of women aged 50-64 years of age was limited to women of Caucasian race due to the evaluation of DNA methylation in this age group in the parent study and limited resources, which prevent the evaluation of more than one racial group.

Participants 65-80 years of age were randomized to one of three treatment groups: higher protein diet with exercise (HP+EX 65-80), higher protein diet without exercise (HP 65-80), or conventional protein with exercise (CP+EX 65-80). All participants 50-64 years of age were assigned to follow a higher protein diet with exercise intervention (HP+EX 50-64).

Measurements

Demographics

Self-reported demographic information such as age, income, race, and education was assessed by interviewers by telephone (participants 65-80 years) and online screening (50-64 years) and subsequently confirmed during in-person screening visits (all participants).

Health history

History of chronic conditions including cardiovascular disease, hypertension, pulmonary disease, arthritis, diabetes, cancer, and thyroid disorder were assessed by self-report. Self-report of cancer was assessed by asking, “Have you been diagnosed with any kind of cancer? If so, please explain.” Self-report of thyroid disorder was assessed by asking, “Do you have hyper or hypothyroidism? If so, please explain.”

Anthropometrics

Body weight was measured to the nearest 0.1 pound or kg with a digital scale, while participants were barefoot and wearing light clothing. Barefoot height was measured to the nearest 0.1 cm with a stadiometer. Waist circumference at the natural waist was measured 3 times with a tape measure by trained research assistants. Body mass index (BMI) (kg/m^2) was calculated from body weight and height from baseline and post-intervention measurements. Whole body fat mass was measured with dual-energy-X-ray absorptiometry (DXA) (GE Lunar-iDXATM, encore 2007, version 11.30.062, Madison, WI). All measurements were taken at baseline, midpoint (3-months), and post-intervention (6-months). For this analysis only baseline and post-intervention measurements will be discussed.

Psychological outcomes

Psychological variables were assessed at baseline, mid-point (3-months), and post-intervention (6-months). Self-motivation was assessed by the self-motivation inventory (SMI), a 40-item scale (range 40-200) designed to measure self-motivation, defined as a behavioral tendency to persevere independent of situational reinforcements (Dishman & Ickes 1980). Satisfaction with life was assessed by the Satisfaction with Life Scale (SWLS), a 5-item scale (range 5-35) designed to measure global life satisfaction. Vitality was assessed with the SF-36

vitality scale, a 4-item scale (range 0-100). Low scores reflect feeling tired and worn out all the time, while high scores indicate feeling full of people and energy all the time (Ware, Kosinski, & Gandek 2005). Psychological variables used as control variables in linear and logistic regression analyses included cognitive restraint measured with the cognitive restraint subscale of the Three Factor Eating Questionnaire (TFEQ; range 0-21) (Stunkard & Messick 1985). Hours of sleep within the past month was assessed by 1 item of the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al 1989).

Dietary assessment

Participants completed 3-day diet records reflecting 2 weekdays and 1 weekend day at baseline and post-intervention testing visits. Participants were given a National Science Foundation (NSF) certified digital food service scale (Escali 136 KP Alimento Pro, Burnsville, MN), and were asked to weigh their food. Participants were provided instruction on how to zero the scale, subtract the weight of plates, and to note whether weight was measured before or after cooking. Participants were asked to use measuring cups and spoons, and were provided a reference sheet with portion sizes when measuring utensils were unavailable. Diet records were reviewed by research dietitians or trained interviewers for clarification, and to allow participants to recall forgotten foods and/or provide details about food and beverages consumed. Diet records were analyzed to provide estimates of energy, macronutrients, micronutrients, and selected food groups, e.g., beef, using the 2013 version of the University of Minnesota's Nutrition Data System for Research (NDSR).

Dietary intervention

Participants randomized to the higher protein diet were advised to follow a diet consisting of 30% energy from protein, 30% energy from fat, and 40% energy from carbohydrates, while

participants in the conventional protein group were advised to follow a diet consisting of 18% energy from protein, 52% energy from carbohydrate, and 30% energy from fat. Participants randomized to the higher protein diet were instructed to consume 3-3.5 ounces of lean beef daily. Lean beef was defined as cuts with less than or equal to 4.5 g saturated fat, less than 10 g total fat, and less than 95 mg cholesterol per 3.5 oz. serving. Participants were instructed on how to choose cuts of lean beef, and were provided with resources from the National Cattlemen's Beef Association, such as information on choosing lean beef cuts, cooking with lean beef, and the nutritional content of lean beef, and participants had access to a lean beef cookbook. Participants were instructed to complete daily beef compliance logs in which they noted amount of beef consumed, cut of beef, and cooking method.

Participants were provided with a multivitamin mineral supplement formulated for older women to ensure adequate intake of micronutrients throughout the intervention (Centrum® Silver® Women, Pfizer, Inc., Madison, NJ) that provided 800 IU of vitamin D (RDA for women 51—70 years is 600 IU or 15 mcg, for women ≥ 71 years is 800 IU or 20 mcg/d), 500 mg of calcium (RDA for women >50 years is 1200 mg), and more than 100% of the RDA for several nutrients, including vitamin C (RDA for women >50 years is 75mg). Additional calcium supplements (Regular Strength TUMS®, 200 mg elemental calcium, Glaxo Smith Kline, St. Louis, MO) were recommended individually to meet the RDA (1,200 mg/d) based on individual intake of calcium-rich foods. Additional calcium supplementation was based on the following method: TUMS per day rounded to nearest 0.5 tablet = $[1200 \text{ mg (RDA for calcium for older women)} - 500 \text{ mg (Centrum® Silver® Women)} - 300 \text{ mg (approximate dietary calcium from non-dairy sources)} - (\text{daily servings dairy food} \times 300 \text{ mg/serving})] \div 200 \text{ mg Ca/TUMS}$.

Participants were instructed to indicate their usage of supplements on paper logs, and use of supplements was confirmed by interventionists at visits.

Participants met individually with a research dietitian (RDN) or nutrition graduate student under the supervision of the RDN individually for a minimum of 2 visits, and were presented with individual diet goals based on a 500 kcal/day energy reduction for weight loss (Mifflin St. Jeor equation using baseline height and body weight; activity factor 1.3) (Seagle et al 2009). No additional adjustments were made to account for energy expended during physical activity, and the minimum energy intake goal assigned to participants was 1,200 kcal. Participants were monitored by the RDN throughout the intervention, and energy goals were adjusted to in order to meet weight loss goals of 0.23 kg (0.5 pounds) to 0.91 kg (2 pounds) per week. Presence of nutrition-related conditions, such as lactose intolerance, was assessed during individual nutrition visits. One participant reported lactose intolerance with milk protein allergy, and was advised to consume non-dairy sources of protein such as meats and vegetable proteins and non-dairy milk such as soy milk and almond milk with protein powder for additional protein. One participant reported lactose intolerance without milk protein allergy, and reported being able to consume cheese, yogurt, and fluid milk in small amounts. For the remainder of the 6-month intervention all participants attended weekly 45-60 minute group education/motivational sessions led by the RDN or supervised graduate student, and met individually with the RDN as needed to meet weight loss goals. Weekly nutrition education meetings provided information on general nutrition (e.g., protein, fiber, carbohydrates, whole grains, fruits and vegetables) as well as information on other nutrition-related topics such as bone health, heart health, healthy eating while away from home, food safety, and mindful eating. A list of group nutrition education topics is included in Appendix F. Weekly education topics were based on the 2010 Dietary

Guidelines for Americans (USDA & USDHHS 2010) and were derived from both the research team to support the research goals, as well as from the participants ensuring the topics addressed their concerns about a range of nutrition-related issues. Nutrition education lessons on general nutrition topics included information describing each food group and/or nutrient (e.g., the definition of a whole grain and food sources of whole grains), benefits of consumption of each food group and/or nutrient, as well as tips to help increase and/or decrease each food group or nutrient to improve diet quality (e.g., add berries to your morning yogurt to increase consumption of fruit and choose low-sodium varieties of canned vegetables to decrease sodium consumption).

Participants were instructed to record intake of all foods and beverages, except water, in a free online monitoring tool, MyFitnessPal. The registered dietitian or supervised nutrition graduate student provided instructions and assisted in the use of this application, and ensured participant's MyFitnessPal accounts accurately reflected each participant's assigned macronutrient composition (higher protein vs. conventional protein) and energy needs. MyFitnessPal accounts were reviewed weekly by a registered dietitian or supervised graduate student, and participants were given individual feedback weekly. Weekly individual feedback was provided to assist participants in meeting energy and/or macronutrient goals, increase intake of nutritionally beneficial food groups and nutrients such fruits, vegetables, and/or whole grains, limit intake of foods that should be consumed in moderation such as desserts and sugar sweetened beverages, and assist participants in choosing food entries in MyFitnessPal that best represent their actual intake. Most participants were able to access MyFitnessPal accounts online through personal computers, smart phones, and/or tablets, while one person chose to use a computer at the public library. When participants were unable to access MyFitnessPal accounts,

such as when participants were travelling and did not have access to the internet, paper food diaries or food logs with the exchange system were used to record food and beverage intake.

Group nutrition education attendance

Number of group nutrition education sessions attended was calculated as the sum of group nutrition education classes each participant attended during the 6 month weight loss intervention. Attendance for individual nutrition counseling sessions was not included. Three participants were missing data for group nutrition attendance, so the mean value for group nutrition education attendance was used for these participants (mean = 14). Attendance data were used primarily for record keeping and follow-up; therefore, some measurement error is likely.

Exercise intervention

Participants randomized to exercise attended 3 (~75 minute) exercise sessions weekly on non-consecutive days. Exercise sessions were conducted by trained graduate students in the University of Georgia, Department of Kinesiology, and consisted of cardiorespiratory training, resistance training, balance, flexibility, and functional exercises. Participants randomized to higher protein and no exercise (HP 65-80) were instructed to maintain their current activity levels (<1 hour/week of physical activity or less than 2 exercise sessions per week as specified by inclusion criteria). Exercise sessions consisted of 30 minutes of continuous cardiorespiratory activity (walking on a treadmill, cycling, or elliptical) at 70-80% of age-predicted maximal heart rate and resistance training focusing on upper body, lower body, and abdominal exercises of 2 sets of 8-10 repetitions at 65% of four-repetition maximum. Additionally, 10-15 minutes of flexibility and balance exercises and two 30-second sets of functional exercises (chair rises, wall push-ups, lift-and-carry, and transfer task) were included in each exercise session.

Statistical analysis

All statistical analyses were performed using SAS version 9.4 Cary, NC. Baseline differences among groups were analyzed with ANOVA and Kruskal Wallis tests for non-normally distributed variables. Chi-square or Fisher's exact tests, when cell size was less than 5, were used to analyze baseline differences among groups for categorical variables. Baseline differences between completers and non-completers of the 6-month intervention were assessed with independent sample t-tests or Wilcoxon-Mann-Whitney tests for non-normally distributed variables, and by Chi-square and Fisher's exact tests for categorical variables. Within group changes were analyzed with paired t-tests and Wilcoxon signed rank sum tests for non-normally distributed variables. Planned comparisons were used to determine differences in the change in adiposity variables, psychological variables, and dietary variables among treatment groups. Three contrasts were tested: higher protein vs. conventional protein (HP vs. CP), exercise intervention vs. no exercise intervention (EX. vs. No EX.), and older vs. middle-aged participants (65-80 vs. 50-64). Percent weight loss was dichotomized to distinguish between participants who achieved and did not to achieve at least 10% weight loss. We chose to categorize participants based on achievement of 10% weight loss because this goal is consistent with recommendations for weight loss interventions, is associated with health benefits, was close to the median split for percent weight change (-9.4%) among completers of the weight loss intervention, and was the weight loss goal for participants enrolled in the weight loss intervention (NIH 1998; Seagle et al 2009). Differences between those who achieved and did not achieve 10% weight loss were determined by independent sample t-tests and Wilcoxon-Mann-Whitney tests for non-normally distributed variables and Chi-square or Fisher's exact test for categorical variables. Linear regression analysis predicting weight change and logistic

regression predicting achieving 10% weight loss were conducted to determine the independent and predictive association of psychological variables and age, while controlling for relevant variables determined by regression analysis and the findings of Berg (2015). For both linear and logistic regression analyses, relevant control variables (baseline energy intake expressed as a percentage of calculated energy needs, change in energy intake from baseline to post-intervention, number of hours of sleep in the past month at baseline, cognitive restraint at post-intervention, treatment group assignment: age group (0 = 50- 64 years, 1 = 65-80 years), protein group (0 = not randomized to higher protein diet, 1 = randomized to higher protein diet), and exercise group (0 = not randomized to exercise intervention, 1 = randomized to exercise intervention), and group nutrition education attendance were entered in model 1. In models 2-4, change in psychological variables of interest (model 2: vitality, model 3: self-motivation, model 4: satisfaction with life) were entered separately along with control variables included in model 1.

Results

Eighty participants completed the 6-month intervention, and attrition was 14% (n = 13). Of the 13 participants who withdrew from the intervention, 7 were non-compliant with study protocol, 3 withdrew for non-study related illness and/or injury, and 3 withdrew because of time constraints. At baseline, 1 participant failed to answer 1 question on the SMI, and values for this question were imputed by substituting the missing value with the average of the remaining SMI questions at baseline. Group nutrition education attendance data were missing for 3 participants, and the mean was imputed for these participants (mean = 14). One participant was excluded from these analyses due to missing anthropometric data at 6-months. Three participants were excluded from analyses involving waist circumference due to measurement error.

Baseline characteristics of participants who completed the 6-month intervention (n = 79) are shown in Table 3.1. Baseline characteristics of participants were similar among groups with the exception of age, work status, marital status, and self-report of diabetes and total medical conditions. As expected, participants in the HP+EX 50-64 group were younger than participants in the HP+EX 65-80, HP 65-80, and CP+EX 65-80 groups. Compared to the other groups the HP+EX 50-64 group was most likely to be working full-time and the CP+EX 65-80 group was least likely to be working full-time, while the HP+EX 65-80 group was most likely to be working part-time and the HP+EX 50-64 group was least likely to be working part-time. Compared to other groups the HP 65-80 group was most likely to not be currently working, while the HP+EX 50-64 group was least likely to not be currently working. The CP+EX 65-80 group was most likely to be currently married and the HP+EX 65-80 group was least likely to be currently married. Compared to other groups the PRO 65-80 group was most likely to self-report having diabetes, while the CP+EX 65-80 and HP+EX 50-64 groups were least likely to self-report having diabetes. Mean total medical conditions were higher in the HP 65-80 group versus the CP+EX 65-80 and HP+EX 50-64 groups.

Table 3.2 shows change in adiposity, psychological, and dietary variables. Overall, participants lost an average $-9.3 \pm 4.8\%$ initial body weight, and 44% met the 10% weight loss goal with no significant differences in total weight loss or in achieving 10% weight loss found between treatment groups. Within the overall sample and within each treatment group, statistically significant reductions in BMI, percent body fat, and waist circumference were found. A significantly higher reduction in waist circumference was found in middle-aged (50-64 years) versus older aged (65-80 years) participants.

No significant changes from baseline to post-intervention were detected for self-motivation. Satisfaction with life significantly increased within the overall sample and within the HP+EX 50-64 group. Vitality significantly increased within the overall sample and within treatment groups randomized to the exercise intervention (HP+EX 65-80, HP+EX 50-64, CP+EX 65-80). Planned comparisons indicated a significant difference in change in vitality for participants randomized to exercise vs. participants not randomized to exercise. Planned comparisons among treatment groups indicated older women attended more group nutrition education classes versus middle-aged women. Analysis of completers versus non-completers of the intervention indicated that completers of the 6-month intervention had higher baseline vitality scores (completers: 55.8 ± 14.3 , non-completers: 40.4 ± 18.7 ; $p < 0.001$; data not shown).

Table 3.3 shows differences among participants who achieved and did not achieve 10% weight loss. Comparisons between participants who achieved and did not achieve 10% weight loss indicated a higher reduction in BMI, percent body fat, waist circumference, percent weight loss, and a significant increase in satisfaction with life in those who achieved 10% weight loss versus those who did not achieve 10% weight loss. Participants who achieved 10% weight loss attended significantly more group nutrition education classes versus participants who did not achieve 10% weight loss. Table 3.4 shows linear regression analyses predicting percent weight change. Group nutrition education attendance was positively associated with percent weight change. The psychological variables of interest (change in SMI, SWLS, and vitality) were not significantly related to weight change in regression analyses. Older age versus middle-age was negatively associated with percent weight change (older women lost less weight). Table 3.5 shows logistic regression analyses predicting achieving 10% weight loss. Group nutrition education attendance, and change in satisfaction with life were positively associated with

achieving 10% weight loss. Older age versus middle age was negatively associated with achieving 10% weight loss. Change in self-motivation and vitality were not significantly associated with achieving 10% weight loss. All linear and logistic regression models were also conducted with age as a continuous variable (Appendix H), and when age was included in regression models as a continuous variable there was no longer a significant association of age with percent weight change (linear regression) or with achieving 10% weight loss (logistic regression). The relationship of psychological variables, protein group, exercise group, and group nutrition class attendance with percent weight change and meeting weight loss goals were not changed substantively when age was coded as a continuous variable.

Discussion

Overall participants were successful in losing weight – 9.3% weight loss and 44% lost 10% or more of initial body weight, and higher attendance at group nutrition education sessions was consistently associated with better weight loss outcomes. Self-motivation, vitality, and life satisfaction varied in their changes following the intervention and their associations with weight loss. Self-motivation did not increase and was not associated with weight loss; vitality increased significantly but was not associated with weight loss; and life satisfaction increased significantly and was associated significantly with achieving 10% weight loss. There was no relationship of protein group or exercise group with percent weight loss or achievement of 10% weight loss, however, the relationship of age with weight loss was inconsistent. Compared to the middle-age group the older group had lower percent weight loss and were less likely to achieve 10% weight loss, but weight loss was not significantly associated with age when age was evaluated as a continuous variable in the regression models. Although the middle-age group lost more waist

circumference than the older age group, we did not further evaluate waist circumference because of concerns about measurement error and missing data.

Our findings are dissimilar from some interventions evaluating the effect of age on intentional weight loss. Older adults enrolled in the Diabetes Prevention Program had higher amounts of weight loss and reductions in waist circumference and had a higher percentage of participants meeting weight loss goals versus middle-aged and younger adults. Older adult participants in the Look AHEAD study experienced higher amounts of weight loss versus middle-aged participants. Several differences among participants and treatments exist between the current study and the Diabetes Prevention Program and Look AHEAD study including their inclusion of male participants, a larger percentage of participants from racial and ethnic minority groups, larger sample size, and the intentional recruitment of participants with or at risk for diabetes. The Look AHEAD study incorporated mostly unsupervised physical activity and participants in the Diabetes Prevention Program were allowed flexibility in choosing modes of physical activity (i.e., walking, biking, etc.) to meet physical activity goals (The Look AHEAD Research Group 2003; The Diabetes Prevention Program Research Group 1999), while participants in our study engaged in supervised exercise training on the University of Georgia campus. Participants in the Diabetes Prevention Program and Look AHEAD study were given advice regarding fat intake (< 25% energy, Diabetes Prevention Program; < 30% energy and <10% energy from saturated fat, Look AHEAD Study), but were not given specific goals to increase protein intake (The Look AHEAD Research Group 2003; The Diabetes Prevention Program Research Group 1999). These differences in participant characteristics and methodology between our study and the Diabetes Prevention Program and Look AHEAD study

may contribute to differences in results regarding the association of age and weight loss in our study.

In this study, change in self-motivation, vitality, and satisfaction with life were not related to percent weight loss in regression analyses. Other researchers have found associations with low vitality and higher body weight and with self-motivation and weight loss. For example, Teixeira et al (2005) found that self-motivation consistently predicted weight loss success in a review of psychosocial pre-treatment predictors of weight loss. A cross-sectional study of participants enrolled in non-surgical or surgical weight loss programs by Anandacoomarasmy et al (2009) found that vitality scores were lower in obese participants compared to age-matched scores for the general population. Ross et al (2009) found that weight loss was a significant contributor to improvements in vitality, measured by the SF-36, in a sample of women 50-75 years of age enrolled in a six-month lifestyle obesity intervention modeled after the Diabetes Prevention Program. Weight loss interventions in which self-motivation was related to weight loss were conducted in a younger sample than our study (47.8 ± 8 years, Teixeira et al 2002; 38.3 ± 5.8 years, Teixeira et al 2004b), and required fewer visits with interventionists (1 meeting for 150 minutes per week) than our study required for participants assigned to the exercise intervention (3 exercise sessions for ~ 75 minutes and 1 individual diet counseling session or group diet class for ~ 45 -60 minutes weekly). Some evidence for a relationship of vitality and/or fatigue with higher body weight have been identified in cross-sectional studies (Anandacoomarasmy et al 2009; Valentine et al 2009), while other researchers have examined the relationship of weight loss on changes in vitality rather than the relationship of changes in vitality on weight loss and achieving weight loss goals (Ross et al 2009; Lasikiewicz et al 2014). These differences in participant age, cross-sectional vs. intervention studies, and intervention

protocols may help explain the lack of association of these psychological variables and weight loss in our study.

Following the intervention, satisfaction with life significantly improved within the overall sample, within the HP+EX 50-64 group, and among participants who achieved 10% weight loss, and an increase in satisfaction was associated significantly with achieving 10% weight loss. Strine et al (2008) found a similar relationship with life satisfaction and body weight from cross-sectional analyses of 2005 BRFSS data in which people who were dissatisfied/very dissatisfied with their life were 1.5 times more likely to be obese than participants who were very satisfied with their life. Our findings contribute to research suggesting an association with increased life satisfaction and weight loss; however, additional research is warranted to determine the causal pathway, e.g., does increased weight loss lead to increased satisfaction with life, or does increased satisfaction with life lead to weight loss. Pavot & Diener (2008) state that evaluating outcomes, such as future behaviors and life outcomes, which can be predicted by life satisfaction is an important area for future research. Given that psychological benefits, such as changes in self-esteem, depressive symptoms, and health related quality of life are associated with intentional weight loss (Lasikiewicz et al 2014), increased satisfaction with life may also result from weight loss. Judgements of life satisfaction are usually derived from the same types of information over time, and when the sources of this information change, life satisfaction often changes as well (Pavot & Diener 2008). As participants in a weight loss intervention become more physically active and/or consume healthier diets, they may become more satisfied with their lives if domains such as physical activity and diet are drawn upon when evaluating satisfaction with their own life. Perhaps participants' increased feelings of life satisfaction provide the necessary motive to engage in behaviors related to successful weight loss. The

Satisfaction with Life Scale represents a judgement of life satisfaction that is broadly based, and Pavot & Diener (2008) state that because life satisfaction judgements are broadly based, changes in life satisfaction that occur as a result of intervention are impressive. The assessment of change in global life satisfaction can be supplemented by the measurement of domain satisfaction (Pavot & Diener 2008). Future studies assessing change in body satisfaction in addition to change in life satisfaction may provide additional insight into the relationship of change in life satisfaction with intentional weight loss.

Group nutrition education attendance was positively associated with percent weight loss and achieving 10% weight loss goals. A similar relationship was found in participants in the Look AHEAD study; among participants in the intensive lifestyle intervention, there was a significant positive correlation of group and individual session attendance and weight loss at 1-year ($r = 0.31$, $p < 0.001$). Participants in the highest quartile of attendance had higher odds of achieving weight loss goals of 7% and 10% at 1-year (7% weight loss odds ratio (95% CI), 5.3 (4.0-7.0), 10% weight loss odds ratio (95% CI), 8.1 (5.7-11.5) versus those in the lowest quartile of attendance (Wadden et al 2009). In our study, participants who attended more group nutrition education classes had increased exposure to nutrition recommendations consistent with the 2010 Dietary Guidelines for Americans (USDA & DHHS 2010), and had increased contact with intervention staff and other participants in the weight loss intervention allowing for social support, which likely contributed to their weight loss success.

Vitality significantly increased in the overall sample and within groups randomized to the exercise intervention. Other researchers have found similar relationships of vitality with weight loss and physical activity. A review by Lasikiewicz et al (2014) analyzing the psychological benefits of weight loss found that vitality was likely to increase with weight loss. A study by

Martin et al (2009) found that in post-menopausal females, vitality increased with increasing physical activity, after controlling for weight change, in a sample of postmenopausal overweight or obese women enrolled in an intervention to assess the effects of engaging in physical activity at 50%, 100% and 150% of the NIH Consensus Panel physical activity recommendations. These findings contribute to the literature suggesting a positive relationship with vitality and physical activity.

Strengths and limitations

Limitations of the current study include the intensity of the weight loss intervention in which participants met at least once per week with intervention staff. This frequency of contact may not be feasible for most people attempting weight loss through commercial weight loss programs, gym memberships, and/or extensive counseling with registered dietitians. The current sample was highly educated (81% reported having a college degree) and most participants were Caucasian (96.2%). By study design all participants aged 50-64 years were Caucasian. Thus, these findings may not be generalizable to individuals with lower levels of education, lower levels of income, and/or minority populations. Due to probable measurement error, 3 participants were excluded from analyses involving waist circumference, and the potential for additional errors is likely; therefore, findings involving waist circumference should be interpreted with caution. The self-motivation inventory (SMI) has been shown to be a valid and reliable measure of a general, non-specific tendency to persevere in the absence of reinforcement (Merkle et al 2002). The SMI does not distinguish between intrinsic and extrinsic motivation. The importance of not only considering quantity, but also quality, of motivation in relation to eating behaviors and weight management has been emphasized (Teixera et al 2012; Teixeira,

Patrick, & Mata 2011). Data for group nutrition education attendance were used primarily for record keeping purposes, and some measurement error is possible.

Although the intensity of this intervention may not be feasible for most people attempting weight loss, the intensity of this intervention likely contributed to participant's success in achieving weight loss with a mean weight change of $-9.3 \pm 4.8\%$ initial body weight and 44% of participants achieving 10% weight loss. Participants were frequently monitored by interventionist staff and were able to pose questions to and receive timely feedback from intervention staff regarding diet and physical activity. Frequent visits to the intervention site allowed participants to form friendships, which provided social support during the intervention. Additionally, the use of the MyFitnessPal application provided a free and easy-to-use application for participants to self-monitor food intake and receive individual feedback from interventionists.

Conclusion

These findings show that participants were successful at losing weight, and that weight loss was similar among treatment groups that differed in protein and exercise recommendations. Older age versus middle-age was negatively associated with percent weight loss and achieving 10% weight loss goals; however, when age was coded as a continuous variable there was no longer a significant association with age and weight loss. Thus, the relationship of age with weight loss was inconsistent. Change in self-motivation, vitality, and satisfaction with life were not associated with percent weight loss, while an increase in satisfaction with life was associated with achieving 10% weight loss.

Additional research is warranted to determine the causal pathway of the relationship of increased satisfaction with life with weight loss, as well as the association of age with successful weight loss.

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Table 3.1 Baseline Characteristics of Participants Completing the 6-month Intervention						
Variable	N ¹	Overall Mean ± SD, Median [Range] or % N = 76-79 ²	HP+EX 65-80 N = 17-18 ²	HP 65-80 N = 19-20 ²	CP+EX 65-80 N = 21-22 ²	HP+EX 50-64 N = 18-19 ²
Age (y)		66.7 ± 5.8, 67 [52-77]	69.9 ± 4.3 ^A , 68 [65-77]	69.3 ± 2.4 ^A , 69 [66-73]	68.8 ± 3.9 ^A , 67.5 [65-76]	58.7 ± 3.8 ^B , 59 [52-64]
Race ⁴						
White (%)		96.2	94.4	100.0	90.9	100.0
Black (%)		1.3	0.0	0.0	4.6	0.0
Hispanic (%)		1.3	5.6	0.0	0.0	0.0
Native American (%)		3.8	0.0	5.0	9.1	0.0
Education						
At Least a HS Degree (%)		19.0	5.6	30.0	18.2	21.1
College Degree (%)		81.0	94.4	70.0	81.8	79.0
Household Income ⁴	59					
\$15,000-<\$30,000 (%)		10.2	15.4	6.3	16.7	5.6
\$30,000-<\$45,000 (%)		20.3	30.8	25.0	16.7	11.1
\$45,000-<\$60,000 (%)		15.3	23.1	12.5	8.3	16.7
\$60,000-<\$75,000 (%)		13.6	7.7	6.3	25.0	16.7
\$75,000-<\$90,000 (%)		22.0	23.1	25.0	16.7	22.2
\$90,000+ (%)		18.6	0.0	25.0	16.7	27.8
Work Status ⁴						
Currently Working Full Time (%) ⁵		25.3	5.6	10.0	4.6	84.2
Currently Working Part Time (%) ⁶		26.6	38.9	20.0	36.4	10.5
Currently Not Working (%) ⁷		48.1	55.6	70.0	59.1	5.3
Currently Married (%) ⁸		63.2	44.4	60.0	77.3	68.4
Health Conditions						
Cardiovascular Disease (%) ⁴		2.5	0.0	5.0	4.6	0.0
Hypertension (%)	77	40.3	44.4	45.0	47.6	22.2
Pulmonary Disease (%)		16.5	16.7	30.0	13.6	5.3
Arthritis (%)		50.6	44.4	70.0	54.6	31.6
Diabetes (%) ^{4,9}		6.3	5.6	20.0	0.0	0.0
Cancer (%) ⁴		17.8	22.2	30.0	13.6	5.3
Thyroid Disorder (%) ⁴		20.3	38.9	25.0	9.1	10.5
Total Medical Conditions	78	1.3 ± 1.1, 1.0 [0.0-5.0]	1.4 ± 1.1, ^{AB} 1.0 [0.0-4.0]	1.9 ± 1.0, ^A 2.0 [1.0-5.0]	1.0 ± 1.0, ^B 1.0 [0.0-3.0]	0.7 ± 1.0 ^B 1.0 [0.0-3.0]
Total Medications	78	4.0 ± 2.8, ^{AB} 4.0 [0.0-11.0]	4.0 ± 2.7, ^{AB} 4.0 [0.0-10.0]	5.5 ± 5.2, ^A 5.5 [1.0-11.0]	3.9 ± 2.6, ^{AB} 4.0 [0.0-9.0]	2.4 ± 2.8, ^B 2.0 [0.0-11.0]
Taking Psychoactive Medications (%)	78	43.6	44.4	65.0	38.1	26.3
Measures of Adiposity						
BMI		31.5 ± 5.5, 30.5 [24.7-48.4]	31.9 ± 6.6, 31.3 [25.2-47.9]	32.6 ± 4.8, 32.3 [25.0-43.4]	29.2 ± 3.2, 28.9 [24.9-39.1]	32.6 ± 6.5, 32.6 [24.7-48.4]
Body Fat (%)		48.0 ± 4.1, 47.9 [38.5-57.3]	49.2 ± 3.7, 49.3 [40.9-56.1]	49.0 ± 4.3, 48.1 [43.6-57.3]	47.2 ± 4.0, 47.2 [40.9-56.0]	47.3 ± 4.2, 47.3 [38.5-54.6]
Waist Circumference (cm)	76	94.8 ± 12.0, 93.8 [75.7-134.7]	97.1 ± 15.0, 93.6 [79.3-134.7]	96.7 ± 10.2, 97.8 [76.8-114.6]	88.9 ± 7.9, 87.3 [75.7-108.9]	97.2 ± 12.8, 94.2 [81.5-125.3]
Body Weight (kg)		83.1 ± 13.6, 81.8 [53.7-128.7]	83.4 ± 13.5, 83.1 [65.3-118.1]	85.4 ± 12.4, 84.1 [64.8-116.8]	78.1 ± 10.0, 77.2 [53.7-100.2]	86.2 ± 17.6, 83.1 [66.1-128.7]
Psychological Variables	Range					

Table 3.1 Baseline Characteristics of Participants Completing the 6-month Intervention						
Variable	N¹	Overall Mean ± SD, Median [Range] or % N = 76-79²	HP+EX 65-80 N = 17-18²	HP 65-80 N = 19-20²	CP+EX 65-80 N = 21-22²	HP+EX 50-64 N = 18-19²
Self-Motivation Inventory (SMI)	40-200	149.8 ± 18.8, 153 [111-187]	147.6 ± 16.5, 152 [119-173]	148.2 ± 18.5, 155 [111-173]	152.0 ± 16.7, 155 [120-181]	150.9 ± 23.8, 153 [113-187]
Satisfaction with Life Scale (SWLS)	5-35	27.6 ± 5.5, 29 [11-35]	28.4 ± 4.3, 30 [20-35]	26.7 ± 5.9, 28.5 [11-34]	28.4 ± 6.1, 28.5 [15-35]	26.8 ± 5.5, 29 [12-34]
Vitality	0-100	55.8 ± 14.3, 56.3 [25-87.5]	53.5 ± 14.7, 50 [25-81.3]	58.8 ± 14.0, 62.5 [31.3-75]	56.5 ± 17.0, 59.4 [25-87.5]	53.9 ± 10.7, 56.3 [21.3- 68.8]
Cognitive Restraint	0-21	10.8 ± 4.3, 11.0 [1.0- 20.0]	11.6 ± 4.0, 12.0 [4.0- 17.0]	10.4 ± 3.4, 11.0 [4.0- 16.0]	10.9 ± 4.5, 10.5 [1.0- 20.0]	10.3 ± 5.1, 11.0 [3.0- 20.0]
Sleep (hrs/d) ¹¹		7.1 ± 1.0, 7.0 [5.0-10.0]	6.9 ± 1.0, 7.0 [5.0-9.0]	7.3 ± 1.3, 7.5 [5.0-10.0]	7.1 ± 0.9, 7.0 [6.0-9.0]	7.1 ± 0.7, 7.0 [6.0-8.0]
Diet Variables						
Energy Intake (kcal)		1737 ± 456, 1678 [879- 3105]	1746 ± 542, 1680 [996- 3105]	1675 ± 398, 1577 [1103- 2503]	1679 ± 370, 1661 [879- 2384]	1859 ± 522, 1841 [1012- 2791]
Energy (% Calculated Needs) ¹²		99.0 ± 24.4, 96.9 [53.6- 170.5]	101.3 ± 32.0, 95.1 [53.6- 170.5]	95.0 ± 20.6, 93.8 [65.3- 137.5]	99.4 ± 20.1, 93.5 [57.7- 141.1]	100.6 ± 26.0, 104.4 [59.1- 158.8]

¹N = 79, unless otherwise indicated

²Range does not include participants who did not disclose income (n = 20)

³Among the four groups, means within a row with different letters are significantly different (p < 0.05)

⁴Fisher's exact test used as cell sizes less than 5

⁵Compared to the other groups the HP+EX 50-64 group was most likely to be working full-time and the CP+EX 65-80 group was least likely to be working full-time

⁶Compared to the other groups the HP+EX 65-80 group was most likely to be working part-time and the HP+EX 50-64 group was least likely to be working part-time

⁷Compared to the other groups the HP 65-80 group was most likely to not be currently working and the HP+EX 50-64 group was least likely to not be currently working

⁸Compared to the other groups the CP+EX 65-80 group was most likely to be currently married and the HP+EX 65-80 group was least likely to be married

⁹Compared to the other groups the HP 65-80 group was most likely to have diabetes, while the CP+EX 65-80 and HP+EX 50-64 groups were least likely to have diabetes

¹⁰Includes SSRI/NE, TCA, antipsychotic, benzodiazepene, anticonvulsant, and other psychoactive medications

¹¹Pittsburgh Sleep Quality Inventory hours of actual sleep per day received within the past month

¹²Energy needs determined by Mifflin-St. Jeor equation with activity factor 1.3

Table 3.2 Baseline, Post-intervention, and Change in Adiposity, Psychological Variables, Sleep, and Energy Intake and Group Nutrition Education Attendance among Completers of the 6-month Intervention

Variable	Overall Sample Mean $\pm$ SD, Median [Range], or % N = 76-79	HP+EX 65-80 Mean $\pm$ SD, Median [Range], or % N = 18	HP 65-80 Mean $\pm$ SD, Median [Range], or % N = 19-20	CP+EX 65-80 Mean $\pm$ SD, Median [Range], or % N = 21-22	HP+EX 50-64 Mean $\pm$ SD, Median [Range], or % N = 18-19	P-value for planned comparisons < ⁴		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Adiposity Variable								
BMI								
Baseline	31.5 $\pm$ 5.5, 30.5 [24.7-48.4]	31.9 $\pm$ 6.6 31.3 [25.2-47.9]	32.6 $\pm$ 4.8 32.3 [25.0-43.4]	29.2 $\pm$ 3.2 28.9 [24.9-39.1]	32.6 $\pm$ 6.5 32.6 [24.7-48.4]			
Post	28.6 $\pm$ 5.2, 27.3 [21.8-46.7]	29.3 $\pm$ 6.1, 29.0 [22.1-44.5]	29.5 $\pm$ 4.8, 28.8 [21.8-39.5]	26.3 $\pm$ 2.8, 25.6 [23.2-35.5]	29.5 $\pm$ 6.5, 27.5 [22.0-46.7]			
Change in Means	-2.9 $\pm$ 1.7, -2.9 [-8.6-0.7]***	-2.5 $\pm$ 1.4, -2.4 [4.7- - 0.009]***	-3.1 $\pm$ 2.1, -3.2 [-8.2-0.7]***	-2.9 $\pm$ 1.2, -2.9 [-5.5- -1.2]***	-3.1 $\pm$ 1.9, -2.9 [-8.6- -0.4]***	0.99	0.50	0.94
Body Fat (%)								
Baseline	48.0 $\pm$ 4.1, 47.9 [38.5-57.3]	49.2 $\pm$ 3.7, 49.3 [40.9-56.1]	49.0 $\pm$ 4.3, 48.1 [43.6-57.3]	47.2 $\pm$ 4.0, 47.2 [40.9-56.0]	47.3 $\pm$ 4.2, 47.3 [38.5-54.6]			
Post	43.5 $\pm$ 5.3, 43.9 [30.6-53.6]	44.8 $\pm$ 4.7, 46.4 [35.4-52.1]	45.1 $\pm$ 5.3, 44.8 [34.2-53.6]	42.5 $\pm$ 5.2, 42.7 [30.6-50.0]	41.9 $\pm$ 5.6, 42.4 [32.0-52.2]			
Change in Means	-4.6 $\pm$ 2.6, -4.4 [-10.6-2.9]***	-4.4 $\pm$ 2.3, -4.0 [-8.8- -1.0] ***	-3.9 $\pm$ 3.1, -3.2 [-10.4-2.9] ***	-4.7 $\pm$ 2.1, -4.7 [-10.6- -1.4] ***	-5.4 $\pm$ 2.6, -5.8 [-10.1-0.2] ***	0.78	0.16	0.11
Waist Circumference (cm)⁶								
Baseline	94.8 $\pm$ 12.0, 93.8 [75.7-134.7]	97.1 $\pm$ 15.0, 93.6 [79.3-134.7]	96.7 $\pm$ 10.2, 97.8 [76.8-114.6]	88.9 $\pm$ 7.9, 87.3 [75.7-108.9]	97.2 $\pm$ 12.8, 94.2 [81.5-125.3]			
Post	87.4 $\pm$ 11.1, 85.4 [66.4-121.1]	90.5 $\pm$ 13.4, 89.6 [73.2-121.1]	89.1 $\pm$ 10.8, 90.1 [66.4-106.2]	83.0 $\pm$ 8.7, 79.3 [70.5-98.5]	87.7 $\pm$ 10.7, 85.3 [76.7-113.0]			
Change in Means	-7.3 $\pm$ 4.8, -6.7 [-24.6-7.7]***	-6.6 $\pm$ 3.8, -5.4 [-13.6- - 0.1]***	-7.7 $\pm$ 6.3, -8.7 [-18.6-7.7]***	-5.9 $\pm$ 2.9, -6.4 [-10.7- - 0.6]***	-9.4 $\pm$ 5.2, -8.3 [-24.6- - 1.1]***	0.11	0.77	0.05*
Body Weight (kg)								
Baseline	83.1 $\pm$ 13.6, 81.8 [53.7-128.7]	83.4 $\pm$ 13.5, 83.1 [65.3-118.1]	85.4 $\pm$ 12.4, 84.1 [64.8-116.8]	78.1 $\pm$ 10.0 77.2 [53.7-100.2]	86.2 $\pm$ 17.6, 83.1 [66.1-128.7]			
Post	75.4 $\pm$ 13.5, 71.8 [49.8-124.1]	76.7 $\pm$ 12.9, 76.4 [61.2-109.7]	77.3 $\pm$ 12.4, 75.6 [55.4-113.9]	70.5 $\pm$ 9.4, 69.4 [49.8-91.5]	78.0 $\pm$ 17.9, 71.6 [59.2-124.1]			
Change in Means	7.7 $\pm$ 4.3, -8.0 [-22.9-1.7]***	-6.6 $\pm$ 3.6, -6.1 [-13.6 0.1]***	-8.0 $\pm$ 5.4, -8.9 [-22.0-1.7]***	-7.7 $\pm$ 2.9, -8.0 [-13.8- -3.0]***	-8.2 $\pm$ 5.0, -7.9 [-22.9- - 1.1]***	0.85	0.49	0.90
Percent Weight Change								
	-9.3 $\pm$ 4.8, -9.4 [-23.1-2.0]	-8.0 $\pm$ 4.3, -8.3 [-17.5-0.14]	-9.4 $\pm$ 6.2, -9.7 [-23.1-2.0]	-9.8 $\pm$ 3.6, -9.8 [-18.1- -4.4]	-9.7 $\pm$ 5.0, -10.0 [-20.0- -1.2]	0.53	0.87	0.61

Table 3.2 Baseline, Post-intervention, and Change in Adiposity, Psychological Variables, Sleep, and Energy Intake and Group Nutrition Education Attendance among Completers of the 6-month Intervention

Variable	Overall Sample Mean $\pm$ SD, Median [Range], or % N = 76-79	HP+EX 65-80 Mean $\pm$ SD, Median [Range], or % N = 18	HP 65-80 Mean $\pm$ SD, Median [Range], or % N = 19-20	CP+EX 65-80 Mean $\pm$ SD, Median [Range], or % N = 21-22	HP+EX 50-64 Mean $\pm$ SD, Median [Range], or % N = 18-19	P-value for planned comparisons < ⁴		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Met 10% Weight Loss Goal (%)	44.0	27.8	45.0	50.0	52.6	0.62	0.99	0.45
Psychological Variable (Range)								
Self-Motivation Inventory (40-200)								
Baseline	149.8 $\pm$ 18.8, 153.0 [111.0-186.7]	147.6 $\pm$ 16.5, 152.0 [119.0-173.0]	148.2 $\pm$ 18.5, 154.5 [111.0-173.0]	152.0 $\pm$ 16.7, 155.0 [120.0-181.0]	150.9 $\pm$ 23.8, 153.0 [113.0-186.7]			
Post	151.7 $\pm$ 20.7, 154.0 [97.0-185.0]	152.6 $\pm$ 18.7, 156.0 [119.0-183.0]	148.7 $\pm$ 21.2, 153.0 [97.0-179.0]	155.2 $\pm$ 20.4, 159.0 [103.0-185.0]	150.1 $\pm$ 23.1, 153.0 [97.0-183.0]			
Change in Means	1.9 $\pm$ 11.5, 2.0 [-29.0-32.0]	5.0 $\pm$ 11.5, 7.0 [-18.0-32.0]	0.5 $\pm$ 10.4, -1.0 [-22.0-20.0]	3.1 $\pm$ 10.4, 5.0 [-27.0-20.0]	-0.8 $\pm$ 13.7, -2.0 [-29.0-25.0]	0.60	0.53	0.24
Satisfaction with Life Scale (5-35)								
Baseline	27.6 $\pm$ 5.5, 29.0 [11.0-35.0]	28.4 $\pm$ 4.3, 30.0 [20.0-35.0]	26.7 $\pm$ 5.9, 28.5 [11.0-34.0]	28.4 $\pm$ 6.1, 28.5 [15.0-35.0]	26.8 $\pm$ 5.5, 29.0 [12.0-34.0]			
Post	29.0 $\pm$ 5.5, 30.0 [5.0-35.0]	29.8 $\pm$ 4.8, 30.5 [14.0-35.0]	27.1 $\pm$ 7.5, 29.0 [5.0-35.0]	30.2 $\pm$ 4.0, 30.0 [18.0-35.0]	28.9 $\pm$ 4.7, 30.0 [15.0-34.0]			
Change in Means	1.4 $\pm$ 4.1, 1.0 [-7.0-14.0]**	1.3 $\pm$ 4.8, 1.0 [-7.0-12.0]	0.5 $\pm$ 3.7, 0.5 [-6.0-6.0]	1.8 $\pm$ 4.5, 2.0 [-5.0-14.0]	2.1 $\pm$ 3.3, 3.0 [-4.0-8.0]*	0.61	0.24	0.45
Vitality (0-100)								
Baseline	55.8 $\pm$ 14.3, 56.3 [25.0-87.5]	53.5 $\pm$ 14.7, 50.0 [25.0-81.3]	58.8 $\pm$ 14.0, 62.5 [31.3-75.0]	56.5 $\pm$ 17.0, 59.4 [25.0-87.5]	53.9 $\pm$ 10.7, 56.3 [31.3-68.8]			
Post	68.0 $\pm$ 14.7, 75.0[31.3-100.0]	69.1 $\pm$ 13.6, 75.0 [37.5-93.8]	64.1 $\pm$ 14.5, 59.4 [43.8-87.5]	69.6 $\pm$ 17.5, 75.0 [31.3-100.0]	69.1 $\pm$ 12.8, 75.0[43.8-81.3]			
Change in Means	12.2 $\pm$ 16.4, 12.5 [-31.3-62.5]***	15.6 $\pm$ 15.0, 18.8 [-25.0-37.5]**	5.3 $\pm$ 15.5, 9.4 [-31.3-25.0]	13.1 $\pm$ 20.2, 6.3 [-18.8-62.5]**	15.1 $\pm$ 12.0, 18.8 [-6.3-37.5]***	0.81	0.04*	0.39

Table 3.2 Baseline, Post-intervention, and Change in Adiposity, Psychological Variables, Sleep, and Energy Intake and Group Nutrition Education Attendance among Completers of the 6-month Intervention

Variable	Overall Sample Mean $\pm$ SD, Median [Range], or % N = 76-79	HP+EX 65-80 Mean $\pm$ SD, Median [Range], or % N = 18	HP 65-80 Mean $\pm$ SD, Median [Range], or % N = 19-20	CP+EX 65-80 Mean $\pm$ SD, Median [Range], or % N = 21-22	HP+EX 50-64 Mean $\pm$ SD, Median [Range], or % N = 18-19	P-value for planned comparisons < ⁴		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Cognitive Restraint (0-21)								
Baseline	10.8 $\pm$ 4.3, 11.0 [1.0-20.0]	11.6 $\pm$ 4.0, 12.0 [4.0-17.0]	10.4 $\pm$ 3.4, 11.0 [4.0-16.0]	10.9 $\pm$ 4.5, 10.5 [1.0-20.0]	10.3 $\pm$ 5.1, 11.0 [3.0-20.0]			
Post	16.3 $\pm$ 2.7, 16.0 [7.0-21.0]	16.3 $\pm$ 2.4, 16.0 [12.0-21.0]	16.8 $\pm$ 2.0, 16.5 [12.0-20.0]	16.2 $\pm$ 3.0, 16.5 [9.0-20.0]	15.8 $\pm$ 3.1, 17.0 [7.0-20.0]			
Change in Means	5.5 $\pm$ 4.1, 5.0 [-3.0-17.0]***	4.8 $\pm$ 4.3, 4.5 [-3.0-17.0]**	6.4 $\pm$ 3.9, 6.0 [-1.0-15.0]***	5.3 $\pm$ 3.8, 5.0 [-1.0-12.0]***	5.5 $\pm$ 4.8, 5.0 [-3.0-13.0]***	0.84	0.28	0.99
Sleep (hrs/d)								
Baseline	7.1 $\pm$ 1.0, 7.0 [5.0-10.0]	6.9 $\pm$ 1.0, 7.0 [5.0-9.0]	7.3 $\pm$ 1.3, 7.5 [5.0-10.0]	7.1 $\pm$ 0.9, 7.0 [6.0-9.0]	7.1 $\pm$ 0.7, 7.0 [6.0-8.0]			
Post	7.1 $\pm$ 1.0, 7.0 [5.0-9.0]	6.6 $\pm$ 1.1, 6.5 [5.0-8.0]	7.4 $\pm$ 1.1, 7.0 [5.0-9.0]	7.2 $\pm$ 1.0, 7.5 [6.0-9.0]	7.2 $\pm$ 0.9, 7.0 [6.0-8.0]			
Change in Means	0.0 $\pm$ 0.9, 0.0 [-3.0-2.0]	-0.3 $\pm$ 1.1, 0.0 [-3.0-2.0]	0.1 $\pm$ 0.6, 0.0 [-1.0-1.0]	0.09 $\pm$ 1.1, 0.0 [-2.0-2.0]	0.05 $\pm$ 0.9, 0.0 [-2.0-1.0]	0.84	0.54	0.62
Diet Variable Energy Intake (kcal)								
Baseline	1736 $\pm$ 456, 1677 [879-3105]	1746 $\pm$ 542, 1680 [996-3105]	1675 $\pm$ 398, 1577 [1103-2503]	1679 $\pm$ 370, 1661 [879-2384]	1859 $\pm$ 522, 1841 [1012-2791]			
Post	1229 $\pm$ 271, 1174 [805-2184]	1271 $\pm$ 212, 1237 [1023-1836]	1182 $\pm$ 254, 1176 [805-1800]	1145 $\pm$ 196, 1134 [844-1711]	1336 $\pm$ 371, 1224 [885-2184]			
Change in Means	-508 $\pm$ 437, -488 [-2042-693]***	-476 $\pm$ 670, -422 [-2042-693]**	-493 $\pm$ 329, -480 [-1260-31]***	-534 $\pm$ 327, -572 [-1263-35]***	-523 $\pm$ 404, -656 [-1082-130]***	0.76	0.89	0.86
Group Nutrition Education Attendance								
	13.8 $\pm$ 3.6, 14.0 [4.0-22.0]	14.3 $\pm$ 2.1, 14.0 [11.0-17.0]	14.9 $\pm$ 2.6, 15.0 [7.0-20.0]	14.9 $\pm$ 2.7, 16.0 [9.0-20.0]	10.7 $\pm$ 4.8, 10.0 [4.0-22.0]	0.07	0.007	0.0001*

¹Post - Baseline may not always equal Change, because of rounding

²Within a group and within each adiposity, psychological, and diet variable the *, **, and *** refer to the statistical significance of the within group change in the variable, such that *** P < 0.001, ** P < 0.01 and * P < 0.05

³Within the planned comparisons, statistically significant differences are indicated by *

⁴Planned comparisons were assessed by ANOVA for parametric and Kruskal-Wallis for non-parametric variables except for met 10% weight loss goal, which was assessed by chi-square

⁶N = 76

Table 3.3 Baseline, Post-Intervention, and Change in Adiposity, Psychological Variables, Energy Intake, Sleep, and Age and Group Nutrition Education Attendance among Participants Who Met and Did Not Meet 10% Weight Loss Goal

Variable	≥ 10% Weight Loss Mean ± SD, Median [Range] N = 35	< 10% Weight Loss Mean ± SD, Median [Range] N = 44	P-value <
Measures of Adiposity			
BMI			
Baseline	31.0 ± 4.0, 30.8 [25-42.9]	31.9 ± 6.4, 30.0 [24.7-48.4]	0.97
Post	26.8 ± 3.3, 26.4 [21.8-34.3]	29.9 ± 6.1, 28.4 [22.4-46.7]	0.04*
Change in Means ¹	-4.2 ± 1.3, -3.8 [-2.7- -8.6]	-1.9 ± 1.1, -1.9 [0.7- -4.2]	0.0001***
Percent Body Fat			
Baseline	47.3 ± 4.2, 46.8 [38.5-56]	48.8 ± 4.0, 48.7 [40.9-57.3]	0.12
Post	41 ± 4.9, 40.8 [30.6-49.8]	45.6 ± 4.8, 45.7 [35.4-53.6]	0.0001***
Change in Means	-6.3 ± 2.2, -6.1 [-2.5- -10.6]	-3.2 ± 1.9, -3.1 [-7.3- 2.9]	0.0001***
Waist Circumference (cm)³			
Baseline	94.7 ± 10.4, 93.9 [76.8-118.5]	94.9 ± 13.3, 93.0 [75.7-134.7]	0.77
Post	85.3 ± 9.6, 82.7 [66.4-106.2]	89.3 ± 12.1, 89.5 [70.5-121.1]	0.24
Change in means	-9.3 ± 4.6, -8.9 [-24.6- -0.1]	-5.6 ± 4.3, -5.1 [-14.9-7.7]	0.0004**
Body Weight (kg)			
Baseline	81.3 ± 9.9, 81.3 [64.8-114.5]	84.5 ± 16, 82.0 [53.7-128.7]	0.54
Post	70.3 ± 7.9, 70.9 [55.4-91.6]	79.5 ± 15.6, 75.8 [49.8-124.1]	0.009**
Percent Weight Change	-13.4 ± 3.0, -12.4 [-10.0- -23.1]	-6.0 ± 3.2, -6.6 [-9.8-2.0]	0.0001***
Psychological Variable (Range)			
Self-Motivation Inventory (40-200)			
Baseline	149.3 ± 18.7, 152.0 [116.0-187.0]	150.1 ± 19.0, 154.0 [111.0-182.0]	0.75
Post	154.0 ± 19.2.0, 154.0 [115.0-185.0]	149.9 ± 21.8, 156.0 [97.0-183.0]	0.44
Change in Means	4.7 ± 11.7, 3.0 [-29.0-32.0]	-0.3 ± 11.0, -0.5 [-27.0-20.0]	0.07
Satisfaction with Life Scale (5-35)			
Baseline	27.2 ± 6.0, 28.0 [12.0-35.0]	27.9 ± 5.1, 29.0 [11.0-35.0]	0.68
Post	29.7 ± 5.1, 30.0 [13.0-35.0]	28.5 ± 5.7, 30.0 [5.0-35.0]	0.28
Change in Means	2.5 ± 4.1, 2.0 [-5.0-14.0]	0.6 ± 3.9, 0.5 [-7.0-11.0]	0.04*

Table 3.3 Baseline, Post-Intervention, and Change in Adiposity, Psychological Variables, Energy Intake, Sleep, and Age and Group Nutrition Education Attendance among Participants Who Met and Did Not Meet 10% Weight Loss Goal

Variable	≥ 10% Weight Loss Mean ± SD, Median [Range] N = 35	< 10% Weight Loss Mean ± SD, Median [Range] N = 44	P-value <
Vitality (0-100)			
Baseline	56.6 ± 15.0, 56.3 [25.0-75.0]	55.1 ± 3.8, 53.1 [31.3-87.5]	0.66
Post	70.9 ± 13.6, 75.0 [43.8-100.0]	65.6 ± 15.3, 68.8 [31.3-93.8]	0.12
Change in Means	14.3 ± 18.5, 18.8 [-31.3-62.5]	10.5 ± 14.5, 12.5 [-25.0-37.5]	0.32
Cognitive Restraint (0-21)			
Baseline	10.5 ± 4.4, 11.0 [3.0-20.0]	10.9 ± 4.1, 11.0 [1.0-17.0]	0.68
Post	16.9 ± 2.0, 17.0 [13.0-20.0]	15.8 ± 3.0, 16.0 [7.0-21.0]	0.07
Change in Means	6.4 ± 4.2, 6.0 [-3.0-15.0]	4.8 ± 4.0, 4.0 [-3.0-17.0]	0.12
Sleep (hrs/d)			
Baseline	7.3 ± 1.0, 8.0 [5.0-9.0]	6.9 ± 1.0, 7.0 [5.0-10.0]	0.23
Post	7.1 ± 1.2, 8.0 [5.0-9.0]	7.1 ± 0.9, 7.0 [5.0-9.0]	0.93
Change in Means	-0.1 ± 1.0, 0.0 [-3.0-2.0]	0.1 ± 0.9, 0.0 [-1.0-2.0]	0.42
Baseline Age (y)	66.5 ± 5.8, 67.0 [52.0-76.0]	67.0 ± 5.9, 66.5 [53.0-77.0]	0.72
Randomized to High Protein Diet (%)	69.0	75.0	0.54
Randomized to Exercise (%)	74.0	75.0	0.95
Diet Variable			
Energy Intake (kcal)			
Baseline	1697 ± 502, 1678 [879-3105]	1768 ± 419, 1678 [1028-2674]	0.43
Post	1183 ± 223, 1153 [841-1914]	1266 ± 301, 1212 [805-2184]	0.35
Change in Means ²	-514 ± 445, -467 [-2041-401]	-503 ± 436, -489 [-1542- -489]	0.94
Baseline Energy Intake (% Needs)²	97.7 ± 26.9, 96.9 [56.0-170.5]	100.0 ± 23.0, 96.3 [53.6-154.5]	0.55
Group Nutrition Education Attendance	15.0 ± 3.1, 15.0 [7.0-22.0]	12.8 ± 3.7, 14.0 [4.0-17.0]	0.008**

1. Post – Baseline may not always equal Change, because of rounding

2. Reported energy intake (average caloric intake per day) as a percentage of energy needs for weight maintenance; % energy needs = baseline kcal/d ÷ estimated energy needs: [(10*body weight (kg)) + (6.25*height (cm)) – (5*age(y) - 161)] × [activity factor, 1.3]

3. N = 76

*** P < 0.001, ** P < 0.01 and * P < 0.05

Table 3.4 Relationships of Vitality, Self-Motivation, and Satisfaction with Life with Percent Weight Change

Variable	Regression coefficient (b)	Standard error	t	P-Value <	Model R ² (Adjusted R ²)
Model 1 – Control Variables					0.28 (0.20) ^{10**}
Intercept	0.2	6.3	0.04	0.98	
Baseline Energy Intake (% needs) ¹	0.06	0.03	1.74	0.10	
Change in Energy Intake (kcal/d) ²	0.003	0.002	1.67	0.10	
Baseline Sleep ³	-0.8	0.5	-1.53	0.14	
Post-intervention Cognitive Restraint ⁴	-0.3	0.2	-1.75	0.08	
Age group ⁵	3.2	1.6	2.08	0.05	
Protein group ⁶	1.2	1.4	0.84	0.42	
Exercise group ⁷	0.3	1.4	0.21	0.85	
Group Nutrition Education Attendance	-0.5	0.2	-2.82	0.007**	
Model 2 – Vitality⁸					0.29 (0.18) ^{10**}
Intercept	0.8	6.7	0.12	0.91	
Baseline Vitality	-0.01	0.04	-0.25	0.81	
Change Vitality	-0.03	0.04	-0.82	0.42	
Model 3 – Self-Motivation Inventory⁸					0.28 (0.17)** ¹⁰
Intercept	0.26	7.3	0.04	0.98	
Baseline Self-Motivation Inventory	-0.001	0.03	-0.03	0.98	
Change Self-Motivation Inventory	-0.03	0.05	-0.07	0.94	
Model 4 – Satisfaction with Life Scale⁸					0.30 (0.20)** ¹⁰
Intercept	-1.0	7.0	-0.2	0.89	
Baseline Satisfaction with Life Scale	0.1	0.1	0.97	0.35	
Change Satisfaction with Life Scale	-0.1	0.1	-0.72	0.49	

1. Reported energy intake (average caloric intake per day) as a percentage of energy needs for weight maintenance; % energy needs = baseline kcal/d ÷ estimated energy needs: $[(10 \times \text{body weight (kg)}) + (6.25 \times \text{height (cm)}) - (5 \times \text{age(y)} - 161)] \times [\text{activity factor}, 1.3]$
 2. Change in energy intake (kcal/d) from baseline to post-intervention
 3. Baseline Pittsburgh Sleep Quality Inventory hours of sleep in the past month
 4. Post-intervention from the Three Factor Eating Questionnaire
 5. Coded as 0 = 50-64 years; 1 = 65-80 years
 6. Coded as 0 = randomized to conventional protein; 1 = randomized to higher protein
 7. Coded as 0 = not randomized to exercise intervention; 1 = randomized to exercise intervention
 8. Controlled for all variables in model 1
 9. N = 79
 10. All models have significant F-values at $P < 0.05$
- *** $P < 0.001$, ** $P < 0.01$ and * $P < 0.05$

Table 3.5 Association of Vitality, Self-Motivation, and Satisfaction with Life with Meeting 10% Weight Loss Goal

Variable	Odds Ratio (95% CI)
Model 1 - Control Variables	Model Likelihood Ratio Chi-Square P < 0.03*
Baseline Energy Intake (% needs) ¹	0.99 (0.96-1.04)
Change in Energy Intake (kcal/d) ²	1.00 (0.99-1.002)
Baseline Sleep ³	1.12 (0.66-1.88)
Post-intervention Cognitive Restraint ⁴	1.15 (0.93-1.43)
Age Group ⁵	0.09 (0.01-0.59)*
Protein Group ⁶	0.43 (0.10-1.81)
Exercise Group ⁷	0.59 (0.13-2.64)
Group Nutrition Education Attendance	1.35 (1.09-1.67)**
Model 2 - Vitality⁸	Model Likelihood Ratio Chi-Square P < 0.05*
Baseline Vitality	1.01 (0.98-1.06)
Vitality Change	1.02 (0.98-1.06)
Model 3 - Self-Motivation Inventory⁸	Model Likelihood Ratio Chi-Square P < 0.03*
Baseline Self-Motivation Inventory	0.99 (0.95-1.02)
Change Self-Motivation Inventory	1.04 (0.99-1.10)
Model 4 - Satisfaction with Life Scale⁸	Model Likelihood Ratio Chi-Square P < 0.001**
Baseline Satisfaction with Life Scale	1.00 (0.89-1.12)
Change Satisfaction with Life Scale	1.29 (1.08-1.55)**

1. Reported energy intake (average caloric intake per day) as a percentage of energy needs for weight maintenance; % energy needs = baseline kcal/d ÷ estimated energy needs: $[(10 \times \text{body weight (kg)}) + (6.25 \times \text{height (cm)}) - (5 \times \text{age(y)} - 161)] \times [\text{activity factor}, 1.3]$
2. Change in energy intake (kcal/d) from baseline to post-intervention
3. Baseline Pittsburgh Sleep Quality Inventory hours of sleep in the past month
4. Post-intervention Three Factor Eating Questionnaire
5. Coded as 0 = 50-64 years; 1 = 65-80 years
6. Coded as 0 = randomized to conventional protein; 1 = randomized to higher protein
7. Coded as 0 = not randomized to exercise intervention; 1 = randomized to exercise intervention
8. Controlled for all variables in model 1
9. N = 79

*** P < 0.001, ** P < 0.01 and * P < 0.05

CHAPTER IV

SELF-MOTIVATION AND AGE ARE ASSOCIATED WITH CHANGES IN DIET QUALITY AMONG POST-MENOPAUSAL MIDDLE-AGED AND OLDER WOMEN FOLLOWING INTENTIONAL WEIGHT LOSS

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Abstract

Background: Higher protein diets (~ 1.2-1.6 g/kg body weight) have shown effectiveness for producing weight loss and fat mass loss, while preserving lean mass, but little is known about the effects of following an energy restricted higher protein diet on diet quality. This study examined the effects of a diet that is energy restricted with different levels of protein intake on diet quality, assessed by the Healthy Eating Index-2010 (HEI-2010), and the relationship of age, self-motivation, life satisfaction, and vitality on diet quality. *Methods:* Eighty middle-aged and older women completed a 6-month weight loss intervention. Women 65-80 years of age were randomized to follow an energy restricted (~500 kcal/day) higher protein or conventional protein diet (30% and 18% energy, respectively) and with or without exercise, and women 50-64 years of age followed an energy restricted (~500 kcal/day) higher protein diet (30% energy) with exercise. Assessments of diet (3-day food records), diet quality (Healthy Eating Index-2010), self-motivation (Self-Motivation Inventory; SMI), satisfaction with life (Satisfaction with Life Scale; SWLS), and vitality (SF-36) were completed at baseline and 6-months. *Results:* At the end of the intervention, HEI-2010 scores increased in the overall sample for total score and total fruit, whole fruit, total vegetables, dairy, total protein foods, refined grains, and empty calorie component scores. Results from regression analyses indicated that following the intervention significant improvements in HEI-2010 total score and/or several component scores were associated with being older (vs. middle-aged) and having higher baseline self-motivation, but not with vitality or life satisfaction. *Conclusion:* Postmenopausal middle-aged and older women who consumed diets that were energy restricted with different levels of protein had improved diet quality, but there was still room for improvement in diet quality following the intervention (post-intervention HEI-2010 total score 67.1 ± 11.4 , maximum score: 100). This suggests that

low self-motivation, but not older age may be barriers to improvements in dietary quality during weight loss interventions.

Introduction

The prevalence of obesity in the United States was estimated at 34.9% in 2011-2012, and older women are one of the few subgroups of the population in which the prevalence of obesity is still increasing (Ogden et al 2014). Intentional weight loss interventions in older adults are efficacious in facilitating weight loss, improving physical function, and fostering favorable changes in health and quality of life (Felix & West 2013; Johnson 2013; Porter Starr, McDonald, & Bales 2014). Following a higher protein diet with protein intake of ~ 1.2-1.6 g/kg body weight has been shown to be effective in facilitating weight loss and loss of fat mass, while preserving lean mass (Leidy et al 2015). Although higher protein intake may be beneficial for older adults, protein intake for some older adults is below the current RDA of 0.8 g/kg body weight (Paddon-Jones et al 2015). Given the high prevalence of obesity and the increasing body of research illustrating the benefits of higher protein diets for intentional weight loss, additional research is warranted to determine the effects of following a higher protein diet for intentional weight loss on diet quality in middle-aged and older women.

The Academy of Nutrition and Dietetics supports a total diet approach to healthy eating, and states that along with adequate physical activity, the foundation of a health-promoting lifestyle consists of a diet consisting of nutrient-dense foods and beverages consumed in moderation (Freeland-Graves & Nitzke 2013). One method to measure diet quality is with the Healthy Eating Index (HEI). The Healthy Eating Index-2010 (HEI-2010) is a measure of diet quality in accordance to the 2010 Dietary Guidelines for Americans. The HEI-2010 is comprised of 12 components, 9 of which are adequacy components (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids) for which consumption should be increased and 3 of which are moderation

components (refined grains, sodium, and empty calories) for which consumption should be decreased (Guenther et al 2013). Component scores are summed to create a total score with a range of 0-100, and total and component scores are scored such that higher values reflect more desirable diet quality (Guenther et al 2013).

Data from 2001-2002 and 2007-2008 NHANES indicate the need for improvement in diet quality as total HEI-2010 scores were calculated at 51.9 in 2001-02 and 53.5 in 2007-08 (USDA 2013). In 2007-2008 most HEI-2010 component scores, except total protein, were below maximum values, and greens and beans, whole grains, fatty acids, sodium, and empty calories were below 50 percent of their maximum value (USDA 2013). Little change in HEI-2010 scores was found from 2001-2002 to 2007-2008 in American adults and children 2 years of age and older. Significant improvements were found in whole fruit and empty calorie HEI-2010 component scores and a significant decrease in sodium HEI-2010 component scores (USDA 2013). Diet quality generally improves with increasing age (Guenther et al 2014; Hiza et al 2013), while lower diet quality has been associated with overweight and obesity (Drenowataz et al 2014; Guo et al 2004; McCabe-Sellers et al 2007; Pate et al 2014).

Psychological variables, such as self-motivation, have been associated with exercise adherence and intentional weight loss, but less is known about the relationship of self-motivation and other psychological variables with changes in diet quality (Dishman, Ickes, & Morgan 1980; Teixeira et al 2002; Teixeira et al 2004a; Teixeira et al 2004b; Teixeira, Going, Sardinha, & Lohman 2005). Teixeira, Patrick, & Mata (2011) suggest that motivation can determine an individual's ability to adopt and maintain a healthy diet; therefore, research is warranted to determine the relationship of psychological variables, such as self-motivation, with changes in diet quality in older and middle-aged women engaging in intentional weight loss.

The purpose of this study was to determine change in diet quality, measured by HEI-2010 scores, in middle-aged and older women enrolled in a 6-month intentional weight loss intervention who are following an energy restricted (~ -500 kcal/day) higher protein (~30 energy) or conventional protein (~18% energy) diet with and without exercise. Another aim of this study was to determine the relationship of change in diet quality with change in self-motivation, life satisfaction, and vitality. It is hypothesized that diet quality will improve from baseline upon completion of the 6-month weight loss intervention among all participants and that older women (65-80 years) will have more favorable changes in HEI-2010 scores versus middle-aged women (50-64 years), and that increases in self-motivation and life satisfaction and vitality will be associated with favorable change in HEI-2010 scores.

Methods

This section was written in collaboration with Alison C. Berg, and was adapted from her dissertation (Berg 2015).

Participants

Female participants aged 50-64 years of age (n = 25) and 65-80 years (n = 75) were recruited from the community in and surrounding Athens, Georgia through word of mouth, flyers, email to listservs, and paid newspaper advertisement. Inclusion criteria include having a BMI of $\geq 25 \text{ kg/m}^2$, weight stable (within 2 kg) for 6 months, postmenopausal status (self-reported and defined as the absence of a menstrual cycle within the past 12 months), sedentary (less than 1 hour/week of planned physical activity and a sedentary job), and physician clearance. Exclusion criteria included tobacco use, normal weight, dietary restrictions that do not allow for beef consumption, weight loss surgery and/or current weight loss medication usage, history of and/or current balance disorders, cancer treatment within the last 5 years or active cancer, recent

history or current unstable cardiovascular disease, history of lung disease, mini-mental state exam score less than 25, and any medical condition that precludes ability to exercise at levels specified by the study. In addition, participation of women aged 50-64 years of age was limited to women of Caucasian race due to the evaluation of DNA methylation in this age group in the parent study and limited resources, which prevent the evaluation of more than one racial group.

Participants 65-80 years of age were randomized to one of three treatment groups: higher protein diet with exercise (HP+EX 65-80), higher protein diet without exercise (HP 65-80), or conventional protein with exercise (CP+EX 65-80). All participants 50-64 years of age were assigned to follow a higher protein diet with exercise intervention (HP+EX 50-64).

Measurements

Demographics

Self-reported demographic information such as age, income, race, and education was assessed by interviewers by telephone (participants 65-80 years) and online screening (50-64 years) and subsequently confirmed during in-person screening visits (all participants).

Health history

History of chronic conditions including cardiovascular disease, hypertension, pulmonary disease, arthritis, diabetes, cancer, and thyroid disorder were assessed by self-report. Self-report of cancer was assessed by asking, “Have you been diagnosed with any kind of cancer? If so, please explain.” Self-report of thyroid disorder was assessed by asking, “Do you have hyper or hypothyroidism? If so, please explain.”

Anthropometrics

Body weight was measured to the nearest 0.1 pound or kg with a digital scale, while participants were barefoot and wearing light clothing. Barefoot height was measured to the nearest 0.1 cm with a stadiometer. Waist circumference at the natural waist was measured 3 times with a tape measure by trained research assistants. Body mass index (BMI) (kg/m^2) was calculated from body weight and height from baseline and post-intervention measurements. Whole body fat mass was measured with dual-energy-X-ray absorptiometry (DXA) (GE Lunar-iDXATM, encore 2007, version 11.30.062, Madison, WI). All measurements were taken at baseline, midpoint (3-months), and post-intervention (6-months). For this analysis only baseline and post-intervention measurements will be discussed.

Psychological Outcomes

Psychological variables were assessed at baseline, mid-point (3-months), and post-intervention (6-months). Self-motivation was assessed by the self-motivation inventory (SMI), a 40-item scale (range 40-200) designed to measure self-motivation, defined as a behavioral tendency to persevere independent of situational reinforcements (Dishman & Ickes 1980). Satisfaction with life was assessed by the Satisfaction with Life Scale (SWLS), a 5-item scale (range 5-35) designed to measure global life satisfaction. Vitality was assessed with the SF-36 vitality scale, a 4-item scale (range 0-100). Low scores reflect feeling tired and worn out all the time, while high scores indicate feeling full of people and energy all the time (Ware, Kosinski, & Gandek 2005).

Dietary assessment

Participants completed 3-day diet records reflecting 2 weekdays and 1 weekend day at baseline and post-intervention testing visits. Participants were given a National Science

Foundation (NSF) certified digital food service scale (Escali 136 KP Alimento Pro, Burnsville, MN), and were asked to weigh their food. Participants were provided instruction on how to zero the scale, subtract the weight of plates, and to note whether weight was measured before or after cooking. Participants were asked to use measuring cups and spoons, and were provided a reference sheet with portion sizes when measuring utensils were unavailable. Diet records were reviewed by research dietitians or trained interviewers for clarification, and to allow participants to recall forgotten foods and/or provide details about food and beverages consumed. Diet records were analyzed to provide estimates of energy, macronutrients, micronutrients, and selected food groups, e.g., beef, using the 2013 version of the University of Minnesota's Nutrition Data System for Research (NDSR).

Healthy eating index

Healthy Eating Index-2010 scores were calculated following the methods proposed by the University of Minnesota (2014). The sum of saturated fatty acids and trans fatty acids were utilized as a proxy for solid fats in the calculation of percent energy from empty calories (University of Minnesota 2014). This approach is reasonable as the Dietary Guidelines for Americans 2010 promote polyunsaturated and monounsaturated fatty acids as the primary source of fat in the American diet and suggest intake of saturated fatty acids be kept below 10% of energy with intake of trans fatty acids as low as possible (University of Minnesota 2014). HEI-2010 component and scoring standards are listed in Figure 4.2.

Group nutrition education attendance

Number of group nutrition education sessions attended was calculated as the sum of group nutrition education classes each participant attended during the 6 month weight loss intervention. Attendance for individual nutrition counseling sessions is not included. Three

participants were missing data for group nutrition attendance, the mean value for group nutrition education attendance was used for these participants (mean = 14). These data were used primarily for record keeping and follow-up purposes; therefore, some measurement error is likely.

Dietary intervention

Participants randomized to the higher protein diet were advised to follow a diet consisting of 30% energy from protein, 30% energy from fat, and 40% energy from carbohydrates, while participants in the conventional protein group were advised to follow a diet consisting of 18% energy from protein, 52% energy from carbohydrate, and 30% energy from fat. Participants randomized to the higher protein diet were instructed to consume 3-3.5 ounces of lean beef daily. Lean beef was defined as cuts with less than or equal to 4.5 g saturated fat, less than 10 g total fat, and less than 95 mg cholesterol per 3.5 oz. serving. Participants were instructed on how to choose cuts of lean beef, and were provided with resources from the National Cattlemen's Beef Association, such as information on choosing lean beef cuts, cooking with lean beef, and the nutritional content of lean beef, and participants had access to a lean beef cookbook. Participants were instructed to complete daily beef compliance logs in which they noted amount of beef consumed, cut of beef, and cooking method.

Participants were provided with a multivitamin mineral supplement formulated for older women to ensure adequate intake of micronutrients throughout the intervention (Centrum® Silver® Women, Pfizer, Inc., Madison, NJ) that provided 800 IU of vitamin D (RDA for women 51—70 years is 600 IU or 15 mcg, for women ≥ 71 years is 800 IU or 20 mcg/d), 500 mg of calcium (RDA for women >50 years is 1200 mg), and more than 100% of the RDA for several nutrients, including vitamin C (RDA for women >50 years is 75mg). Additional calcium

supplements (Regular Strength TUMS®, 200 mg elemental calcium, Glaxo Smith Kline, St. Louis, MO) were recommended individually to meet the RDA (1,200 mg/d) based on individual intake of calcium-rich foods. Additional calcium supplementation was based on the following method: TUMS per day rounded to nearest 0.5 tablet = $[1200 \text{ mg (RDA for calcium for older women)} - 500 \text{ mg (Centrum® Silver® Women)} - 300 \text{ mg (approximate dietary calcium from non-dairy sources)} - (\text{daily servings dairy food} \times 300 \text{ mg/serving})] \div 200 \text{ mg Ca/TUMS}$. Participants were instructed to indicate their usage of supplements on paper logs, and use of supplements was confirmed by interventionists at visits.

Participants met individually with a research dietitian (RDN) or nutrition graduate student under the supervision of the RDN individually for a minimum of 2 visits, and were presented with individual diet goals based on a 500 kcal/day energy reduction for weight loss (Mifflin St. Jeor equation using baseline height and body weight; activity factor 1.3) (Seagle et al 2009). No additional adjustments were made to account for energy expended during physical activity, and the minimum energy intake goal assigned to participants was 1,200 kcal. Participants were monitored by the RDN throughout the intervention, and energy goals were adjusted to in order to meet weight loss goals of 0.23 kg (0.5 pounds) to 0.91 kg (2 pounds) per week. For the remainder of the 6-month intervention participants attended weekly 45-60 minute group education/motivational sessions led by the RDN or supervised graduate student, and met individually with the RDN as needed to meet weight loss goals. Presence of nutrition-related conditions, such as lactose intolerance, was assessed during individual nutrition visits. One participant reported lactose intolerance with milk protein allergy, and was advised to consume non-dairy sources of protein such as meats and vegetable proteins and non-dairy milk such as soy milk and almond milk with protein powder for additional protein. One participant reported

lactose intolerance without milk protein allergy, and reported being able to consume cheese, yogurt, and fluid milk in small amounts. Weekly nutrition education meetings provided information on general nutrition (e.g., protein, fiber, carbohydrates, whole grains, fruits and vegetables) as well as information on other nutrition-related topics such as bone health, heart health, healthy eating while away from home, food safety, and mindful eating. Nutrition education lessons on general nutrition topics included information describing each food group and/or nutrient (e.g., the definition of a whole grain and food sources of whole grains), benefits of consumption of each food group and/or nutrient, as well as tips to help increase and/or decrease each food group or nutrient to improve diet quality (e.g., add berries to your morning yogurt to increase consumption of fruit and choose low-sodium canned vegetables to decrease sodium consumption). Weekly education topics were based on the 2010 Dietary Guidelines for Americans (USDA & USDHHS 2010) and were derived from both the research team to support the research goals, as well as from the participants ensuring the topics addressed their concerns about a range of nutrition-related issues. A list of group nutrition education topics is included in Appendix F.

Participants were instructed to record intake of all foods and beverages, except water, in a free online monitoring tool, MyFitnessPal. The registered dietitian or supervised nutrition graduate student provided instructions and assisted in the use of this application, and ensured participant's MyFitnessPal accounts accurately reflected each participant's assigned macronutrient composition (higher protein vs. conventional protein) and energy needs. MyFitnessPal accounts were reviewed weekly by a registered dietitian or supervised graduate student, and participants were given individual feedback weekly. Most participants were able to access MyFitnessPal accounts online through personal computers, smart phones, and/or tablets,

while one person chose to use a computer at the public library. When participants were unable to access MyFitnessPal accounts, such as when participants were travelling and did not have access to the internet, paper food diaries or food logs with the exchange system were used to record food and beverage intake.

Exercise intervention

Participants randomized to exercise attended 3 (~75 minute) exercise sessions weekly on non-consecutive days. Exercise sessions were conducted by trained graduated students in the University of Georgia, Department of Kinesiology, and consisted of cardiorespiratory training, resistance training, balance, flexibility, and functional exercises. Participants randomized to higher protein and no exercise (HP 65-80) were instructed to maintain their current activity levels (<1 hour/week of physical activity or less than 2 exercise sessions per week as specified by inclusion criteria). Exercise sessions consisted of 30 minutes of continuous cardiorespiratory activity (walking on a treadmill, cycling, or elliptical) at 70-80% of age-predicted maximal heart rate and resistance training focusing on upper body, lower body, and abdominal exercises of 2 sets of 8-10 repetitions at 65% of four-repetition maximum. Additionally, 10-15 minutes of flexibility and balance exercises and two 30-second sets of functional exercises (chair rises, wall push-ups, lift-and-carry, and transfer task) were included in each exercise session.

Statistical analysis

All statistical analyses were performed using SAS version 9.4 Cary, NC. Baseline differences among groups were analyzed with ANOVA and Kruskal Wallis tests for non-normally distributed variables. Chi-square or Fisher's exact tests, when cell size was less than 5, were used to analyze baseline differences among groups for categorical variables. Baseline differences between completers and non-completers of the 6-month intervention were assessed

with independent sample t-tests or Wilcoxon-Mann-Whitney tests for non-normally distributed variables, and by Chi-square and Fisher's exact tests for categorical variables. Within group changes were analyzed with paired t-tests and Wilcoxon signed rank sum tests for non-normally distributed variables. Planned comparisons were used to determine differences in the change in diet quality among treatment groups. Three contrasts were tested: higher protein vs. conventional protein (HP vs. CP), exercise intervention vs. no exercise intervention (EX. vs. No EX.), and older vs. middle-aged participants (65-80 vs. 50-64). Linear regression analyses explored the independent and predictive association of treatment group assignment (assignment to higher protein vs. conventional protein and assignment to the exercise intervention vs. no exercise intervention), age group (65-80 vs. 50-64), group nutrition education attendance, and psychological variables on change in HEI-2010 total and component scores. Vitality and satisfaction with life were not associated with change in HEI-2010 scores, and because self-motivation did not significantly change from baseline to post-intervention, baseline self-motivation scores were included for analysis. The association of change in diet quality with depression, hours of sleep, education, working status, total medical conditions, total medications, and psychoactive medication use were assessed in regression models, but as these variables were not significantly associated with change in HEI-2010 scores, these variables were not included in the final model. Income was not included in regression models because 20 participants did not disclose their income.

Results

Baseline characteristics of participants who completed the 6-month intervention (n = 79) are shown in Table 4.1. Baseline characteristics of participants were similar among groups with the exception of age, work status, marital status, and self-report of diabetes and total medical

conditions. As expected, participants in the HP+EX 50-64 group were younger than participants in the HP+EX 65-80, HP 65-80, and CP+EX 65-80 groups. Compared to the other groups the HP+EX 50-64 group was most likely to be working full-time and the CP+EX 65-80 group was least likely to be working full-time, while the HP+EX 65-80 group was most likely to be working part-time and the HP+EX 50-64 group was least likely to be working part-time. Compared to other groups the HP 65-80 group was most likely to not be currently working, while the HP+EX 50-64 group was least likely to not be currently working. The CP+EX 65-80 group was most likely to be currently married and the HP+EX 65-80 group was least likely to be currently married. Compared to other groups the HP 65-80 group was most likely to self-report having diabetes, while the CP+EX 65-80 and the HP+EX 50-64 groups were least likely to self-report having diabetes. Mean total medical conditions were higher in the HP 65-80 group versus the CP+EX 65-80 and HP+EX 50-64 groups. Baseline HEI-2010 total and component scores, shown in Table 4.2, were similar among groups.

Eighty participants completed the 6-month intervention, and attrition was 14% (n = 13). Of the 13 participants who withdrew from the intervention, 7 were non-compliant with study protocol, 3 withdrew for non-study related illness and/or injury, and 3 withdrew because of time constraints. Participants lost $-9.3 \pm 4.8\%$ initial body weight, and 44.8% met the 10% weight loss goal. Percent weight change and the percentage of participants meeting the 10% weight loss goal did not differ by group (discussed further in chapter 3). Analysis of baseline characteristics between individuals who completed and those who did not complete the intervention indicated that baseline HEI-2010 values were significantly higher for total score (completers: 58.9 ± 11.3 , non-completers: 51.4 ± 13.0 ; $p < 0.04$) and total vegetable component scores (completers: 3.9 ± 1.2 , non-completers: 2.9 ± 1.6 ; $p < 0.04$) and significantly lower for sodium component scores

(completers: 4.1 ± 3.0 , non-completers: 6.5 ± 3.6 ; $p < 0.03$) for completers versus non-completers of the 6-month intervention. Completers of the 6-month intervention had higher baseline vitality scores (completers: 55.8 ± 14.3 , non-completers: 40.4 ± 18.7 ; $p < 0.001$) versus non-completers (data not shown). One participant was excluded from these analyses due to missing anthropometric data at 6-months. At baseline 1 participant failed to answer 1 question on the SMI, and values for this question were imputed by substituting the missing value with the average of the remaining SMI questions at baseline. Data were missing for group nutrition education attendance for 3 participants, so the mean value was used for these participants (mean = 14).

Table 4.2 shows baseline, post-intervention, and change in HEI-2010 scores and group nutrition education attendance. Statistically significant improvements in diet quality from baseline to post-intervention were found in the overall sample for HEI-2010 total score and total fruit, whole fruit, greens and beans, total vegetable, dairy, total protein foods, refined grains, and empty calorie component scores. Within the HP+EX 65-80 group, HEI-2010 total score and total fruit, whole fruit, refined grains, and empty calories component scores significantly improved. Within the CP+EX 65-80 group, HEI-2010 total score and total fruit, whole fruit, and total vegetable component scores significantly improved. Within the HP 65-80 group, whole fruit and dairy component scores significantly improved. Within the HP+EX 50-64 group, greens and beans and refined grains component score significantly improved. Although not significant, HEI-2010 sodium component scores decreased in the overall sample and within treatment groups. Planned comparisons among treatment groups for change in HEI-2010 total and component scores indicated a significant difference in the change of whole fruit component score between participants 65-80 and 50-64 years of age, and in seafood and plant protein and

fatty acid scores between participants in the exercise intervention vs. those who were not in the exercise intervention. Planned comparisons among treatment groups indicated group nutrition education attendance was significantly higher in older versus middle-aged women.

Further analysis of the intake of protein foods was done because baseline values for the HEI-2010 total protein foods component scores were close to the maximum value of 5, and increases in protein intake of above 2.5 oz. eq./1,000 kcal would not have resulted in higher HEI-2010 total protein foods component scores. Figure 4.1 shows baseline, post-intervention, and change in consumption of total protein foods. In the overall group, protein intake significantly increased from baseline to post-intervention. As expected, a significant increase in total protein food intake (oz. eq./1,000 kcal) was seen within groups assigned to higher protein diets. Intake of total protein foods increased within the CP+EX 65-80 group, but this increase was non-significant. Results from planned comparisons of total protein foods between groups assigned to higher protein versus conventional protein diets indicated that the change in intake of total protein foods was significantly higher in groups assigned to the higher protein diets versus conventional protein diets.

Table 4.3 shows baseline, post-intervention, and change in psychological variables. Self-motivation did not significantly increase within the overall group or within any treatment groups. Satisfaction with life significantly improved within the overall sample and within the HP+EX 50-64 group. Vitality significantly increased within the overall group and in the HP+EX 65-80, CP+EX 65-80, and HP+EX 50-64 groups. Planned comparisons indicated a significant change in vitality between groups randomized to the exercise intervention and groups not randomized to the exercise intervention (discussed more in chapter 3).

Table 4.4 shows linear regression analysis predicting change in HEI-2010 total score and component scores, while controlling for intervention group assignment (higher protein vs. conventional protein diet, exercise vs. no exercise, age 65-80 vs. 50-64), baseline SMI values, baseline HEI-2010 scores, and group nutrition education attendance. Linear regression analyses revealed that assignment to a higher protein diet was positively associated with nutritionally beneficial improvements in HEI-2010 refined grain component scores. Assignment to the exercise intervention was positively associated with change in HEI-2010 total fruit and fatty acid component scores, and negatively associated with change in HEI-2010 dairy component scores. Older age (65-80 vs. 50-64) was positively associated with change in total fruit, whole fruit, and fatty acid component scores. Baseline self-motivation was positively related to change in total score and total fruit, total vegetable, and refined grains component scores. Group nutrition class attendance was related to nutritionally beneficial improvements in percent empty calorie component scores, and negatively associated with change in dairy component scores. All linear regression models were conducted with age as a continuous variable, and there were no substantive changes except for the model predicting change in HEI-2010 total score in which continuous age was significant ($b = 0.5$, $p = 0.04$), the model predicting change in total fruit in which assignment to the exercise intervention was no longer significant ($b = 0.6$, $p = 0.17$), and the model predicting change in whole fruit in which age (continuous) was no longer significant ($b = 0.06$, $p = 0.1$).

Discussion

These findings show that postmenopausal middle-aged and older women enrolled in a weight loss intervention lost weight and improved diet quality with significant improvements in the overall sample for HEI-2010 total score and several component scores. While others have

found that HEI-2010 scores can improve during intentional weight loss with portion-controlled meals (Ptomey et al 2015), the present study extends these findings to older women and identifies other factors that are associated with dietary quality. The primary findings are overall improvements in total score, total fruit, whole fruit, total vegetables, greens and beans, dairy, total protein foods, refined grains, and empty calories and declines in sodium, while some changes in diet were associated significantly with age group, protein group, exercise group, group nutrition education attendance, and self-motivation. These findings are discussed below.

Overall, HEI-2010 total score and total fruit, whole fruit, greens and beans, total vegetables, dairy, total protein foods, refined grains, and empty calorie component scores increased. Ptomey et al (2015) found similar increases in HEI-2010 total scores in a younger sample of overweight and obese adults (46.1 ± 8.9 years) enrolled in a 6-month weight loss intervention utilizing portion controlled meals for weight loss, which persisted throughout the 12- and 18-month weight loss maintenance phase. Similar to our findings, these researchers found an increase in the whole fruit, total vegetables, refined grains, and empty calories HEI-2010 component scores as well an increase in fatty acid HEI-2010 component score at 18-months compared to baseline.

In the overall sample, HEI-2010 total protein foods component score and intake of total protein foods (oz. eq./1,000 kcal) significantly increased, but the within group change for total protein foods (oz. eq./1,000 kcal) was only significant for participants assigned to higher protein diets (HP+EX 65-80, HP 65-80, and HP+EX 50-64). At baseline, HEI-2010 total protein foods component scores were close to maximum values (baseline, 4.8 ± 0.6 ; maximum value, 5); therefore, the HEI-2010 total protein foods component score was not a sensitive measure of protein intake in a sample of participants already meeting the RDA for protein. Regression

analyses indicated that assignment to higher protein diets was associated with nutritionally beneficial improvements in HEI-2010 refined grains component scores. Thus, older and middle-aged women can improve diet quality when being counseled by a research dietitian to consume a diet with varying amounts of protein along with other recommendations consistent with the 2010 Dietary Guidelines for Americans such as increasing fruit, vegetable, and whole grain consumption and decreasing consumption of solid fats, added sugars, and refined grains (USDA & DHHS 2010).

Although sodium intake decreased overall (baseline, 2,847 mg/d; post, 2,203 mg/d; $p < 0.0001$) a non-significant decrease was found in the overall sample as well as within treatment groups for the HEI-2010 sodium component score, because the HEI considers sodium/1,000 kcal. Sodium intake per 1,000 kcal (baseline, 1.7 g/1,000 kcal; post, 1.8 g/1,000 kcal; $p < 0.01$) may have increased for participants assigned to higher protein diets as participants frequently chose lean roast beef deli meats to meet the 3 oz. daily requirement for lean beef (from personal observation). Older women (65-80 years) randomized to higher protein diets consumed 0.67 ± 0.92 ounce equivalents from lean cold cuts and 0.13 ± 0.27 ounce equivalents from regular cold cuts, although it is unknown if these cold cuts were roast beef or other types of cold cuts, such as ham or turkey (Berg 2015). Participants in all treatment groups may have also relied on other types of packaged food items that are higher in sodium content for portability and ease of preparation during this intense intervention in which participants were required to attend on-campus intervention sessions weekly for participants not randomized to exercise interventions and 3 times per week for participants randomized to the exercise intervention.

Compared to those not randomized to exercise, those randomized to the exercise intervention had improvements in total fruit and fatty acid component scores, but decreased dairy

component scores (from regression analyses). This finding was unexpected. Perhaps participants randomized to exercise were more likely to consume whole fruits for a portable snack as they were attending on-campus intervention visits more often than those not randomized to exercise, and were less likely to choose full fat dairy products to meet protein requirements. Participants randomized to the exercise intervention had more contact with participants enrolled in the weight loss intervention and with intervention staff as they attended 3 weekly supervised exercise sessions. Perhaps the increased contact with fellow participants and intervention staff influenced change in diet quality among those randomized to the exercise intervention versus those not randomized to the exercise intervention.

As we hypothesized, older women 65-80 years experienced significantly higher increases in some component scores versus middle-aged participants, including total fruit, whole fruit, and fatty acids (from regression analyses). When age was entered in regression analyses as a continuous variable, age was significantly associated with change in HEI-2010 total score, but no longer significantly associated with change in whole fruit component scores. Thus, the relationship of age with change in diet quality is somewhat dependent on how age is coded in linear regression models. In a nationally representative sample of adults in the United States, Guenther et al (2014) found higher HEI-2010 total scores and total fruit, whole fruit, total vegetables, greens and beans, whole grains, seafood and plant proteins, refined grains, and empty calories in adults 51 years and older versus adults 20-30 years of age. Hiza et al (2013) analyzed data from NHANES 2003-2004 and similarly found that with increasing age there was an increase in HEI-2005 total score and total fruit, whole fruit, total vegetables, dark green and orange vegetables and legumes, whole grains, oils, and calories from solid fats, alcoholic

beverages, and add sugars component scores with adults 75 years and older having the highest HEI-2005 total scores of any subgroup.

Perhaps older adults may be more driven to improve diet quality as older adults may be particularly conscious of the need to consume a high quality diet for the prevention and/or management of chronic conditions (Hiza et al 2013). Older women may have been better able to improve diet quality, versus middle aged women, because they attended more group nutrition education classes and thus had more contact with intervention staff and fellow participants. These differences in change in diet quality among older and middle-aged women may also be attributable to the effect of birth cohorts. Beatty, Lin, & Smith (2013) examined change in HEI-2005 scores to determine the association of age effects and birth cohort effects on change in diet quality. These researchers found a U-shaped trajectory for HEI-2005 scores over a person's lifetime with the lowest HEI-2005 scores occurring during 20-50 years of age. Examination of birth cohorts suggested that HEI-2005 scores were relatively stable for individuals born before 1955, but HEI-2005 total scores decreased for individuals born in the late 1950s to early 1990s.

Group nutrition education attendance was positively associated with change in HEI-2010 percent empty calories component scores and negatively associated with change in HEI-2010 dairy component scores. Participants who attended group nutrition education classes more often had increased exposure to intervention staff, other participants enrolled in the weight loss intervention, and had increased exposure to nutrition education materials, which were based on the 2010 Dietary Guidelines for Americans (USDA & USDHHS 2010), thus assisting them in making improvements in dietary quality by reduced consumption of empty calories. Tinker et al (2007) found that attendance at group sessions among participants in the Women's Health

Initiative Dietary Modification Trial was a strong predictor of dietary change at 1 year and maintenance of dietary change at 3 years.

Group nutrition education was negatively associated with change in the HEI-2010 dairy component score. This finding was unexpected as the importance of the consumption of dairy foods was emphasized for all participants during individual nutrition counseling and group nutrition education classes. Perhaps participants felt their consumption of dairy products was not as important as other food groups because they were taking a multivitamin mineral supplement and calcium supplement to ensure adequate intake of calcium and vitamin D. Group nutrition education also may be negatively associated with change in HEI-2010 dairy component scores because participants not assigned to the exercise intervention attended more diet classes than those assigned to the exercise intervention (assigned to exercise: 15.0 ± 2.7 , not assigned to exercise: 13.4 ± 3.8 ; p-value from planned comparisons $p = 0.06$), and those not assigned to the exercise intervention increased HEI-2010 dairy scores more than those assigned to the exercise intervention (not assigned to exercise: 2.8 ± 3.0 , assigned to exercise: 1.1 ± 3.8 ; p-value from planned comparisons = 0.07).

Self-motivation scores at baseline were positively related to improvements in diet quality including the HEI-2010 total score and total fruit, total vegetables, and refined grains component scores. A review by Shaikh et al (2008) found evidence, from both cross-sectional and longitudinal studies, of a positive relationship with autonomous motivation and fruit and vegetable intake in adults; however, as this field of research is relatively new, additional research may further define this relationship. An intervention study by Shaikh et al (2011) suggested that participants who had lower autonomous motivation at baseline may be more receptive to

motivational interviewing interventions targeted at increasing consumption of fruits and vegetables (Shaikh et al 2011).

Data from this study suggests that individuals with higher levels of self-motivation may be better able to improve their diet quality by increasing intake of fruits and vegetables and decreasing intake of refined grains. Teixeira, Patrick, & Mata (2011) suggest that motivation determines an individual's ability to adopt and maintain a healthy diet, and providing experiences that foster autonomous motivation, in addition to instructing participants on self-regulatory techniques, such as self-monitoring and contingency management, may provide additional benefits in soliciting dietary change (Teixiera, Patrick, & Mata 2011). Identifying individuals who may experience more difficulty in improving diet quality, such as those with lower self-motivation, may allow interventionists and health providers to target strategies for these individuals. These participants may benefit from techniques, which allow them to develop a sense of ownership over their eating routines and deeply identify with goals associated with dietary change. Researchers and health professionals may encourage these participants to develop their own goals and choices, reduce social pressures, present participants with difficult (but not overwhelming) challenges, and foster feelings of acceptance regardless of goal achievement (Shaikh et al 2011; Teixeira, Patrick, & Mata 2011).

Although increasing self-motivation was not a primary aim of the current study there were some aspects of our intervention, which may have fostered self-motivation. For example, during the first 1-2 weeks of the intervention participants were asked to identify goals, in addition to weight loss, to provide encouragement and direction throughout the intervention period. An example of a frequently mentioned intervention goal was to have more energy and be more physically able to play with grandchildren. This experience may have encouraged some

participants to develop a sense of ownership over changes made during the intervention. However, some aspects of the intervention may have hindered the development of self-motivation. For example, some dietary goals were assigned to participants (such as the goal for protein intake), which may have made it difficult for some participants, particularly those who preferred non-meat sources of protein, to identify with and take ownership of dietary change.

Although participants in this intervention made nutritionally beneficial changes in diet quality, room for improvement in overall diet quality was seen at the end of the 6-month intervention (post intervention HEI-2010 total score 67.1 ± 11.4 , maximum score 100). Despite improvements in HEI-2010 total and component scores, at post-intervention HEI-2010 total score and most of the HEI-2010 component scores, with the exception of total protein foods, remained below maximum values. Berg (2015) analyzed macronutrient and micronutrient intake in participants aged 65-80 years enrolled in this 6-month weight loss intervention, and found that mean protein intake in participants assigned to higher protein diets increased from baseline to post-intervention; however, more than half of these participants failed to meet the goal of 30% energy from protein. In addition, ~40% of participants failed to meet goals for saturated fat (< 10% of energy) and ~ 56% of participants failed to meet goals for fiber intake (14 g/1,000 kcal). Participants assigned to higher protein diets were less likely to meet goals for fiber. Thus, participants in this intervention experienced nutritionally beneficial improvements in diet quality, but may still fall short of meeting goals for some nutrients.

Strengths and limitations

Limitations of the current study include the intensity of the weight loss intervention in which participants met at least once per week with intervention staff. This frequency of contact may not be feasible for most people attempting weight loss through commercial weight loss

programs, gym memberships, and/or extensive individual counseling with registered dietitians. The current sample was highly educated (81% reported having a college degree) and most participants were Caucasian (96.2%). By study design all participants aged 50-64 years were Caucasian. Thus, these findings may not be generalizable to individuals with lower levels of education, lower levels of income, and/or minority populations. Additionally, the sum of saturated and trans fatty acids were used as a proxy for solid fat intake in the calculation of the empty calories HEI-2010 component score (University of Minnesota 2014); however, this approach is reasonable as it is in line with the 2010 Dietary Guidelines for Americans recommendation that polyunsaturated and monounsaturated fats should be primary sources of fat, saturated fat intake should be below 10% of total energy, and trans fat intake should be as low as possible (USDA & USDHHS 2010). The self-motivation inventory (SMI) has been shown to be a valid and reliable measure of a general, non-specific tendency to persevere in the absence of reinforcement (Merkle et al 2002). The SMI does not distinguish between intrinsic and extrinsic motivation. The importance of not only considering quantity, but also quality, of motivation in relation to eating behaviors and weight management has been emphasized (Teixera et al 2012; Teixeira, Patrick, & Mata 2011). Data for group nutrition education attendance used primarily for record keeping purposes, and some measurement error is possible.

Although the intensity of this intervention may not be feasible for most people attempting weight loss, the intensity of this intervention likely contributed to participant's success in achieving weight loss with a mean weight change of $-9.3 \pm 4.8\%$ of initial body weight and 44% of participants achieving 10% weight loss. Participants were frequently monitored by interventionist staff and were able to pose questions to and receive timely feedback from intervention staff regarding diet and physical activity. Frequent visits to the intervention site

allowed participants to form friendships, which provided social support during the intervention. Additionally, the use of the MyFitnessPal application provided a free and easy-to-use application for participants to self-monitor food intake and receive individual feedback from interventionists.

Conclusion

Overall these findings show that postmenopausal middle-aged and older women following a diet that is energy restricted with different levels of protein intake are able to improve diet quality; however, despite these improvements, there was room for improvement in diet quality following the intervention. Compared to women 50-64 years of age, older women 65-80 years of age made a larger number of nutritional improvements as documented by improved HEI-2010 total fruit, whole fruit, and fatty acids component scores. In addition, these findings provide evidence for the relationship between higher baseline self-motivation values and improvements in diet quality. Identifying participants who may experience difficulty in making dietary improvements, such as those with low self-motivation, may allow interventionists and health providers to target strategies for these individuals, thus increasing the likelihood that they will be able to make nutritionally beneficial dietary changes during energy restriction.

Acknowledgements

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Table 4.1 Baseline Characteristics of Participants Completing the 6-month Intervention

Variable	N ¹	Overall Mean $\pm$ SD, Median [Range] or %	HP+EX 65-80 N = 17-18 ²	HP 65-80 N = 19-20 ²	CP+EX 65-80 N = 21-22 ²	HP+EX 50-64 N = 18-19 ²
		N = 76-79 ²				
Age (y)		67 $\pm$ 5.8, 67 [52-77]	69.9 $\pm$ 4.3 ^A , 68 [65-77]	69.3 $\pm$ 2.4 ^A , 69 [66-73]	68.8 $\pm$ 3.9 ^A , 67.5 [65-76]	58.7 $\pm$ 3.8 ^B , 59 [52-64]
Race ⁴						
White (%)		96.2	94.4	100.0	90.9	100.0
Black (%)		1.3	0.0	0.0	4.6	0.0
Hispanic (%)		1.3	5.6	0.0	0.0	0.0
Native American (%)		3.8	0.0	5.0	9.1	0.0
Education						
At Least a HS Degree (%)		19.0	5.6	30.0	18.2	21.1
College Degree (%)		81.0	94.4	70.0	81.8	79.0
Household Income ⁴	59					
\$15,000-<\$30,000 (%)		10.2	15.4	6.3	16.7	5.6
\$30,000-<\$45,000 (%)		20.3	30.8	25.0	16.7	11.1
\$45,000-<\$60,000 (%)		15.3	23.1	12.5	8.3	16.7
\$60,000-<\$75,000 (%)		13.6	7.7	6.3	25.0	16.7
\$75,000-<\$90,000 (%)		22.0	23.1	25.0	16.7	22.2
\$90,000+ (%)		18.6	0.0	25.0	16.7	27.8
Work Status ⁴						
Currently Working Full Time (%) ⁵		25.3	5.6	10.0	4.6	84.2
Currently Working Part Time (%) ⁶		26.6	38.9	20.0	36.4	10.5
Currently Not Working (%) ⁷		48.1	55.6	70.0	59.1	5.3
Currently Married (%) ⁸		63.2	44.4	60.0	77.3	68.4
Health Conditions						
Cardiovascular Disease (%) ⁴		2.5	0.0	5.0	4.6	0.0
Hypertension (%)	77	40.3	44.4	45.0	47.6	22.2
Pulmonary Disease (%)		16.5	16.7	30.0	13.6	5.3
Arthritis (%)		50.6	44.4	70.0	54.6	31.6
Diabetes (%) ^{4,9}		6.3	5.6	20.0	0.0	0.0
Cancer (%) ⁴		17.8	22.2	30.0	13.6	5.3
Thyroid Disorder (%) ⁴		20.3	38.9	25.0	9.1	10.5
Total Medical Conditions	78	1.3 $\pm$ 1.1, 1.0 [0.0-5.0]	1.4 $\pm$ 1.1, ^{AB} 1.0 [0.0-4.0]	1.9 $\pm$ 1.0, ^A 2.0 [1.0-5.0]	1.0 $\pm$ 1.0 ^B 1.0 [0.0-3.0]	0.7 $\pm$ 1.0 ^B 1.0 [0.0-3.0]
Total Medications	78	4.0 $\pm$ 2.8, ^{AB} 4.0 [0.0-11.0]	4.0 $\pm$ 2.7, ^{AB} 4.0 [0.0-10.0]	5.5 $\pm$ 5.2, ^A 5.5 [1.0-11.0]	3.9 $\pm$ 2.6, ^{AB} 4.0 [0.0-9.0]	2.4 $\pm$ 2.8, ^B 2.0 [0.0-11.0]
Taking Psychoactive Medications (%)	78	43.6	44.4	65.0	38.1	26.3
Measures of Adiposity						
BMI		31.5 $\pm$ 5.5, 30.5 [24.7-48.4]	31.9 $\pm$ 6.6 31.3 [25.2-47.9]	32.6 $\pm$ 4.8 32.3 [25.0-43.4]	29.2 $\pm$ 3.2 28.9 [24.9-39.1]	32.6 $\pm$ 6.5 32.6 [24.7-48.4]
Body Fat (%)		48.0 $\pm$ 4.1, 47.9 [38.5-57.3]	49.2 $\pm$ 3.7, 49.3 [40.9-56.1]	49.0 $\pm$ 4.3, 48.1 [43.6-57.3]	47.2 $\pm$ 4.0, 47.2 [40.9-56.0]	47.3 $\pm$ 4.2, 47.3 [38.5-54.6]
Waist Circumference (cm)	76	94.8 $\pm$ 12.0, 93.8 [75.7-134.7]	97.1 $\pm$ 15.0, 93.6 [79.3-134.7]	96.7 $\pm$ 10.2, 97.8 [76.8-114.6]	88.9 $\pm$ 7.9, 87.3 [75.7-108.9]	97.2 $\pm$ 12.8, 94.2 [81.5-125.3]
Body Weight (kg)		83.1 $\pm$ 13.6, 81.8 [53.7-128.7]	83.4 $\pm$ 13.5, 83.1 [65.3-118.1]	85.4 $\pm$ 12.4, 84.1 [64.8-116.8]	78.1 $\pm$ 10.0 77.2 [53.7-100.2]	86.2 $\pm$ 17.6, 83.1 [66.1-128.7]

Table 4.1 Baseline Characteristics of Participants Completing the 6-month Intervention						
		Overall				
		Mean $\pm$ SD,				
		Median				
		[Range] or %	HP+EX	HP	CP+EX	HP+EX
Variable	N¹	N = 76-79²	65-80	65-80	65-80	50-64
			N = 17-18²	N = 19-20²	N = 21-22²	N = 18-19²
Psychological Variables	Possible Range					
Self-Motivation Inventory (SMI)	40-200	149.8 $\pm$ 18.8, 153 [111-187]	147.6 $\pm$ 16.5, 152 [119-173]	148.2 $\pm$ 18.5, 155 [111-173]	152.0 $\pm$ 16.7, 155 [120-181]	150.9 $\pm$ 23.8, 153 [113-187]
Satisfaction With Life Scale (SWLS)	5-35	27.6 $\pm$ 5.5, 29 [11-35]	28.4 $\pm$ 4.3, 30 [20-35]	26.7 $\pm$ 5.9, 28.5 [11-34]	28.4 $\pm$ 6.1, 28.5 [15-35]	26.8 $\pm$ 5.5, 29 [12-34]
Vitality	0-100	55.8 $\pm$ 14.3, 56.3 [25-87.5]	53.5 $\pm$ 14.7, 50 [25-81.3]	58.8 $\pm$ 14.0, 62.5 [31.3-75]	56.5 $\pm$ 17.0, 59.4 [25-87.5]	53.9 $\pm$ 10.7, 56.3 [21.3-68.8]
Cognitive Restraint	0-21	10.8 $\pm$ 4.3, 11.0 [1.0-20.0]	11.6 $\pm$ 4.0, 12.0 [4.0-17.0]	10.4 $\pm$ 3.4, 11.0 [4.0-16.0]	10.9 $\pm$ 4.5, 10.5 [1.0-20.0]	10.3 $\pm$ 5.1, 11.0 [3.0-20.0]
Sleep (hrs/d) ¹¹		7.1 $\pm$ 1.0, 7.0 [5.0-10.0]	6.9 $\pm$ 1.0, 7.0 [5.0-9.0]	7.3 $\pm$ 1.3, 7.5 [5.0-10.0]	7.1 $\pm$ 0.9, 7.0 [6.0-9.0]	7.1 $\pm$ 0.7, 7.0 [6.0-8.0]
Diet Variables						
Energy Intake (kcal)		1737 $\pm$ 456, 1678 [879-3105]	1746 $\pm$ 542, 1680 [996-3105]	1675 $\pm$ 398, 1577 [1103-2503]	1679 $\pm$ 370, 1661 [879-2384]	1859 $\pm$ 522, 1841 [1012-2791]
Energy (% Calculated Needs) ¹²		99.0 $\pm$ 24.4, 96.9 [53.6-170.5]	101.3 $\pm$ 32.0, 95.1 [53.6-170.5]	95.0 $\pm$ 20.6, 93.8 [65.3-137.5]	99.4 $\pm$ 20.1, 93.5 [57.7-141.1]	100.6 $\pm$ 26.0, 104.4 [59.1-158.8]

¹N = 79, unless otherwise indicated

²Range does not include participants who did not disclose income (n = 20)

³Among the four groups, means within a row with different letters are significantly different (p < 0.05)

⁴Fisher's exact test used as cell sizes less than 5

⁵Compared to the other groups the HP+EX 50-64 group was most likely to be working full-time and the CP+EX 65-80 group was least likely to be working full-time

⁶Compared to the other groups the HP+EX 65-80 group was most likely to be working part-time and the HP+EX 50-64 group was least likely to be working part-time

⁷Compared to the other groups the HP 65-80 group was most likely to not be currently working and the HP+EX 50-64 group was least likely to not be currently working

⁸Compared to the other groups the CP+EX 65-80 group was most likely to be currently married and the HP+EX 65-80 group was least likely to be married

⁹Compared to the other groups the PRO 65-80 group was most likely to have diabetes, while the CP+EX 65-80 and HP+EX 50-64 groups were least likely to have diabetes

¹⁰Includes SSRI/NE, TCA, antipsychotic, benzodiazepene, anticonvulsant, and other psychoactive medications

¹¹Pittsburgh Sleep Quality Inventory hours of actual sleep per day received within the past month

¹²Energy needs determined by Mifflin-St. Jeor equation with activity factor 1.3

Table 4.2 Baseline, Post-intervention, and Change in HEI Scores and Group Nutrition Education Attendance among Participants Completing the 6-month Intervention

HEI Score (Range)	Overall Sample Mean $\pm$ SD, Median [Range] N = 79	HP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 18	HP 65-80 Mean $\pm$ SD, Median [Range] N = 20	CP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 22	HP+EX 50-64 Mean $\pm$ SD, Median [Range] N = 19	P-value for planned comparisons <		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Total Score (0-100)								
Baseline	58.9 $\pm$ 11.3, 60.1 [24.0-88.9]	58.6 $\pm$ 15.1, 62.6 [24.0-85.6]	59.5 $\pm$ 8.4, 59.9 [46.5-73.6]	59.8 $\pm$ 8.0, 59.8 [44.9-74.3]	57.4 $\pm$ 13.5, 58.7 [28.7-88.9]			
Post	67.1 $\pm$ 11.4, 67.4 [37.4-87.4]	70.7 $\pm$ 10.6, 71.4 [48.1-86.9]	65.9 $\pm$ 11.3, 67.2 [43.8-81.6]	68.9 $\pm$ 9.8, 68.1 [49.6-87.4]	62.9 $\pm$ 13.0, 63.9 [37.0-87.1]			
Change in Means	8.2 $\pm$ 13.3,*** 9.1 [-27.3-43.1]	12.2 $\pm$ 13.6,*** 10.6 [-8.1-43.1]	6.4 $\pm$ 15.7, 7.1 [-27.3-28.9]	9.0 $\pm$ 12.1,** 9.9 [-13.5-38.8]	5.6 $\pm$ 11.5, 5.0 [-20.5-26.3]	0.77	0.48	0.32
Total Fruit (0-5)								
Baseline	2.4 $\pm$ 1.7, 2.2 [0.0-5.0]	2.6 $\pm$ 1.5, 2.6 [0.3-5.0]	2.2 $\pm$ 1.9, 1.6 [0.0-5.0]	2.7 $\pm$ 1.8, 2.4 [0.0-5.0]	2.0 $\pm$ 1.4, 1.9 [0.0-5.0]			
Post	3.1 $\pm$ 1.7, 3.4 [0.0-5.0]	3.9 $\pm$ 1.2, 5.0 [0.0-5.0]	2.8 $\pm$ 1.7, 4.7 [0.0-5.0]	3.5 $\pm$ 1.5, 4.0 [0.2-5.0]	2.2 $\pm$ 1.8, 2.3 [0.0-5.0]			
Change in Means	0.8 $\pm$ 1.9,** 0.6 [-3.8-4.7]	1.3 $\pm$ 1.9,** 1.2 [-2.3-4.7]	0.6 $\pm$ 2.2, 0.0 [-2.9-3.5]	0.9 $\pm$ 1.8,* 1.0 [-3.8-4.0]	0.2 $\pm$ 1.4, 0.4 [-2.7-2.6]	0.72	0.70	0.13
Whole Fruit (0-5)								
Baseline	3.4 $\pm$ 1.9, 4.3 [0.0-5.0]	3.6 $\pm$ 1.6, 4.2 [0.5-5.0]	2.9 $\pm$ 2.1, 3.1 [0.0-5.0]	3.6 $\pm$ 1.9, 4.8 [0.0-5.0]	3.4 $\pm$ 1.9, 4.0 [0.0-5.0]			
Post	4.1 $\pm$ 1.6, 5.0 [0.0-5.0]	4.6 $\pm$ 0.88, 5.0 [1.6-5.0]	4.1 $\pm$ 1.5, 5.0 [0.0-5.0]	4.4 $\pm$ 1.2, 5.0 [0.30-5.0]	3.0 $\pm$ 2.1, 4.4 [0.0-5.0]			
Change in Means	0.7 $\pm$ 2.1,** 0.0 [-4.6-5.0]	1.0 $\pm$ 1.5,** 0.2 [-0.3-4.5]	1.3 $\pm$ 2.0,* 0.1 [-2.1-4.4]	0.9 $\pm$ 1.8,* 0.0 [-2.5-5.0]	-0.4 $\pm$ 2.6, -0.5 [-4.6-5.0]	0.58	0.30	0.02*
Total Vegetables (0-5)								
Baseline	3.9 $\pm$ 1.2, 4.2 [0.7-5.0]	3.9 $\pm$ 1.2, 4.5 [1.5-5.0]	4.1 $\pm$ 1.1, 4.7 [1.5-5.0]	3.9 $\pm$ 1.2, 4.2 [1.4-5.0]	3.8 $\pm$ 1.2, 3.9 [0.7-5.0]			
Post	4.4 $\pm$ 1.0, 5.0 [0.7-5.0]	4.5 $\pm$ 0.9, 5.0 [2.1-5.0]	4.4 $\pm$ 1.1, 5.0 [1.2-5.0]	4.6 $\pm$ 0.7, 5.0 [2.5-5.0]	4.2 $\pm$ 1.3, 5.0 [0.7-5.0]			
Change in Means	0.5 $\pm$ 1.3,*** 0.03 [-2.8-3.6]	0.5 $\pm$ 1.2, 0.1 [-1.7-3.2]	0.3 $\pm$ 1.5, 0.0 [-2.8-3.5]	0.7 $\pm$ 1.1,** 0.3 [-0.2-3.6]	0.4 $\pm$ 1.4, 0.4 [-2.5-2.8]	0.34	0.37	0.83

Table 4.2 Baseline, Post-intervention, and Change in HEI Scores and Group Nutrition Education Attendance among Participants Completing the 6-month Intervention

HEI Score (Range)	Overall Sample Mean $\pm$ SD, Median [Range] N = 79	HP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 18	HP 65-80 Mean $\pm$ SD, Median [Range] N = 20	CP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 22	HP+EX 50-64 Mean $\pm$ SD, Median [Range] N = 19	P-value for planned comparisons <		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Greens and Beans (0-5)								
Baseline	2.9 $\pm$ 2.1, 3.0 [0.0-5.0]	2.8 $\pm$ 2.1, 3.0 [0.0-5.0]	2.8 $\pm$ 2.2, 2.6 [0.0-5.0]	3.1 $\pm$ 2.2, 4.3 [0.0-5.0]	2.9 $\pm$ 2.0, 3.0 [0.0-5.0]			
Post	3.7 $\pm$ 1.9, 5.0 [0.0-5.0]	3.8 $\pm$ 2.0, 5.0 [0.0-5.0]	3.2 $\pm$ 2.2, 5.0 [0.0-5.0]	3.8 $\pm$ 1.9, 5.0 [0.0-5.0]	4.0 $\pm$ 1.6, 5.0 [0.5-5.0]			
Change in Means	0.8 $\pm$ 2.5, 0.0 [-5.0-5.0]**	1.0 $\pm$ 2.8, 0.6 [-5.0 -5.0]	0.4 $\pm$ 2.7, 0.0 [-5.0-5.0]	0.7 $\pm$ 2.5, 0.0 [-5.0-5.0]	1.2 $\pm$ 2.0,* 1.1 [-3.3-5.0]	0.78	0.39	0.36
Whole Grains (0-10)								
Baseline	5.5 $\pm$ 3.2, 5.2 [0.0-10.0]	5.7 $\pm$ 2.8, 5.5 [0.9-10.0]	4.7 $\pm$ 2.8, 4.3 [0.3-10.0]	5.5 $\pm$ 2.8, 5.2 [0.3-10.0]	6.1 $\pm$ 3.6, 7.1 [0.9-10.0]			
Post	6.2 $\pm$ 3.2, 6.5 [0.0-10.0]	6.1 $\pm$ 3.3, 6.7 [1.6-10.0]	6.1 $\pm$ 3.3, 6.7 [1.6-10.0]	7.6 $\pm$ 3.1, 8.8 [1.5-10.0]	5.7 $\pm$ 3.2, 5.4 [0.9-10.0]			
Change in Means	0.8 $\pm$ 4.0, 0.5 [-8.4-10.0]	0.4 $\pm$ 3.6, 0.4 [-8.4-6.5]	0.7 $\pm$ 3.5, 1.1 [-6.2-6.0]	2.0 $\pm$ 4.6, 1.0 [-8.3-10.0]	-0.3 $\pm$ 4.0, 0.0 [-7.8-6.0]	0.09	0.97	0.21
Dairy (0-10)								
Baseline	5.2 $\pm$ 2.7, 4.6 [0.3-10.0]	4.6 $\pm$ 2.9, 4.4 [0.5-10.0]	5.3 $\pm$ 2.5, 4.5 [1.7-10.0]	5.4 $\pm$ 2.8, 5.2 [0.3-10.0]	5.5 $\pm$ 2.8, 4.6 [1.5-10.0]			
Post	6.7 $\pm$ 2.8, 6.7 [0.9-10.0]	5.5 $\pm$ 2.3, 5.3 [1.7-10.0]	8.1 $\pm$ 2.7, 9.6 [0.9-10.0]	6.3 $\pm$ 3.0, 6.1 [1.0-10.0]	6.9 $\pm$ 2.7, 7.4 [0.9-10.0]			
Change in Means	1.5 $\pm$ 3.7,*** 2.1 [-8.3-3.3]	0.9 $\pm$ 3.3, 0.9 [-6.3-7.1]	2.8 $\pm$ 3.0,** 2.8 [-2.3, 8.3]	0.9 $\pm$ 4.0, 1.4 [-8.3-6.1]	1.4 $\pm$ 4.1, 2.3 [6.5-6.9]	0.39	0.07	0.99
Total Protein Foods (0-5)								
Baseline	4.8 $\pm$ 0.6, 5.0 [2.1-5.0]	4.7 $\pm$ 0.6, 5.0 [2.9-5.0]	4.7 $\pm$ 0.8, 5.0 [2.1-5.0]	4.9 $\pm$ 0.4, 5.0 [3.5-5.0]	4.7 $\pm$ 0.5, 5.0 [3.6-5.0]			
Post	4.9 $\pm$ 0.4, 5.0 [1.6-5.0]	5.0 $\pm$ 0.0, 5.0 [5.0-5.0]	5.0 $\pm$ 0.0, 5.0 [5.0-5.0]	4.8 $\pm$ 0.7, 5.0 [1.6-5.0]	4.9 $\pm$ 0.4, 5.0 [3.5-5.0]			
Change in Means	0.2 $\pm$ 0.7,** 0.0 [-3.4-2.9]	0.3 $\pm$ 0.6, 0.0 [0.0-2.1]	0.3 $\pm$ 0.8, 0.0 [0.0-2.9]	-0.05 $\pm$ 0.8, 0.0 [-3.4-1.5]	0.2 $\pm$ 0.5, 0.0 [-0.5-1.4]	0.34	0.90	0.99

Table 4.2 Baseline, Post-intervention, and Change in HEI Scores and Group Nutrition Education Attendance among Participants Completing the 6-month Intervention

HEI Score (Range)	Overall Sample Mean $\pm$ SD, Median [Range] N = 79	HP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 18	HP 65-80 Mean $\pm$ SD, Median [Range] N = 20	CP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 22	HP+EX 50-64 Mean $\pm$ SD, Median [Range] N = 19	P-value for planned comparisons <		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Seafood and Plant Proteins (0-5)								
Baseline	3.5 $\pm$ 2.0, 5.0 [0.0-5.0]	3.4 $\pm$ 1.9, 4.1 [0.0-5.0]	4.1 $\pm$ 1.7, 5.0 [0.0-5.0]	3.7 $\pm$ 1.8, 4.9 [0.0-5.0]	2.7 $\pm$ 2.4, 3.6 [0.0-5.0]			
Post	3.6 $\pm$ 2.1, 5.0 [0.0-5.0]	4.2 $\pm$ 1.9, 5.0 [0.0-5.0]	3.4 $\pm$ 2.2, 5.0 [0.0-5.0]	3.8 $\pm$ 2.0, 5.0 [0.0-5.0]	3.0 $\pm$ 2.1, 3.6 [0-5]			
Change in Means	0.10 $\pm$ 2.3, 0.0 [-5.0-5.0]	0.8 $\pm$ 1.8, 0.0 [-2.1-5.0]	-0.7 $\pm$ 2.5, 0.0 [-5.0-5.0]	0.1 $\pm$ 2.2, 0.0 [-5.0-4.8]	0.4 $\pm$ 2.3, 0.0 [-4.3-5.0]	0.65	0.04*	0.73
Fatty Acids (0-10)								
Baseline	4.7 $\pm$ 3.2, 4.2 [0.0-10.0]	4.7 $\pm$ 3.2, 4.8 [0.0-10.0]	5.4 $\pm$ 3.2, 5.1 [0.8-10.0]	4.6 $\pm$ 2.6, 4.4 [0.0-10.0]	4.1 $\pm$ 4.0, 2.7 [0.0-10.0]			
Post	5.0 $\pm$ 3.2, 4.8 [0.0-10.0]	6.4 $\pm$ 3.5, 7.1 [0.0-10.0]	3.9 $\pm$ 2.6, 5.0 [0.0-5.0]	5.7 $\pm$ 3.0, 6.1 [0.5-10.0]	3.8 $\pm$ 3.2, 2.9 [0.0-10.0]			
Change in Means	0.3 $\pm$ 4.4, 0.6 [-9.4-10.0]	1.7 $\pm$ 3.5, 0.6 [-4.6-9.8]	-1.5 $\pm$ 4.1, -0.9 [-8.0-5.7]	1.1 $\pm$ 4.2, 2.0 [-9.4-10.0]	-0.3 $\pm$ 5.1, 0.6 [-8.6-8.7]	0.31	0.04*	0.56
Refined Grains (0-10)								
Baseline	6.6 $\pm$ 3.4, 7.7 [0.0-10.0]	6.6 $\pm$ 3.5, 7.9 [0.3-10.0]	7.2 $\pm$ 3.6, 9.1 [0.0-10.0]	6.1 $\pm$ 3.3, 6.5 [0.0-10.0]	6.7 $\pm$ 3.6, 7.4 [0.0-10.0]			
Post	8.5 $\pm$ 2.6, 10.0 [0.0-10.0]	9.3 $\pm$ 1.8, 10.0 [3.1-10.0]	8.8 $\pm$ 2.4, 10.0 [0.0-10.0]	7.4 $\pm$ 3.1, 8.8 [1.5-10.0]	8.9 $\pm$ 2.6, 10.0 [0.0-10.0]			
Change in Means	1.9 $\pm$ 3.8,*** 1.1 [-10.0-10.0]	2.7 $\pm$ 3.5,** 1.2 [-1.3-9.7]	1.6 $\pm$ 4.4, 0.9 [-10.0-9.4]	1.2 $\pm$ 3.5, 1.0 [-7.4-7.1]	2.2 $\pm$ 3.9,* 1.5 [-7.1-10.0]	0.57	0.93	0.89
Sodium (0-10)								
Baseline	4.1 $\pm$ 3.0, 4.6 [0.0-10.0]	4.3 $\pm$ 3.5, 3.5 [0.0-10.0]	4.4 $\pm$ 2.4, 5.0 [0.0-8.4]	4.1 $\pm$ 3.0, 4.3 [0.0-10.0]	3.8 $\pm$ 3.2, 4.6 [0.0-10.0]			
Post	3.4 $\pm$ 3.4, 2.6 [0.0-10.0]	3.7 $\pm$ 3.6, 3.9 [0.0-10.0]	3.8 $\pm$ 3.8, 3.3 [0.0-10.0]	3.4 $\pm$ 2.9, 3.3 [0.0-8.5]	2.7 $\pm$ 3.4, 1.1 [0.0-10.0]			
Change in Means	-0.7 $\pm$ 4.2, -0.2 [-10.0-8.7]	-0.6 $\pm$ 4.3, -0.5 [-8.7-6.7]	-0.6 $\pm$ 3.8, -0.01 [-8.4-5.7]	-0.7 $\pm$ 4.4, -0.4 [-10-8.4]	-1.1 $\pm$ 4.7, 0.0 [-8.9-8.7]	0.93	0.86	0.65

Table 4.2 Baseline, Post-intervention, and Change in HEI Scores and Group Nutrition Education Attendance among Participants Completing the 6-month Intervention

HEI Score (Range)	Overall Sample Mean ± SD, Median [Range] N = 79	HP+EX 65-80 Mean ± SD, Median [Range] N = 18	HP 65-80 Mean ± SD, Median [Range] N = 20	CP+EX 65-80 Mean ± SD, Median [Range] N = 22	HP+EX 50-64 Mean ± SD, Median [Range] N = 19	P-value for planned comparisons <		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Empty Calories (0-20)								
Baseline	11.9 ± 3.2, 12.2 [1.3-18.8]	11.6 ± 3.3, 10.9 [5.7-18.8]	11.8 ± 2.4, 12.1 [7.6-15.8]	12.2 ± 3.5, 12.5 [4.2-18.4]	11.8 ± 3.8, 13.2 [1.3-16.3]			
Post	13.4 ± 3.2, 13.8 [5.5-20.0]	13.7 ± 2.7, 14.0 [7.4-18.0]	13.1 ± 3.3, 13.3 [6.0-18.9]	13.4 ± 3.4, 13.5 [7.6-20.0]	13.6 ± 3.3, 14.2 [5.5-17.4]			
Change in Means	1.5 ± 3.7,*** 1.1 [-6.2-10.1]	2.1 ± 3.1,* 1.7 [-3.9-6.5]	1.3 ± 3.3, 2.0 [-6.2-7.0]	1.1 ± 3.4, 0.6 [-3.6-6.4]	1.7 ± 4.9, 0.5 [-6.1-10.1]	0.56	0.69	0.81
Group Nutrition Education Attendance	13.8 ± 3.6, 14.0 [4.0-22.0]	14.3 ± 2.1, 14.0 [11.0-17.0]	14.9 ± 2.7, 16.0 [7.0-20.0]	14.9 ± 2.7, 16.0 [9.0-20.0]	10.7 ± 4.8, 10.0 [4.0-22.0]	0.07	0.07	0.0001*

¹Post - Baseline may not always equal Change, because of rounding

²Within a group and within an HEI food group, the *, **, and *** refer to the statistical significance of the within group change in the HEI food category, such that

*** P < 0.001, ** P < 0.01 and * P < 0.05

³Within the planned comparisons, statistically significant differences are indicated by * P < 0.05

Table 4.3 Baseline, Post-intervention, and Change in Psychological Variables among Completers of the 6-month Intervention

Psychological Variable (Range)	Overall Sample Mean $\pm$ SD, Median [Range] N = 79	HP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 18	HP 65-80 Mean $\pm$ SD, Median [Range] N = 20	CP+EX 65-80 Mean $\pm$ SD, Median [Range] N = 22	HP+EX 50-64 Mean $\pm$ SD, Median [Range] N = 19	P-value for planned comparisons <		
						HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Self-Motivation Inventory (40-200)								
Baseline	149.8 $\pm$ 18.8, 153.0 [111.0-186.7]	147.6 $\pm$ 16.5, 152.0 [119.0-173.0]	148.2 $\pm$ 18.5, 154.5 [111.0-173.0]	152.0 $\pm$ 16.7, 155.0 [120.0-181.0]	150.9 $\pm$ 23.8, 153.0 [113.0-186.7]			
Post	151.7 $\pm$ 20.7, 154.0 [97.0-185.0]	152.6 $\pm$ 18.7, 156.0 [119.0-183.0]	148.7 $\pm$ 21.2, 153.0 [97.0-179.0]	155.2 $\pm$ 20.4, 159.0 [103.0-185.0]	150.1 $\pm$ 23.1, 153.0 [97.0-183.0]			
Change in Means	1.9 $\pm$ 11.5, 2.0 [-29.0-32.0]	5.0 $\pm$ 11.5, 7.0 [-18.0-32.0]	0.5 $\pm$ 10.4, -1.0 [-22.0-20.0]	3.1 $\pm$ 10.4, 5.0 [-27.0-20.0]	-0.8 $\pm$ 13.7, -2.0 [-29.0-25.0]	0.60	0.53	0.24
Satisfaction with Life Scale (5-35)								
Baseline	27.6 $\pm$ 5.5, 29.0 [11.0-35.0]	28.4 $\pm$ 4.3, 30.0 [20.0-35.0]	26.7 $\pm$ 5.9, 28.5 [11.0-34.0]	28.4 $\pm$ 6.1, 28.5 [15.0-35.0]	26.8 $\pm$ 5.5, 29.0 [12.0-34.0]			
Post	29.0 $\pm$ 5.5, 30.0 [5.0-35.0]	29.8 $\pm$ 4.8, 30.5 [14.0-35.0]	27.1 $\pm$ 7.5, 29.0 [5.0-35.0]	30.2 $\pm$ 4.0, 30.0 [18.0-35.0]	28.9 $\pm$ 4.7, 30.0 [15.0-34.0]			
Change in Means	1.4 $\pm$ 4.1, 1.0 [-7.0-14.0]**	1.3 $\pm$ 4.8, 1.0 [-7.0-12.0]	0.5 $\pm$ 3.7, 0.5 [-6.0-6.0]	1.8 $\pm$ 4.5, 2.0 [-5.0-14.0]	2.1 $\pm$ 3.3, 3.0 [-4.0-8.0]*	0.61	0.24	0.45
Vitality (0-100)								
Baseline	55.8 $\pm$ 14.3, 56.3 [25.0-87.5]	53.5 $\pm$ 14.7, 50.0 [25.0-81.3]	58.8 $\pm$ 14.0, 62.5 [31.3-75.0]	56.5 $\pm$ 17.0, 59.4 [25.0-87.5]	53.9 $\pm$ 10.7, 56.3 [31.3-68.8]			
Post	68.0 $\pm$ 14.7, 75.0 [31.3-100.0]	69.1 $\pm$ 13.6, 75.0 [37.5-93.8]	64.1 $\pm$ 14.5, 59.4 [43.8-87.5]	69.6 $\pm$ 17.5, 75.0 [31.3-100.0]	69.1 $\pm$ 12.8, 75.0 [43.8-81.3]			
Change in Means	12.2 $\pm$ 16.4, 12.5 [-31.3-62.5]***	15.6 $\pm$ 15.0, 18.8 [-25.0-37.5]**	5.3 $\pm$ 15.5, 9.4 [-31.3-25.0]	13.1 $\pm$ 20.2, 6.3 [-18.8-62.5]**	15.1 $\pm$ 12.0, 18.8 [-6.3-37.5]***	0.81	0.04*	0.39

¹Post - Baseline may not always equal Change, because of rounding

²Within a group and within psychological variables, the *, **, and *** refer to the statistical significance of the within group change in the psychological variable, such that

*** P < 0.001, ** P < 0.01 and * P < 0.05

³Within the planned comparisons, statistically significant differences are indicated by * P < 0.05

Table 4.4 Relationships of Protein Group, Exercise Group, Age Group, Baseline HEI-2010, Baseline Self-Motivation, and Group Nutrition Education Attendance with Change in HEI-2010 Total Score and Component Scores and Total Protein Foods

Variable	Regression coefficient (b)	Standard error	t	P-Value <	Model R ² (Adjusted R ²) ⁴
HEI-2010 Variable (Range)					
Total Score Change (0-100)					0.45 (0.40)***
Intercept	9.2	13.3	0.70	0.50	
Protein Group ¹	3.2	3.3	0.96	0.35	
Exercise Group ²	5.4	3.3	1.60	0.12	
Age Group ³	7.1	3.6	1.94	0.07	
Baseline Self-Motivation Inventory	0.2	0.06	2.77	0.008***	
Baseline HEI-2010 Total Score	-0.7	0.1	-6.90	0.001***	
Group Nutrition Education Attendance	0.3	0.4	0.70	0.50	
Total Fruit Change (0-5)					0.45 (0.41)***
Intercept	-3.7	1.7	-2.19	0.04*	
Protein Group	0.5	0.5	1.14	0.27	
Exercise Group	1.0	0.5	2.14	0.05*	
Age Group	1.6	0.5	3.14	0.004**	
Baseline Self-Motivation Inventory	0.02	0.1	2.78	0.008**	
Baseline HEI-2010 Total Fruit Score	-0.6	0.1	-6.53	0.0001***	
Group Nutrition Education Attendance	0.001	0.05	0.02	0.99	
Whole Fruit Change (0-5)					0.55 (0.51)***
Intercept	0.93	1.7	0.54	0.60	
Protein Group	0.2	0.5	0.42	0.68	
Exercise Group	0.3	0.5	0.61	0.54	
Age Group	1.7	0.5	3.34	0.002**	
Baseline Self-Motivation Inventory	0.007	0.009	0.82	0.43	
Baseline HEI-2010 Whole Fruit Score	-0.7	0.09	-8.36	0.0001*	
Group Nutrition Education Attendance	-0.03	0.05	-0.64	0.53	
Greens and Beans Change (0-5)					0.48 (0.43)***
Intercept	-1.0	2.2	-0.44	0.68	
Protein Group	0.1	0.6	0.20	0.86	
Exercise Group	0.6	0.6	1.04	0.32	
Age Group	-0.4	0.7	-0.60	0.56	
Baseline Self-Motivation Inventory	0.02	0.01	1.76	0.09	
Baseline HEI-2010 Greens and Beans Score	-0.8	0.1	-7.62	0.0001***	
Group Nutrition Education Attendance	0.06	0.07	0.83	0.42	

Table 4.4 Relationships of Protein Group, Exercise Group, Age Group, Baseline HEI-2010, Baseline Self-Motivation, and Group Nutrition Education Attendance with Change in HEI-2010 Total Score and Component Scores and Total Protein Foods

Variable	Regression coefficient (b)	Standard error	t	P-Value <	Model R ² (Adjusted R ²) ⁴
Total Vegetable Change (0-5)					0.52 (0.48)***
Intercept	0.3	1.1	0.29	0.79	
Protein Group	-0.06	0.3	-0.20	0.85	
Exercise Group	0.2	0.3	0.58	0.57	
Age Group	0.2	0.3	0.63	0.54	
Baseline Self-Motivation Inventory	0.02	0.006	2.96	0.005***	
Baseline HEI-2010 Total Vegetable Score	-0.7	0.09	-8.13	0.0001***	
Group Nutrition Education Attendance	0.02	0.03	0.63	0.54	
Whole Grain Change (0-10)					0.45 (0.40)***
Intercept	1.4	3.7	0.40	0.71	
Protein Group	-1.3	1.0	-1.36	0.19	
Exercise Group	0.6	1.0	0.60	0.56	
Age Group	0.3	1.1	0.28	0.79	
Baseline Self-Motivation Inventory	0.02	0.02	1.11	0.28	
Baseline HEI-2010 Whole Grain Score	-0.8	0.1	-7.1	0.0001***	
Group Nutrition Education Attendance	0.06	0.1	0.52	0.61	
Dairy Change (0-10)					0.51 (0.46)***
Intercept	10.6	3.2	3.29	0.003**	
Protein Group	-0.8	0.9	-0.95	0.36	
Exercise Group	-2.6	0.9	-3.00	0.005**	
Age Group	-0.5	1.0	-0.53	0.61	
Baseline Self-Motivation Inventory	0.009	0.02	0.58	0.58	
Baseline HEI-2010 Dairy Score	-0.9	0.1	-7.88	0.0001***	
Group Nutrition Education Attendance	-0.2	0.1	-2.20	0.04*	
Total Protein Change (0-5)					0.69 (0.66)***
Intercept	3.9	0.6	6.15	0.0001***	
Protein Group	0.2	0.1	1.52	0.14	
Exercise Group	0.009	0.1	0.07	0.96	
Age Group	0.06	0.1	0.41	0.69	
Baseline Self-Motivation Inventory	0.004	0.003	1.58	0.12	
Baseline HEI-2010 Total Protein Scores	-1.0	0.09	-11.86	0.0001***	
Group Nutrition Education Attendance	0.009	0.02	0.60	0.56	

Table 4.4 Relationships of Protein Group, Exercise Group, Age Group, Baseline HEI-2010, Baseline Self-Motivation, and Group Nutrition Education Attendance with Change in HEI-2010 Total Score and Component Scores and Total Protein Foods

Variable	Regression coefficient (b)	Standard error	t	P-Value <	Model R ² (Adjusted R ²) ⁴
Seafood and Plant Protein Change (0-5)					0.33 (0.27)***
Intercept	-1.6	2.3	-0.68	0.51	
Protein Group	0.5	0.6	0.85	0.41	
Exercise Group	1.1	0.6	1.73	0.10	
Age Group	0.8	0.7	1.18	0.25	
Baseline Self-Motivation Inventory	0.01	0.01	0.96	0.35	
Baseline HEI-2010 Seafood and Plant Protein Score	-0.6	0.1	-5.25	0.0001***	
Group Nutrition Education Attendance	0.02	0.07	0.25	0.81	
Fat Acids Change (0-10)					0.54 (0.51)***
Intercept	-4.5	3.7	-1.21	0.24	
Protein Group	0.8	1.0	0.83	0.42	
Exercise Group	2.6	1.0	2.58	0.02*	
Age Group	2.3	1.1	2.07	0.05*	
Baseline Self-Motivation Inventory	0.02	0.02	1.28	0.21	
Baseline HEI-2010 Fat Ratio Score	-0.9	0.1	-8.08	0.0001***	
Group Nutrition Education Attendance	0.08	0.1	0.72	0.48	
Refined Grains Change (0-10)					0.62 (0.59)***
Intercept	0.7	2.9	0.26	0.81	
Protein Group	2.1	0.8	2.61	0.02*	
Exercise Group	0.6	0.8	0.72	0.49	
Age Group	0.8	0.9	0.93	0.37	
Baseline Self-Motivation Inventory	0.04	0.02	2.30	0.03*	
Baseline HEI-2010 Refined Grains Score	-0.9	0.08	-10.34	0.0001***	
Group Nutrition Education Attendance	-0.06	0.09	-0.68	0.51	
Sodium Change (0-10)					0.38 (0.33)***
Intercept	-0.7	4.1	-0.18	0.86	
Protein Group	0.3	1.1	0.29	0.78	
Exercise Group	-0.06	1.1	-0.05	0.97	
Age Group	1.1	1.2	0.91	0.38	
Baseline Self-Motivation Inventory	0.02	0.02	0.89	0.39	
Baseline HEI-2010 Sodium Score	-0.9	0.1	-6.58	0.0001***	
Group Nutrition Education Attendance	-0.01	0.1	-0.12	0.92	

Table 4.4 Relationships of Protein Group, Exercise Group, Age Group, Baseline HEI-2010, Baseline Self-Motivation, and Group Nutrition Education Attendance with Change in HEI-2010 Total Score and Component Scores and Total Protein Foods

Variable	Regression coefficient (b)	Standard error	t	P-Value <	Model R ² (Adjusted R ²) ⁴
Percent Empty Calories Change (0-20)					0.43 (0.38)***
Intercept	4.8	3.7	1.28	0.21	
Protein Group	0.7	0.9	0.79	0.44	
Exercise Group	0.9	0.9	0.96	0.35	
Age Group	-1.0	1.0	-1.00	0.33	
Baseline Self-Motivation Inventory	-0.008	0.02	-0.44	0.67	
Baseline HEI-2010	-0.6	0.1	-5.91	0.0001***	
Percent Empty Calorie Score					
Group Nutrition Education Attendance	0.3	0.1	3.23	0.003**	
Total Protein Foods Total Protein Foods Change (oz. eq./1,000 kcal)					0.47 (0.43)***
Intercept	-0.6	1.6	-0.34	0.74	
Protein Group	2.5	0.4	5.68	0.0001***	
Exercise Group	0.6	0.4	1.35	0.19	
Age Group	0.3	0.5	0.71	0.49	
Baseline Self-Motivation Inventory	0.007	0.008	0.88	0.38	
Baseline Total Protein Food (oz. eq./1,000 kcal)	-0.7	0.1	-5.66	0.0001***	
Group Nutrition Education Attendance	0.08	0.05	1.59	0.13	

1. Coded as 0 = randomized to conventional protein; 1 = randomized to higher protein
2. Coded as 0 = not randomized to exercise intervention; 1 = randomized to exercise intervention
3. Coded as 0 = 50-64 years; 1 = 65-80 years
4. P-value represents significance of model F-values, and all models have statistically significant F-values (p < 0.0001)
5. N = 79

*** P < 0.001, ** P < 0.01 and * P < 0.05

Figure 4.1 Baseline, Post-intervention, and Change in Consumption of Total Protein Foods among Completers of the 6-month intervention								
Variable	Overall Sample	HP+EX 65-80	HP 65-80	CP+EX 65-80	HP+EX 50-64	P-value for planned comparisons <		
	Mean ± SD, Median [Range] N = 79	Mean ± SD, Median [Range] N = 18	Mean ± SD, Median [Range] N = 20	Mean ± SD, Median [Range] N = 22	Mean ± SD, Median [Range] N = 19	HP vs. CP	Ex. vs. No Ex	65-80 vs. 50-64
Total Protein Foods (oz. eq./1,000 kcal)⁴								
Baseline	3.5 ± 1.3, 3.5 [1.1-7.1]	3.4 ± 1.3, 3.4 [1.5-7.1]	3.7 ± 1.5, 3.5 [1.1-6.3]	3.2 ± 0.9, 3.1 [1.7-5.1]	3.8 ± 1.3, 3.9 [1.8-5.9]			
Post	4.9 ± 1.7, 5.1 [0.8-9.0]	6.1 ± 1.3, 6.1 [3.1-8.4]	5.6 ± 1.5, 5.9 [2.7-8.1]	3.6 ± 1.1, 3.5 [0.8-6.0]	5.6 ± 1.7, 5.7 [1.7-9.0]			
Change in Means	1.6 ± 1.8,*** 1.5 [-2.6-5.6]	2.6 ± 1.7,*** 2.7 [-1.2-5.2]	1.9 ± 1.6,*** 1.9 [-0.6-5.2]	0.4 ± 1.3, 0.6 [-2.6-3.2]	1.8 ± 1.8,** 1.9 [-0.9- -5.6]	0.0001*	0.48	0.74

¹Post - Baseline may not always equal Change, because of rounding

²Within a group and within total protein foods, the *, **, and *** refer to the statistical significance of the within group change in total protein foods, such that

*** P < 0.001, ** P < 0.01 and * P < 0.05

³Within the planned comparisons, statistically significant differences are indicated by * P < 0.05

⁴Total protein foods (eq./1,000 kcal) are used to calculate HEI-2010 total protein foods, seafood and plant protein, total vegetables, and greens and beans component scores. Beans and peas are included in the HEI-2010 total protein foods component score when the protein standard (2.5 oz. eq./1,000 kcal) is otherwise not met. Beans and peas not counted as total protein foods are counted as vegetables. Total protein foods (oz. eq./1,000 kcal) was analyzed in addition to HEI-2010 total protein food component scores to detect differences in protein food intake among treatment groups as an upper limit is placed on HEI-2010 total protein foods component scores (maximum value: 5 points; 2.5 oz. eq./1,000 kcal).

Figure 4.1 Baseline, Post-intervention, and Change in Consumption of Total Protein Foods among Completers of the 6-month Intervention

Figure 4.2 HEI-2010 Components and Scoring Standards^A

Component	Optimum Score	Standard for Maximum Score	Standard for Minimum Score of Zero
Total Fruit ¹	5	≥ 0.8 cup eq./1,000 kcal	No fruit
Whole Fruit ²	5	≥ 0.4 cup eq./1,000 kcal	No whole fruit
Total Vegetables ³	5	≥ 1.1 cup eq./1,000 kcal	No vegetables
Greens and Beans ³	5	≥ 0.2 cup eq./1,000 kcal	No dark-green vegetables or beans or peas
Whole Grains	10	≥ 1.5 oz. eq./1,000 kcal	No whole grains
Dairy ⁴	10	≥ 1.3 cup eq./1,000 kcal	No dairy
Total Protein Foods ⁵	5	≥ 2.5 oz. eq./1,000 kcal	No protein foods
Seafood and Plant Proteins ^{5,6}	5	≥ 0.8 oz. eq./1,000 kcal	No seafood or plant proteins
Fatty Acids ⁷	10	(PUFAs + MUFAs)/SFAs > 2.5	(PUFAs + MUFAs)/SFAs ≤ 1.2
Refined Grains	10	≤ 1.8 oz. eq./1,000 kcal	≥ 4.3 oz. eq./1,000 kcal
Sodium	10	≤ 1.1 g/1,000 kcal	≥ 2.0 g/1,000 kcal
Empty Calories ⁸	20	≤ 19% of energy	≥ 50% of energy

^AFigure and definitions of cup and oz. eq. are from (Guenther et al 2013 and University of Minnesota 2014)

¹Includes 100% fruit juice

²Includes all forms except fruit juice

³Includes any beans and peas not counted as Total Protein Foods

⁴Includes all milk products (fluid milk, yogurt, cheese, and fortified soy products)

⁵Beans and peas are included as Total Protein Foods (not with vegetables) when the Total Protein Foods standard (2.5 oz. eq./1,000 kcal) is otherwise not met

⁶Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods

⁷Ratio of poly- and monounsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs)

⁸Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 g/1,000 kcal

Figure 4.2 HEI-2010 Components and Scoring Standards^A

CHAPTER V

CONCLUSION

This dissertation adds to the understanding of the relationship of age and change in self-motivation, vitality, and satisfaction with life on intentional weight loss and change in diet quality in middle-aged and older women following an energy restricted (- ~500 kcal/day), higher protein (~30% energy) or conventional protein (~18% energy) diet, and with or without exercise. Overall conclusions were that middle-aged and older women were successful at weight loss with an average weight loss of 9.3% initial body weight at post-intervention, and 44% of participants achieved 10% weight loss. Older age versus middle-age was negatively associated with percent weight loss and achieving 10% weight loss, but when age was included in regression models as a continuous variable there was no longer a significant relationship of age with weight loss; therefore, the relationship of age and weight loss was inconsistent. Change in self-motivation and vitality were not related to weight loss, while an increase in satisfaction with life was significantly associated with achieving weight loss goals of 10% initial body weight. Thus, an increase in satisfaction with life may be associated with weight loss, but additional research is warranted to determine the causal pathway. Middle aged and older women improved diet quality from baseline to post-intervention; however, at post-intervention there was room for additional improvements in diet quality. Older women were able to make a larger number of nutritionally beneficial improvements in diet quality compared to middle-aged women, and higher baseline self-motivation was related to improvements in HEI-2010 total score and several component

scores. Thus, low self-motivation, but not age, may be a barrier to making improvements in diet quality during weight loss interventions.

The intensity of this study likely contributed to participants' success in achieving weight loss. Also, number of group nutrition education sessions attended was associated with greater percent weight loss, achieving 10% weight loss, and with nutritionally beneficial improvements in the HEI-2010 empty calorie component score. Participants were in frequent contact with intervention staff consisting of health professionals and/or trained doctoral students in nutrition and kinesiology. Thus, participants were frequently monitored by this intervention staff, were able to ask questions regarding diet and physical activity and receive timely feedback, and received social support from other participants. Although this frequent contact helped participants succeed in achieving weight loss and making improvements in dietary patterns, the intensity of this intervention may not be possible for most people attempting weight loss, and was difficult for some participants who were working full time during the intervention.

While working closely with participants throughout this intervention allowed for the realization of the burden an intensive weight loss intervention placed on some participants. Many women in the HP+EX 50-64 treatment group were currently working full time during the intervention period, and attending 3 exercise sessions and 1 individual diet counseling or group nutrition education class weekly placed an additional burden on these participants who were already facing time constraints and stress from employment. Some participants had to seek permission to arrive to work late, leave work early, and/or attend intervention visits during their lunch break in order to attend the required weekly diet and exercise sessions. Further, some participants had to travel to the intervention site multiple times in a day (i.e., arrive at the University of Georgia campus in the morning before work for exercise and again in the evening

after work for group diet class) in order to meet intervention requirements. Future research incorporating alternative methods for diet counseling such as internet, video conferencing, email, mobile apps, and/or telephone calls to replace some or all of the in-person diet counseling may identify effective methods for diet counseling, while minimizing the stress and time constraints participants face when required to make frequent in-person visits with interventionists. Such intervention methods have been successfully utilized in other studies over a wide age-range (Arem & Irwin 2011), however less is known about their effectiveness in older people.

In the current study, participants were instructed to use MyFitnessPal to monitor food intake throughout the intervention. I believe this application worked well to facilitate positive dietary change. This application is free, easy to use, and could be used with various types of electronic devices including computers, smart phones, and tablets. Participants could easily access the application at home, at work, and at community locations such as the public library. In addition, participants were aware that intervention staff monitored this application weekly to provide individual feedback, which provided accountability as participants consumed meals and snacks away from interventionists and the intervention site.

As a registered dietitian I realize the importance of self-monitoring and the benefit of an application, such as MyFitnessPal, which allows for meal planning. The MyFitnessPal application allowed participants to view the impact of food choices on meeting diet goals before consumption. While working with participants on this intervention, I noted differences in how some participants chose to use this application. Some participants used the application as a planning tool. For example, they may have used this application to determine energy and nutrient content of items on a restaurant menu in order to make an informed decision on the meal they would consume before ordering. This way they would be less tempted by social pressure

from others with whom they were dining and from other higher energy menu items, and would be more likely to choose a meal that fit within their diet plan. On the other hand, some participants used this tool as a food diary, and rather than using the application to plan meals beforehand, entered meals and snacks after consumption. Although both practices were beneficial to participants, I would be interested, in future studies, to determine how the frequency and the type of use of this application affected change in weight and diet quality. In future studies, I may ask questions such as:

1. Do you use MyFitnessPal to plan meals and snacks ***before*** consuming them to ensure the foods fit within your diet plan?
 - a. No
 - b. Yes
 - i. If yes, how often do you use MyFitnessPal to plan meals and snacks?
 1. More than once per day
 2. Once per day
 3. Once per week
 4. More than once per week
 5. Once or more per month

Throughout the intervention participants were provided with print and social media resources to assist them in making dietary change. A lean beef cookbook was provided as an optional resource to assist those participants assigned to higher protein diets in meeting the requirement of consuming 3 oz. of lean beef each day. An intervention Facebook page was created to provide encouragement and an opportunity for social engagement with interventionists

and participants, and an intervention Pinterest page provided recipes and links to reputable articles with information on nutrition-related topics. In this study we did not have a formal assessment of participants' use of these resources. In future interventions, I would be interested to determine whether frequency of use of these resources, particularly social media websites, was related to weight loss and dietary change. In future studies, I may ask a question such as:

1. How often did you access the DIVAS intervention Pinterest page?
 - a. Once or more per day
 - b. Once or more per week
 - c. Once or more per month
 - d. I did not access the DIVAS intervention Pinterest page

Working closely with individuals engaging in weight loss allowed me to realize the impact that life events have on an individual's capability to commit to intervention requirements and make dietary changes. Many participants experienced life events, both positive and negative, which sometimes decreased their ability to fully commit to the intervention. Life events such as retirements, births, weddings, and providing care for parents, children, grandchildren, and other family members were not captured in data analysis, but made a significant impact on participant's lives. Often these life events resulted in stress and time constraints, which interfered with participant's ability to engage in physical activity, make dietary changes, and lose weight. Future research, which assesses the impact of major life events on weight loss and dietary change, would be important to better understand the needs of individuals engaging in weight loss. In future studies, I may include a questionnaire designed to measure life experiences, such as the Life Experiences Survey (Sarason, Johnson, & Siegel 1978), in order to assess the impact of major life events on weight loss and dietary change.

Berg (2015) analyzed data from older women enrolled in this intervention, and found that older women assigned to higher protein diets increased protein intake following the intervention, but more than 50% did not meet protein recommendations (~ 30% energy from protein). In this study, weight loss was similar among women assigned to higher protein and conventional protein diets. This large percentage of participants who did not meet protein requirements may provide reasoning for this lack of association. Additionally, older women assigned to higher protein diets consumed less lean beef at post-intervention than the required 3 oz. of lean beef per day. Many women grew tired of consuming beef daily, and refused to consume lean beef by the end of the weight loss intervention (Berg 2015). Thus, future interventions are warranted to determine beneficial, yet feasible, protein recommendations for intentional weight loss. Future studies allowing for the consumption of a variety of protein sources may result in better adherence to protein recommendations.

Following the weight loss intervention, middle-aged and older women following an energy restricted diet with different levels of protein intake improved diet quality, however, at post-intervention there was room for additional improvements in diet quality and older women were able to make a larger number of nutritionally beneficial improvements in diet quality compared to middle-aged women. Berg (2015) found that older women who completed this weight loss intervention made dietary improvements, but still fell short of meeting goals for some nutrients, including saturated fat and fiber. In addition, those assigned to higher protein diets were less likely to meet goals for fiber intake. Thus, the findings from this dissertation, along with the findings of Berg (2015), show that age was not a barrier to making positive dietary change; however, future studies, particularly those assessing higher protein diets for weight loss, should include monitoring for saturated fat and fiber intake.

Findings from this study, along with those of Berg (2015), show psychological factors associated with successful with loss and dietary change, including self-motivation, satisfaction with life, and flexible cognitive restraint. These findings may be incorporated in future weight loss interventions. Additional studies may benefit from incorporating strategies to increase self-motivation and strategies that encourage a flexible approach to eating behaviors (Berg 2015). In addition, including mental health professionals as members of the intervention team may help address mental health issues, such as depression, which are related to weight loss and attrition in weight loss interventions (Berg 2015). In this study we found an association with increased life satisfaction and achieving weight loss goals. The potential for increasing a person's satisfaction with life may be used as an incentive to enroll participants and/or increase adherence to intervention protocol in future weight loss interventions.

A logical next step for additional research would include assessing maintenance of weight loss following this intervention. Although interventions are successful in producing weight loss, often participants regain weight and return to baseline weight within 3-5 years after treatment ends (Middleton, Patidar, & Perri 2012). In this study, many participants were successful in losing weight, but research is warranted to determine if participants were successful at maintaining weight loss. Determining participant characteristics associated with successful weight loss maintenance and effective methodology for weight loss maintenance are important areas in which additional research is warranted.

Data from middle-aged women who completed this intervention will be used in future analyses to determine epigenetic changes, which may result from an intervention that included higher protein intakes than is typical, supervised exercise, and weight loss. Natalie Hohos, doctoral candidate in the department of Foods and Nutrition at the University of Georgia, will be

performing these analyses, and these findings will be incorporated in her dissertation. Natalie described that the major aim of these analyses is to examine DNA cytosine methylation resulting from weight loss. If changes are found, the genes containing these epigenetic changes will be identified, and additional analyses will determine if these genes are enriched in pathways related to human health. Natalie says these analyses will be performed on a single cell type, CD 4+ T cells, which is a novel concept as similar studies have analyzed epigenetic changes from adipose tissue and blood mononuclear cells (Martinez et al 2014). Although all middle-aged participants were assigned to the same treatment group (higher protein diet with exercise), individual variations in diet and weight loss still occurred. I may be able to contribute to the epigenetic analysis by assisting in data analysis that includes data used in this dissertation, pertaining to weight loss and diet, to help control for individual variation.

Overall, the findings of this dissertation contribute to the understanding of the influence of age and psychological constructs on intentional weight loss and change in diet quality in middle-aged and older women. As a dietitian on this intervention, I further realized the importance of concepts such as self-monitoring, meal planning, accountability, and social support in facilitating weight loss and dietary change. Additional research that incorporates remote nutrition counseling and determines the influence of online applications, social media, and major life events on weight loss and dietary change would provide additional insight into effective methods to facilitate weight loss and provide a better understanding of the needs of individuals engaging in weight loss. Additional research that assesses participant characteristics related to and successful methods for weight loss maintenance are also of importance.

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APPENDIX A

PARTICIPANT INFORMED CONSENT DOCUMENT



Consent to Participate in a Research Study

Title of Study: Effects of a Higher Protein Weight Loss Diet and Exercise on Body Composition, Physical Function and Fatigue in Overweight Older Women

Principal Investigators: Dr. Ellen M. Evans (706-542-4395; emevans@uga.edu)

UGA Department: Kinesiology

Purpose of this Research Study: This research, sponsored by the National Cattlemen's Beef Association, is being conducted by the responsible principal investigator listed above. The purpose of this study is to compare the effectiveness of a higher-protein, reduced-carbohydrate (PRO) diet including beef combined with exercise, a standard higher carbohydrate (CARB) diet combined with exercise and PRO diet including beef without exercise on weight loss, body composition, muscular strength and quality and feelings of energy and fatigue.

Major Activities of Your Involvement:

1. Time: Your participation in the study will last approximately 7 months with multiple visits to our research sites. These visits will last from approximately 0.5 hour to 3 hours in length for a total of approximately 40-130 hours depending on the study group to which you are randomly assigned. Research visits, diet education classes and exercise sessions will occur in our laboratories on the first floor of the Ramsey Student Center. MRI scanning will take place in the Coverdale Building and screening blood work will be done at the University Health Center.

2. Screening: Because of your health status and the nature of this study, you will undergo screening to insure safety for participation. This will involve evaluation of your medical history, screening blood work, and for those assigned to an exercise group, a physician administered stress test will be conducted to determine that your cardiovascular system is healthy for exercise.

3. Treatment Groups: Upon successful screening, you will be randomly placed in to one of the following three groups: 1) higher-protein, reduced-carbohydrate diet (PRO) plus exercise group, 2) conventional higher carbohydrate diet (CARB) plus exercise group, 3) PRO without exercise group. The intervention is 24 weeks in length; however, you

will need to remain in compliance with your assigned treatment until you complete your final testing session.

Dietary Prescriptions: All diet recommendations will be designed to reduce your caloric intake by 500 calories per day to induce a 10% weight loss from your initial body weight over the course of the intervention. The PRO diet will be designed to provide ~30% of your daily calories from protein sources, including one serving of beef per day. Fats and carbohydrates will be prescribed as 30% and 40% of your remaining energy intake, respectively. The ~30% protein/kcal target will be prescribed at all meals and snacks; therefore, the 3-3.5 ounces of beef per day will provide 25-33% of daily protein intake. The CARB diet will be designed to provide ~18% of your daily calorie intake from protein emphasizing grains and limited beef consumption. For the CARB group, fats and carbohydrates will be prescribed as 30% and 52% of your remaining energy intake, respectively. PRO and CARB will be the same in that they will be similar in daily calories, dietary fat intake and fruit and vegetable consumption recommendations. All participants will have an individual meeting with the dietetics counselor for initial prescriptions and will also attend weekly educational meetings in small groups. These meetings will last from half an hour to an hour, depending on the topic.

Exercise Intervention: Both of the exercise groups will be required to attend 3 exercise sessions per week. If you do not attend at least 75% of exercise session (54 sessions over the 6 months), you may be asked to withdraw from the study. Exercise sessions will be held on Monday, Wednesday and Fridays and participants can attend one session per day during a morning, afternoon or evening session that will be held in the UGA Department of Kinesiology Fitness Center. For your safety, all exercise sessions will be supervised with trained personnel. The exercise sessions will include walking, lifting weights with your arms, abdominals, back and legs, stretching and balance exercises. Each session will last one hour and 15 minutes. During each exercise session you will wear a heart rate monitor that consists of a soft plastic transmitter, an elastic strap which fastens around your chest and a watch which will display the heart rate. If you are assigned to the PRO diet only group, you will be asked to maintain your current physical activity patterns for the duration of the intervention.

Details of Study Involvement:

Screening Visit #1 (S1) [~ 1 hour]

When visiting the lab for S1, you will do the following:

1. Review your phone screening form with study staff for accuracy.
2. If you are still eligible, you will read the approved informed consent document and then orally describe what your participation will involve to a member of the research team. If you are still interested in participating in the study, both you and a member of the research team will sign three copies of this informed consent document. One will be stored in a locked cabinet separate from all of your other study materials. One will be provided to the University Health Center and you will keep one for your records.
3. You will read and sign an informed consent for the dual energy x-ray absorptiometry (DEXA) scan. This procedure is used to determine your body composition and bone density.

4. You will read and sign an informed consent regarding MRI scanning procedures for this study.
5. We will measure your height, weight and waist circumferences using standard clinical instruments.
6. You will complete forms that assess your medical history, cognitive status, physical activity habits, and dietary intake.
7. You will be given instructions for a screening blood draw at the University Health Center.
8. We will again explain to you that for safe participation in our study, you will need to obtain medical clearance and we will provide you with forms to take to your personal physician.

Screening Visit #2 (S2) [~0.5 hour]

When visiting the lab for S2, you will do the following:

1. You will visit the Laboratory at the University Health Center for a fasting screening blood draw.

Randomization: At this point in the study, you will now be randomized (equal chance of assignment) to one of the three groups described above. If you are assigned to the exercise group, you will be asked to complete Screening Visit #3, described below.

Screening Visit #3 (S3) [~0.75 hour]

When visiting the lab for S3, you will do the following:

Once the research team receives clearance from your personal physician clears allowing you to participate in the study, you will be scheduled for a stress test which will be conducted under the supervision of Jonathan Murrow, MD. Dr. Murrow is a Cardiologist in the Athens area with an appointment in the Medical School and an adjunct appointment in the Department of Kinesiology. This standard clinical test is used to determine safety for exercise participation. You will be asked to walk on a treadmill at a brisk pace with the grade increasing every 2 minutes until you cannot go any longer or the physician indicates that the test should be terminated. Your heart and blood pressure will be monitored at every stage. This test usually lasts ~5 minutes for rest, ~10-15 minutes of graded exercise and 5 minutes of post-exercise recovery, depending on individual health status.

All participants will complete visits B1, B2, B3, M1, M2, P1, P2, and P3.

Baseline Visit #1 (B1) [~ 2 hours]

When visiting the lab for B1, you will do the following:

1. You will be asked to arrive at our laboratory (Ramsey Center, Room 101A) in a fasted state to provide us with a fasting blood sample. We will provide you with a snack once this has been completed.
2. We will then have you complete a DXA scan which will allow us to assess your body composition, including your fat mass, lean mass and bone mass. DXA technology uses

a low-dose X-ray beam to determine bone mineral content, fat mass and fat-free mass. Non-metal containing garments must be worn for the scan and scrubs will be provided for you if needed. The scan involves lying on your back on a table while the DXA arm moves across the length of your body. There is no discomfort associated with this scan.

3. We Will then ask you to fill out questionnaires that ask you about how you have been feeling over the past week and the past month and about your physical activity levels. These questionnaires include the: a) Profile of Mood States, b) Self-Motivation Inventory, c) Labeled Magnitude Scale, d) Affect Grid, e) SF-36, f) Satisfaction with Life Scale, g) Pittsburgh Sleep Quality Index, h) Geriatric Depression Scale, i) Perceived Stress Scale, j) Trails B, and k) Physical Activity Scale for the Elderly (PASE).
4. You will then be provided with an activity monitor that we will ask you to wear for 7 days. This monitor is worn on an elastic belt that you fasten around your waist. You will be asked to wear it for one week during all hours that you are awake. At this visit, you will be provided with written instructions on how to wear the monitor properly.
5. You will also be provided with forms to record your 3 day food record. We will provide you with written instructions on how to properly complete these forms at this visit.

Baseline Visit #2 (B2) [~ 3 hours]

When visiting the lab for B2, you will do the following:

1. You will be accompanied by a member of the research team to the Coverdale building to undergo MRI scanning. You will be asked to lie on a bed that slides into the long tube of the scanner. The scanner is a small enclosed space. Radio waves and strong, changing magnetic fields are used to make images of your muscle, fat and bone tissue. You will be given earplugs to protect your ears since these changing magnetic fields can cause loud knocking, thumping, or pinging noises. You will be asked to remain very still at these times. The MRI will allow us to obtain another measure of your body composition, including abdominal visceral and subcutaneous adiposity, and muscle area and adipose infiltration of muscle will be measured using MR imaging.
2. After completing the MRI scanning, you will accompanied by a member of our research team to our laboratory in the Ramsey Student Center where you will complete assessments of your muscular strength and endurance. The strength testing will involve measuring the maximum amount of weight you are able to lift when extending and bending your knee and measuring the amount of force you can produce with the muscles in your legs when you repeatedly kick out and back with your knee.

Baseline Visit #3 (B3) [~ 2 hours]

When visiting the lab for B3, you will do the following:

1. To assess your physical function you will be asked to attempt tasks that require you to stand and balance with your feet side by side and then one in front of the other, to stand up from a chair 5 times in a row as quickly as you can, to walk as quickly as possible over a 4 meter course, to get down to the floor from a standing position and

return to a standing position, to stand up from a chair, walk around an obstacle and return to the chair, to lift a crate of items walk around an obstacle, in a seated position pushing out with your legs as hard and as quickly as you can, and walking as quickly as you can for 6 minutes.

2. A member of the research team will collect your activity monitor and review the forms that you filled out.

3. A member of the research team will sit down with you to review your 3 day food record to make sure that it is complete.

Mid-Point Visit #1 (M1) [~ 3 hours]

When visiting the lab for M1, you will do the following:

1. You will have another DXA scan allowing us to assess any changes that may have occurred with your body composition over the first half of our study.

2. You will answer questionnaires that ask you about how you are feeling and about your physical activity level. These will be the same questionnaires that you answered at the beginning of the study.

3. You will do the same functional tasks that you did in visit B3 so that we can assess your physical function at the midpoint of the study. You will be asked to attempt tasks that require you to stand and balance with your feet side by side and then one in front of the other, to stand up from a chair 5 times in a row as quickly as you can, to walk as quickly as possible over a 4 meter course, to get down to the floor from a standing position and return to a standing position, to stand up from a chair, walk around an obstacle and return to the chair, to lift a crate of items walk around an obstacle, in a seated position pushing out with your legs as hard and as quickly as you can, and walking as quickly as you can for 6 minutes.

4. You will be provided with an activity monitor and you will be asked to wear it for 7 days. You will be given the same activity monitor that you were given at the beginning of the study and we will review how to use the activity monitor at this visit.

5. You will be asked to fill out another 3 day food record and the instructions for how to do this properly will be reviewed at this visit.

Mid-Point Visit #2 (M2) [~ 1.5 hours]

When visiting the lab for M2, you will do the following:

1. We will test your muscular strength and endurance at this point in our protocol. The strength testing will be the same as B2 and will involve measuring of the maximum amount of weight you are able to lift when extending and bending your knee and measuring the amount of force you can produce with the muscles in your legs when you repeatedly kick out and back with your knee.

2. A member of the research team will collect your activity monitor and review the forms that you filled out.

3. A member of the research team will sit down with you to review your 3 day food record to make sure that it is complete.

Post-Intervention Visit #1(P1) [~ 2 hours]

When visiting the lab for P1, you will do the following:

1. You will be asked to arrive at our laboratory (Ramsey Center, Room 101A) in a fasted state to provide us with a fasting blood sample. We will provide you with a snack once this has been completed.
2. You will complete your third DXA scan which will allow us to assess your body composition, including your fat mass, lean mass and bone mass.
3. You will fill out the same questionnaires that you filled out at B1 and M1.
4. You will be provided with an activity monitor that we will ask you to wear for 7 days. This monitor is worn on an elastic belt that you fasten around your waist. You will be asked to wear it during all hours that you are awake for one week. You will be provided with written instructions on how to wear the monitor properly at this visit.
5. You will also be provided with forms to record your 3 day food record. We will provide you with written instructions on how to properly fill complete these forms at this visit.

Post-Intervention Visit #2 (P2) [~ 3 hours]

When visiting the lab for P2, you will do the following:

1. You will be accompanied by a member of the research team to the Coverdale building to undergo MRI scanning for the second time.
2. After completing the MRI scanning, you will accompanied by a member of our research team to our laboratory in the Ramsey Student Center where you will complete the same assessments of your muscular strength and endurance that you completed at B2 and M2.

Post-Intervention Visit #3 (P3) [~ 2 hours]

When visiting the lab for P3, you will do the following:

1. You will do the same tasks that you did in visit B3 and M1 so that we can assess your physical function at the end of the study. You will be asked to attempt tasks that require you to stand and balance with your feet side by side and then one in front of the other, to stand up from a chair 5 times in a row as quickly as you can, to walk as quickly as possible over a 4 meter course, to get down to the floor from a standing position and return to a standing position, to stand up from a chair, walk around an obstacle and return to the chair, to lift a crate of items walk around an obstacle, in a seated position pushing out with your legs as hard and as quickly as you can, and walking as quickly as you can for 6 minutes.
2. A member of the research team will collect your activity monitor and review the forms that you filled out.
3. A member of the research team will sit down with you to review your 3 day food record to make sure that it is complete.

Post-Intervention #4(P4) [~ 1 hour]

When visiting the lab for P4, you will do the following:

1. You will be asked to participate in a focus group with other participants and answer questions about how you felt about participating in our study.

Benefits: After the study, you will be provided with information about your body composition (percent fat, fat mass, bone mineral density, and lean soft tissue mass) and

you will be provided with the results of your screening blood work. You are encouraged to share this information with your personal physician. The results of this study may increase understanding of additional health benefits of weight loss using a high-protein diet alone, a high protein diet combined with exercise or a high protein diet combined with exercise. The results may have important implications for improving overall cardiovascular and metabolic health for postmenopausal women.

Incentives: You will be provided with a payment of \$25.00 when all screening and baseline visits have been completed. Upon successful completion of the intervention and all midpoint and post intervention visits, you will be provided with an additional \$75.00.

Blood Analysis: You will be provided a copy of your clinically relevant blood work and you are encouraged to share this information with your personal physician. Our research team will not diagnose disease from your blood work results.

Potential risks/discomforts from participation in the study: The primary risks in this study are (1) the performance of strenuous exercise which may make you fatigued, give you sore muscles or make you experience discomfort in breathing or your muscles, (2) possible but unlikely pooling of blood in the lower extremities after strenuous exercise, (3) possibility of fainting, development of a small bruise, or infection with the blood draw, (4) the DXA scan and (5) the MRI scan.

We will reduce risks to you by doing the following:

1. Carefully screening you for safety to exercise with a physician administered graded exercise test and clearance from your personal physician prior to performing high-intensity exercise.
2. During the exercise training sessions, you will have an individual monitoring your heart rate and ensuring that you do not have any signs of exercise distress. If signs of illness such as headache, nausea, mental disorientation, lack of coordination, or dizziness occur, an emergency protocol will be immediately initiated. All testing will be carefully supervised by the investigators and other trained personnel to reduce the possible risk. In the unlikely event of an emergency, laboratory personnel trained in CPR/AED will be present during all testing conditions.
3. The risks involved in drawing blood will be minimized by using only qualified and experienced staff to draw blood. These individuals will follow standard sterile techniques and procedures, will observe the subject after the needle is withdrawn, and will apply pressure to the blood-draw site to stop bleeding. All procedures used in this laboratory for blood drawing are per the MBC Laboratory's Standard Operating Procedure and are approved on file with the University's Biosafety Office.
4. DXA scans are used to determine body composition involves exposure to radiation from x-rays and the radiation exposure from this procedure is typically 1-5 mrem. A comparable exposure is equivalent to less than one day's amount of natural background radiation exposure persons in the United States receive each year. The risk from radiation exposure of this magnitude is too small to be measured directly and is considered to be low when compared with other everyday risks.

5. MRI is a non-invasive procedure and allows the investigator to study your body without surgery or radiation. MRI uses a strong magnet and radio waves to make medical images of the body. MRI uses computer technology to make detailed images of the soft tissues, muscles, nerves, and bones in your body. There have been no ill effects reported from exposure to the magnetism or radio waves used in this test. However, it is possible that harmful effects could be recognized in the future. A known risk is that the magnet could attract certain kinds of metal. Therefore, you will be asked about metal in or on your body (this includes certain dyes found in tattoos). If there is any question about potentially hazardous metal within your body, you will be excluded from participation in this research study. The researchers will also keep the examining room locked so that no one carrying metal objects can enter while you are in the scanner. MRI can also cause claustrophobia (feeling “closed in”) in some participants. The study involves entering a large room in which a magnet is present. Claustrophobic participants may not tolerate the confinement in the magnet. You will be in visual and verbal contact with the experimenter throughout the scan through an observation window, headphones, and a microphone and the test can be stopped quickly at any time due to any of these discomforts. You understand that there is no risk or harm associated with the visual assessments; however, in some instances, mild discomfort may occur during the scanning portion of the study, as this process is accompanied by moderately loud operating noise. To minimize any discomfort caused by noise, you will be provided with earplugs, and the headphones used for communication with the experimenter will further reduce the generated noise. If undue discomfort or stress occurs, you have the right to discontinue the test at any time. The MRI results will be explained to you and may be clinically relevant, but for diagnosis and health questions, you should consult a qualified physician.

If you are injured: The researchers involved in this study will exercise all reasonable care to protect you from harm as a result of your participation. In the event of an injury as an immediate and direct result of your participation in this study, the researchers’ sole responsibility is to arrange transportation to an appropriate facility if additional care is required. In the event that you suffer a research-related injury, your medical expenses will be your responsibility or that of your third-party payer, although you are not precluded from seeking to collect compensation for injury related to malpractice, fault, or blame on the part of those involved in the research.

Confidentiality and Privacy Protection: Your name will not appear on any data relating to you except for the Informed Consent Document for the study, DXA, and MRI informed consent document. These items will be kept in a locked cabinet in a locked office separate from your other study information. Upon entrance in the study, you will be assigned a code number. Only the principal investigator will have access to the list of names and corresponding code numbers. All codes and identifiers will be destroyed one year following the completion of the study. Additionally, your name will not appear on any publication that might result from the data obtained in this study. All information regarding your personal information (height, weight, test performance, etc.) will be kept strictly confidential unless required by law or necessary to protect your welfare (for example, if you were injured and needed physician care). This study will be performed,

in part, at the University Health Center (UHC). Refusal to participate or decision to stop participating at any time will not compromise your access to care, treatment, and UHC services not related to the research, if you otherwise have such access. If you have a health record at UHC, your participation in this project will be noted on the summary list unless you specifically request that it not be added.

Voluntary participation and withdrawal from the study: Your participation in this study is voluntary. Refusal to participate in this study will involve no penalty or loss of benefits to which you are otherwise entitled. You are free to withdraw from the study at any time without penalty or loss of benefits to which you are otherwise entitled. Also, the researchers reserve the right to stop your participation in the study at any time as a result of you having an unexpected response during the study, failing to follow instructions, or because the study has been stopped. It is important for you to know, however, that information about you collected up to the point of your withdrawal will be kept as part of the study data and may continue to be analyzed.

Questions: If you have any questions at any time throughout the study, you have a right to ask and are encouraged to contact the principal investigator Dr. Ellen M. Evans at emevans@uga.edu or by phone at 706-542-4395.

Participant's agreement:

I have read the information provided on the preceding pages. The researchers have answered all of my questions to my satisfaction, and I voluntarily agree to participate in this study. I have been given a copy of this form.

Signature of Research Participant

Date

Printed Name of Research Participant

Signature of Researcher

Date

Printed Name of Researcher

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu



Consent to Participate in a Research Study

Title of Study: Exercise-Induced Epigenetic Modifications in Obese Aging Women

Principal Investigators: Dr. Ellen M. Evans (706-542-4395; emevans@uga.edu)

UGA Department: Kinesiology

Purpose of this Research Study: The primary aim of this study is to examine epigenetic changes resulting from exercise and caloric restriction induced weight loss in older women known to be at risk for metabolic syndrome. This pilot data will be used to generate an NIH proposal of the same topic. A secondary aim is to assess the impact of weight loss on physical function and psychological well-being, which will provide pilot data for an additional grant proposal for weight management in postmenopausal women.

Major Activities of Your Involvement:

1. Time: Your participation in the study will last approximately 6 months with multiple visits to our research sites. *These visits will last from approximately 0.5 hour to 2.5 hours in length for a total of approximately 133 hours. This equates to ~5 hours a week for the 6 months.* Research visits, diet education classes and exercise sessions will occur in our laboratories on the first floor of the Ramsey Student Center.
2. Screening: Because of the nature of this study, you will undergo screening to insure that it is safe for you to participate. This will involve evaluation of your medical history and clearance from your personal physician, and completion of the physical activity readiness questionnaire (PAR-Q) to determine that your cardiovascular system is healthy for exercise.

3. Treatment Groups:

Dietary Prescriptions: All participants will be individually counseled by an RD for ~ 4 sessions (about 30 to 60 minutes), and more often if necessary to meet weight loss goals. During the duration of the study, participants will be required to attend a 30 to 60 minute (depending on the topic) group educational/motivational meeting weekly (first 1 to 2 months) and then biweekly (for the remainder of the study). This diet recommendation will include high quality proteins at every meal and snack with an emphasis on lean meats. Regarding beef intake specifically, the prescribed diet will

include a minimum of one serving of beef per day, which is approximately 3 to 3.5 ounces or ~100 grams. The diet will consist of protein at ~30% of calories, carbohydrates at ~40% of calories, and fats at ~30% of calories. Based on our previous work, we anticipate that when on protocol you will consume ~92 grams of protein a day. By reducing energy from carbohydrates and fat from your diet, it will create an overall energy deficit of 500 kcal/day to facilitate weight loss. This diet will also include 5 servings/day of vegetables and 2-3 servings/day of fruits. You must discontinue all dietary supplements except those recommended by your physician or provided to you by this study (multivitamin-mineral supplement and calcium supplements will be provided to you at no cost during this study).

Exercise Intervention: The exercise groups will be required to attend 3 exercise sessions per week. If you do not attend at least 75% of exercise session (54 sessions over the 6 months), you may be asked to withdraw from the study. Attendance at exercise sessions on Tuesdays and Thursdays is required, and participants can choose to attend during a morning, afternoon, or evening session. The third exercise session will be held on Monday, Wednesday and Friday and participants can choose one session during a morning, afternoon or evening to attend. All sessions will be held in the UGA Department of Kinesiology Fitness Center. The exercise sessions will include walking, lifting weights with your arms, abdominals, back and legs, stretching and balance exercises. Each session will last one hour and 15 minutes. During each exercise session you will wear a heart rate monitor that consists of a soft plastic transmitter, an elastic strap which fastens around your chest and a watch which will display the heart rate. In addition, participants will be asked to complete 2 days of unsupervised walking of moderate intensity for a minimum of 45 minutes.

Details of Study Involvement:

Screening Visit #1 (S1) [~ 1 hour]

In the Ramsey Center lab, you will go over your online screening information with study staff, and if you are eligible the staff will go over information about the dual energy x-ray absorptiometry (DEXA) scan to determine your body composition and bone density. You will be provided with the physician clearance form and instructed that this form is to be completed and signed by their primary care physician (PCP) prior to enrollment into the intervention. You will complete the Physical Activity Readiness Questionnaire (PAR-Q).

Baseline Visit #1 (B1) [~ 2.5 hours]

You will be asked to arrive at our laboratory (Ramsey Center, Room 101A) in a fasted state to provide us with a fasting blood sample. This sample will be stored and analyzed for metabolic markers analyzed at a later date. We will provide you with a snack once this has been completed. Then you will have a complete DEXA scan. DEXA technology uses a low-dose X-ray beam to determine bone mass and body composition. You will then fill out questionnaires that ask how you have been feeling over the past week and month and about your physical activity and eating behaviors. You will be

provided with an activity monitor that we will ask you to wear for 7 days during all hours that you are awake. This monitor is worn on an elastic band that fastens around your waist. You will meet with the RD/LD, and you will be provided with forms to record what you eat and drink for 3 days. We will measure your height, weight, and waist circumference.

Baseline Visit #2B (B2) [~ 2 hours]

In the Ramsey Center Lab we will measure your muscular strength and endurance using a Biodex isokinetic dynamometer.

Baseline Visit #3 (B3) [~ 2 hours]

In the Ramsey Center Lab you will complete tasks that mimic activities of daily living like standing up from a chair, getting off the floor from a sitting position, walking, and carrying small objects. You should return your activity monitor and the food records you received in the B1 visit.

Mid-Point Visit #1 (M1) [~ 3 hours]

In the Ramsey Lab you will have a complete DEXA scan. DEXA technology uses a low-dose X-ray beam to determine bone mass and body composition. You will then fill out questionnaires that ask how you have been feeling over the past week and month and about your physical activity and eating behaviors. You will be provided with an activity monitor that we will ask you to wear for 7 days during all hours that you are awake. This monitor is worn on an elastic band that fastens around your waist. You will meet with the RD/LD, and you will be provided with forms to record what you eat and drink for 3 days. We will measure your height, weight, and waist circumference. You will then complete tasks that mimic activities of daily living like standing up from a chair, getting off the floor from a sitting position, walking, and carrying small objects.

Mid-Point Visits #2 (M2) [~ 2 hours]

In the Ramsey Center Lab we will measure your muscular strength and endurance using a Biodex isokinetic dynamometer. We will also measure your height, weight and waist circumference. You should return your activity monitor and the food records you received in the B1 visit.

Post-Intervention Visits [~ 6 hours]

After completing all 6 months of the intervention, you will be scheduled for 3 post-intervention testing visits. These 3 visits include the same baseline testing visits outlined above.

Benefits: The potential benefits to you include participation in a free structured supervised exercise, nutrition and weight loss program that will provide health benefits for disease risk and general well-being. In addition, health information regarding your body composition (percent fat, fat mass, bone mineral density, and lean soft tissue mass) and dietary intake information will be provided to you. The results of this study

may increase the understanding of epigenetic changes that occur as a result of weight loss induced by caloric restriction and exercise as well as the functional and psychological benefits associated with weight loss. Participants may also receive a pedometer, valued at \$20. To receive the pedometer, participants must complete all portions of the study (online screening form, screening visit, 3 baseline visits, exercise intervention, diet intervention, 2 midpoint visits, and 3 post intervention visits). Participants will receive the pedometer following the completion of their 3rd post intervention (P3) visit. Additional incentives include being eligible to win a 3 month memberships (1 in 5 chance) to the Department of Kinesiology's Fitness center, valued at \$105 each, for use following the completion of the study.

Additionally, results of this research should help reveal genes whose expression is potentially modifiable due to changes in whole body adiposity and help determine mechanisms accounting for individual variability in adiposity. This may provide a basis for future, personalized diet and exercise interventions to maximize adiposity and body weight maintenance. Data collected will be individually identifiable.

Potential risks/discomforts from participation in the study:

1. General: The potential for a serious health problem to arise directly attributable to participation in the investigation is minimal. We anticipate no psychological, social, or legal risks beyond those of participation in health-related research in general.

2. Exercise and Caloric Restriction (Weight Loss) Intervention: The potential risks of exercise-training include development of ventricular arrhythmia, myocardial infarction, cardiac arrest, and death as well as the less serious problems of injury to tendons, ligaments, joints and muscles. The research participants will be required to attend 3 supervised exercise sessions per week and complete a minimum of 2 unsupervised walking sessions on alternate days of the week. Caloric restriction can have psychosocial effects due to restriction of lifestyle and potential fatigue effects depending on the participant's response to the intervention.

3. DXA Imaging: Risk of radiation exposure from DXA scans is minimal. Exposure for 4 scans is very small, equivalent to <2% of the natural annual dose of radiation (depending on location, lifestyle and medical procedures). Alternatively, this exposure is approximately equivalent to 1/6 that which is experienced with a standard chest x-ray. While alternative measures of body composition exist which do not necessitate a radiation dose, these alternatives are of lower precision and/or feasibility than the DXA measurements and also preclude regional assessments of adiposity. Such precision is needed for the current study objectives (i.e. central adiposity).

4. Blood collection: The collection of 30 ml blood at screening, baseline, and at the end of the 4 month intervention period is associated with minimal risk when completed by a lab technician trained in phlebotomy. Risks of blood draw include bruising, bleeding or infection at the site of the venipuncture.

5. *Loss of Privacy:* Participant information will only be accessed by individuals involved in data collection and/or data analysis, and will be stored in locked file cabinet.

We will reduce risks to you by doing the following:

1. *Intervention:* To protect against or minimize potential risk subjects will be screened to exclude those with chronic health conditions that might increase the risk of developing complications due to exercise participation or caloric restriction. All participants will be required to obtain clearance from your physician. All exercise prescriptions will gradually increase their exercise intensity and duration to prevent injuries. Supervision of the exercise program sessions will be conducted by doctoral level students in the Department of Kinesiology within the laboratory of Professor Evans. All exercise sessions will have an individual trained in CPR and First Aid within the Center. The exercise program for all participants will follow a conventional multi-modal program endorsed by the American College of Sports Medicine for older adults that combines weight bearing endurance exercise and resistance training. All dietary prescriptions will be given by a research dietitian and participants will be monitored for side effects including rapid weight loss which will be targeted at ~0.5 per week.

2. *DXA:* You will be informed of the risks of DXA imaging and, as always, have the option to not participate. As all participants are postmenopausal there is no risk to unborn fetus.

3. *Blood Drawing:* Risks will be minimized by the draws being performed by lab technicians trained in phlebotomy using established techniques.

If you are injured: The researchers involved in this study will exercise all reasonable care to protect you from harm as a result of your participation. In the event of an injury as an immediate and direct result of your participation in this study, the researchers' sole responsibility is to arrange transportation to an appropriate facility if additional care is required. In the event that you suffer a research-related injury, your medical expenses will be your responsibility or that of your third-party payer, although you are not precluded from seeking to collect compensation for injury related to malpractice, fault, or blame on the part of those involved in the research.

Confidentiality and Privacy Protection: All information that can identify you will be kept strictly confidential unless required by law or necessary to protect your welfare (for example, if you were injured and needed physician care). Your name will not appear on any data relating to you except for the Informed Consent Document for the study and DXA informed consent document. These items will be kept in a locked cabinet in a locked office separate from your other study information. Upon entrance in the study, you will be assigned a code number. Only investigators will have access to the list of names and corresponding code numbers. All codes and identifiers will be destroyed one year following the completion of all data collection.

Voluntary participation and withdrawal from the study: Your participation in this study is voluntary. You can refuse or withdraw from the study at any time without penalty or loss of benefits to which you are otherwise entitled. Also, the researchers will terminate your participation in the study at any time as a result of you having an unexpected response during the study, failing to follow instructions, or because the study has been stopped. It is important for you to know, however, that information collected from or about you up to the point of your withdrawal or termination by the researcher will be kept as part of the study data and may continue to be analyzed.

Questions: If you have any questions at any time throughout the study, you have a right to ask and are encouraged to contact the principal investigator Dr. Ellen M. Evans at emevans@uga.edu or by phone at 706-542-4395.

Participant's agreement:

I have read the information provided on the preceding pages. The researchers have answered all of my questions to my satisfaction, and I voluntarily agree to participate in this study.

Signature of Research Participant

Date

Printed Name of Research Participant

Signature of Researcher

Date

Printed Name of Researcher

Please sign three copies of this informed consent document. One will be stored in a locked cabinet separate from all of your other study materials. One will be provided to the University Health Center and you will keep one for your records.

Participation in future studies: Would you like your contact information to be kept on file for participation in future studies? Agreement to allow contact information to be retained for future studies does not constitute consent to participate in future studies. Additional consent will be obtained for future studies.

Yes

No

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu

APPENDIX B
QUESTIONNAIRES

Demographics & Health History

Demographics				
Date of Birth:				
	MM	DD	YYYY	
	Age:			
Are you currently married?			☐ Yes ☐ No <i>If no, please specify:</i> ☐ Never married ☐ Separated ☐ Living with partner ☐ Divorced ☐ Widowed ☐ Other	
What is your race? <i>(Please specify all categories that apply.)</i>			☐ Asian/Pacific Islander ☐ Black ☐ Hispanic ☐ Native American/Alaskan ☐ White	
How many years of education have you completed?				
	# of years attended		Degree?	Specify the major area of study
Elementary (grades 1-8)	years		☐ Yes ☐ No	
High school (grades 9-12)	years		☐ Yes ☐ No	
Vocational/Technical School	years		☐ Yes ☐ No	
2-year College	years		☐ Yes ☐ No	
4 –year College	years		☐ Yes ☐ No	
Graduate School	years		☐ Yes ☐ No	

Professional School		years	☐ Yes ☐ No	
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What is your current employment status?

1	☐	Full time – working at least 35 hours/week
2	☐	Part time – working less than 35 hours/week
3	☐	Laid-off or unemployed, but looking for work
4	☐	Laid-off or unemployed, but not looking for work
5	☐	Retired, not working at all
6	☐	Retired, working part-time
7	☐	Disabled
8	☐	Full time homemaker
9	☐	Other, <i>please specify</i> : _____

What is your primary occupation (the one you work most hours a week)?

If you are retired and not working, what WAS your primary occupation?

Do you have any children?	☐ Yes ☐ No <i>If yes, please specify how many:</i>
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How many people live in your household including yourself?	adults (at least 18 years of age) children (less than 18 years of age)
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Other than yourself and your spouse or significant other, please describe any additional household members:

Children	Age(s)
Grandchildren	Age(s)
Other relatives	Age(s)
Other non-relatives	Age(s)

What is your total gross household annual income (before taxes and deductions)?			
0 ☐	\$0- \$14,999	1 ☐	\$15,000- \$29,999
2 ☐	\$30,000- \$44,999	3 ☐	\$45,000-\$59,999
4 ☐	\$60,000- \$74,999	5 ☐	\$75,000- \$89,999
6 ☐	\$90,000 and above	7 ☐	I choose not to answer

Health History	
<i>Do you have any of the following:</i>	
Have you been diagnosed with a past or present cardiovascular disease?	1 ☐ Yes 0 ☐ No
Do you have any significant heart rhythm disorders?	1 ☐ Yes 0 ☐ No
Is it a chronic disorder?	1 ☐ Yes 0 ☐ No
Have you been diagnosed with hypertension (high blood pressure)?	1 ☐ Yes 0 ☐ No
Have you been diagnosed with peripheral vascular disease?	1 ☐ Yes 0 ☐ No
Have you ever been diagnosed with a pulmonary disease such as asthma or emphysema?	1 ☐ Yes 0 ☐ No
Do you have obstructive sleep apnea?	1 ☐ Yes 0 ☐ No
Are you epileptic?	1 ☐ Yes 0 ☐ No
Do you have arthritis? If so please describe where and severity (i.e., left knee, moderate pain):	1 ☐ Yes 0 ☐ No
Are you diabetic? If so please explain:	1 ☐ Yes 0 ☐ No
Have you been diagnosed with any kind of cancer? If so, please explain:	1 ☐ Yes 0 ☐ No
Do you have hyper or hypothyroidism? If so, please explain:	1 ☐ Yes 0 ☐ No
Have you recently been hospitalized? If so please explain why and for how long:	1 ☐ Yes 0 ☐ No

Have you had any recent illnesses or recently received antibiotics? If so, please explain:	1 ☐ Yes 0 ☐ No
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Medications: Please indicate if you take the following medicine or drugs (circle all that you take), **and** list all other medicines or drugs you presently take and include the amount taken (dosage) and how often. Please include over-the-counter medicines as well as prescription medicine.

Medicine/Drug/Supplement Name	Dosage (strength, i.e. mg, units, etc.)	Frequency Taken (i.e., times per day, week, etc.)
Anti-inflammatory drugs (e.g. aspirin, ibuprofen)		
Statins (e.g. Lipitor, Crestor, Mevacor, Vytorin)		
Hypothyroidism drugs (e.g. Synthroid)		
Any Other Medications:		

How much sleep did you get last night? How much sleep do you typically get each night?		Hours last night
		Hours each night

Have you ever smoked in the past? If yes, How many years did you smoke? Approximately how much did you smoke each day? How long ago did you quit smoking?	1 ☐ Yes 0 ☐ No Years smoked Cigarettes/day Years ago
--	--

How many cups of caffeinated coffee do you have daily? <i>(If none, please write "0")</i>	cups of caffeinated coffee/day
How many caffeinated soft drinks do you have daily?	soft drinks/day
How many cups of tea do you have daily?	cups of tea/week
How many cans of beer do you have weekly?	cans of beer/week
How many glasses of wine do you have weekly?	glasses/week
How many ounces of liquor do you have weekly?	ounces/week
How many cigars or pipes do you smoke daily?	cigars or pipes/day
How often would you rate your stress level as high?	☐ 0 Occasionally ☐ 1 Frequently ☐ 2 Constantly
Is there anything else you feel we should know about you or your current/past health? If yes, please explain:	☐ 1 Yes ☐ 0 No

Beef Consumption History

Do you regularly consume beef?	☐ 1 Yes ☐ 0 No <i>If yes, please specify how many days per week you consume beef:</i> <i>How many serving of beef do you eat per week?</i>
--------------------------------	--

Self-Motivation Inventory

Read each of the following statements and write by each item the letter of the alternative which best describes how characteristic the statement is when applied to you. Please be sure to answer every item and try to be as honest and accurate as possible in your response.

PLEASE WRITE RESPONSES IN CAPITAL LETTERS!!

The alternatives are:

- A. Extremely uncharacteristic of me
- B. Somewhat uncharacteristic of me
- C. Neither characteristic nor uncharacteristic of me
- D. Somewhat characteristic of me
- E. Extremely characteristic of me

- ___ 1. I'm not very good at committing myself to doing things.
- ___ 2. Whenever I get bored with projects I start, I drop them to do something else.
- ___ 3. I can persevere at stressful tasks, even when they are physically tiring or painful.
- ___ 4. If something gets to be too much of an effort to do, I'm likely to just forget it.
- ___ 5. I'm really concerned about developing and maintaining self-discipline.
- ___ 6. I'm good at keeping promises, especially the ones I make to myself.
- ___ 7. I don't work any harder than I have to.
- ___ 8. I seldom work to my full capacity.
- ___ 9. I'm just not the goal setting type.
- ___ 10. When I take on a difficult job, I make a point of sticking with it until it's completed.
- ___ 11. I'm willing to work for things I want as long as it's not a big hassle for me.
- ___ 12. I have a lot of self-motivation.
- ___ 13. I'm good at making decisions and standing by them.
- ___ 14. I generally take the path of least resistance.
- ___ 15. I get discouraged easily.

PLEASE GO TO THE NEXT PAGE

The alternatives are:

- A. Extremely uncharacteristic of me
- B. Somewhat uncharacteristic of me
- C. Neither characteristic nor uncharacteristic of me
- D. Somewhat characteristic of me
- E. Extremely characteristic of me

- ___ 16. If I tell somebody I'll do something, you can depend on it being done.
- ___ 17. I don't like to overextend myself.
- ___ 18. I'm basically lazy.
- ___ 19. I have a very hard-driving, aggressive personality.
- ___ 20. I work harder than most of my friends.
- ___ 21. I can persist in spite of pain or discomfort.
- ___ 22. I like to set goals and work toward them.
- ___ 23. Sometimes I push myself harder than I should.
- ___ 24. I tend to be overly apathetic.
- ___ 25. I seldom if ever let myself down.
- ___ 26. I'm not very reliable.
- ___ 27. I like to take on jobs that challenge me.
- ___ 28. I change my mind about things quite easily.
- ___ 29. I have a lot of will power.
- ___ 30. I'm not likely to put myself out if I don't have to.
- ___ 31. Things just don't matter much to me.
- ___ 32. I avoid stressful situations.
- ___ 33. I often work to the point of exhaustion.
- ___ 34. I don't impose much structure on my activities.

PLEASE GO TO THE NEXT PAGE

The alternatives are:

- A. Extremely uncharacteristic of me
- B. Somewhat uncharacteristic of me
- C. Neither characteristic nor uncharacteristic of me
- D. Somewhat characteristic of me
- E. Extremely characteristic of me

- ___ 35. I never force myself to do things I don't feel like doing.
- ___ 36. It takes a lot to get me going.
- ___ 37. Whenever I reach a goal, I set a higher one.
- ___ 38. I can persist in spite of failure.
- ___ 39. I have a strong desire to achieve.
- ___ 40. I don't have much self-discipline.

SF-36 Health Survey

This survey asks for your views about your health. This information will help you keep track of how you feel and how well you are able to do your usual activities. Thank you for completing this survey!

1. In general, would you say your health is (mark one box):				
Excellent	Very Good	Good	Fair	Poor
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

2. <u>Compared to one year ago</u> , how would you rate your health in general now? (mark one box):				
Much better now than one year ago	Somewhat better now than one year ago	About the same as one year ago	Somewhat worse now than one year ago	Much worse now than one year ago
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

HEALTH AND DAILY ACTIVITIES

3. The following items are about activities you might do during a typical day. Does <u>your health now limit you</u> in these activities? If so, how much? (mark one box)			
ACTIVITIES	Yes, Limited A Lot	Yes, Limited A Little	No, Not Limited At All
a. <u>Vigorous activities</u> , such as running, lifting heavy objects, participating in strenuous sports	☐ 1	☐ 2	☐ 3
b. <u>Moderate activities</u> , such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	☐ 1	☐ 2	☐ 3
c. Lifting or carrying groceries	☐ 1	☐ 2	☐ 3
d. Climbing <u>several</u> flights of stairs	☐ 1	☐ 2	☐ 3
e. Climbing <u>one</u> flight of stairs	☐ 1	☐ 2	☐ 3
f. Bending, kneeling or stooping	☐ 1	☐ 2	☐ 3
g. Walking <u>more than a mile</u>	☐ 1	☐ 2	☐ 3
h. Walking <u>several hundred yards</u>	☐ 1	☐ 2	☐ 3

i. Walking <u>one hundred yards</u>	☐ 1	☐ 2	☐ 3
j. Bathing or dressing yourself	☐ 1	☐ 2	☐ 3

4. During the <u>past 4 weeks</u> , have you had any of the following problems with your work or other regular daily activities <u>as a result of your physical health</u> ? (mark one box)				
a. Cut down on the <u>amount of time</u> you spent on work or other activities				
All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b. <u>Accomplished less</u> than you would like				
All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c. Were limited in the <u>kind</u> of work or other activities				
All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d. Had <u>difficulty</u> doing work or other activities (for example, it took extra effort)				
All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

5. During the <u>past 4 weeks</u> , have you had any of the following problems with your work or other regular daily activities <u>as a result of any emotional problems</u> (such as feeling depressed or anxious)? (mark one box)				
a. Cut down on the <u>amount of time</u> you spent on work or other activities				
All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b. <u>Accomplished less</u> than you would like				
All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c. Did work or other activities <u>less carefully as usual</u> .				
All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

6. During the <u>past 4 weeks</u> , to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors or groups? (mark one box):				
Not at all	Slightly	Moderately	Quite a Bit	Extremely
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

7. How much <u>bodily</u> pain have you had during the <u>past 4 weeks</u> ?					
None	Very mild	Mild	Moderate	Severe	Very severe
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

8. During the <u>past 4 weeks</u> , how much did <u>pain</u> interfere with your normal work (including both work outside the home and housework)?(mark one box):				
Not at all	A little bit	Moderately	Quite a Bit	Extremely
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

YOUR FEELINGS

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling.

How much of the time during the past 4 weeks: (check one box for each)

	All of the Time	Most of the Time	Some of the Time	A Little of the Time	None of the Time
a. Did you feel full of pep?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b. Have you been very nervous?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c. Have you felt so down in the dumps that nothing could cheer you up?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d. Have you felt calm and peaceful?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
e. Did you have a lot of energy?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
f. Have you felt downhearted and depressed?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
g. Did you feel worn out?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
h. Have you been happy?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
i. Did you feel tired?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

HEALTH IN GENERAL					
10. During the <u>past 4 weeks</u> , how much of the time has your <u>physical health or emotional problems</u> interfered with your social activities (like visiting friends, relatives, etc.)?					
	All of the Time	Most of the Time	Some of the Time	A Little of the Time	None of the Time
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

11. How TRUE or FALSE is <u>each</u> of the following statements for you? (check one box)					
	Definitely True	Mostly True	Don't Know	Mostly False	Definitely False
a. I seem to get sick a little easier than other people	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b. I am as healthy as anybody I know	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c. I expect my health to get worse	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d. My health is excellent	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

THANK YOU FOR COMPLETING THESE QUESTIONS

Satisfaction with Life Scale

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

- 7 - Strongly agree
- 6 - Agree
- 5 - Slightly agree
- 4 - Neither agree nor disagree
- 3 - Slightly disagree
- 2 - Disagree
- 1 - Strongly disagree

_____ In most ways my life is close to my ideal.

_____ The conditions of my life are excellent.

_____ I am satisfied with my life.

_____ So far I have gotten the important things I want in life.

_____ If I could live my life over, I would change almost nothing.

Three Factor Eating Questionnaire

Directions: For items 1-36, please respond by circling True or False.

Part I

	Please circle your answer	
1. When I smell a sizzling steak, I find it very difficult to keep from eating, even if I have just finished a meal.	True	False
2. I usually eat too much at social occasions, like parties and picnics.	True	False
3. I am usually so hungry that I eat more than three times a day.	True	False
4. When I have eaten my quota of calories, I am usually good about not eating any more.	True	False
5. Dieting is so hard for me because I just get too hungry.	True	False
6. I deliberately take small helpings as a means of controlling my weight.	True	False
7. Sometimes things just taste so good that I keep on eating even when I am no longer hungry.	True	False
8. Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat.	True	False
9. When I feel anxious, I find myself eating.	True	False
10. Life is too short to worry about dieting.	True	False
11. Since my weight goes up and down, I have gone on reducing diets more than once.	True	False
12. I often feel so hungry that I just have to eat something.	True	False
13. When I am with someone who is overeating, I usually overeat too.	True	False
14. I have a pretty good idea of the number of calories in common food.	True	False
15. Sometimes when I start eating, I just can't seem to stop.	True	False
16. It is not difficult for me to leave something on my plate.	True	False
17. At certain times of the day, I get hungry because I have gotten used to eating then.	True	False
18. While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	True	False
19. Being with someone who is eating often makes me hungry enough to eat also.	True	False
20. When I feel blue, I often overeat.	True	False
21. I enjoy eating too much to spoil it by counting calories or watching my weight.	True	False
22. When I see a real delicacy, I often get so hungry that I have to eat right away.	True	False
23. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.	True	False
24. I get so hungry that my stomach often seems like a bottomless pit.	True	False
25. My weight has hardly changed at all in the last ten years.	True	False
26. I am always hungry so it is hard for me to stop eating before I finish the food on my plate.	True	False

27. When I feel lonely, I console myself by eating.	True	False
28. I consciously hold back at meals in order not to gain weight.	True	False
29. I sometimes get very hungry late in the evening or at night.	True	False
30. I eat anything I want, any time I want.	True	False
31. Without even thinking about it, I take a long time to eat.	True	False
32. I count calories as a conscious means of controlling my weight.	True	False
33. I do not eat some foods because they make me fat.	True	False
34. I am always hungry enough to eat at any time.	True	False
35. I pay a great deal of attention to changes in my figure.	True	False
36. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.	True	False

Part II

Directions: Please answer the following questions by circling your answers.

-
37. How often are you dieting in a conscious effort to control your weight?
A = rarely B = sometimes C = usually D = always
-
38. Would a weight fluctuation of five pounds affect the way you live your life?
A = rarely B = sometimes C = usually D = always
-
39. How often do you feel hungry?
A = rarely B = sometimes C = usually D = always
-
40. Do your feelings of guilt about overeating help you to control your food intake?
A = rarely B = sometimes C = usually D = always
-
41. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?
A = easy B = slightly difficult C = moderately difficult D = very difficult
-
42. How conscious are you of what you are eating?
A = not at all B = slightly C = moderately D = extremely
-
43. How frequently do you avoid "stocking up" on tempting foods?
A = almost never B = seldom C = usually D = almost always
-
44. How likely are you to shop for low calorie foods?
A = unlikely B = slightly unlikely C = moderately likely D = very likely
-
45. Do you eat sensibly in front of others and splurge alone?
A = never B = rarely C = often D = always
-
46. How likely are you to consciously eat slowly in order to cut down on how much you eat?
A = unlikely B = slightly likely C = moderately likely D = very likely
-
47. How frequently do you skip dessert because you are no longer hungry?
1 = almost never 2 = seldom 3 = at least once a week 4 = almost everyday
-
48. How likely are you to consciously eat less than you want?
A = unlikely B = slightly unlikely C = moderately likely D = very likely
-
49. Do you go on eating binges though you are not hungry?
A = never B = rarely C = sometimes D = at least once a week
-
50. On a scale of A to E, where A means no restraint in eating (eating whatever you want, whenever you want it) and E means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself? Circle your answer:
A = usually eat whatever you want, whenever you want it
B = often eat whatever you want, whenever you want it
C = often limit food intake, but often "give in"
D = usually limit food intake, rarely "give in"
E = constantly limiting food intake, never "giving in"
-
51. To what extent does this statement describe your eating behavior? "I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow."
A = not like me
B = little like me
C = pretty good description of me
D = describes me perfectly
-

Pittsburgh Sleep Quality Index

*Instructions: The following questions relate to your usual sleep habits **during the past month only**. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.*

During the past month:

1. When have you usually gone to bed? _____
2. How long (in minutes) has it taken you to fall asleep each night? _____
3. When have you usually gotten up in the morning? _____
4. How many hours of actual sleep did you get that night? (This may be different than the number of hours you spend in bed) _____

5. During the past month, how often have you had trouble sleeping because you...	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				

	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)
9. During the past month, how would you rate your sleep quality overall?				

APPENDIX C

ANTHROPOMETRIC MEASURES

ANTHROPOMETRIC MEASURES

Time Point (please circle):

Baseline Midpoint Post

Date of Birth						
MM		DD		YYYY		

Measures	Measurement	Comments
Body Weight (kg)	.	
Natural Waist Circumference 1 (cm)	.	
Natural Waist Circumference 2 (cm)	.	
Natural Waist Circumference 3 (cm)	.	
Natural Waist Circumference Average (cm)	.	
Umbilicus Waist Circumference 1 (cm)	.	
Umbilicus Waist Circumference 2 (cm)	.	
Umbilicus Waist Circumference 3 (cm)	.	
Umbilicus Waist Circumference Average (cm)	.	

BMI Measurements

Body Mass	.	kg	.	lbs
Height	.	cm	. inches	
BMI	.	Kg/m ²		

DXA Information

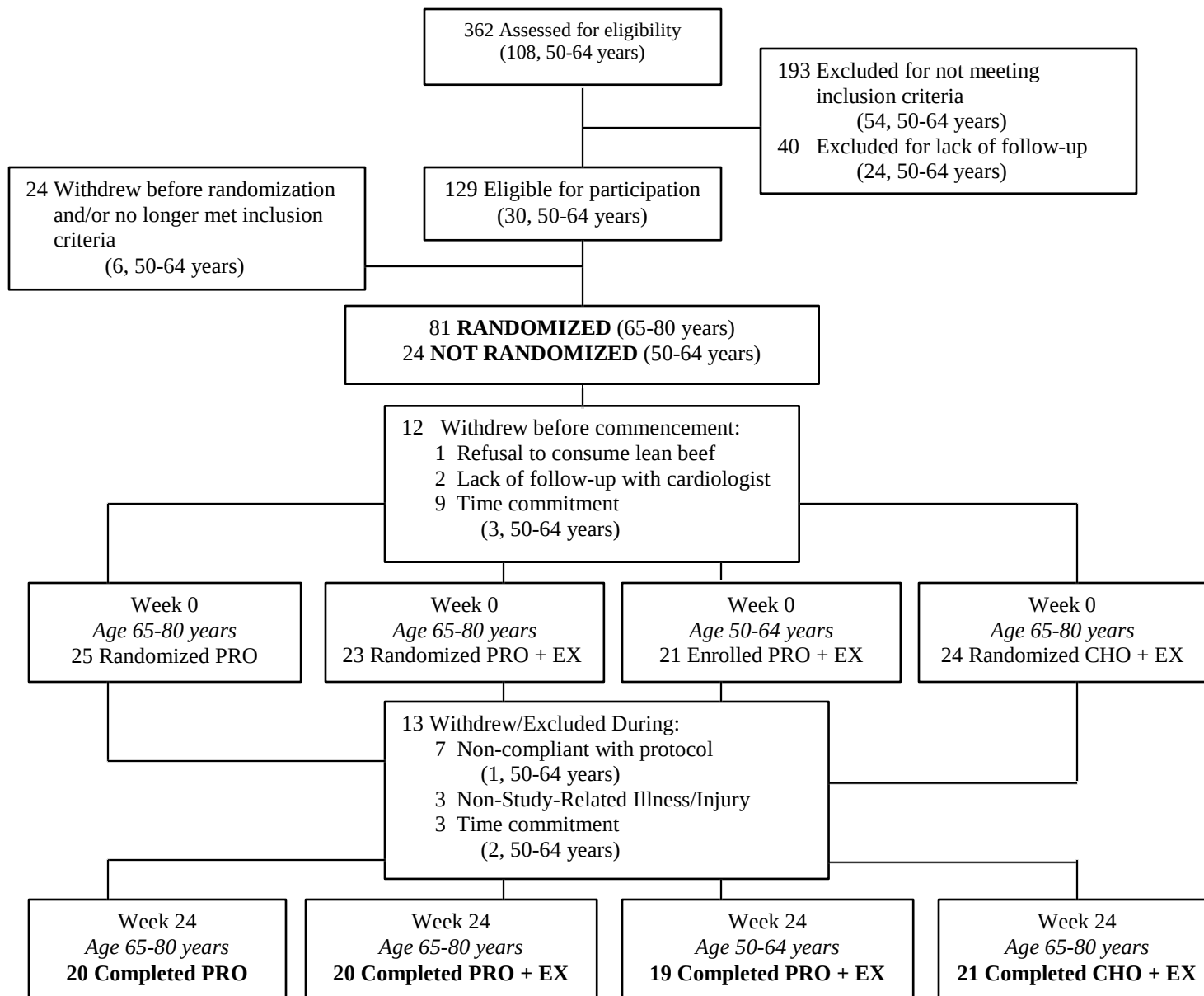
Whole Body DXA Scan Completed by Investigator of Record:

Hand Position: ₁ ☐ Flat ₀ ☐ Upright Artifacts present? ₁ ☐ Yes ₀ ☐ No

Comments:

APPENDIX D

PARTICIPANT FLOWCHART



APPENDIX E

MEDICAL RELEASE FORM

Effects of a Higher Protein Weight Loss Diet and Exercise on Body Composition, Physical Function, and Fatigue in Overweight Women



Body Composition and Metabolism Laboratory
Phone: 706-542-6872 Fax: 706-542-3148

To the Attending Physician of Ms. _____
Patient Name *Phone*
Number

Patient will be a new enrollee in the above listed study through the Department of Kinesiology at the University of Georgia.

*Patient understands that a medical examination is required before participation is permitted.

-

To be completed by the attending physician

The above named individual has asked to be included in a weight loss intervention. She will be randomly assigned to a diet + exercise group or a diet only group. The dietary intervention be aimed at participants losing 10% of initial body weight. The exercise program involves mild to moderate exercise in the form of stretching, walking and weight training, 3 days per week, ~ 75 minutes total in duration.

Applicant's Name _____ Date _____

Age _____ DOB _____ Date of last complete physical examination _____

Please supply the following information, if available:

1. Height: _____ Weight: _____
2. Resting Blood pressure: _____ Resting Heart Rate: _____
3. Cholesterol: _____ mg/dL LDL _____ HDL _____ Triglycerides _____
4. 12-lead supine EKG (**Please attach a copy if available**)
Date recorded _____ Normal _____ Abnormal _____
5. Most recent Graded Exercise Test (**Please attach a copy if available**)
Date administered _____ Positive _____ Negative _____ Equivocal _____
6. DXA (**Please attach a copy if available**)
Date administered _____ Normal _____ Osteopenia _____
Osteoporosis _____

7. **Cardiovascular Disease Risk Factors**

- ☐ Age (Men ≥ 45 ; Women ≥ 55)
☐ Family History (MI, coronary revascularization, or sudden death in first-degree family member)
☐ Smoking (Current or quit within last 6 months)
☐ Sedentary (Less than 30 min of moderate intensity exercise, 3 days/week for the past 3 months)
☐ Obesity (BMI ≥ 30)
☐ Hypertension (SBP ≥ 140 mm Hg and/or DBP ≥ 90 mm Hg; currently on hypertensive medications)
☐ Dyslipidemia (LDL-C ≥ 130 mg/dL and/or HDL-C < 40 mg/dL; TC ≥ 200 mg/dL; or on lipid lowering medication)
☐ Pre-diabetes ($100 \text{ mg/dL} \leq \text{IFG} < 126 \text{ mg/dL}$; $140 \text{ mg/dL} \leq \text{OGTT} < 200 \text{ mg/dL}$)
☐ High-serum HDL-C (HDL-C ≥ 60 mg/dL)

8. **Known Disease**

- ☐ Known Cardiovascular Disease:

☐ Known Metabolic
Disease: _____
☐ Known Pulmonary
Disease: _____

9. **Contraindications**

- ☐ Unstable Angina
☐ Uncontrolled Symptomatic Heart Failure
☐ Significant EKG Abnormality
☐ Hypertension
☐ Syncope
☐ Disorder
☐ Significant Cognitive or Emotional Disorder
☐ Uncontrolled Cardiac Dysrhythmia
☐ Significant Valvular Disease
☐ Severe/Uncontrolled
☐ Significant Musculoskeletal
☐ Other Uncontrolled Disease

10. Please list any other chronic conditions or abnormalities that you are aware of:

11. Orthopedic Surgeries
(Location/When): _____

12. Exercise

Limitations: _____

Please list any medications the applicant is currently taking:

MEDICATION	DOSAGE	FREQUENCY	CONDITION / SPECIAL NOTES

I have examined the above applicant and approve his/her participation in a weight loss intervention at the University of Georgia.

Print Physician's Name: _____

Physician's Signature: _____

Date: _____

MD Address: _____

Phone: _____

RETURN APPLICATION TO:

Body Composition and Metabolism Laboratory
University of Georgia Department of Kinesiology
Suite 101 Ramsey Student Center
330 River Road
Athens, GA 30602-6554

E-mail: bcmluga@gmail.com
Phone: 706-542-4230
Fax: 706-542-3148

APPENDIX F

GROUP NUTRITION EDUCATION TOPICS

1. All about carbs
2. All about fats
3. All about fiber
4. All about sodium
5. Energy density
6. Fruits and vegetables
7. Nutrition labeling
8. Whole grains
9. Healthy snacking
10. Food safety
11. Dining out
12. Beverages
13. All about protein
14. Cooking with lean beef
15. Eating out and frozen meals with lean beef
16. Mindful eating
17. Goal setting
18. Surviving the summer and other food-centric events
19. Bone health, calcium, and vitamin D
20. Heart health and stroke
21. Traveling
22. Holiday healthy
23. New years and trusted health information

24. Weight loss behaviors (i.e., self-monitoring, positive reinforcement)

25. Organic vs. non-organic

26. Hormones and metabolism

APPENDIX G

SAMPLE GROUP NUTRITION EDUCATION LESSON

Healthy Snacking - Protein

Make snacks work for you by choosing nutrient-rich and low-calorie foods. Snacks can boost your energy between meals and offer the opportunity to add another fruit, vegetable, or nutrient dense food to complement your daily intake.

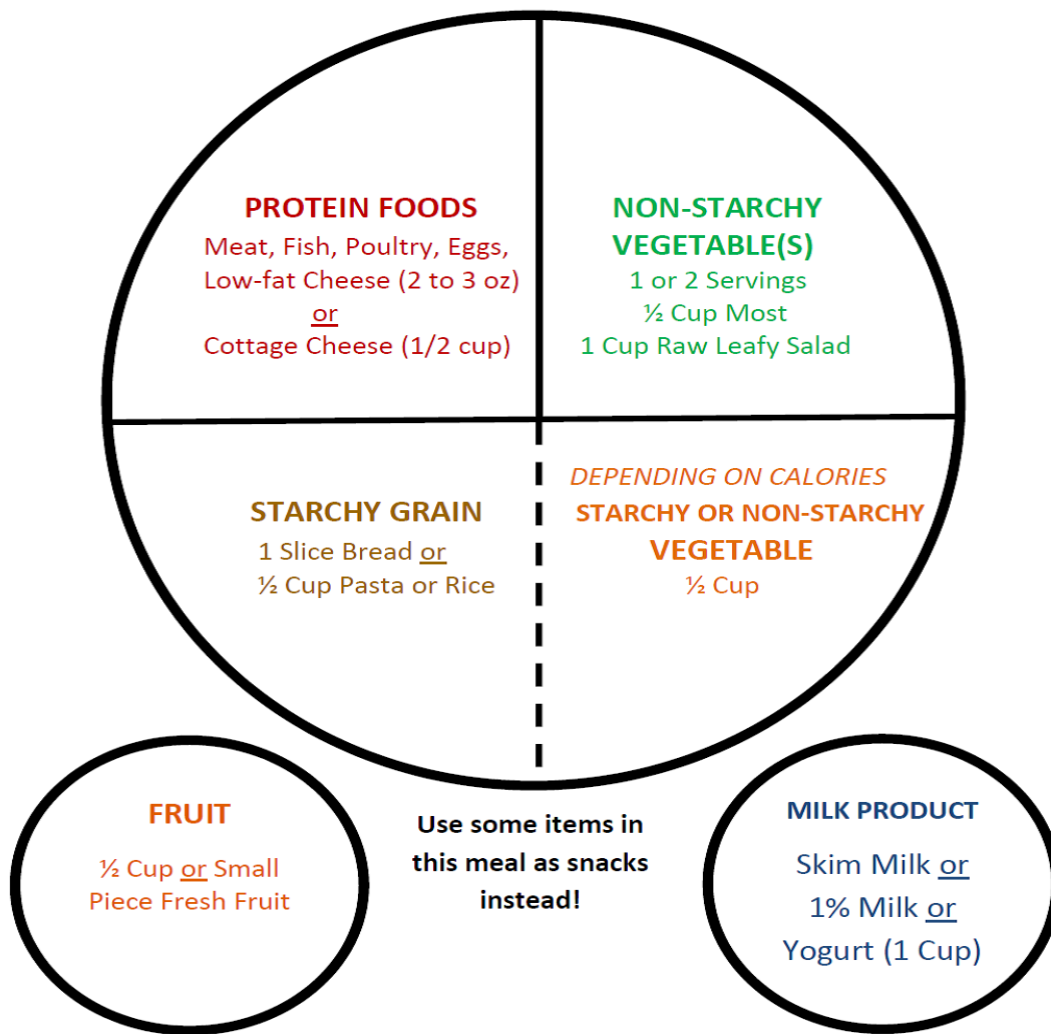
Choose wisely

- Think of snacks as mini-meals that contribute nutrient-rich foods. You can fit snack calories into your personal healthy eating plan without over-spending your day's calorie budget.
- Snack only when hungry. Skip the urge to nibble when bored, frustrated or stressed. Feed that urge to do something by taking a walk, doing a household chore, or doing something with your hands, like sewing or playing cards, instead.
- Keep portion control in mind. Have single serve containers with snacks available. Eating directly from a multiple serving package can lead to overeating. You can portion a larger package of something into smaller containers or individual bags or you can purchase individual servings, such as "100 calorie packs."
- Plan ahead. Keep a variety of nutritious ready-to-eat snacks on hand. If you are frequently away from home, you can keep non-perishable snacks in your car or purse. If you travel frequently, you might consider keeping a cooler with an icepack in your vehicle so that you can keep it interesting by also having perishable snacks on hand.
- To increase protein, choose peanut butter, low-fat cheese, skim milk, nuts, hummus, low-fat yogurt, or 1 slice of deli turkey or beef as part of your snack.

Snacks with 200 calories or less

- 1 tablespoon peanut butter with one apple, sliced.
- 3 cups air-popped popcorn sprinkled with 3 tablespoons parmesan cheese.
- Tri-color veggie snack: 6 baby carrots, 10 sugar snap peas, 6 cherry tomatoes, plus 2 tablespoons reduced fat ranch dressing.
- 6 whole wheat crackers with 1 slice low fat cheddar cheese.
- Fruit smoothie: blend 1 cup skim milk or yogurt, ½ c frozen strawberries and ½ banana.
- 1 x 6-in flour tortilla with ¼ cup black beans and 2 tablespoons salsa.
- Mini sandwich: whole wheat dinner roll with 1 slice deli turkey, 1 slice low fat cheese, 1 lettuce leaf, and mustard.
- Veggie pizzas: ½ whole wheat English muffin with 2 tablespoons marinara sauce, ½ c diced fresh veggies, and 1 ounce low fat mozzarella cheese. Heat in toaster oven.
- ½ of a whole wheat pita with 2 tablespoons hummus.
- Trail mix: 20 almonds, small box of raisins, and ¼ c sunflower seeds.
- 1 cup skim milk.
- 1 low-fat or non-fat yogurt (4 - 8 oz.): aim for yogurt with less than 15 grams of sugar per serving.

How does what we learned today fit into your plate?



More thoughts about snacking

What are some ways that you manage to keep your snacks within your daily calorie limits?

What types of snacks work for you?

Do you have any favorite snack strategies to share?

What do you find difficult about healthy snacking?

If or when you get the “munchies,” what types of healthy snacks help you out??

What other challenges are you having as you make changes to lower your daily calorie intake and to eat a variety of healthy foods?

This information was adapted from:

The Academy of Nutrition and Dietetics, Food and Nutrition Health Tips, Smart Snacking for Adults and Teens.

Duke University, *MEASUR-UP Program*, Dr. Connie Bales.

APPENDIX H

REGRESSION MODELS WITH AGE AS A CONTINUOUS VARIABLE

Relationships of Vitality, Self-Motivation, and Satisfaction with Life with Percent Weight Change with Age Coded as Continuous Variable

Variable	Regression coefficient (b)	Standard error	t	P-Value <	Model R ² (Adjusted R ²)
Model 1 – Control Variables					0.24 (0.15) ^{10*}
Intercept	-0.8	9.3	-0.09	0.94	
Baseline Energy Intake (% needs) ¹	0.07	0.04	1.90	0.07	
Change in Energy Intake (kcal/d) ²	0.004	0.002	1.78	0.09	
Baseline Sleep ³	-0.9	0.5	-1.79	0.09	
Post-intervention Cognitive Restraint ⁴	-0.3	0.2	-1.67	0.10	
Age ⁵	0.07	0.1	0.63	0.54	
Protein group ⁶	-0.02	1.3	-0.01	0.99	
Exercise group ⁷	-0.9	1.4	-0.65	0.53	
Group Nutrition Education Attendance	-0.4	0.2	-2.21	0.04*	
Model 2 – Vitality⁸					0.25 (0.14) ^{10*}
Intercept	0.9	9.9	0.09	0.94	
Baseline Vitality	-0.02	0.05	-0.40	0.70	
Change Vitality	-0.04	0.04	-0.90	0.38	
Model 3 – Self-Motivation Inventory⁸					0.24 (0.13) ^{*10}
Intercept	-0.3	9.9	-0.03	0.99	
Baseline Self-Motivation Inventory	-0.005	0.03	-0.15	0.89	
Change Self-Motivation Inventory	-0.004	0.05	0.09	0.94	
Model 4 – Satisfaction with Life Scale⁸					0.26 (0.15) ^{*10}
Intercept	-1.0	9.7	-0.11	0.93	
Baseline Satisfaction with Life Scale	0.1	0.1	0.93	0.36	
Change Satisfaction with Life Scale	-0.09	0.1	-0.63	0.54	

11. Reported energy intake (average caloric intake per day) as a percentage of energy needs for weight maintenance; % energy needs = baseline kcal/d ÷ estimated energy needs: [((10*body weight (kg)) + (6.25*height (cm)) – (5*age(y) - 161)) × [activity factor, 1.3]

12. Change in energy intake (kcal/d) from baseline to post-intervention

13. Baseline Pittsburgh Sleep Quality Inventory hours of sleep in the past month

14. Post-intervention from the Three Factor Eating Questionnaire

15. Baseline age coded as a continuous variable

16. Coded as 0 = randomized to conventional protein; 1 = randomized to higher protein

17. Coded as 0 = not randomized to exercise intervention; 1 = randomized to exercise intervention

18. Controlled for all variables in model 1

19. N = 79

20. All models have significant F-values at P < 0.05

*** P < 0.001, ** P < 0.01 and * P < 0.05

Association of Vitality, Self-Motivation, and Satisfaction with Life with Meeting 10% Weight Loss Goal with Age Coded as Continuous Variable

Variable	Odds Ratio (95% CI)
Model 1 - Control Variables	Model Likelihood Ratio Chi-Square is NS
Baseline Energy Intake (% needs) ¹	0.999 (0.997-1.0)
Change in Energy Intake (kcal/d) ²	0.99 (0.96-1.03)
Baseline Sleep ³	1.22 (0.74-2.00)
Post-intervention Cognitive Restraint ⁴	1.15 (0.93-1.43)
Age ⁵	0.92 (0.82-1.02)
Protein Group ⁶	0.85 (0.24-3.02)
Exercise Group ⁷	1.10 (0.29-4.17)
Group Nutrition Education Attendance	1.26 (1.05-1.51)*
Model 2 - Vitality⁸	Model Likelihood Ratio Chi-Square is NS
Baseline Vitality	1.01 (0.97-1.06)
Vitality Change	1.02 (0.98-1.06)
Model 3 - Self-Motivation Inventory⁸	Model Likelihood Ratio Chi-Square is NS
Baseline Self-Motivation Inventory	0.99 (0.96-1.02)
Change Self-Motivation Inventory	1.18 (0.94-1.47)
Model 4 - Satisfaction with Life Scale⁸	Model Likelihood Ratio Chi-Square P < 0.01**
Baseline Satisfaction with Life Scale	1.00 (0.89-1.13)
Change Satisfaction with Life Scale	1.26 (1.06-1.50)**

1. Reported energy intake (average caloric intake per day) as a percentage of energy needs for weight maintenance; % energy needs = baseline kcal/d ÷ estimated energy needs: [((10*body weight (kg)) + (6.25*height (cm)) – (5*age(y) - 161)) × [activity factor, 1.3]
2. Change in energy intake (kcal/d) from baseline to post-intervention
3. Baseline Pittsburgh Sleep Quality Inventory hours of sleep in the past month
4. Post-intervention Three Factor Eating Questionnaire
5. Baseline age coded as a continuous variable
6. Coded as 0 = randomized to conventional protein; 1 = randomized to higher protein
7. Coded as 0 = not randomized to exercise intervention; 1 = randomized to exercise intervention
8. Controlled for all variables in model 1
9. N = 79

*** P < 0.001, ** P < 0.01 and * P < 0.05