South Dakota State University
Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange

Electronic Theses and Dissertations

2017

Relationship of Stress, Sleep, Physical Activity, and Food Insecurity on Eating Behaviors and Obesity

Amy Lee Richards
South Dakota State University

Follow this and additional works at: https://openprairie.sdstate.edu/etd

Part of the Health Psychology Commons, Nutrition Commons, Nutritional and Metabolic Diseases Commons, and the Sports Sciences Commons

Recommended Citation

Richards, Amy Lee, "Relationship of Stress, Sleep, Physical Activity, and Food Insecurity on Eating Behaviors and Obesity" (2017). *Electronic Theses and Dissertations*. 1775.
https://openprairie.sdstate.edu/etd/1775

This Dissertation - Open Access is brought to you for free and open access by Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. For more information, please contact michael.biondo@sdstate.edu.

RELATIONSHIP OF STRESS, SLEEP, PHYSICAL ACTIVITY, AND FOOD INSECURITY ON EATING BEHAVIORS AND OBESITY

BY

AMY LEE RICHARDS

A dissertation submitted in partial fulfillment of the requirements for the

Doctor of Philosophy

Major in Nutrition, Exercise and Food Science

South Dakota State University

2017

RELATIONSHIP OF STRESS, SLEEP, PHYSICAL ACTIVITY, AND FOOD INSECURITY ON EATING BEHAVIORS AND OBESITY

AMY RICHARDS

This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this dissertation does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Bonny L. Specker, Ph.D.
Dissertation Advisor — Date

Matthew Vukovich, Ph.D. — Date
Head, Health & Nutritional Sciences

Dean, Graduate School — Date

ACKNOWLEDGEMENTS

The three research projects and dissertation would not have been possible without a lot of help and encouragement from friends, colleagues, family, my advisor, and my committee. I would like to thank the following people in particular:

- Dr. Bonny Specker, my dissertation and major advisor, who did an exceptional job of advising me on the research projects, on the writing of the three manuscripts, and on the compilation of this dissertation. Thank you so much for your help and all of the time that you took to guide me through this process. I will eternally be grateful for all that you did.
- My graduate committee members (Dr. C.Y. Wang, Dr. Matt Vukovich, Dr. Moul Dey, Dr. Gregg Carlson, and Dr. Brent Turnipseed). I greatly appreciate the time that you took to be on my committee and your support throughout this process.
- The University of Tennessee at Martin and Dr. Deborah Gibson for providing access to the Health 111 students for survey collection.
- The participants in all three studies. By volunteering for these studies, you have helped advance knowledge that may contribute to the reduction of overweight and obesity.
- My parents who believed in me and encouraged me throughout the process.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

BMI – Body Mass Index

CR – Cognitive Restraint

EE – Emotional Eating

GPAQ – Global Physical Activity Questionnaire

PSQI -Pittsburg Sleep Quality Index

PSS-10 – Perceived Stress Scale (10 item questionnaire)

TFEQ – Three-Factor Eating Questionnaire

TFEQ-R18 – Three-Factor Eating Questionnaire Revised (18 questions)

UE – Uncontrolled Eating

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

RELATIONSHIP OF STRESS, SLEEP, PHYSICAL ACTIVITY, AND FOOD INSECURITY ON EATING BEHAVIORS AND OBESITY

AMY LEE RICHARDS

2017

There is an urgent need to find effective interventions to prevent and reduce obesity as it is associated with chronic disease and decreased quality of life. Gaining a better understanding of how modifiable variables such as stress, sleep, physical activity, and food insecurity are related to eating behaviors associated with obesity is essential to guide the direction of future interventions and research. Interventions that hold promise need to be tested to determine if they have merit or not.

This dissertation presents three papers. Two papers are cross-sectional studies evaluating associations between eating behaviors, obesity, and modifiable variables (stress, sleep, physical activity, and food insecurity). The first paper describes a study completed with college students. This study found that higher emotional eating was associated with higher stress levels and female sex ($P<.001$ and $P=.02$); It also found that higher uncontrolled eating scores were associated with higher perceived stress ($P<.001$).

The second study was an evaluation of baseline data from a study with individuals that were dually enrolled in a weight loss program and in an intervention testing yoga as an intervention. This study found that stress, female gender, working 40 or more hours a week, and lack of sleep were associated with greater emotional eating while getting the

recommended amount of physical activity was associated with lower emotional eating (model r^2=.208, p<.001). An interaction between stress and sleep quality was significant in a model for uncontrolled eating (r^2=.12, p=.002): Uncontrolled eating was associated with higher stress when there was good sleep, but not when there was poor sleep. An interaction between age and BMI was significant in a model for cognitive restraint (r^2=.18, p<.001): a positive relationship between cognitive restraint and age was observed for individuals with lower BMI, but not among individuals with high BMIs.

The third paper reports on a randomized trial that tested yoga as an innovative form of physical activity to determine whether yoga could lower stress, improve eating behaviors, and reduce weight more than stretching exercise. There was no difference in weight loss between the groups at 3 (p=.17) or 6 months (p=.25). Emotional eating and uncontrolled eating decreased in the yoga group at 6 months compared to the stretching group (p=.04 and p=.03, respectively).

The insights gained from these three studies have added to the current knowledge in the field of obesity research. Getting adequate sleep, minimizing stress, and getting the recommended amount of physical activity may positively impact eating behaviors associated with obesity and yoga also appears to have some benefit as an intervention to improve emotional and uncontrolled eating.

CHAPTER 1

Introduction

Introduction: Statement of the Problem

More than two thirds of Americans are overweight or obese[1] which is associated with chronic disease and decreased productivity.[2-4] The issue is complex with multiple variables playing a role including genetics, environmental factors, individual behaviors, and biological modifications in response to changes in energy balance.[5-7] Add to this the hormonal dysregulation that can occur as a result of extra fat mass[8], and losing and maintaining weight loss is difficult.

Behavioral interventions are recommended as the first treatment in the primary care setting with behavioral counseling, physical activity, nutrition education, goal setting, stimulus control, and developing strategies to overcome emotional eating as part of the treatment.[9] When behavioral interventions are not successful, weight loss medications and surgery are sometimes considered. Pharmaceutical companies have been trying for decades without much success to find drugs that can be used to reduce obesity without detrimental side effects utilizing various strategies including attempts to manage weight by suppression of appetite, increasing energy expenditure, and decreasing absorption of nutrients.[10,11] Weight loss surgery has become a medically recommended treatment for many individuals who have tried and been unsuccessful at behavioral changes, however, there is risk of significant complications and the long term outcomes for weight management and health status are not known. [12,13]

Although many environmental and behavioral interventions to decrease obesity have been tested, results have been mixed and the impact on the overall rate of overweight and obesity nationally has been minimal at best.[7,14] Additionally, there is not always consensus among scientific experts about appropriate research methodology, underlying causes of obesity, and the utility of various approaches (e.g., economic strategies to increase purchase of healthier options in school cafeterias) due the unknown adaptation that may occur to offset the potential benefits (e.g., students might buy candy and sugary beverages on the way home from school instead of buying it at school and therefore overall energy balance might not be impacted). [7,14]

There is an urgent need for more effective ways to prevent overweight and obesity and more effective ways to help people successfully lose and maintain weight loss. In order to develop more effective interventions, more needs to be understood about modifiable factors that may influence the development and maintenance of obesity.[7]

Physical Activity, Appetite, and Weight

Physical Activity

Exercise burns calories, but if the intake of calories increases to match the amount of calories burned by exercise or exceeds the calories burned, exercise is not able to promote weight loss. Studies have not been consistent as to whether increasing physical activity levels leads to negative energy balance and weight loss.[15] Cohort studies have shown evidence that higher levels of exercise are protective against weight gain[16,17] and consensus based upon studies is that exercise should be recommended to help prevent weight gain.[15] While there is some evidence for reduced appetite from aerobic exercise on a short term basis, this does not seem to be able to impact weight loss in the long term without some restriction on dietary intake.[18]

As far as the mechanism for how exercise may decrease appetite, a meta-analysis of 20 studies found that exercises such as running, walking, bicycling, and resistance training tended to decrease ghrelin (P=.024) and increase peptide YY (PYY) (P=.044) and glucagon-like peptide (GLP-1) (P=.078), as well as moderately increase pancreatic polypeptide (PP) (P=.011).[19] Decreasing hunger hormones such as ghrelin and increasing satiety hormones such as PYY, PP, and GLP-1 would be expected to decrease food intake. [20] Aerobic exercise has been shown to decrease appetite and energy intake in humans on a short-term basis.[18,21,22]

Also, exercise has been found to activate the brain's reward system much in the same way as highly palliative food and drugs.[23,24] Because of this, exercise has been used as a treatment to help with recovery from substance abuse and found to decrease relapse.[25-27] This raises the question as to whether exercise might have the potential to decrease cravings for highly palliative foods in the same way that it appears to help with withdrawal from alcohol and drugs.

Stress, Sleep, and Food Insecurity

Stress. Stress is associated with addiction, appetite, and obesity. When under stress, intake of favorite high calorie foods tends to increase as a way to reward oneself and cope with the situation. In the process, neurons in the brain's reward center are activated which increases craving for high calorie favorite foods often resulting in weight gain.[28,29]

In addition to food cravings for highly palliative foods, stress also affects appetite through increases in glucocorticoids such as cortisol, which in turn increase ghrelin and leptin levels.[30,31] While short-term intensely stressful situations will generally reduce appetite, as stress is repeated or becomes chronic, dysregulation of the hypothalmic-pituitary-adrenal (HPA) axis can occur. [28,29]

Sleep. In research studies, reduced sleep has been associated with increased calorie intake and with studies reporting inconsistent effects on weight.[32] Reduced sleep has been shown to interfere with regulation of hormones associated with appetite and to increase risk for development of obesity and diabetes.[33]

Food Insecurity. Many studies have found an association between food insecurity and obesity with the evidence strongest for women.[34] Several theories exist for this relationship, including economics (inexpensive energy dense foods), psychological factors (stress and other psychological manifestations may lead to food cravings and dysregulation of appetite), and low fruit and vegetable intake. Food insecurity as a child has been shown to increase the chance that adults in food insecure situations will be overweight or obese.[34]

Emotional Eating, Uncontrolled Eating, Cognitive Restraint

Behaviors related to eating and obesity have been the subject of many studies in an effort to understand the mechanisms of obesity.[35] The original Three-Factor Eating Questionnaire (TFEQ) developed in the 1980’s contains 51 questions and evaluates individuals on hunger, eating behaviors, and cognitive processes related to eating decisions. Subjects are scored on three scales: disinhibited eating, cognitive restraint, and hunger.[36] The TFEQ has been used in numerous studies to examine associations between eating behaviors and obesity. A much shorter revision of the instrument, TFEQ-R18, was developed that scores three constructs: emotional eating, uncontrolled eating, and cognitive restraint.[37]

In the development of the TFEQ-R18 from the original TFEQ, the authors noted that during analysis that it was not possible to delineate between the original constructs of disinhibition and hunger because hunger and disinhibition were associated with one another. This led the researchers to recategorize questions and responses to increase the validity of the model. The three categories of uncontrolled eating, cognitive restraint, and emotional eating were found to best represent the data. Uncontrolled eating, a new category, contained questions that assessed difficulty with regulating dietary intake including overeating due to hunger. Emotional eating, a new category as well, assessed overeating that resulted due to experiencing various psychological moods such as sadness and anxiety. Cognitive restraint remained as a category in the model as it held up well with testing and it contained questions assessing the extent to which subjects attempted to restrict intake (to prevent weight gain or promote weight loss).[37]

Yoga

Traditional yoga offers an approach to exercise that includes a cognitive component in which participants learn to slow down their mind, to relax and let go of worries, breathe deeply, and have a positive outlook on life.[38] Additionally, poses are typically held for several minutes which requires staying in positions that are not always comfortable which may help participants increase discipline and persistence as they learn to calm the desire to change positions before it is time to move. Internationally known yoga teacher, author, and originator of the Iyengar method of yoga, B.K.S. Iyengar states that the ancient yoga sage, Patanjali indicates that "the aim of yoga is to calm the chaos of conflicting impulses."[39] Gard and colleagues have proposed a theoretical model for how yoga is able to decrease impulsivity, decrease stress, and improve self-regulation.[40] Their model describes how four components of yoga (meditation, breathing practices, holding yoga poses, and philosophical messages) work together to increase inhibition of behavior that is not perceived to be aligned with goals and increase focus and effort towards behavior that is perceived to be needed to reach goals.

Yoga in prison populations has been found to decrease perceived stress, increase scores on a cognitive test requiring focus and attention, and increase positivity.[41] Yoga practitioners have been found to have better response to stress as measured by heart rate, hormone levels, inflammatory markers, improved mood, and lower emotional response to stressful situations.[42-45] Lee, et al.[46] found in a small study that yoga was effective in lowering weight, lowering blood pressure (both systolic and diastolic), lowering total cholesterol, decreasing insulin resistance, and increasing adiponectin (a hormone that has insulin sensitizing effects). Refer to Figures 1.1-1.3.

In another study looking at the effects of yoga on weight, Sarvottam and colleagues[47] conducted a very brief two-week (10 days) yoga intervention without a control group. There were 51 overweight and obese men enrolled with 30 remaining at the end of the intervention. Yoga specialists, medical doctors, and dietitians conducted the intervention, which consisted of yoga poses and breathing exercises for about an hour each day and another hour each day of education, theory, and advise. A diet that was nearly vegetarian was encouraged, but no meals were provided. Weight, BMI, systolic blood pressure, and plasma IL-6 all decreased from baseline to day 10. Adiponectin increased and plasma ET-1 remained unchanged (Figure 1.4).

Rationale for Studies and Specific Aims

Exploring possible associations between obesity and sleep, stress, food insecurity, and physical activity has the potential to reveal insights that might prove to be helpful in developing successful interventions. Much is still not known about these modifiable variables and their role in obesity. Even with the complexities of environmental influences and genetic predisposition to obesity, it appears likely that there are variables that can be modified and maximized for best outcomes within the individual situation.

Studying eating behaviors (emotional eating, uncontrolled eating, and cognitive restraint) and possible relationships to sleep, stress, food insecurity, and physical activity may result in new knowledge that will prove to be beneficial in designing interventions that can improve obesity-related behaviors. Eating behaviors may be able to be modified slightly through changes in sleep, stress levels, physical activity, and food security to gradually lead to improvements in dietary intake and weight.

Testing yoga as an intervention to determine its effectiveness for weight loss, improving eating behaviors, and lowering stress has the potential to add to the knowledge base and in turn help guide future research and weight loss interventions. There is evidence from studies to suggest that yoga is beneficial for lowering blood pressure, improving insulin sensitivity, lowering catecholamine levels, improving lipid profiles, lowering anxiety, and reducing weight. There is a need for studies to be conducted to determine if yoga can attenuate hunger signals and reduce overeating. Emotional eating scores, uncontrolled eating scores, and cognitive restraint scores provide an avenue to evaluate the potential effectiveness of yoga to improve self-regulation of food intake in addition to changes in weight.

The following chapters describe three studies that have added to the current knowledge about eating behaviors, stress, sleep, physical activity, food insecurity and obesity. Chapter Two provides results from a study in which college students in multiple sections of a general education class completed a survey that assessed eating behaviors, perceived stress, sleep, amount of physical activity, food insecurity, and other self-reported variables. Chapter Three presents results from analysis of baseline data from participants in a weight loss program that were dually enrolled in an intervention comparing yoga to stretching exercises. In this study, statistical models were developed that predicted emotional eating, uncontrolled eating, and cognitive restraint. Chapter Four describes the results from a yoga intervention on weight loss, perceived stress, and eating behaviors.

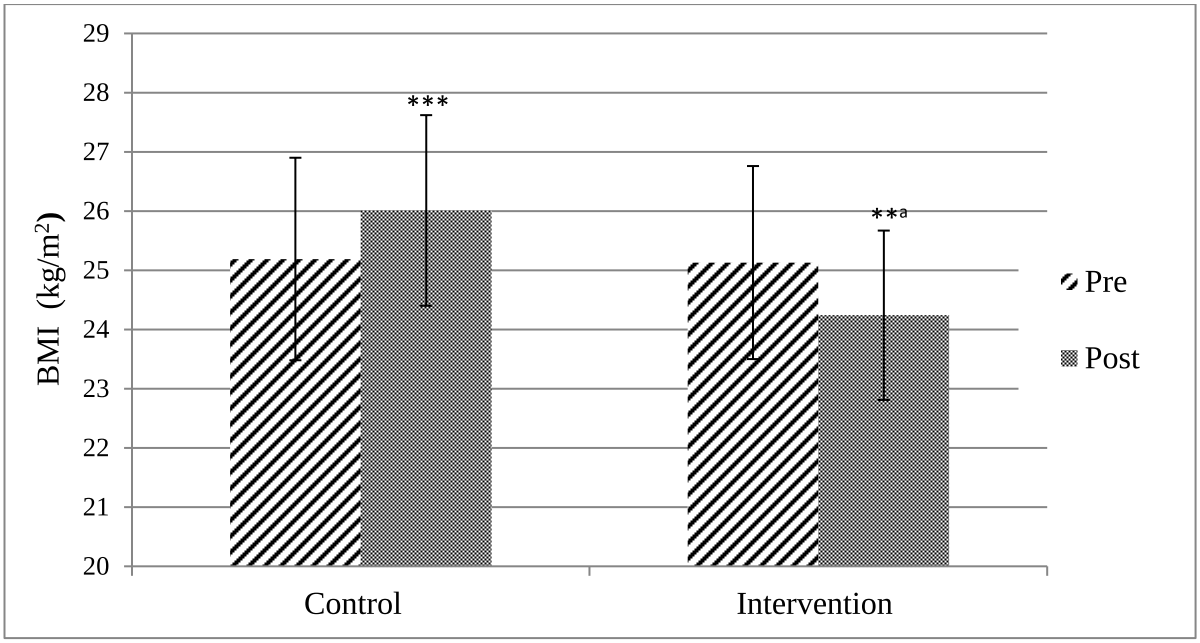


Figure 1. 1. Effect of 16-week yoga intervention on BMI. ***P<.001 compared with pre, **P<.01 compared with pre, [a]P<.05 compared with control. (Lee, et al. 2012)

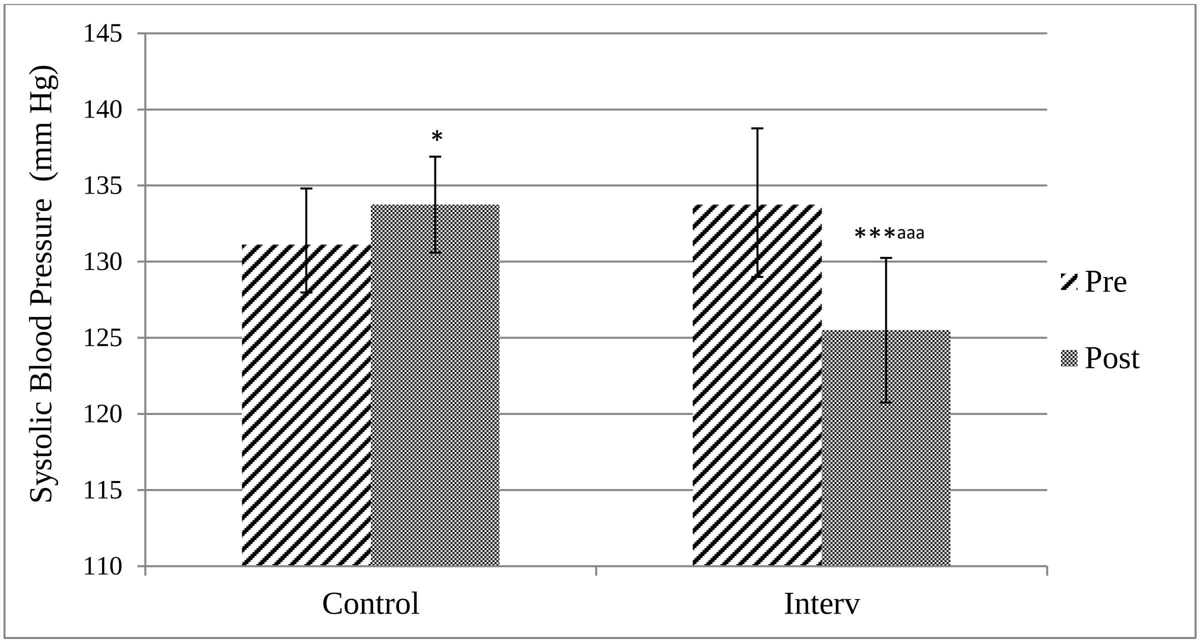


Fig. 1.2. Effect of 16 week intervention on Systolic Blood Pressure. *P<.05 compared to pre, ***P<.001 compared to pre, [aaa]P<.001 compared to control. (Lee, et al. 2012)

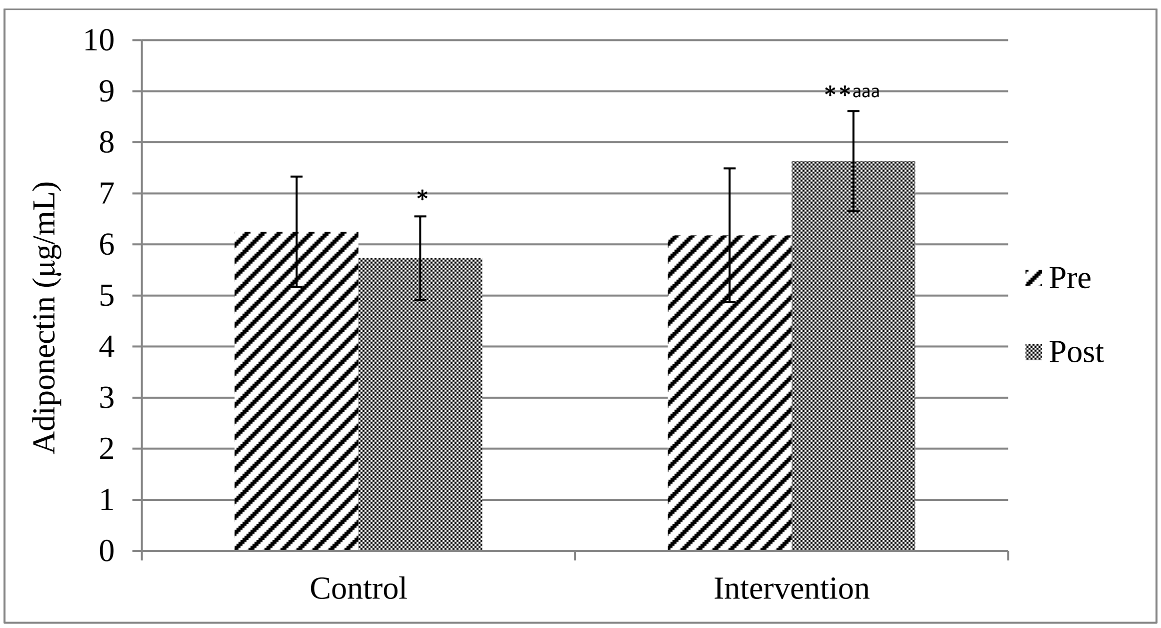


Figure 1.3. Effect of 16-week yoga intervention on adiponectin. *P<.05 compared to pre, **P<.01 compared to pre, [aaa]P<.001 compared to control. (Lee, et al. 2012)

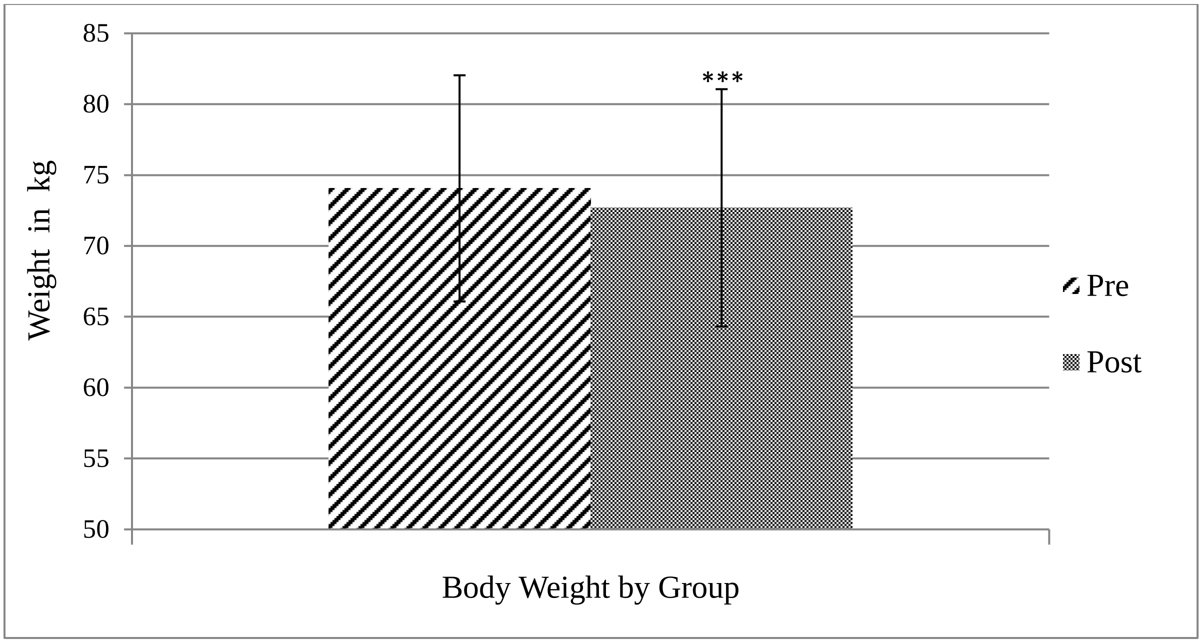


Figure 1.4. Effect of a 2-week yoga (10 days) intervention on overweight and obese men. ***P<.001. (Sarvottam et al. 2013)

References

1. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA.* 2012;307(5):491-497.
2. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. *JAMA.* 2013;309(1):71-82.
3. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. *JAMA.* 2003;289(2):187-193.
4. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health.* 2009;9:88.
5. Silventoinen K, Jelenkovic A, Sund R, et al. Genetic and environmental effects on body mass index from infancy to the onset of adulthood: an individual-based pooled analysis of 45 twin cohorts participating in the COllaborative project of Development of Anthropometrical measures in Twins (CODATwins) study. *Am J Clin Nutr.* 2016;104(2):371-379.
6. MacLean PS, Blundell JE, Mennella JA, Batterham RL. Biological control of appetite: A daunting complexity. *Obesity (Silver Spring).* 2017;25 Suppl 1:S8-s16.
7. Hebert JR, Allison DB, Archer E, Lavie CJ, Blair SN. Scientific decision making, policy decisions, and the obesity pandemic. *Mayo Clin Proc.* 2013;88(6):593-604.

8. Ronti T, Lupattelli G, Mannarino E. The endocrine function of adipose tissue: an update. *Clin Endocrinol (Oxf).* 2006;64(4):355-365.

9. Kelley CP, Sbrocco G, Sbrocco T. Behavioral modification for the management of obesity. *Prim Care.* 2016;43(1):159-175.

10. Valsamakis G, Konstantakou P, Mastorakos G. New targets for drug treatment of obesity. *Annu Rev Pharmacol Toxicol.* 2017;57:585-605.

11. Bray GA, Tartaglia LA. Medicinal strategies in the treatment of obesity. *Nature.* 2000;404(6778):672-677.

12. Cadegiani FA, Diniz GC, Alves G. Aggressive clinical approach to obesity improves metabolic and clinical outcomes and can prevent bariatric surgery: a single center experience. *BMC Obes.* 2017;4:9.

13. Colquitt JL, Pickett K, Loveman E, Frampton GK. Surgery for weight loss in adults. *Cochrane Database Syst Rev.* 2014(8):Cd003641.

14. Gortmaker SL, Swinburn B, Levy D, et al. Changing the future of obesity: science, policy and action. *Lancet.* 2011;378(9793):838-847.

15. Swift DL, Johannsen NM, Lavie CJ, Earnest CP, Church TS. The role of exercise and physical activity in weight loss and maintenance. *Prog Cardiovasc Dis.* 2014;56(4):441-447.

16. Lee IM, Djousse L, Sesso HD, Wang L, Buring JE. Physical activity and weight gain prevention. *JAMA.* 2010;303(12):1173-1179.

17. Shiroma EJ, Sesso HD, Lee IM. Physical activity and weight gain prevention in older men. *Int J Obes (Lond).* 2012;36(9):1165-1169.

18. Martins C, Robertson MD, Morgan LM. Effects of exercise and restrained eating behaviour on appetite control. *Proc Nutr Soc.* 2008;67(1):28-41.

19. Schubert MM, Sabapathy S, Leveritt M, Desbrow B. Acute exercise and hormones related to appetite regulation: a meta-analysis. *Sports Med.* 2013.

20. Cummings DE, Overduin J. Gastrointestinal regulation of food intake. *J Clin Invest.* 2007;117(1):13-23.

21. King NA, Horner K, Hills AP, et al. Exercise, appetite and weight management: understanding the compensatory responses in eating behaviour and how they contribute to variability in exercise-induced weight loss. *Br J Sports Med.* 2012;46(5):315-322.

22. Martins C, Morgan LM, Bloom SR, Robertson MD. Effects of exercise on gut peptides, energy intake and appetite. *J Endocrinol.* 2007;193(2):251-258.

23. Lynch WJ, Peterson AB, Sanchez V, Abel J, Smith MA. Exercise as a novel treatment for drug addiction: a neurobiological and stage-dependent hypothesis. *Neurosci Biobehav Rev.* 2013;37(8):1622-1644.

24. Egecioglu E, Skibicka KP, Hansson C, et al. Hedonic and incentive signals for body weight control. *Rev Endocr Metab Disord.* 2011;12(3):141-151.

25. Brown RA, Abrantes AM, Minami H, et al. A preliminary, randomized trial of aerobic exercise for alcohol dependence. *J Subst Abuse Treat.* 2014;47(1):1-9.

26. Brown RA, Abrantes AM, Read JP, et al. A pilot study of aerobic exercise as an adjunctive treatment for drug dependence. *Ment Health Phys Act.* 2010;3(1):27-34.

27. Weinstock J, Barry D, Petry NM. Exercise-related activities are associated with positive outcome in contingency management treatment for substance use disorders. *Addict Behav.* 2008;33(8):1072-1075.

28. Sinha R, Jastreboff AM. Stress as a common risk factor for obesity and addiction. *Biol Psychiatry.* 2013;73(9):827-835.

29. Yau YH, Potenza MN. Stress and eating behaviors. *Minerva Endocrinol.* 2013;38(3):255-267.

30. Leal-Cerro A, Soto A, Martinez MA, Dieguez C, Casanueva FF. Influence of cortisol status on leptin secretion. *Pituitary.* 2001;4(1-2):111-116.

31. Haleem DJ, Inam QU, Haider S, Perveen T, Haleem MA. Serum leptin and cortisol, related to acutely perceived academic examination stress and performance in female university students. *Appl Psychophysiol Biofeedback.* 2015;40(4):305-312.

32. Capers PL, Fobian AD, Kaiser KA, Borah R, Allison DB. A systemic review and meta-analysis of randomized controlled trials of the impact of sleep duration on adiposity and components of energy balance. *Obes Rev.* 2015.

33. Knutson KL, Van Cauter E. Associations between sleep loss and increased risk of obesity and diabetes. *Ann N Y Acad Sci.* 2008;1129:287-304.

34. Dinour LM, Bergen D, Yeh M-C. The food insecurity–obesity paradox: a review of the literature and the role food stamps may play. *J Acad Nutr Diet.* 2007;107(11):1952-1961.

35. French SA, Epstein LH, Jeffery RW, Blundell JE, Wardle J. Eating behavior dimensions: associations with energy intake and body weight: a review. *Appetite.* 2012;59(2):541-549.

36. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res.* 1985;29(1):71-83.

37. Karlsson J, Persson LO, Sjostrom L, Sullivan M. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *Int J Obes Relat Metab Disord.* 2000;24(12):1715-1725.

38. Woodyard C. Exploring the therapeutic effects of yoga and its ability to increase quality of life. *Int J Yoga.* 2011;4(2):49-54.

39. Iyengar BKS. *Yoga: The Path to Holistic Health.* London, United Kingdom: Dorling Kindersley Ltd; 2007.

40. Gard T, Noggle JJ, Park CL, Vago DR, Wilson A. Potential self-regulatory mechanisms of yoga for psychological health. *Front Hum Neurosci.* 2014;8:770.

41. Bilderbeck AC, Farias M, Brazil IA, Jakobowitz S, Wikholm C. Participation in a 10-week course of yoga improves behavioural control and decreases psychological distress in a prison population. *J Psychiatr Res.* 2013;47(10):1438-1445.

42. Streeter CC, Whitfield TH, Owen L, et al. Effects of yoga versus walking on mood, anxiety, and brain GABA levels: a randomized controlled MRS study. *J Altern Complement Med.* 2010;16(11):1145-1152.

43. Aftanas L, Golosheykin S. Impact of regular meditation practice on EEG activity at rest and during evoked negative emotions. *Int J Neurosci.* 2005;115(6):893-909.

44. Carlson LE, Doll R, Stephen J, et al. Randomized controlled trial of Mindfulness-based cancer recovery versus supportive expressive group therapy for distressed survivors of breast cancer. *J Clin Oncol.* 2013;31(25):3119-3126.

45. Kiecolt-Glaser JK, Bennett JM, Andridge R, et al. Yoga's impact on inflammation, mood, and fatigue in breast cancer survivors: a randomized controlled trial. *J Clin Oncol.* 2014;32(10):1040-1049.

46. Lee JA, Kim JW, Kim DY. Effects of yoga exercise on serum adiponectin and metabolic syndrome factors in obese postmenopausal women. *Menopause.* 2012;19(3):296-301.

47. Sarvottam K, Magan D, Yadav RK, Mehta N, Mahapatra SC. Adiponectin, interleukin-6, and cardiovascular disease risk factors are modified by a short-term yoga-based lifestyle intervention in overweight and obese men. *J Altern Complement Med.* 2012.

CHAPTER 2

More Sleep and Higher Perceived Stress Scores Are Associated with Higher Dietary Cognitive Restraint in College Freshmen at a Mid-South University

Amy Richards, MS, RDN[1]
Bonny L. Specker, PhD[2]

[1]Department of Family and Consumer Sciences, University of Tennessee at Martin
[2]Ethel Austin Martin Program in Human Nutrition, South Dakota State University

Abstract

Objective: To examine associations of sleep quality and quantity, food security, and physical activity with eating behaviors that may be associated with college weight gain.

Design: Cross-sectional.

Setting: On-line survey.

Participants: College students enrolled in multiple sections of a general education class [n=153; 18-52 years of age (20.7 ± 4.8 years; mean ± SD); 76.1% female; 83.4% white].

Main Outcome Measure: Emotional Eating (EE), Uncontrolled Eating (UE), and Cognitive Restraint (CR) as measured by The Three-Factor Eating Questionnaire Revised.

Analysis: Bivariate analyses and multiple linear regression with significance at $P \leq .05$.

Results: Higher EE was associated with higher stress levels and female sex ($P<.001$ and $P=.02$); Higher UE scores were associated with higher perceived stress ($P<.001$) while lower UE scores were associated with tobacco use ($P=.03$ regression, $P=.098$, bivariate). Higher CR was associated with higher parental education and use of relaxation methods. Higher CR also was associated with perceived stress, but this relationship differed depending upon freshmen status and amount of physical activity, and a relationship with sleep was observed that differed depending upon freshmen status.

Conclusions and Implications: Interventions to help freshmen reduce stress and improve sleep may reduce freshmen weight gain.

Key Words: Eating Behavior; Young Adults; Stress, Psychological; Sleep

INTRODUCTION

The transition from high school to college is a time period with an increased risk of weight gain and often the development of less than healthy eating habits.[1-3] For many students, the college years are a time of adjusting from living at home to living on campus and learning to make decisions independently including choosing what and when to eat and drink, how much sleep to get, and whether or not to exercise. Data from the National College Health Assessment II (NCHA) completed in the spring of 2016 found that 36.8 % of responding students were overweight or obese.[4] A meta-analysis of 24 studies on freshmen weight gain found that average (SD) weight gain across all studies was 3.9 ± 1.6 pounds over a range of time periods during the freshmen year (12 weeks to 12 months.)[3]

Disturbances in sleep quality and length of sleep have been found to be associated with appetite, caloric intake, and energy balance.[5] Half of college students in a cross-sectional study by Vargas and colleagues[6] were found to score 5 or higher on the Pittsburg Sleep Quality Index (PSQI), which is associated with poor sleep quality. In their study, Vargas and colleagues found that sleep disturbances were associated with being overweight (BMI $\geq$ 25 kg/m^2) in college students when controlling for age and sex.

Dietary intake studies have revealed that college students are not meeting the dietary guidelines and have especially low fruit and vegetable intake.[7,8] In a study looking at factors associated with overweight and obesity in college students, Quick and colleagues[9] found that those with a higher than normal weight were more likely to have higher emotional eating, uncontrolled eating, and cognitive restraint as measured by the Three-Factor Eating Questionnaire[10]. However, there is still much that remains unknown about modifiable factors that may be associated positively or negatively with emotional eating, uncontrolled eating, and cognitive restraint in college students.

The authors are not aware of any published studies with college populations that have evaluated food security in relationship to emotional eating, cognitive restraint, and uncontrolled eating and included sleep quality, physical activity levels, hours of work, extracurricular time, and perceived stress. By including possible covariates and confounders, a better understanding of what is contributing to eating behaviors as measured by the TFEQ-R18V2 may be possible.

The following hypotheses were tested: 1.) Poor sleep quality and lower hours of sleep will increase uncontrolled eating, emotional eating, and decrease cognitive restraint; 2.) food insecurity will increase uncontrolled eating and emotional eating and decrease cognitive restraint; and 3.) meeting physical activity guidelines will be associated with lower uncontrolled eating and emotional eating scores and with higher cognitive restraint scores.

METHODS

Study Population

College students enrolled in seven sections of Health 111, a general education course at a mid-south university, were provided the opportunity to participate in a web-based, cross-sectional survey with the option of an equivalent, alternate assignment for extra credit. Of the total undergraduate students enrolled for the 2015-2016 year, 23.4% were freshmen (1507 freshmen; 6436 total undergraduate students)[11] and 175 were enrolled in Health 111 at the time of this study. Prior approval was received by the Institutional Review Board of the university where the survey was conducted as well as at the university of the graduate advisor to the primary investigator.

Study Procedures

The cross-sectional survey was administered in January, 2016 prior to exposure to classroom content that might influence student answers. Participants reviewed an online informed consent prior to beginning the survey. A brief (5 minute) overview, informed consent, and an alternative assignment were provided to students in class sections that met on campus and a video with the same information was provided to students enrolled in an online section. Missing data were handled per protocol of each validated survey instrument in order to calculate scores.

The survey included the Pittsburg Sleep Quality Index (PSQI)[12], the Three-Factor Eating Questionnaire Revised (TFEQ-R18V2) [10,13], the United States Department of Agriculture (USDA) 6-item Short Form of the Household Food Security Scale[14], Global Physical Activity Questionnaire (GPAQ),[15,16] and 8 of the 10 questions from the Perceived Stress Scale (PSS-10).[17] Demographic information and other characteristics were gathered via survey questions.

The TFEQ-R18V2 contains 18 questions that ask participants about thoughts related to eating, patterns of hunger, and food related behavior. Scores for three separate eating behaviors were calculated: emotional eating, uncontrolled eating, and cognitive restraint. Higher scores for emotional eating and uncontrolled eating imply more emotional eating and uncontrolled eating respectively compared to those with lower scores while higher cognitive restraint scores imply more attempt to restrain eating.[10,13]

The GPAQ contains 16 questions to calculate the total weekly metabolic equivalent ratio (MET). MET is a standardized method of comparing physical activity levels. Total MET minutes were calculated by multiplying total minutes of moderate activity by 4 and multiplying total minutes of vigorous physical activity by 8 and then adding the two numbers together.[18] The GPAQ was developed to be administered by an interviewer; however, a self-rated version has been found to be comparable in reliability and validity.[16]

The PSQI contains 18 self-administered items. A range from 0 to 21 points is possible with a score of zero implying no difficulty in sleep occurred (good sleep quality) while a score of 21 would imply very poor sleep quality and less than recommended amount of sleep. The PSQI includes items such as length of time in bed, hours of sleep, difficulty sleeping due to various disturbances, and daytime sleepiness during activities. A score of greater than 5 is indicative of poor sleep and that difficulty is occurring in at least two components of sleep quality. [12,19]

The USDA 6-item Short Form of the Household Food Security Scale has been validated as a proxy for the longer 18-item scale with 97.7% of households correctly identified and with only 0.3 % of those with food insecurity missed.[14] Food security is measured for the previous 12-months and a raw score is determined by adding up “yes” answers on the 6-item scale with answers of “often” and “sometimes” coded as “yes”.[20]

Perceived stress was measured using the Perceived Stress Scale (PSS-10). The PSS-10 contains 10 items that assess to what extent individuals felt stressed over the last month. The scale is not designed to determine whether an individual’s level of stress is high or low but rather to compare stress levels among study participants in each individual study sample.[17] Two of the positive questions missed getting included in our online survey ("In the past month, how often have you felt confident in your ability to handle your personal problems?"; "In the past month, how often have you been able to control irritations in your life?"). Because of the two missed questions, which were each worth up to 4 points, the most points possible was 32 instead of 40.

Statistical Analyses

Summary statistics were calculated for demographic factors utilizing Chi Square and ANOVA. One-way ANOVA was completed to determine group differences using Bonferroni adjustment. Kruskal-Wallis was used when the data were nonparametric. Student's t tests for unequal variances were completed to compare means for variables with unequal variances.

Linear regression was completed to test the relationships between eating behavior and individual continuous dependent variables. One-way ANOVA was used to test the relationship between eating behaviors and categorical dependent variables. Multiple regression was conducted to identify predictive models for eating behaviors and test for interactions. Potential covariates were grouped into different categories and tested to determine which variables should be included in initial model development. The demographics category included age, gender, parental education, living situation, and year in college. Anthropometrics included self-reported height and weight, which were used to calculate BMI and self-reported high and low weights over the last three years were used to calculate weight range. Lifestyle factors included tobacco use, whether methods to reduce stress were used, number of college credits, grade point average, hours of work per week, number of volunteer hours, and number of hours in extracurricular activities. Variable(s) within each category that had the highest correlation with eating behaviors were determined and those with the highest correlation were used in the development of a final regression model.

Scores for two of the three eating behaviors (emotional eating and cognitive restraint) were normally distributed. The scores for uncontrolled eating were not normally distributed but residuals from the regression model were normally distributed. Multicollinearity was tested using the variance inflation factor (VIF). Statistical analysis was completed using Stata Statistical Software: Release 12, College Station, TX: StataCorp, 2011. Results were considered significant at the level of $p < .05$.

RESULTS

Population Characteristics

A total of 153 participants (87.4%) completed the survey out of 175 potential students. The survey included 2.2% of all enrolled students for the 2015-2016 school year and 3.8% of all enrolled freshmen for the same time period.[11] Average age was 20.7 ± 4.8 years (mean ± SD) with a range of 18 to 52 years. The majority of participants were female (n=105, 76.1%), white (n= 126, 83.4%), and were either freshmen or sophomores (73.9%). Close to half of the students lived on campus or in a fraternity (n=69, 45.1%), while 26.8% (n=41) rented off campus, 21.6% (n=33) lived with family, and the remainder owned their own home (n=10). The highest level of educational attainment of the parents of the students was as follows: 19.7% having a high school degree or less, 36.9% having attended some college, 23.7% having a bachelor's degree, and 19.7% having a master's degree or higher.

Average BMI and hours of sleep per night were 26.1 ± 5.9 kg/m^2 and 7.1 ± 1.5 hours respectively. Nearly half were overweight or obese (n=46, 30.5% and n=28, 18.5% respectively) and 60.1% (n=92) had poor sleep as measured by the PQSI.[19] Over three fourths (n=127, 86.4%) met the physical activity recommendations of 150 minutes/week of moderate activity, 75 minutes/week of vigorous activity, or a combination of vigorous and moderate activity. MET minutes per week averaged 6,992 ± 7,559 with a range of zero to 32,640.

Average grade point average was 3.1 ± .5, hours worked per week was 14.8 ± 18.7 hours, and number of credits per semester was 15.2 ± 3.1. The majority of students were enrolled in the College of Education, Health and Behavioral Sciences (75.0%, n=114). The College of Agriculture and Applied Sciences had the next highest percent of students in the study at 11.2% (n=17).

A high percent of students (77.6%, n=118) indicated that they had "used strategies, activities, or coping mechanisms to decrease" their stress level in the last month. Current tobacco use was reported by 15.7% of students (n=24) with another 5.2% indicating they were past users of tobacco. The presence of a chronic disease was reported by 24 students (15.7%).

Fifteen percent of students indicated that over the last 12 months that they had eaten less than they "felt that they should because there wasn't enough money for food" and 34% indicated that over the last 12 months that food that they "bought just didn't last" and that they "didn't have money to get more". Nine students (5.9 %) had very low food security and 43 students had low food security (28.1 %). The remainder of students (n=101, 66%) had marginal or high food security.

Emotional eating

Using multiple regression techniques, we found that perceived stress and gender were independently associated with emotional eating (Table 2.1). In both bivariate analyses and in a multiple regression model, individuals with higher perceived stress had higher emotional eating scores ($P<.001$, bivariate; $P<.001$, model). Females had higher emotional eating scores than males in both bivariate analysis and in the multiple regression model ($P=.02$, bivariate; $P =.02$, model). Decreased sleep quality was associated with higher emotional eating score in bivariate analysis ($P=.02$), however, it was not significant when included in the final regression model. There were no significant interactions among variables.

Uncontrolled eating

Perceived stress and tobacco use were independently associated with uncontrolled eating using multiple regression techniques (Table 2.1). In both bivariate analyses and in a multiple regression model, individuals with higher perceived stress had higher uncontrolled eating scores ($P<.001$, bivariate; $P<.001$, model). The use of tobacco was associated with reduced uncontrolled eating in the model ($P=.03$), but not in bivariate analysis ($P=.10$). Food insecurity was associated with increased uncontrolled eating in a bivariate analysis ($P=.003$), but not in the final regression model ($P=.10$). There were no significant interactions among variables.

Cognitive restraint

Having at least one parent with education beyond high school and self-reported use of relaxation methods were associated with higher cognitive restraint (P=.02 and P=.04, multiple regression model). The multiple regression model also included three interactions (stress-by-class rank, stress-by-amount of physical activity, and class rank-by-number of hours of sleep; Figures 2.1-2.3). There was an association between cognitive restraint score and perceived stress score that differed by class rank (perceived stress-by-freshman status interaction, P=.01, Figure 2.1). Students classified as freshmen had higher cognitive restraint when perceived stress levels were high and lower cognitive restraint when perceived stress levels were low, whereas cognitive restraint scores of students with a class rank of sophomore or higher were unaffected by perceived stress.

An association between cognitive restraint and hours of sleep that differed by class rank was also significant (hours of sleep-by-freshman status interaction, P=.04, Figure 2.2). Freshmen with fewer hours of sleep had lower cognitive restraint scores than freshmen with more hours of sleep. Cognitive restraint of students with a class rank of sophomore or higher was not affected by hours of sleep.

Additionally, there was a significant association between cognitive restraint score and physical activity that differed by perceived stress score (physical activity-by-perceived stress interaction, p =.01, Figure 2.3). When stress levels were low, higher physical activity levels were associated with higher cognitive restraint. When stress levels were high, higher physical activity levels were associated with lower cognitive restraint scores.

DISCUSSION

The primary purpose of our study was to examine relationships among various modifiable factors that college students experience that may be contributing to eating behaviors that are associated with weight gain. Perceived stress was the only variable included as a predictor for all three behaviors. Other studies have also found a relationship with eating behaviors and perceived stress.[21-23] Our hypotheses as outlined in the introduction were only partially met and no relationship was found between any eating behaviors and food insecurity when other covariates were taken into account that implies that modifying other factors is more likely to improve eating behaviors.

Our results indicate that high stress levels and lack of sleep may affect freshmen's cognitive restraint more than it does students who have been attending college longer, with lack of sleep leading to lowered cognitive restraint and higher stress levels associated with higher cognitive restraint. Because we found that higher stress levels are associated with increased emotional and uncontrolled eating scores, we speculate that it might be possible that cognitive restraint increases in an attempt to try to control stress-induced eating desires. No association was found between lack of sleep (or poor sleep quality) and emotional eating or uncontrolled eating in our study. Along similar lines, in a study evaluating snack consumption, Dweck and colleges found in a laboratory setting that those with higher emotional eating scores ate more under stressful conditions if they were not short on sleep (a three-way interaction between stress, hours of sleep, and emotional eating on quantity of food eaten).[23]

We did not find an association between overweight/obese status and any of the eating behaviors either in bivariate or regression analysis. In one of the few published studies that administered the TFEQ with college students, Quick and colleagues found an association between short sleep and poor quality of sleep and prevalence of overweight and obesity in college students. In addition, they reported an association between higher scores on all three scales of the TFEQ and above normal BMI.[9]

We did not find food insecurity to be a predictor of eating behaviors in any of the regression models. Food insecurity has been associated with overweight and obesity in women in several studies[24], however, very little research has been conducted looking at food insecurity and eating behaviors. Analysis of baseline data of an intervention study by Sharpe and colleagues[25] (2016) found no differences in weight, BMI, and waist circumference between food secure and food insecure individuals and very little difference in dietary intake. In the Sharpe et al. study, those classified as food insecure were found to have higher emotional eating and lower self-efficacy for eating healthy.[25] In a study of adults participating in congregate meals, Myles and colleagues[26] found that emotional eating was not associated with food insecurity, however, cognitive restraint was associated with food insecurity and to some extent so was uncontrolled eating.[26]

Cognitive restraint can be defined in simple terms as an attempt to control dietary intake to control weight. Studies have been mixed as to the helpfulness of cognitive restraint in weight management and in a review of literature, Johnson and colleagues attribute this controversy to how cognitive restraint has been measured and interpreted. Johnson et al. indicate that cognitive restraint might be better thought of as an indicator of the tendency to overeat with disinhibition being the actual cause of weight gain. In their review, Johnson and colleagues refer to multiple studies with association between higher cognitive restraint scores and weight loss and weight maintenance.[27] Along similar lines, Phelan and colleagues found that those who successfully maintained weight loss had higher restraint scores and lower disinhibition scores. [28] As further evidence that disinhibition scores are key to weight maintenance, Niemeier and colleagues analyzed baseline disinhibition scales looking specifically at questions related to internal disinhibition in relationship with weight changes over time and found lower internal disinhibition scores to be correlated with weight loss.[29] The authors of this paper believe that cognitive restraint can be a helpful component in weight loss and weight loss.

In regression models, physical activity levels were not associated with emotional or uncontrolled eating. Higher physical activity levels were associated with higher cognitive restraint scores when individuals were experiencing low stress levels, but not when individuals were experiencing high stress levels. This would imply that more physically active individuals have greater cognitive restraint unless they are experiencing high perceived stress. The association between cognitive restraint and physical activity is consistent with Riou and colleagues[30] who found correlations between eating behaviors and BMI that were different based upon physical activity. In their study, there was stronger correlation for a negative association between dietary restraint and BMI in women at the highest physical activity level.

The number of students in our study that met or exceeded the recommended amount of physical activity[31] was higher than other reports[4,7-9], however, some studies did not include work and transportation physical activity. While not entirely unexpected, tobacco use was associated with lower levels of uncontrolled eating. Along similar lines, Kovacs and colleagues[32] (2014) found that smokers who had higher levels of dietary cognitive restraint appeared to use cigarettes as a method to resist food cues presented to them.

As part of our study, we found that students who indicated that they used stress reduction methods were predicted to have higher cognitive restraint. While a large percentage of students indicated that they used various methods to reduce stress, interventions targeted towards college freshmen to increase their ability to utilize stress reduction techniques effectively to lower stress levels and help them take steps to improve sleep quality might be beneficial in regard to dietary eating patterns associated with overweight and obesity.

Study Limitations

The study is a cross sectional study and therefore cause and effect cannot be determined. Eating behaviors are complicated and influenced by multiple factors. Individual differences in subjects' response to stress, lack of sleep, sleep quality, food insecurity, and physical activity can lead to results that may not be consistent from study to study. Also, individuals may vary in their interpretation of questions. There is no way to know if all of the students were honest in their answers or if students' interpretations of questions were the same. Self-reported height and weight also is a limitation of the study as some students may have been more accurate in their reporting than others.

While we had 153 respondents, utilizing an English or speech communications class with a larger number of sections may have been able to detect differences and associations better due to increased statistical power and may have been more representative of the entire university population than a general education class. An additional limitation is the lack of two questions being included in our survey from the

PSS-10 instrument, which means that the scores for perceived stress are not comparable to other published studies. The population was largely white with a high percentage of females, so generalizability to other campuses in the U.S. may be limited.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Interventions that teach freshmen how to effectively reduce stress, stress the importance of getting adequate sleep, and encourage the recommended amount of physical activity have the potential to reduce eating behaviors associated with weight gain. Interestingly, tobacco use was found to be associated with lower uncontrolled eating. More research is needed to understand if there is something about tobacco use (other than tobacco or nicotine) that can be applied in an effort to lower uncontrolled eating such as a non-food treat to get a person away from food temptations before over consumption occurs.

REFERENCES

1. Deforche B, Van Dyck D, Deliens T, De Bourdeaudhuij I. Changes in weight, physical activity, sedentary behaviour and dietary intake during the transition to higher education: a prospective study. *Int J Behav Nutr Phys Act.* 2015;12:16.
2. Gordon-Larsen P, Adair LS, Nelson MC, Popkin BM. Five-year obesity incidence in the transition period between adolescence and adulthood: the National Longitudinal Study of Adolescent Health. *Am J Clin Nutr.* 2004;80(3):569-575.
3. Vella-Zarb RA, Elgar FJ. The ‘Freshman 5’: a meta-analysis of weight gain in the freshman year of college. *J Am Coll Health.* 2009;58(2):161-166.
4. American College Health Association. *American College Health Association-National College Health Assessment II: Reference Group Executive Summary Spring 2016.* Hanover, MD: American College Health Association;2016.
5. Horne JA. Human REM sleep: influence on feeding behaviour, with clinical implications. *Sleep Med.* 2015.
6. Vargas PA, Flores M, Robles E. Sleep quality and body mass index in college students: the role of sleep disturbances. *J Am Coll Health.* 2014;62(8):534-541.
7. Huang TTK, Harris KJ, Lee RE, Nazir N, Born W, Kaur H. Assessing overweight, obesity, diet, and physical activity in college students. *J Am Coll Health.* 2003;52(2):83-86.
8. Small M, Bailey-Davis L, Morgan N, Maggs J. Changes in eating and physical activity behaviors across seven semesters of college: living on or off campus matters. *Health Educ Behav.* 2013;40(4):435-441.

9. Quick V, Byrd-Bredbenner C, White AA, et al. Eat, sleep, work, play: associations of weight status and health-related behaviors among young adult college students. *Am J Health Promot.* 2014;29(2):e64-72.

10. de Lauzon B, Romon M, Deschamps V, et al. The Three-Factor Eating Questionnaire-R18 is able to distinguish among different eating patterns in a general population. *J Nutr.* 2004;134(9):2372-2380.

11. University of Tennessee at Martin website. 2016-2017 Fact Book: Headcount enrollment by student classification. https://www.utm.edu/departments/irp/statistical_reports.php. Accessed January 14, 2017.

12. Buysse DJ, Reynolds CF, 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;28(2):193-213.

13. Karlsson J, Persson LO, Sjostrom L, Sullivan M. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *Int J Obes Relat Metab Disord.* 2000;24(12):1715-1725.

14. Blumberg SJ, Bialostosky K, Hamilton WL, Briefel RR. The effectiveness of a short form of the Household Food Security Scale. *Am J Public Health.* 1999;89(8):1231-1234.

15. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health.* 2009;6(6):790-804.

16. Chu AH, Ng SH, Koh D, Muller-Riemenschneider F. Reliability and validity of the self-and-interviewer-administered versions of the Global Physical Activity Questionnaire (GPAQ). *PloS One.* 2015;10(9):e0136944.

17. Cohen S, Williamson G. Perceived stress in a probability sample of the United States. In: Spacapan S, Oskamp S, eds. *The Social Psychology of Health: Claremont Symposium on Applied Social Psychology*. Newbury Park, CA: Sage; 1988.

18. World Health Organization. Global Physical Activity Questionnaire (GPAQ) analysis guide. Prevention of Noncommunicable Diseases Department. Geneva, Switzerland: World Health Organization.

19. The University of Pittsburgh. Pittsburgh Sleep Quality Index: Form Administration Instructions, References, and Scoring. http://www.psychiatry.pitt.edu/node/8240. The University of Pittsburgh. 2005.

20. Economic Research Service. U.S. Household Food Security Survey Module: Six-Item Short Form Revision Notes. September, 2012; https://www.ers.usda.gov/media/8282/short2012.pdf. Accessed December 25, 2016.

21. Diggins A, Woods-Giscombe C, Waters S. The association of perceived stress, contextualized stress, and emotional eating with body mass index in college-aged Black women. *Eat Behav.* 2015;19:188-192.

22. Richardson AS, Arsenault JE, Cates SC, Muth MK. Perceived stress, unhealthy eating behaviors, and severe obesity in low-income women. *Nutr J.* 2015;14:122.

23. Dweck JS, Jenkins SM, Nolan LJ. The role of emotional eating and stress in the influence of short sleep on food consumption. *Appetite.* 2014;72:106-113.

24. Dinour LM, Bergen D, Yeh M-C. The food insecurity–obesity paradox: a review of the literature and the role food stamps may play. *J Acad Nutr Diet.* 2007;107(11):1952-1961.

25. Sharpe PA, Whitaker K, Alia KA, Wilcox S, Hutto B. Dietary intake, behaviors and psychosocial factors among women from food-secure and food-insecure households in the United States. *Ethn Dis.* 2016;26(2):139-146.

26. Myles T, Porter Starr KN, Johnson KB, Sun Lee J, Fischer JG, Ann Johnson M. Food insecurity and eating behavior relationships among congregate meal participants in Georgia. *J Nutr Gerontol Geriatr.* 2016;35(1):32-42.

27. Johnson F, Pratt M, Wardle J. Dietary restraint and self-regulation in eating behavior. *Int J Obes (Lond).* 2012;36(5):665-674.

28. Phelan S, Liu T, Gorin A, et al. What distinguishes weight-loss maintainers from the treatment-seeking obese? Analysis of environmental, behavioral, and psychosocial variables in diverse populations. *Ann Behav Med.* 2009;38(2):94-104.

29. Niemeier HM, Phelan S, Fava JL, Wing RR. Internal disinhibition predicts weight regain following weight loss and weight loss maintenance. *Obesity (Silver Spring).* 2007;15(10):2485-2494.

30. Riou ME, Doucet E, Provencher V, et al. Influence of physical activity participation on the associations between eating behaviour traits and body mass index in healthy postmenopausal women. *J Obes.* 2011;2011.

31. World Health Organization: Global recommendations on physical activity for health. Geneva, Switzerland: World Health Organization; 2010.

32. Kovacs MA, Correa JB, Brandon TH. Smoking as alternative to eating among restrained eaters: effect of food prime on young adult female smokers. *Health Psychol.* 2014;33(10):1174-1184.

LEGEND

Figure 2.1. Association between cognitive restraint score and perceived stress by freshmen status (stress-by-class rank interaction, p=.01).

Figure 2.2. Association between cognitive restraint score and hours sleep by freshmen status (hours of sleep-by-class rank interaction, p=.04).

Figure 2.3. Association between cognitive restraint score and perceived stress score by hours per week of moderate physical activity equivalent (hours of sleep-by-physical activity interaction, p=.01).

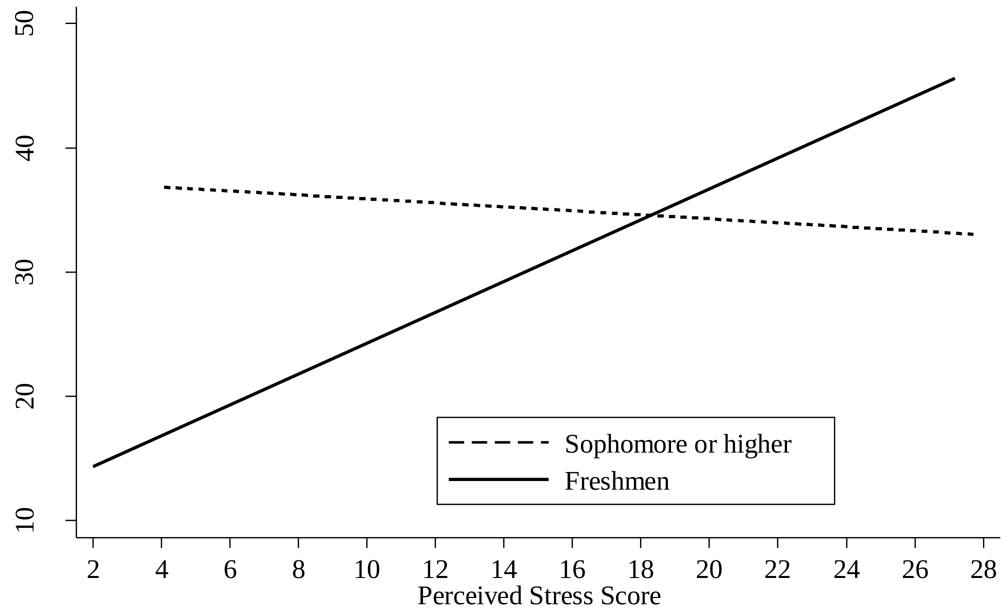

50
40
30
20
10
2 4 6 8 10 12 14 16 18 20 22 24 26 28
Perceived Stress Score
Sophomore or higher
Freshmen

Figure 2.1.

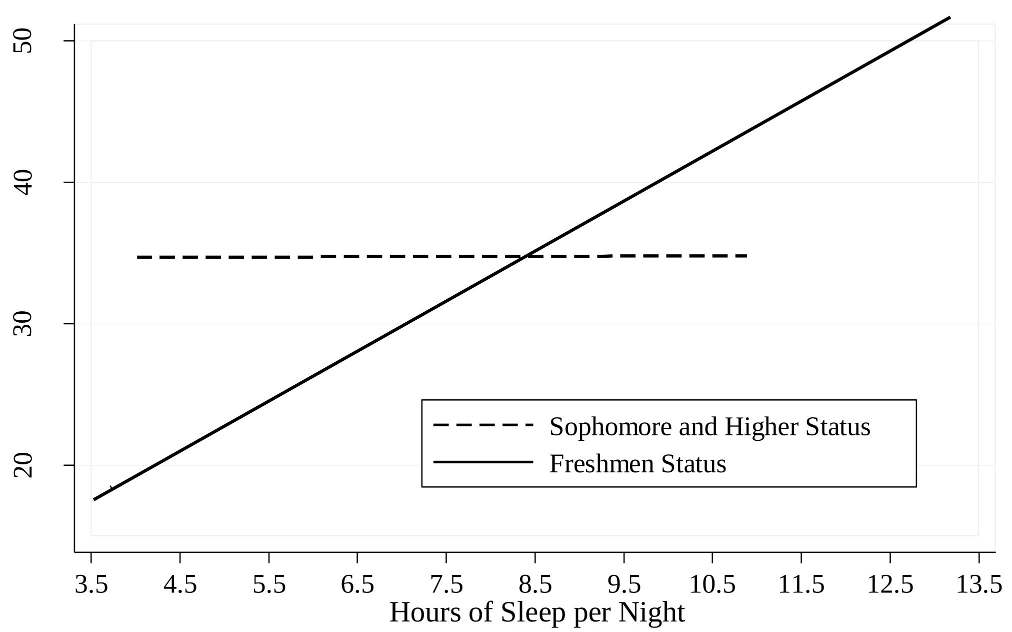
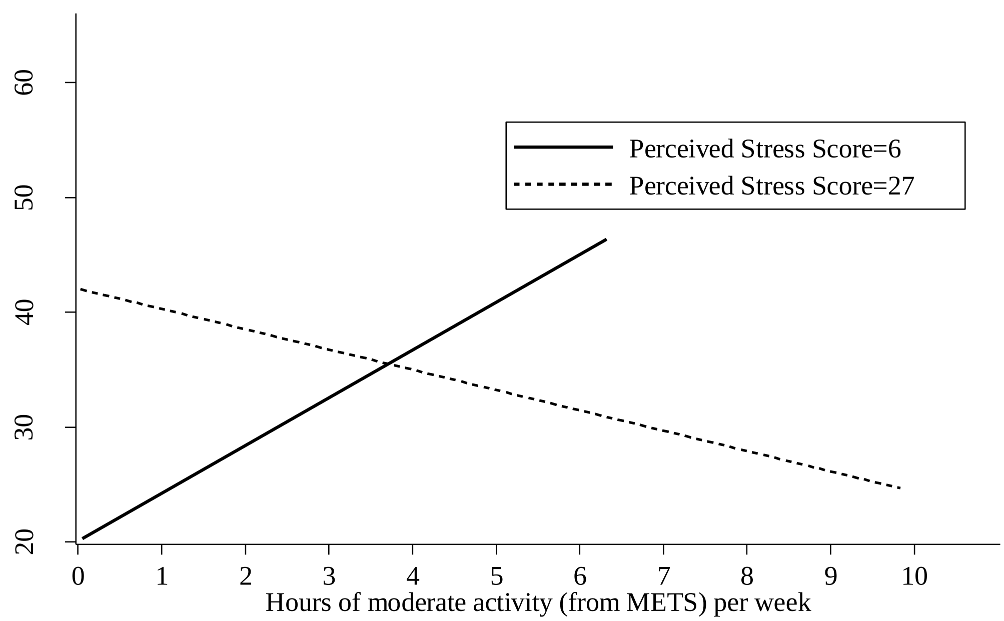

50
40
30
20
Sophomore and Higher Status
Freshmen Status
3.5
4.5
5.5
6.5
7.5
8.5
9.5
10.5
11.5
12.5
13.5
Hours of Sleep per Night

Figure 2.2.



60
50
40
30
20
Perceived Stress Score=6
Perceived Stress Score=27
0
1
2
3
4
5
6
7
8
9
10
Hours of moderate activity (from METS) per week

Figure 2.3.

Table 2.1. Multiple Linear Regression Models Predicting Eating Behaviors

	Coef.	β	SE	P
Emotional Eating				Model r^2=.15
Intercept	2.0	--	6.3	P<0.001
Stress	1.4	0.33	0.34	< 0.001
Female	10.8	0.19	4.6	0.02
Uncontrolled Eating				Model r^2=.14
Intercept	21.1	--	4.6	P<0.001
Stress	1.1	0.33	0.27	<0.001
Tobacco	-9.3	-0.17	4.3	0.03
Freshmen	6.1	0.15	3.2	0.06
Cognitive Restraint				Model r^2=.18
Intercept	22.5	--		P=.002
Stress	0.82	0.18	0.53	0.13
Freshmen Status	-75.9	-1.4	26.6	0.005
Relaxation	10.2	0.17	5.0	0.04
Sleep Hours	-1.3	-0.72	1.8	0.50
Parents' Education	-12.3	-0.19	5.3	0.02
Physical Activity	0.0024	0.70	0.0008	0.004
Stress-by-Freshman	1.9	0.60	0.75	0.01
Sleep-by-Freshman	6.1	0.87	2.9	0.04
Stress-by-Physical Activity	-0.00012	-0.71	0.000044	0.005

Stress score ranged from 2 to 28: female=15.6 ± 5.9 (mean ± SD), male=14.4 ± 6.0. Freshmen status (1= freshmen, 0= all other students). Relaxation (1= used relaxation strategies, 0= did not use relaxation strategies). Sleep hours ranged from 3.5 to 13: female=7.1 ± 1.6, male= 7.2 ± 1.3. Parents' Education (1= high school education or less; 0= more than high school education). Physical Activity METs ranged from 0 to 32640; female=6020 ± 7134, male=9433 ± 6958.

CHAPTER 3

Working 40 or more hours per week, perceived stress, and lack of sleep are associated with higher emotional eating while meeting physical activity guidelines is associated with lower emotional eating.

Amy Richards, MS, RDN[1]
Bonny L. Specker, PhD[2]

[1]Department of Family and Consumer Sciences, University of Tennessee at Martin
[2]Ethel Austin Martin Program in Human Nutrition, South Dakota State University

ABSTRACT

Background: Little is known about the possible effects of regular physical activity and sleep on emotional eating, uncontrolled eating, and cognitive restraint.

Objective: This cross-sectional study investigated baseline data to evaluate associations among self-reported physical activity and sleep on eating behaviors of 162 adults aged 19 to 75 years enrolled in a weight loss program.

Methods: Perceived sleep quality and quantity were compared to physical activity levels and to scores for hunger and eating behavior. Emotional Eating (EE), Cognitive Restraint (CR), and Uncontrolled Eating (UE) were measured by Three-Factor Eating Questionnaire Revised (TFEQ-R18V2). Global Physical Activity Questionnaire (GPAQ) was administered and total metabolic equivalent ratio (MET) per week were calculated. Stress was measured by the Perceived Stress Scale (PSS-10). Height and weight were measured and body mass index (BMI) was calculated. Linear regression models were developed for predicting all three eating behaviors.

Results: Stress, female gender, working 40 or more hours a week, and lack of sleep were associated with greater EE while getting the recommended amount of physical activity was associated with lower EE (model r^2=.208, $p<.001$). An interaction between stress and sleep quality was significant in a model for UE (r^2=.12, p=.002): UE was associated with higher stress when there was good sleep, but not when there was poor sleep. An interaction between age and BMI was significant in a model for CR (r^2=.18, $p<.001$): a

positive relationship between CR and age was observed for individuals with lower BMI, but not among individuals with high BMIs.

Conclusions: Increasing physical activity to recommended levels, reducing stress, having adequate sleep, and increasing CR as one ages may result in better weight management.

INTRODUCTION

There is an urgent need to find a solution to the obesity epidemic. Obese individuals are at increased risk for chronic disease, decreased quality of life, and shortened life span.[1-5] The economic cost to society due to lost productivity and health care costs is enormous.[6-8] Researchers have conducted studies to better understand the regulation and dysregulation of hormonal and neural control of appetite and weight.[9-12] Eating behavior is complex and individuals often eat for reasons other than appetite which contributes to obesity.[13,14] It is well documented that people often consume food as a special treat or because they especially like the food item rather than to meet caloric needs.[15]

There is some evidence that exercise may help prevent substance abuse as well as improve outcomes in treatment programs for addictions.[16-18] Addictive drugs, highly palatable foods, and exercise are all able to function as stimuli for the reward pathway. [19-21] The reward pathway is a term used to describe a process in which the brain determines stimuli to be rewarding, pleasure is created through chemical signals, memory of steps taken to get the pleasurable sensation are recorded, and motivation to experience the feeling again is generated. Technically, the reward pathway refers to when the ventral tegmental area (VTA) of the brain is activated by stimuli and dopamine-producing neurons transmit information to the nucleus accumbens, which is an area of the brain associated with pleasure. The message continues from the nucleus accumbens to other parts of the brain involved in motivation and memory that in turn contribute to behavior necessary to start the process all over again[22-24].

Because ongoing or "chronic" exercise has been able to reduce the intake of highly addictive drugs[16,25-27], one might wonder whether habitual exercise also might have the potential to reduce cravings for highly palliative foods in individuals struggling with overweight and obesity. In a study with mice, exercise in the form of voluntary running on a wheel was able to reduce the consumption of highly palliative food. [28]

Exercise has the potential to help with weight loss even when individuals eat more after exercising, as the increase in calories consumed may be less than the increase in energy expenditure.[29] A study with ten young, physically fit men that each completed the three arms of the study found that energy expenditure was higher with aerobic exercise than resistance exercise but that caloric intake from an ad libitum meal after the exercise was not different which meant that those in the aerobic exercise group did not increase intake to match calories burned. The study also found that resistance exercise was able to lower ghrelin more than aerobic exercise or not exercising and that aerobic exercise and resistance exercise were able to increase pancreatic polypeptide more than not doing exercise but one was not significantly better than the other at doing so.[30] Lowering ghrelin, a hormone associated with hunger, would be expected to decrease appetite while increasing pancreatic peptide would be expected to increase satiety and decrease food intake.[31] In another small study, no change was found in perceived hunger during the fasting state in 33 overweight and obese men after 12 weeks of participation in an aerobic group, resistance group, or no exercise control group; however, perception of fullness as measured by a visual analogue scale after a 10 hour overnight fast and after consumption of 75 grams of carbohydrate was higher post intervention compared to pre-intervention fullness score in the aerobic group.[32] Additional studies also have found that aerobic exercise is able to induce a temporary suppression of appetite.[33]

Sleep quantity and quality have been studied and found to play a role in appetite, energy intake, and obesity.[34-36] Capers and colleagues completed a review of studies that evaluated sleep duration, dietary intake, and weight.[37] The meta-analysis found weight loss to be significant in studies when sleep length was increased. However, the meta-analysis of studies in which sleep length was shortened did not find weight gain to be significant, and the authors noted that individually, three of the four studies found weight gain or less weight loss than those who slept longer. The authors chose not to complete a meta-analysis on studies that evaluated sleep length and dietary intake due to variability in methodologies and use of laboratory setting.[37] A lack of reliable methodology for assessing food intake has been noted in the literature[38] and this hinders efforts to determine to what extent various factors are influencing dietary intake.

The extent to which sleep quality and quantity may interact with the ability of exercise to prevent, promote, and maintain weight loss is unknown. In a small cross-over study, fragmented sleep resulted in shorter rapid eye movement (REM) sleep, but not significantly shorter slow wave sleep (SLW). Loss of REM sleep has been associated with an increase in hunger and caloric intake.[34-36] The afternoon of the day following sleep fragmentation, glucagon-like peptide (GLP-1) levels were lower and feelings of fullness were decreased compared to those who did not experience sleep fragmentation. Subjects who experienced fragmented sleep also reported higher scores for wanting to eat after the evening meal. [35]

While knowledge has been gained in previous studies regarding hormonal effects of exercise, the effect of aerobic exercise on short term energy intake, and the benefits of exercise in maintaining weight loss,[19] there is still much to be learned in regards to how ongoing, habitual exercise affects specific eating behaviors in humans and whether sleep quality and quantity affects the ability of exercise to influence eating behavior. Interviews with nurses working overnight shifts (n=27) found an increase in cravings for sweets and carbohydrates on the days after a night shift and reduced exercise levels due to being tired.[39] A question yet to be answered is whether exercise is able to improve eating behaviors when a person is sleep-deprived. Reducing the desire to eat when not hungry has the potential to reduce overweight and obesity.

We hypothesized that individuals who meet the recommended levels of physical activity will have lower emotional and uncontrolled eating and higher cognitive restraint on the Three-Factor Eating Questionnaire Revised (TFEQ-R18V2)[40]; that reported sleep quantity and quality will be inversely correlated with emotional and uncontrolled eating scores and positively correlated to cognitive restraint; and that the relationship between physical activity levels and eating behavior scores will be modified by sleep quantity.

METHODS

Baseline data were collected from 162 participants upon enrollment in a randomized, controlled trial comparing yoga to stretching in a weight loss program. The study protocol was approved by the South Dakota State University and the Sanford Health Institutional Review Boards. Written informed consent was received from all study participants prior to their enrollment. The trial was registered at clinicaltrials.gov (NCT02451800).

Study population

Study subjects were newly enrolled Sanford Profile® participants recruited to participate in a randomized, controlled intervention study to determine if yoga was able to improve weight loss and eating behaviors over time. Sanford Profile® is a weight loss program available in the upper Midwest and participants were recruited from two communities in South Dakota, a city in North Dakota, and a city in Minnesota. Participants in the weight loss program follow a specific plan in regard to diet and are encouraged to exercise. One hundred sixty-two participants (146 females), aged 19 to 75 years, provided data and access to height and weight measurements. For purposes of this study, baseline data (2015-2016) were used for a cross-sectional evaluation of the relationships between self-reported sleep quantity and quality and amount of physical activity per week with eating behaviors.

Study procedures

Demographics and participant characteristics (e.g., chronic disease, medications, alcohol intake, hours of sleep) were collected via telephone survey. Online survey instruments were used to collect data on eating behaviors and perceived stress at baseline, 3 months, and 6 months. Physical activity was collected by online survey at baseline only.

Eating behavior was determined by the Three-Factor Eating Questionnaire Revised (TFEQ-R18V2). The Three-Factor Eating Questionnaire Revised 18-Item version (TFEQ-R18V2)[40-43] contains 18 questions related to hunger, thoughts related to food, and patterns of eating. Each question is on a 4-point scale and three separate categories of eating behavior are measured in the survey: emotional eating, uncontrolled eating, and cognitive restraint.

To determine usual physical activity levels of participants, the Global Physical Activity Questionnaire (GPAQ)[44-48] was administered and total metabolic equivalent ratio (MET) per week were calculated following the scoring system as described in the GPAQ Analysis Guide written by the World Health Organization. The GPAQ asks a series of 16 questions that collect information on the amount of time per week that the individual is moderately and vigorously active for work, transportation, and recreation/exercise. Moderate level activity is multiplied times 4 and vigorous activity is multiplied times 8 and then all of the minutes are summed.[46,48] From the MET equivalents per week, it was also determined if individuals met the physical activity recommendations of the World Health Organization of 150 minutes per week of moderate level activity, 75 minutes per week of vigorous level activity, or an equivalent combination.[49]

Sleep quantity was determined by asking participants to list the average number of hours they sleep per night. Perceived sleep quality was measured by asking participants to rate their sleep quality as: very good, good, poor, or very poor. For purposes of analysis, the categories for sleep were combined into good sleep (very good and good) and poor sleep (poor and very poor).

Possible covariates that were considered, included demographic characteristics (age, gender, number of children, number in household, marital status, race, education and income), methods used to relax (yoga, meditation, biofeedback, prayer, massage, healing touch, gardening, sitting outside in nature, going for a walk, spending time with animals, painting or other artwork, quilting or other crafts, playing soothing music, or other activities) and perceived stress. Information on demographic characteristics and methods used to relax were obtained by questionnaire and perceived stress was measured using the Perceived Stress Scale (PSS-10). The PSS-10 contains 10 items that assess to what extent individuals felt stressed over the last month. Scoring is completed by reversing 4 positive items and then adding the 10 items together and the PSS-10 score can range from 0 to 40 with higher scores indicating more perceived stress.[50]

Statistical Analyses

Linear regression was completed to test the relationship between sleep quantity and amount of physical activity per week. One-way ANOVA was used to test the relationship between the sleep quality and amount of physical activity per week. Multiple regression was used to determine the best predictive models for eating behaviors and test for interactions.

In order to determine which variables contribute to eating behaviors, the variables were grouped into different categories: demographics, body measurements (body mass index [BMI]), physical activity (total MET hours, regular stretching), lifestyle factors (tobacco use, alcohol consumption, caffeine intake, prior yoga experience, hours of work per week, number of medications used), medical factors (birth control, hormone replacement therapy, menopause, high cholesterol, diabetes, high blood pressure, hypothyroidism, insomnia, presence of anxiety or depression), and relaxation methods.

The variables within each category that had the highest correlation with eating behaviors were determined. Once the variables from the various groups were narrowed down to those with the highest correlation to eating behavior, regression models were developed to determine whether those variables as well as the PSS, physical activity, and sleep variables were independently associated with eating behaviors.

The scores for the three eating behaviors (emotional eating, uncontrolled eating, and cognitive restraint) from the TFEQ-R18V2 were normally distributed. Missing data was handled per the protocol of each validated survey instrument to calculate scores for each instrument. Bivariate and multivariate regression analysis were completed. Multicollinearity was tested using the variance inflation factor (VIF). A significance value of $p=0.05$ was used.

RESULTS

Population Characteristics

The characteristics of the study population are given in Table 3.1. A total of 162 participants completed demographic information, 130 participants completed the TFEQ-R18V2, 118 participants completed the GPAQ, and 124 completed the PSS. The majority of participants were female, married, college-educated, and worked full-time. The average BMI and hours of sleep per night were 33.6 kg/m^2 and 6.9 hours respectively. Approximately half of the population met the physical activity recommendations of 150 minutes/week of moderate activity, 75 minutes/week of vigorous activity, or a combination of vigorous and moderate activity to add to 600 or more METS. MET minutes per week for all participants ranged from zero minutes to 11,160.

Bivariate Associations

There was a negative association between self-reported hours of sleep per night and total MET minutes per week with those getting more sleep reporting lower amounts of physical activity (p=0.048; Figure 3.1). There was no association between self-reported hours of sleep and whether individuals met the cut-off for the recommended amount of physical activity per week: 6.8±1.1 hours of sleep [mean ± SD] for those who met the physical activity guidelines compared to 7.0±1.0 hours of sleep for those who did not (p=.25).

Those who reported poor sleep quality were more likely to have met the recommended physical activity guidelines than those who reported good sleep quality (p=.04). There was no association between perceived quality of sleep and total number of calculated MET minutes per week. Those reporting good sleep completed the equivalent of 6.5±10.2 hours of moderate physical activity per week [means ± SD] while those reporting poor sleep completed the equivalent of 9.6±12.4 hours of moderate physical activity per week (p=.19).

Without controlling for covariates, there was no association between emotional eating, uncontrolled eating, or cognitive restraint and either quality of sleep or MET minutes per week (all, p>0.20). Multiple regression analyses were conducted to determine which variables were associated with eating behavior scales and to explore possible interactions between the independent variables, and to determine whether quality of sleep or MET minutes per week were associated with eating behaviors when covariates were included in the statistical models.

Emotional Eating

Using multiple regression techniques, we found that perceived stress, physical activity, sex, hours working, and hours of sleep were independently associated with emotional eating (Table 3.2). In both bivariate and multiple regression analyses, individuals with higher perceived stress had higher emotional eating scores (p=.02, bivariate; p=.006, model). Meeting the recommended amount of physical activity for the week was associated with lower emotional eating scores when included in a model (p=.08, bivariate; p=.03, model). Working 40 or more hours a week was also associated with higher emotional eating scores in the multiple regression model (p=.29, bivariate; p=.02 model); however, hours of sleep did not quite reach statistical significance (p=.12, bivariate; p=.07 model). Females had higher emotional eating scores than males in both bivariate and multiple regression analyses (p=.008, bivariate; p=.002, model). Due to only 16 males in the study (9.9%), conclusions that can be made regarding associations between sex and emotional eating are limited. There were no significant interactions among variables.

Uncontrolled Eating

Sleep quality was not associated with uncontrolled eating in a bivariate analysis (p=.47), however, in multiple regression it was found to modify the relationship between uncontrolled eating and stress (sleep quality-by-perceived stress interaction, p=.04, Figure 3.2). A positive relationship between uncontrolled eating and perceived stress was observed for individuals with good sleep, whereas the relationship between uncontrolled eating and perceived stress was either negligible or negative for individuals with poor sleep. Another way of interpreting these results is that poor sleep was associated with higher scores for uncontrolled eating compared to individuals with good sleep, but only when stress levels were low. At higher stress levels, individuals with good sleep quality reported higher scores for uncontrolled eating than individuals with poor sleep. No other variables were associated with uncontrolled eating.

Cognitive Restraint

There was a significant association between cognitive restraint score and age that differed by BMI (age-by-BMI interaction, $p<0.001$, Figure 3.3). At younger ages, there was little difference in cognitive restraint by BMI. However, in older individuals a higher BMI was associated with lower cognitive restraint whereas a lower BMI was associated with greater cognitive restraint. No other variables, including sleep and physical activity, were associated with cognitive restraint scores.

DISCUSSION

Our results were not consistent with our hypotheses. We originally hypothesized that there would be a relationship between emotional eating, uncontrolled eating or lack of cognitive restraint with lower amounts of sleep and this relationship would be attenuated among individuals who exercised. Individuals who reported physical activity that met the recommended guidelines or had greater hours of sleep a night scored lower for emotional eating, but an interaction between sleep and exercise was not found to be significant. As would be expected, study participants that scored higher for perceived stress scored higher for emotional eating. Many studies have found a positive relationship with hours of sleep and weight gain.[51] Dweck et al. found an association between emotional eating scores and sleep, however, they found the association with sleep quality, not hours of sleep.[52]

Studies have found that short sleep duration (equal or less than 6 hours of sleep per night) is associated with increased energy intake, however, experimental studies have not been able to consistently show a relationship between lack of sleep and weight gain or sleep and eating behaviors.[53] Experimental studies typically restrict sleep more severely and for a shorter amount of time than would occur outside of a laboratory. The artificial environment that is created in a sleep study could contribute to changes in eating behavior that would not be experienced in a normal environment (e.g., inability to leave a room could increase stress). This limits the interpretation of experimental sleep studies[51] and provides a rationale to continue to look at associations associated with stress, sleep, and eating behaviors to gain further insight into how they are related.

Chaput et al. used the original full length TFEQ in a six-year longitudinal study. Baseline data analysis found an association between disinhibited eating (uncontrolled eating) and BMI with highest BMIs among those with the highest disinhibited eating. However, over the course of 6 years time, they found an interaction between quantity of sleep and disinhibited eating. Individuals with higher scores for disinhibited eating and who slept less than other study participants gained more weight than short sleepers who did not have disinhibited eating behavior. There was not a difference in weight gain between those with high and low inhibition when an adequate amount of sleep was received. However, high disinhibition scores were also associated with weight gain in those that slept more than nine hours a night.[54]

It is conceivable that individuals in our study who experienced poor sleep and who were also experiencing high stress might experience hypophagia when both sleep deprived and under high stress. This would explain our findings of low uncontrolled eating scores among individuals with poor sleep and high perceived stress scores. Animal and human studies have found undereating and overeating during stressful situations. The possibility that mild stress might lead to overeating and high levels of stress result in undereating has been hypothesized in the past.[55]

The best model for predicting cognitive restraint included an interaction between age and BMI. The fact that older adults who had a lower BMI had high cognitive restraint while older adults that had a higher BMI had low cognitive restraint raises the question as to whether cognitive restraint was helping those with lower BMI maintain a healthier weight while those with higher BMI had a high BMI due in part to low cognitive restraint. Due to the nature of a cross-sectional study, it is unknown which came first in our participants, a high BMI and low cognitive restraint or vice versa. Also, interpretation of the interaction between age and BMI is limited by the fact that everyone in our study was enrolled in a weight loss program.

There is some disagreement in the scientific community regarding cognitive restraint and its role in weight management, development of eating disorders, and ability to reduce obesity. Some studies have shown cognitive restraint to be positively associated with BMI while others have found it be negatively associated with BMI.[56] Johnson et al. (2012) in a review of literature suggest that instruments used to measure cognitive restraint in older studies did not accurately measure cognitive restraint which confused the issue and led to the belief that cognitive restraint not only did not work, but also was linked to the development of less than helpful eating behaviors such as dysregulated eating and the development of eating disorders. In their review, Johnson et al. cited intervention studies in which study participants were able to reduce binge eating by increasing cognitive restraint as evidence that increasing cognitive restraint can be helpful for those with eating behaviors associated with obesity.[56] The authors also addressed the belief by some that using cognitive restraint leads to loss of the ability to respond naturally to external and internal cues and that a non-dieting approach is better for weight management. In support of cognitive restraint, they cited research studies in which those who lose and maintain weight have more cognitive restraint.[56] DelParigi et al. (2007) found that individuals that previously had successfully lost weight demonstrated higher cognitive restraint than non-dieting individuals with a similar percent body fat when tested in an experimental setting.[57]

There is discussion in the literature as to the addictive qualities of highly palliative foods and similarities in the reward center of the brain for food, gambling, and drug cravings. [58] It is possible that as some individuals get older due to hormonal or other changes that they become more susceptible to the potential addictive quality of palliative food and lose their ability to use cognitive restraint to resist this temptation.

An association between BMI and number of hours sleep has been shown in some studies.[59,60] A possible reason that our study did not find an association between hours of sleep and BMI is that everyone in the study was enrolled in a weight loss program and did not represent the general population. Additionally, sleep hours were self-reported so accuracy was dependent upon participants remembering and entering the amount correctly. Also, our study size was relatively small and the percent of individuals reporting less than six hours of sleep per night was lower than from a nationally representative sample (24.7% compared to 36.6% percent of individuals from the 2005-2010 National Health and Nutrition Examination Surveys).[59]

Acquiring a better understanding of associations between habitual physical activity and emotional and uncontrolled eating behavior, as well as cognitive restraint, has the potential to improve weight control. Gaining insight into how sleep and ongoing physical activity are related to eating behaviors is an important area of research in the search for effective solutions to the obesity epidemic. The results of this study add to the evidence that stress, sleep, and physical activity are associated with eating behaviors. As stress, sleep, and physical activity are modifiable to at least some extent, these results support current efforts to manage stress as much as possible and make a concerted effort to get enough sleep and adequate amount of physical activity.

Study Limitations

This study has several limitations. The very nature of a cross sectional study limits the interpretations that can be made about associations that were found. Additionally, not everyone completed all of the surveys, thus decreasing the sample size available for analyses. The results may be more applicable to women than to the general population due to the large number of women in comparison to men in the study. Generalizability of the study is limited due to all subjects participating in a weight loss program. Due to costs associated with participating in the weight loss program, the study population's income was higher than the general population. A validated sleep quality instrument was not used, but rather participants were asked to describe their sleep quality as very good, good, poor, or very poor. Participants' interpretation of sleep quality is subjective and may not be a good indicator of actual sleep quality. The authors feel that the perception of sleep quality by the participants sheds light on possible relationships among perceived sleep quality, amount of regular exercise, and eating behaviors and therefore can be useful in an exploratory manner and help guide the direction of future research.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the design, implementation, analysis, or publication of the study.

Acknowledgements: The authors would like to thank the participants in this study.

Funding Support: This study was funded by Sanford Profile Program®/South Dakota State University Collaborative Research Seed Grant Program and the Ethel Austin Martin Endowment in Human Nutrition at South Dakota State University.

References

1. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. *JAMA.* 2013;309(1):71-82.
2. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. *JAMA.* 2003;289(2):187-193.
3. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health.* 2009;9:88.
4. Juonala M, Magnussen CG, Berenson GS, et al. Childhood adiposity, adult adiposity, and cardiovascular risk factors. *N Engl J Med.* 2011;365(20):1876-1885.
5. Cefalu WT, Bray GA, Home PD, et al. Advances in the science, treatment, and prevention of the disease of obesity: reflections from a diabetes care editors' expert forum. *Diabetes Care.* 2015;38(8):1567-1582.
6. Finkelstein EA, Graham WC, Malhotra R. Lifetime direct medical costs of childhood obesity. *Pediatrics.* 2014;133(5):854-862.
7. Dee A, Kearns K, O'Neill C, et al. The direct and indirect costs of both overweight and obesity: a systematic review. *BMC Res Notes.* 2014;7:242.
8. Reuser M, Bonneux LG, Willekens FJ. Smoking kills, obesity disables: a multistate approach of the US Health and Retirement Survey. *Obesity (Silver Spring).* 2009;17(4):783-789.

9. Rahmouni K, Correia ML, Haynes WG, Mark AL. Obesity-associated hypertension: new insights into mechanisms. *Hypertension.* 2005;45(1):9-14.

10. Keen-Rhinehart E, Ondek K, Schneider JE. Neuroendocrine regulation of appetitive ingestive behavior. *Front Neurosci.* 2013;7:213.

11. Canale MP, Manca di Villahermosa S, Martino G, et al. Obesity-related metabolic syndrome: mechanisms of sympathetic overactivity. *Int J Endocrinol.* 2013;2013:865965.

12. Bellocchio L, Soria-Gomez E, Quarta C, et al. Activation of the sympathetic nervous system mediates hypophagic and anxiety-like effects of CB(1) receptor blockade. *Proc Natl Acad Sci U S A.* 2013;110(12):4786-4791.

13. Adam TC, Epel ES. Stress, eating and the reward system. *Physiol Behav.* 2007;91(4):449-458.

14. Tomiyama AJ, Dallman MF, Epel ES. Comfort food is comforting to those most stressed: evidence of the chronic stress response network in high stress women. *Psychoneuroendocrinology.* 2011;36(10):1513-1519.

15. Egecioglu E, Skibicka KP, Hansson C, et al. Hedonic and incentive signals for body weight control. *Rev Endocr Metab Disord.* 2011;12(3):141-151.

16. Brown RA, Abrantes AM, Minami H, et al. A preliminary, randomized trial of aerobic exercise for alcohol dependence. *J Subst Abuse Treat.* 2014;47(1):1-9.

17. Henchoz Y, Dupuis M, Deline S, et al. Associations of physical activity and sport and exercise with at-risk substance use in young men: a longitudinal study. *Prev Med.* 2014;64:27-31.

18. Weinstock J, Barry D, Petry NM. Exercise-related activities are associated with positive outcome in contingency management treatment for substance use disorders. *Addict Behav.* 2008;33(8):1072-1075.

19. Lenard NR, Berthoud HR. Central and peripheral regulation of food intake and physical activity: pathways and genes. *Obesity (Silver Spring).* 2008;16 Suppl 3:S11-22.

20. Alcaro A, Huber R, Panksepp J. Behavioral functions of the mesolimbic dopaminergic system: an affective neuroethological perspective. *Brain Res Rev.* 2007;56(2):283-321.

21. Lynch WJ, Peterson AB, Sanchez V, Abel J, Smith MA. Exercise as a novel treatment for drug addiction: a neurobiological and stage-dependent hypothesis. *Neurosci Biobehav Rev.* 2013;37(8):1622-1644.

22. Adinoff B. Neurobiologic processes in drug reward and addiction. *Harv Rev Psychiatry.* 2004;12(6):305-320.

23. Arias-Carrion O, Stamelou M, Murillo-Rodriguez E, Menendez-Gonzalez M, Poppel E. Dopaminergic reward system: a short integrative review. *Int Arch Med.* 2010;3:24.

24. Baik JH. Dopamine signaling in reward-related behaviors. *Front Neural Circuits.* 2013;7:152.

25. Zlebnik NE, Hedges VL, Carroll ME, Meisel RL. Chronic wheel running affects cocaine-induced c-Fos expression in brain reward areas in rats. *Behav Brain Res.* 2014;261:71-78.

26. Ogbonmwan YE, Schroeder JP, Holmes PV, Weinshenker D. The effects of post-extinction exercise on cocaine-primed and stress-induced reinstatement of cocaine seeking in rats. *Psychopharmacology.* 2015;232(8):1395-1403.

27. Chen HI, Kuo YM, Liao CH, et al. Long-term compulsive exercise reduces the rewarding efficacy of 3,4-methylenedioxymethamphetamine. *Behav Brain Res.* 2008;187(1):185-189.

28. Liang NC, Bello NT, Moran TH. Wheel running reduces high-fat diet intake, preference and mu-opioid agonist stimulated intake. *Behav Brain Res.* 2015;284:1-10.

29. Martins C, Morgan LM, Bloom SR, Robertson MD. Effects of exercise on gut peptides, energy intake and appetite. *J Endocrinol.* 2007;193(2):251-258.

30. Balaguera-Cortes L, Wallman KE, Fairchild TJ, Guelfi KJ. Energy intake and appetite-related hormones following acute aerobic and resistance exercise. *Appl Physiol Nutr Metab.* 2011;36(6):958-966.

31. Cummings DE, Overduin J. Gastrointestinal regulation of food intake. *J Clin Invest.* 2007;117(1):13-23.

32. Guelfi KJ, Donges CE, Duffield R. Beneficial effects of 12 weeks of aerobic compared with resistance exercise training on perceived appetite in previously sedentary overweight and obese men. *Metabolism.* 2013;62(2):235-243.

33. Martins C, Robertson MD, Morgan LM. Effects of exercise and restrained eating behaviour on appetite control. *Proc Nutr Soc.* 2008;67(1):28-41.

34. Shechter A, O'Keeffe M, Roberts AL, Zammit GK, RoyChoudhury A, St-Onge MP. Alterations in sleep architecture in response to experimental sleep

curtailment are associated with signs of positive energy balance. *Am J Physiol Regul Integr Comp Physiol.* 2012;303(9):R883-889.

35. Gonnissen HK, Hursel R, Rutters F, Martens EA, Westerterp-Plantenga MS. Effects of sleep fragmentation on appetite and related hormone concentrations over 24 h in healthy men. *Br J Nutr.* 2013;109(4):748-756.

36. Horne JA. Human REM sleep: influence on feeding behaviour, with clinical implications. *Sleep Med.* 2015.

37. Capers PL, Fobian AD, Kaiser KA, Borah R, Allison DB. A systemic review and meta-analysis of randomized controlled trials of the impact of sleep duration on adiposity and components of energy balance. *Obes Rev.* 2015.

38. Collins CE, Watson J, Burrows T. Measuring dietary intake in children and adolescents in the context of overweight and obesity. *Int J Obes (Lond).* 2010;34(7):1103-1115.

39. Persson M, Martensson J. Situations influencing habits in diet and exercise among nurses working night shift. *J Nurs Manag.* 2006;14(5):414-423.

40. Karlsson J, Persson LO, Sjostrom L, Sullivan M. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *Int J Obes Relat Metab Disord.* 2000;24(12):1715-1725.

41. de Lauzon B, Romon M, Deschamps V, et al. The Three-Factor Eating Questionnaire-R18 is able to distinguish among different eating patterns in a general population. *J Nutr.* 2004;134(9):2372-2380.

42. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res.* 1985;29(1):71-83.

43. Langlois F, Langlois MF, Carpentier AC, Brown C, Lemieux S, Hivert MF. Ghrelin levels are associated with hunger as measured by the Three-Factor Eating Questionnaire in healthy young adults. *Physiol Behav.* 2011;104(3):373-377.

44. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health.* 2009;6(6):790-804.

45. Cleland CL, Hunter RF, Kee F, Cupples ME, Sallis JF, Tully MA. Validity of the global physical activity questionnaire (GPAQ) in assessing levels and change in moderate-vigorous physical activity and sedentary behaviour. *BMC Public Health.* 2014;14:1255.

46. World Health Organization: WHO STEPS Surveillance Manual: the WHO STEPwise Approach to Chronic Disease Risk Factor Surveillance. Geneva, Switzerland: World Health Organization; 2005.

47. Chu AH, Ng SH, Koh D, Muller-Riemenschneider F. Reliability and validity of the self-and-interviewer-administered versions of the Global Physical Activity Questionnaire (GPAQ). *PloS One.* 2015;10(9):e0136944.

48. World Health Organization. Global Physical Activity Questionnaire (GPAQ) analysis guide. Prevention of Noncommunicable Diseases Department. Geneva, Switzerland: World Health Organization.

49. World Health Organization: Global recommendations on physical activity for health. Geneva, Switzerland: World Health Organization; 2010.

50. Cohen S, Williamson G. Perceived stress in a probability sample of the United States. In: Spacapan S, Oskamp S, eds. *The Social Psychology of Health: Claremont Symposium on Applied Social Psychology*. Newbury Park, CA: Sage; 1988.

51. Chaput JP. Sleep patterns, diet quality and energy balance. *Physiol Behav.* 2014;134:86-91.

52. Dweck JS, Jenkins SM, Nolan LJ. The role of emotional eating and stress in the influence of short sleep on food consumption. *Appetite.* 2014;72:106-113.

53. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity (Silver Spring).* 2008;16(3):643-653.

54. Chaput JP, Despres JP, Bouchard C, Tremblay A. The association between short sleep duration and weight gain is dependent on disinhibited eating behavior in adults. *Sleep.* 2011;34(10):1291-1297.

55. Yau YH, Potenza MN. Stress and eating behaviors. *Minerva Endocrinol.* 2013;38(3):255-267.

56. Johnson F, Pratt M, Wardle J. Dietary restraint and self-regulation in eating behavior. *Int J Obes (Lond).* 2012;36(5):665-674.

57. DelParigi A, Chen K, Salbe AD, et al. Successful dieters have increased neural activity in cortical areas involved in the control of behavior. *Int J Obes (Lond).* 2007;31(3):440-448.

58. Meule A, Gearhardt AN. Food addiction in the light of DSM-5. *Nutrients.* 2014;6(9):3653-3671.

59. Ford ES, Li C, Wheaton AG, Chapman DP, Perry GS, Croft JB. Sleep duration and body mass index and waist circumference among U.S. adults. *Obesity (Silver Spring).* 2014;22(2):598-607.

60. Patel SR, Malhotra A, White DP, Gottlieb DJ, Hu FB. Association between reduced sleep and weight gain in women. *Am J Epidemiol.* 2006;164(10):947-954.

FIGURE LEGEND

Figure 3.1. Relationship between self-reported MET hours per week and average hours of sleep per night (r^2=.03, p=.048).

Figure 3.2. Relationship between uncontrolled eating score and perceived stress by sleep quality. Uncontrolled eating = 35.2 + .92 (stress score) + 22.2 (sleep quality) -1.1 (stress score*poor sleep), where sleep quality = 1 for poor and 0 for good. Perceived stress-by-sleep quality interaction, p=.04.

Figure 3.3. Association between cognitive restraint score and age by BMI. Cognitive restraint = -23.4 + 2.2 (age [years]) + 1.6 (BMI) - .06 (age*BMI). Age-by-BMI interaction, p=.006.

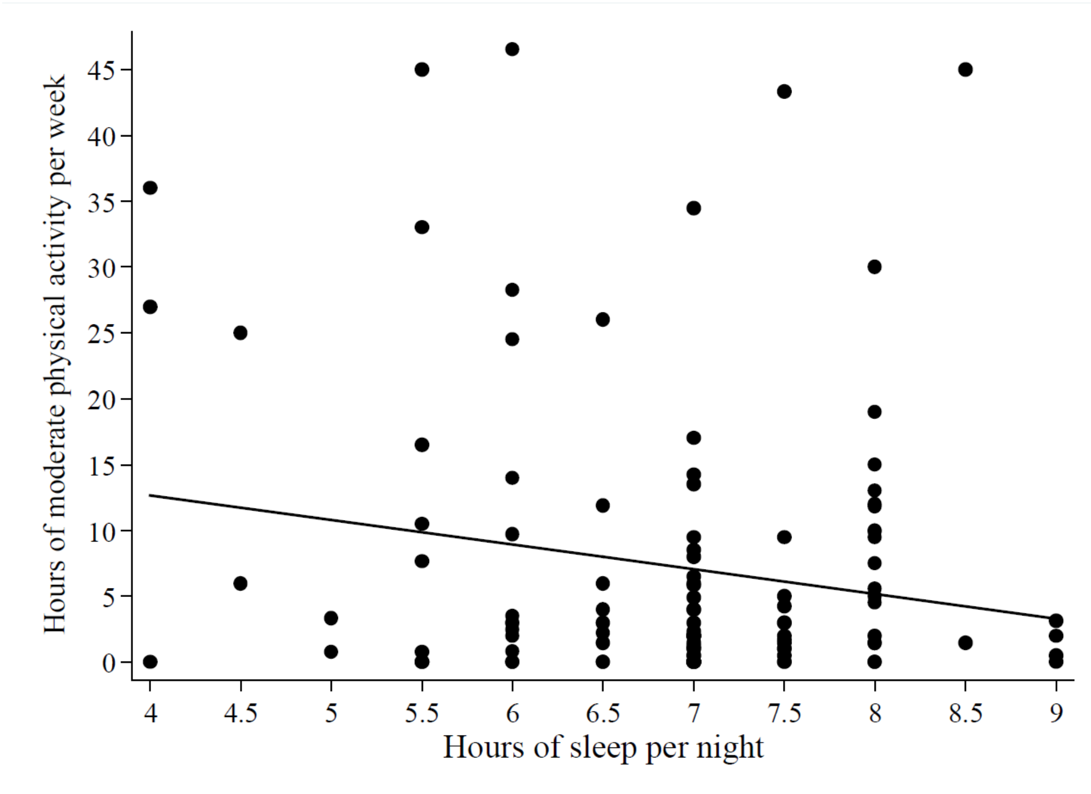
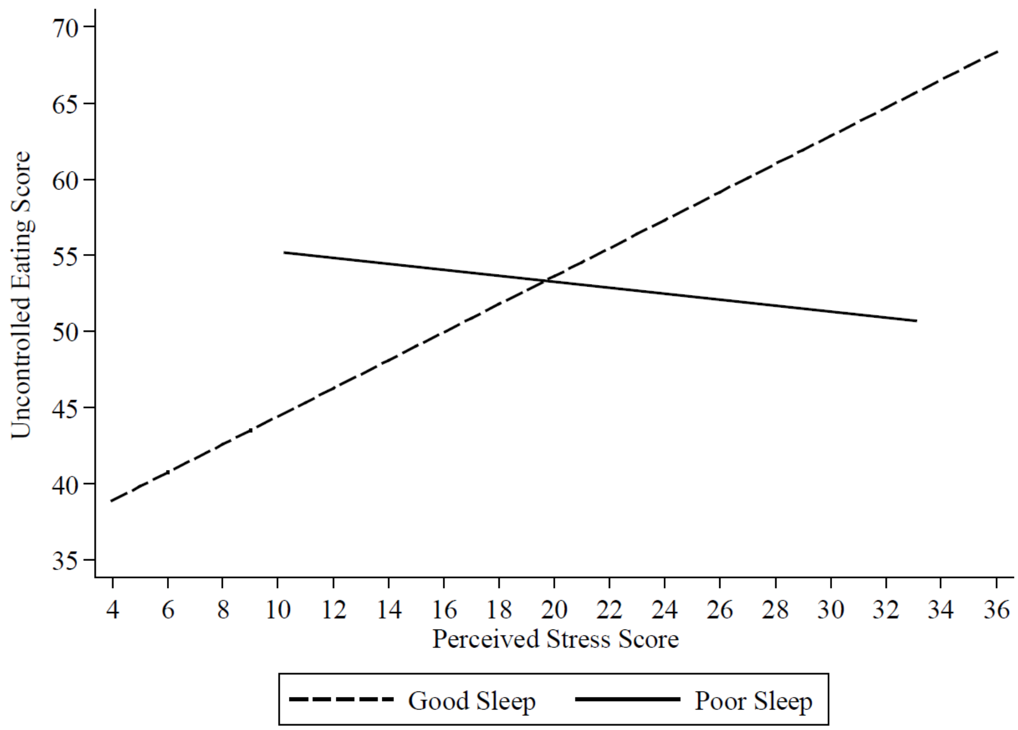

Hours of moderate physical activity per week
0
5
10
15
20
25
30
35
40
45
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
Hours of sleep per night

Figure 3.1.



Uncontrolled Eating Score
70
65
60
55
50
45
40
35
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
Perceived Stress Score
Good Sleep
Poor Sleep

Figure 3.2.

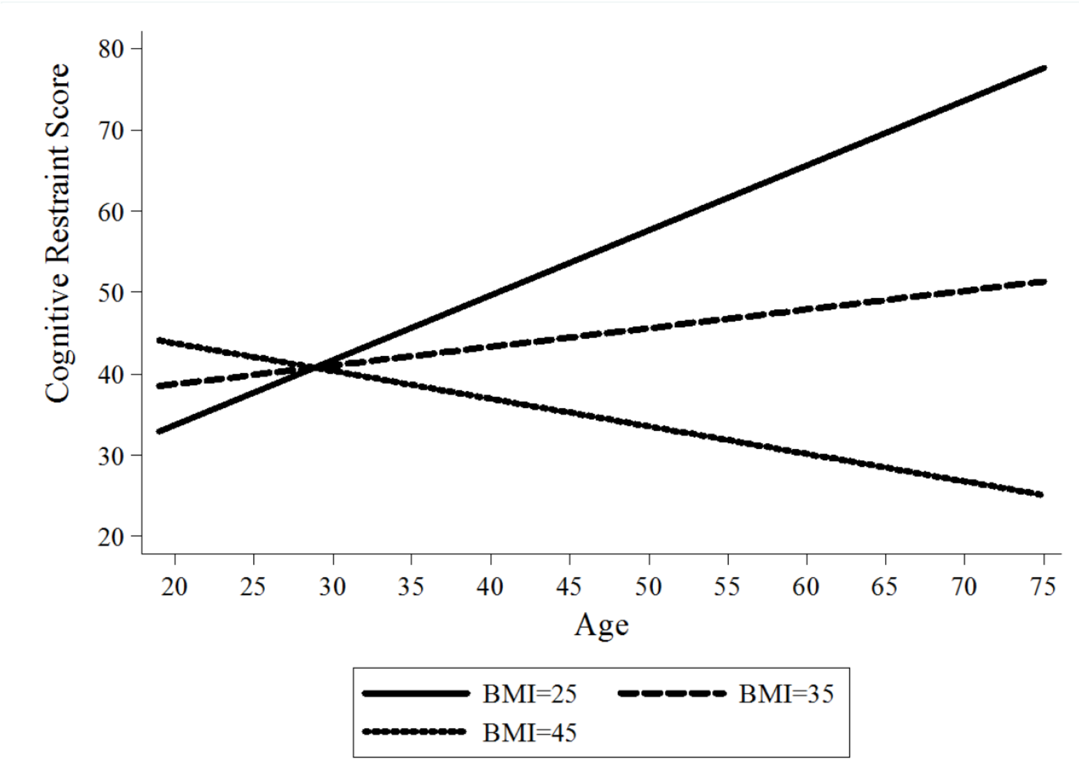

Cognitive Restraint Score
80
70
60
50
40
30
20
20
25
30
35
40
45
50
55
60
65
70
75
Age
BMI=25
BMI=35
BMI=45

Figure 3.3.

Table 3.1. Baseline demographic, socioeconomic, and behavioral characteristics of 162 weight loss program participants.[a]

Characteristics	
Age (years)	43.6 (1.0)
Gender (male/female)	16/146
Race/Ethnicity (white/other)	155/7
Marital status	
Married	108 (66.7%)
Other	54 (33.3%)
Education	
High school or less	16 (9.9%)
College (up to a bachelor's degree)	126 (77.8%)
Advanced degree	20 (12.3%)
Annual Income	
<$50,000	45 (27.8%)
$50,000-100,000	66 (40.7%)
$100,000+	41 (25.3%)
Refused to answer	10 (6.2%)
Hours worked	
<40 hrs/week	41 (25.3%)
40+ hrs/week	121 (74.7%)
Mean number of children in home	.8 (.1)
Mean number in home (other than self)	2.1 (.2)
Tobacco use	
Never	88 (54.3%)
Current	15 (9.3%)
Past	59 (36.4%)
Cups of caffeine/day	1.5 (.1)
Body mass index (kg/m^2)	33.6 (.5)
Hours sleep/night	6.9 (.1)
Physical activity recommendations	
Met guidelines	60 (50.8%)
Did not meet guidelines	58 (49.2%)

[a] Data are numbers of participants (%) or mean (SE)

Table 3.2. Multiple linear regression model predicting emotional eating scores[a]

	β	SE	P
Stress[b]	0.25	0.29	0.01
Physical Activity[c]	-0.20	3.87	0.03
Female	0.27	6.49	< 0.01
Work[d]	0.21	4.39	0.02
Sleep[e]	-0.16	1.81	0.07

[a] Model $r^2 = 0.21$, $P < .001$

[b] Stress = score on the Perceived Stress Scale

[c] Physical Activity = met 2008 national guidelines for amount of physical activity per week (0=no, 1=yes)

[d] Work= working 40 or more a week (0=no, 1=yes)

[e] Sleep= hours of sleep per week

CHAPTER 4

Emotional and uncontrolled eating scores are lower with yoga compared to stretching exercise in a weight loss program at 3 months post intervention, but no difference in weight loss or perceived stress

Amy Richards, MS, RDN[1]
Bonny L. Specker, PhD[2]

[1]Department of Family and Consumer Sciences, University of Tennessee at Martin
[2]Ethel Austin Martin Program in Human Nutrition, South Dakota State University

ABSTRACT

Objective: Compare effectiveness of 3-month yoga versus stretching program for enhancing weight loss with an additional 3-month follow-up.

Setting: Weight loss program in mid-western United States

Participants: Adults (N=116 [103 females]) enrolled in a weight loss program. Average age of 43.7 years and 34.0 kg/m^2 BMI.

Intervention: Participants randomized to either yoga or stretching group and asked to complete exercises 3/week for 3 months.

Main Outcome Measures: Weight loss.

Analysis: Bivariate and multiple regression analyses were completed.

Results: There was no difference in weight loss between the groups at 3 (p=.17) or 6 months (p=.25). Emotional eating and uncontrolled eating decreased in the yoga group at 6 months compared to the stretching group (p=.04 and p=.03, respectively).

Conclusions and Implications: Yoga may improve eating behaviors associated with obesity. More research is needed to determine if relaxation strategies, positivity, and stress reduction combined with yoga poses can reduce weight.

INTRODUCTION

Stress has been associated with hunger, hormonal response, hedonistic eating, and obesity.[1-10] Activation of the sympathetic nervous system through the stress response may be contributing to the obesity epidemic as increased hunger messages are generated in response to hormones associated with the fight or flight response.[11-13] When under stress, determination to act in healthy ways can weaken and cravings for less healthy foods can increase leading to increased difficulty with eating healthy and being physically active. Eating for reasons other than hunger has been linked to overweight and obesity.[14] Dieting to lose weight generally fails either with actual weight not being lost or a regain in the weight that was lost. There is a need to find ways to help people successfully manage their weight. Teaching people how to lower their perceived stress levels may have the potential of improving weight management.

A small cross-sectional study measured inflammatory markers, stress hormones, and heart rate and found that those individuals who practiced yoga were less affected by stressful situations than those who did not practice yoga.[15] Another small study that measured γ- aminobutyric acid (GABA) levels in yoga practitioners and walkers reported decreased anxiety and improved mood with increased GABA levels in yoga practitioners.[16] Individuals who practice Sahaja Yoga meditation had a lower emotional response as measured by EEG to negative film clips than did controls with no experience in meditation.[17] A randomized, controlled trial that incorporated mindfulness and yoga was able to show decreased stress symptoms in cancer survivors[18], and another study found improved sleep quality among individuals practicing yoga.[19] A promising area of research is in the area of stress reduction combined with nutritional guidance. A small pilot study conducted in Greece found that nutritional guidance and a low-calorie diet combined with stress reduction techniques resulted in greater weight loss in obese women than nutritional guidance and low-calorie calorie diet only. Additionally, restrained eating increased as measured by the Dutch Eating Behavior Questionnaire in the stress management group compared to control group[20]

Anxiety at even low levels has the potential to change an individual's breathing pattern with a resultant increase in the breathing rate or the individual taking in deeper breaths than normal and this can trigger a sympathetic nervous system response.[21] Activating the sympathetic nervous system increases hunger messages that the body receives.[11-13] Learning to breathe in a more relaxed manner may be able to influence actions of the autonomic system.[22] If an intervention is able to reduce stress, it may improve eating behaviors and ultimately reduce overweight and obesity.

Yoga presents a unique opportunity to combine physical activity in the form of strength training and stretching along with training in meditation, breathing, and relaxation. The overall aim of the current study was to determine the effectiveness of a 3-month yoga program to improve weight loss while participating in the Sanford Profile® program, a structured low-calorie, low-carbohydrate weight loss program. We hypothesized that individuals randomized to yoga would have reduced stress levels and greater weight loss than individuals randomized to a stretching program.

METHODS

This study was conducted from February 2015 through August 2016. It included a 3-month randomized, controlled trial using in-person yoga, a yoga DVD, and a stretching DVD (control group) followed by a 3-month post-intervention follow-up for a total length of 6 months. The in-person yoga was discontinued part way into the trial due to difficulty recruiting and retaining participants into this arm of the study. The study continued with participants either receiving a yoga DVD or a stretching DVD. The study protocol was approved by the South Dakota State University Institutional Review Board and the Sanford Health Institutional Review Board. Written informed consent was received from all study participants prior to their enrollment in the study. The trial was registered at clinicaltrials.gov as NCT02451800.

Study population

Subjects were recruited at the Sanford Profile Program through informational emails sent by the Profile program, and via an informational brochure attached to the electronic scale that each Sanford Profile participant receives. Participating Sanford Profile Programs were in Sioux Falls and Brookings, South Dakota; Fargo, North Dakota; and Worthington, MN. Interested individuals were contacted and were provided with additional information and assessed for program eligibility.

Eligibility criteria included the following: 18 years of age or older; passing a medical questionnaire or receiving a physician’s clearance to participate in the study; submission of a signed, informed consent; and enrollment in the Sanford Profile Program.

A total of 358 potential participants were contacted and assessed for eligibility and 162 were randomized to one of 3 groups. Two of the groups were combined (yoga class and yoga DVD) after the start of the intervention. See Figure 1 for a participant flow chart following CONSORT Guidelines.

Study Design

This study was designed as a randomized, controlled trial with 3 arms (two treatment groups and a control group) and a goal to recruit 225 participants based upon sample size calculation of 64 individuals needed per group to detect a difference in weight loss of 3 pounds between study groups assuming an attrition of 20% of the participants.[23] Randomization was stratified by location and completed in a manner that ensured approximately equal numbers in each group within each location.

Participants were randomized to attend a yoga class, to receive a yoga DVD to watch and participate on their own at home, or to receive a stretching DVD to participate on their own (control group). All groups were to perform their exercises three times per week. Participants who were randomized to the yoga DVD group received a copy of "More Yoga for the Rest of Us with Peggy Cappy". Participants who were randomized to the stretching DVD group received a copy of "Stretching: the DVD" which features Bob Anderson. Participants randomized to the Yoga Class were asked to attend a one-hour yoga class based on the Peggy Cappy video at the Sanford Wellness Center in their community. Participants that felt that the video was too easy were offered a more challenging video (Elements of Yoga: Earth Foundation with Tara Lee for the yoga group and Perfect in 10 Stretch with Annette Fletcher for the stretching group) or the opportunity to use a video of their own choosing that was the same type of video as they were originally assigned (yoga or stretching).

Study Measurements

Participants were provided with an electronic scale to measure their weight through the Profile program. Profile participants are encouraged to weigh themselves daily and the weights are transmitted electronically to the Profile server. Participants were asked to continue to weigh themselves after completion of the 3-month intervention for an additional 3 months even if they no longer participated in the Profile program. Height was measured at enrollment by Profile program staff using a stadiometer (standing height measured utilizing a horizontal bar attached to an adjustable vertical rod).

Questionnaires were completed by participants and included demographic information, perceived stress, eating behaviors, and physical activity. Demographic information and participant characteristics (e.g., caffeine intake, chronic disease, medications) were collected via telephone interview after medical clearance to participate in the study was received. Perceived stress and eating behaviors (emotional eating, uncontrolled eating, and cognitive restraint) were measured through online surveys at baseline and at the completion of the 3-month intervention. Physical activity was assessed through an online survey at baseline only.

The effect of stress on weight loss was determined using the Perceived Stress Scale, 10-item scale (PSS-10) at baseline, at 3 months, and at 6 months to determine if stress level was associated with weight loss. The PSS-10 contains 10 items that assess to what extent individuals felt stressed over the last month.[24] The TFEQ -R18 has been validated in obese and non-obese populations to evaluate eating behaviors (emotional eating, uncontrolled eating, and cognitive restraint).[25,26] The GPAQ was developed by the World Health Organization and has been validated in population studies. It includes 19 questions used to determine metabolic equivalents (METs) for physical activity completed on average per week including time at work, transportation, and leisure activities. [27,28]

The in-person yoga class was difficult for many people to attend due to schedule conflicts and distance they would need to travel and some individuals declined to participate in the study when they learned they would need to attend an in-person class. As a result, the study protocol was modified to randomize participants to one of two groups instead of three groups (either the stretching DVD or the yoga DVD).

Participants were considered to have completed the study if they did not indicate that they wanted to withdraw from the study within 70 days from randomization and follow-up weights were available for them regardless of whether they completed follow-up surveys. Intent-to-treat analysis was completed and included those that had not withdrawn from the study prior to 70 days into the study and that had at least one follow-up weight that was at least one month from baseline. When there was no weight at the three-month time period, the closest weight to three months from baseline was used. For three participants, that resulted in weights being used for the 3-month follow-up that were only one month from baseline (n=2 in the yoga group, n=1 in stretching group).

Participants were considered to have completed the 3-month follow-up period (6 months from baseline) if weight measurements were available after the initial three month time period regardless of whether they completed the follow-up surveys. Intent-to-treat analysis was completed for participants that completed at least one weight measurement after the completion of the intervention. Three participants included in 6-month analysis had weights that were completed less than one month after the end of the intervention and all three were in the yoga group.

Statistical Analysis: Statistical analyses were completed using Stata Statistical Software (Release 12, College Station, TX: StataCorp, 2011). Baseline measurements among groups were analyzed using chi-square and ANOVA. Variables that were different among groups and were associated with outcome measures were included in final statistical analyses. Data that were not found to be normally distributed included weight at baseline, 3 months, and 6 months; uncontrolled eating at 3 months; and perceived stress score at 3 and 6 months. T-tests were used for repeated measures that were normally distributed and Wilcoxon Signed-Rank for paired data that was not normally distributed. Two-sample Wilcoxon Rank Sum tests were used when variables were not normally distributed in comparisons between groups. T-tests for unequal variances were used for those variables with unequal variances. Intent-to-treat analyses were completed. Statistical significance was determined at $p<.05$.

RESULTS

Overview of Study Population

Of the 162 participants that began the study, 116 (72%) completed the 3-month intervention and 99 (61%) remained in the study three months later (6-month follow-up). Approximately one-fourth of participants (25.9%) indicated that they completed regular stretching prior to the start of the study and about half indicated that they had taken a yoga class or tried yoga on their own (54.3%) with no difference between groups at baseline (P=.87, P=.13). There were no difference between completers and non-completers for regular stretching (P=.71) or yoga experience prior to enrollment (P=.94).

Baseline characteristics of the 116 who completed the intervention compared to those did not complete the intervention are given in Table 4.1. Physical activity was higher at baseline for those who completed the intervention compared to those who did not complete the study. Additionally, there were no differences at baseline between the yoga and stretching groups for those that completed the intervention (Table 4.2).

Outcome Measures

Weight loss. Both the yoga and stretching groups lost weight at three months that remained significant at follow-up three months later (P<.001, Table 4.3). There were no differences in weight loss between the yoga and stretching groups at 3 or 6 months.

Regression models were developed to predict weight loss at 3 and 6 months (Table 4.4). None of the eating behaviors were significant predictors for weight loss in bivariate analyses. The best model for predicting greater weight loss at 3 months included older age, greater weight at randomization, and fewer alcoholic drinks per week.

Fewer caffeine containing beverages per day also tended to be associated with greater weight loss (P=.08). The best model for predicting greater weight loss at 6 months included older age, working less than 40 hours a week, and greater weight at randomization. There was a trend toward greater weight loss in people that slept more hours per night and being a female (both, P<0.10). Differences between yoga and stretching remained non-significant when the covariates included in Table 4.4 were considered in the analysis (Figure 4.2).

Perceived Stress. Perceived stress scores decreased significantly in the stretching group by 3 months and in the yoga groups by 6 months (Table 4.3). There were no differences between groups in perceived stress scores at either 3 or 6 months. Weight loss at 3 months was not associated with a decrease in perceived stress (P=.13).

Emotional Eating. Emotional eating scores decreased significantly in both the yoga and stretching groups from both baseline to 3-months, but only remained significant at 6-months among the yoga group. While there was no difference between groups for emotional eating scores at the end of the intervention (3 months), emotional eating scores were significantly lower in the yoga group than in the stretching group at the 6-month follow-up.

Uncontrolled Eating. Uncontrolled eating scores decreased in the yoga group from baseline to the end of the intervention (3-months) and this difference remained at the 6-month follow-up (Table 4.3). Uncontrolled eating scores also decreased from baseline to the 3-months in the stretching group, but this difference did not remain significant at 6-months. There was no difference in uncontrolled eating scores between the yoga and stretching groups at 3-months, but by 6-months the yoga group had decreased their uncontrolled eating scores significantly more than the stretching group.

Cognitive Restraint. Cognitive restraint scores increased significantly in the yoga group from baseline to 3- and 6-months (Table 4.3), but only increased from baseline to 3-months in the stretching group. There were no differences between the groups at either 3- or 6-month time points.

There was no difference between those that completed a yoga class and those that were assigned a yoga DVD for any of the outcome measures.

DISCUSSION

Our hypotheses that individuals who participated in the 3-month yoga intervention would have lower stress levels and lose more weight than individuals in a stretching group was not confirmed. While both groups lost weight, there were no differences between groups for either weight or stress levels. Regression models were not able to find modifiable predictors of weight loss other than alcohol intake and hours worked per week and a couple of variables that approached significance. Hours worked per week and alcohol intake could both be indicators of stress and certainly alcohol intake contributes calories to the diet. Alcohol intake and caffeine intake are discouraged for those on the Profile weight loss plan so their use may also be an indicator of overall compliance with the weight loss program. Decreased emotional and uncontrolled eating scores in the yoga group at 6 months post intervention may indicate greater effectiveness of yoga versus stretching for eating behaviors associated with obesity.

The modification in the design of the study to stop recruiting for the yoga class group and to merge the yoga class group with the yoga DVD group may have impacted the ability of the yoga intervention to reduce weight and reduce stress levels. Receiving a yoga video is not the same as attending an in-person class and this potentially influenced our results. In a randomized, controlled study completed in India[29], 8 weeks of yoga was compared to a walking intervention with both groups receiving information on nutrition, smoking cessation, and benefits of physical activity. Weight and waist circumference were lower in the yoga group after completion of the intervention. In each 75-minute yoga class, participants completed yoga poses, chanting exercises, breathing exercises, meditation practice, and in didactic portion learned about the philosophy, beliefs, and principles related to yoga as well as coping with emotion. McDermott and colleagues noted that the yoga intervention was intended to lower stress and increase feelings of positivity.[29]

However, another study that provided in-person yoga sessions[30] did not find a difference in weight loss between intervention and control groups and differences within the groups for weight loss were not significant at 12 months after the start of the intervention. Kanaya and colleagues compared restorative yoga (intervention designed with a physical therapist and a person considered to be a yoga expert) to stretching with both groups receiving 12 weeks of biweekly group sessions followed by 12 weekly sessions and finally monthly sessions for 6 months with subjects instructed to do yoga or stretching on their own for a minimum of 30 minutes three times a week. Participants stayed in most yoga poses for 10-15 minutes with eyes closed or a towel over their eyes. Both intervention and control groups received information on benefits of physical activity and nutrition. Waist circumference and weight improved in both groups without a difference between groups at 12 months. The only difference found between groups was decreased fasting glucose in the yoga group.[30]

A 2017 Cochran review of yoga's effectiveness in women with breast cancer diagnosis[31] concluded that short term yoga was not able to reduce anxiety or depression. However, the study found moderate to weak evidence of yoga's ability to reduce sleep disturbances and improve "health-related quality of life". Additionally, there was weak evidence that yoga produced similar results to other forms of exercise in those with breast cancer diagnosis. The authors concluded that yoga might be appropriate to use in place of other forms of exercise.

There are great variations in how yoga is taught and some interventions include an emphasis on relaxation, positive thinking, and teaching stress reduction techniques while others only teach specific yoga poses. It is possible that these differences are contributing to discrepancies among studies in the effectiveness of yoga over other forms of exercise. More traditional yoga with messages of positivity, meditation, reducing stress, and breathing exercises might have the potential to be more effective for weight loss than yoga that focuses on physical poses with little or no emphasis on the calming messages of more traditional Eastern yoga. Complicating the comparison between yoga and stretching is the fact that some stretching classes and DVDs may include references to breathing and stress reduction.

There still are many unanswered questions about the ability of yoga to improve weight and to lower stress, uncontrolled eating and emotional eating. Future research should investigate interventions aimed at reducing stress, increasing positivity, and teaching relaxation techniques in combination with yoga poses compared to yoga poses without these messages and relaxation techniques. It may be possible that it is a combination of learning to discipline oneself to remain in the various yoga positions in addition to messages that teach the participant to calm their breathing and relax that helps people decrease emotional eating and uncontrolled eating, and ultimately lose weight.

There are several limitations to this study. We have no measure of compliance with performing either of the DVD exercises at home. However, we did see reductions in perceived stress in both groups and group differences in eating behaviors in our intent-to-treat analysis. The study was conducted in the upper Midwest and may not be generalizable to subjects living in other parts of the United States. Only 16 males enrolled in the study out of 162 individuals randomized at baseline, so the study has limited generalizability to males. Finally, correlations found between variables may indicate an association, however, associations do not mean that a causal relationship exists.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Reduced uncontrolled eating scores and lowered emotional eating scores after six months in the yoga group may indicate an advantage of yoga over stretching interventions. More research is needed to determine the ability of yoga to reduce emotional and uncontrolled eating and any possible effects on weight over a longer time.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the design, implementation, analysis, or publication of the study.

Acknowledgements The authors would like to thank the participants in this study.

Funding Support This study was funded by Sanford Health/South Dakota State University Collaborative Research Seed Grant Program and the Ethel Austin Martin Endowment in Human Nutrition at South Dakota State University.

References

1. Vicennati V, Pasqui F, Cavazza C, Pagotto U, Pasquali R. Stress-related development of obesity and cortisol in women. *Obesity (Silver Spring).* 2009;17(9):1678-1683.

2. Sinha R, Jastreboff AM. Stress as a common risk factor for obesity and addiction. *Biol Psychiatry.* 2013;73(9):827-835.

3. Kumar J, Chuang JC, Na ES, et al. Differential effects of chronic social stress and fluoxetine on meal patterns in mice. *Appetite.* 2013;64:81-88.

4. Tomiyama AJ, Dallman MF, Epel ES. Comfort food is comforting to those most stressed: evidence of the chronic stress response network in high stress women. *Psychoneuroendocrinology.* 2011;36(10):1513-1519.

5. Arce M, Michopoulos V, Shepard KN, Ha QC, Wilson ME. Diet choice, cortisol reactivity, and emotional feeding in socially housed rhesus monkeys. *Physiol Behav.* 2010;101(4):446-455.

6. Tryon MS, DeCant R, Laugero KD. Having your cake and eating it too: a habit of comfort food may link chronic social stress exposure and acute stress-induced cortisol hyporesponsiveness. *Physiol Behav.* 2013;114-115:32-37.

7. Berthoud HR. Metabolic and hedonic drives in the neural control of appetite: who is the boss? *Curr Opin Neurobiol.* 2011;21(6):888-896.

8. Egecioglu E, Skibicka KP, Hansson C, et al. Hedonic and incentive signals for body weight control. *Rev Endocr Metab Disord.* 2011;12(3):141-151.

9. Torres SJ, Nowson CA. Relationship between stress, eating behavior, and obesity. *Nutrition.* 2007;23(11-12):887-894.

10. Adam TC, Epel ES. Stress, eating and the reward system. *Physiol Behav.* 2007;91(4):449-458.

11. Sanghez V, Razzoli M, Carobbio S, et al. Psychosocial stress induces hyperphagia and exacerbates diet-induced insulin resistance and the manifestations of the Metabolic Syndrome. *Psychoneuroendocrinology.* 2013;38(12):2933-2942.

12. Gluck ME, Yahav E, Hashim SA, Geliebter A. Ghrelin levels after a cold pressor stress test in obese women with binge eating disorder. *Psychosom Med.* 2013;76(1):74-79.

13. Mundinger TO, Cummings DE, Taborsky GJ, Jr. Direct stimulation of ghrelin secretion by sympathetic nerves. *Endocrinology.* 2006;147(6):2893-2901.

14. French SA, Epstein LH, Jeffery RW, Blundell JE, Wardle J. Eating behavior dimensions. Associations with energy intake and body weight. A review. *Appetite.* 2012;59(2):541-549.

15. Kiecolt-Glaser JK, Christian L, Preston H, et al. Stress, inflammation, and yoga practice. *Psychosom Med.* 2010;72(2):113-121.

16. Streeter CC, Whitfield TH, Owen L, et al. Effects of yoga versus walking on mood, anxiety, and brain GABA levels: a randomized controlled MRS study. *J Altern Complement Med.* 2010;16(11):1145-1152.

17. Aftanas L, Golosheykin S. Impact of regular meditation practice on EEG activity at rest and during evoked negative emotions. *Int J Neurosci.* 2005;115(6):893-909.

18. Carlson LE, Doll R, Stephen J, et al. Randomized controlled trial of Mindfulness-based cancer recovery versus supportive expressive group therapy for distressed survivors of breast cancer. *J Clin Oncol.* 2013;31(25):3119-3126.

19. Cohen L, Warneke C, Fouladi RT, Rodriguez MA, Chaoul-Reich A. Psychological adjustment and sleep quality in a randomized trial of the effects of a Tibetan yoga intervention in patients with lymphoma. *Cancer.* 2004;100(10):2253-2260.

20. Christaki E, Kokkinos A, Costarelli V, Alexopoulos EC, Chrousos GP, Darviri C. Stress management can facilitate weight loss in Greek overweight and obese women: a pilot study. *J Hum Nutr Diet.* 2013;26 Suppl 1:132-139.

21. Wilhelm FH, Gevirtz R, Roth WT. Respiratory dysregulation in anxiety, functional cardiac, and pain disorders. Assessment, phenomenology, and treatment. *Behav Modif.* 2001;25(4):513-545.

22. Mourya M, Mahajan AS, Singh NP, Jain AK. Effect of slow- and fast-breathing exercises on autonomic functions in patients with essential hypertension. *J Altern Complement Med.* 2009;15(7):711-717.

23. Cohen BE, Chang AA, Grady D, Kanaya AM. Restorative yoga in adults with metabolic syndrome: a randomized, controlled pilot trial. *Metab Syndr Relat Disord.* 2008;6(3):223-229.

24. Cohen S, Williamson G. Perceived stress in a probability sample of the United States. In: Spacapan S, Oskamp S, eds. *The Social Psychology of Health: Claremont Symposium on Applied Social Psychology*. Newbury Park, CA: Sage; 1988.

25. Karlsson J, Persson LO, Sjostrom L, Sullivan M. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *Int J Obes Relat Metab Disord.* 2000;24(12):1715-1725.

26. de Lauzon B, Romon M, Deschamps V, et al. The Three-Factor Eating Questionnaire-R18 is able to distinguish among different eating patterns in a general population. *J Nutr.* 2004;134(9):2372-2380.

27. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health.* 2009;6(6):790-804.

28. Chu AH, Ng SH, Koh D, Muller-Riemenschneider F. Reliability and validity of the self-and-interviewer-administered versions of the Global Physical Activity Questionnaire (GPAQ). *PloS One.* 2015;10(9):e0136944.

29. McDermott KA, Rao MR, Nagarathna R, et al. A yoga intervention for type 2 diabetes risk reduction: a pilot randomized controlled trial. *BMC Complement Altern Med.* 2014;14:212.

30. Kanaya AM, Araneta MR, Pawlowsky SB, et al. Restorative yoga and metabolic risk factors: the Practicing Restorative Yoga vs. Stretching for the Metabolic Syndrome (PRYSMS) randomized trial. *J Diabetes Complications.* 2014;28(3):406-412.

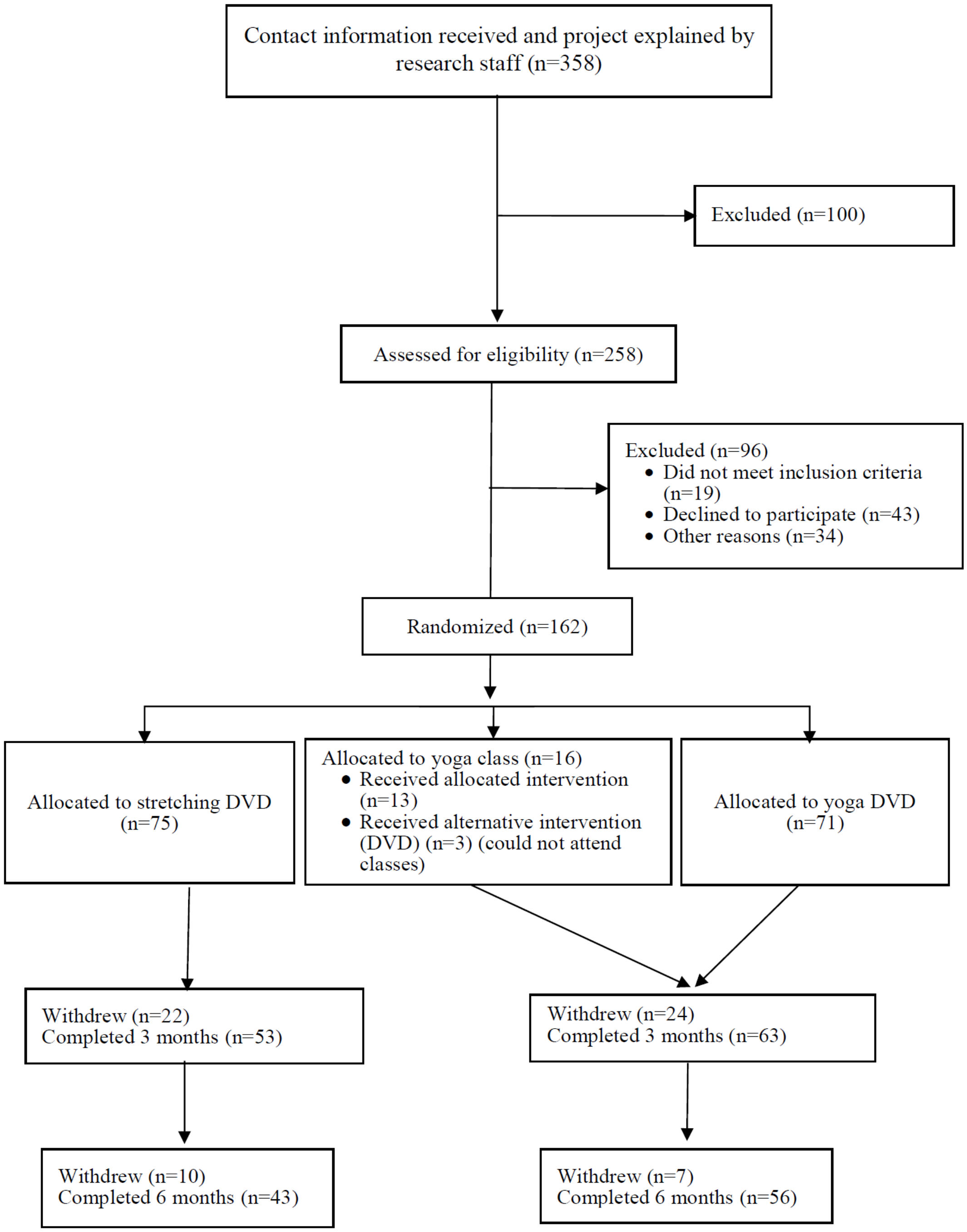
31. Cramer H, Lauche R, Klose P, Lange S, Langhorst J, Dobos GJ. Yoga for improving health-related quality of life, mental health and cancer-related

symptoms in women diagnosed with breast cancer. *Cochrane Database Syst Rev.* 2017;1:Cd010802.

Figure Legend

Figure 4.1: Participant flow (n=358) of included and excluded participants, allocation to intervention groups, and completion status for a yoga versus stretching weight loss intervention.

Figure 4.2. Multiple regression adjusted estimates of weight change at 3 and 6 months by yoga and stretching group (groups were not different: $P=.34$; $P=.10$, respectively)



Contact information received and project explained by research staff (n=358)
Excluded (n=100)
Assessed for eligibility (n=258)
Excluded (n=96)
• Did not meet inclusion criteria (n=19)
• Declined to participate (n=43)
• Other reasons (n=34)
Randomized (n=162)
Allocated to stretching DVD (n=75)
Allocated to yoga class (n=16)
• Received allocated intervention (n=13)
• Received alternative intervention (DVD) (n=3) (could not attend classes)
Allocated to yoga DVD (n=71)
Withdrew (n=22)
Completed 3 months (n=53)
Withdrew (n=24)
Completed 3 months (n=63)
Withdrew (n=10)
Completed 6 months (n=43)
Withdrew (n=7)
Completed 6 months (n=56)

Figure 4.1

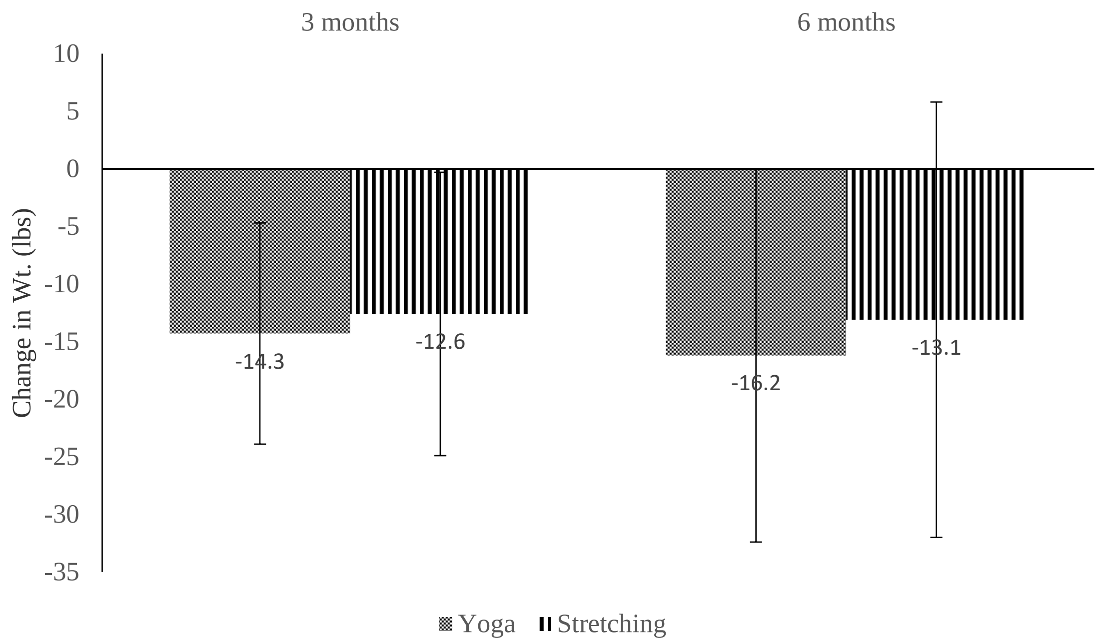

3 months
6 months
10
5
0
-5
-10
-15
-20
-25
-30
-35
Change in Wt. (lbs)
-14.3
-12.6
-16.2
-13.1
Yoga
Stretching

Figure 4.2

Table 4.1. Baseline Characteristics of Completers and Non-completers [1]

Variable	Completers (n=116)	Non-completers (n=46)	P-value
Age	43.7 (12.3)	43.3 (11.6)	.87
Gender (M/F)	13/103	3/43	.37
Race (White/Other[2])	113/3	42/4	.09
Marital status			.11
Married	73 (62.9)	35 (76.1)	
Not married	43 (37.1)	11 (23.9)	
Education			.37
High School or Less	13 (11.2)	3 (6.5)	
More than High School	103 (88.8)	43 (93.5)	
Income			.79
<$50,000	34 (29.3)	11 (23.9)	
$50,000-$100,000	47 (40.5)	19 (41.3)	
>$100,000	29 (25.0)	12 (26.1)	
Missing/Refused	6(5.2)	4(8.7)	
Hours worked			.80
<40 Hrs/week	30 (25.9)	11 (23.9)	
40+ Hrs/week	86 (74.1)	35 (76.1)	
Children in home	0.75 (.98)	1.1 (1.4)	.08
Number in home	2.1 (2.9)	2.2 (1.6)	.77
Tobacco use			.11
Never	58 (50.0)	30 (65.2)	
Current	10 (8.6)	5 (10.9)	
Past	48 (41.4)	11 (23.9)	
Cups of caffeine/day	1.5 (1.8)	1.3 (1.2)	.33
BMI (kg/m^2)	34.0 (6.4)	32.5 (6.4)	.19
Physical Activity (METs)	2,017 (2,771)	710 (1,341)	<.01

[1]Data are means (SD) or number (%)

Table 4.2. Baseline Characteristics of Intervention Completers [1]

Variable	Stretching (n=53)	Yoga (n=63)	P-value
Age	43.0 (13.4)	44.2 (11.4)	.61
Gender (M/F)	5/48	8/55	.58
Race (White/Other[2])	52/1	61/2	.66
Marital status			.89
Married	33 (62.3)	40 (63.5)	
Not married	20 (37.7)	23 (36.5)	
Education			.97
High School or Less	6 (11.3)	7 (11.1)	
More than High School	47 (88.7)	56 (88.9)	
Income			.46
<50,000	18 (34.0)	16 (25.4)	
50,000-100,000	20 (37.7)	27 (42.9)	
>100,000	11 (20.8)	18 (28.6)	
Missing/Refused	4(7.6)	2(3.2)	
Hours worked			.58
<40 Hrs/week	15 (28.3)	15 (23.8)	
40+ Hrs/week	38 (71.7)	48 (76.2)	
Children in home	0.60 (.91)	0.87 (1.0)	.14
Number in home	1.7 (1.1)	2.4 (3.8)	.18
Tobacco use			.13
Never	22 (41.5)	36(57.1)	
Current	7 (13.2)	3 (4.8)	
Past	24 (45.3)	24 (38.1)	
Cups of caffeine/day	1.5 (1.9)	1.5 (1.7)	.93
BMI (kg/m^2)	34.5 (7.8)	33.6 (4.9)	.48
Physical Activity	1,776 (2.328)	2,309 (3,235)	.50

[1]Data are means (SD) or number (%)

Table 4.3. Change in Weight, Perceived Stress, and Eating Behaviors in Study Participants Enrolled in a Weight Loss Program by Intervention at 3 and 6 months

Outcome/treatment	**Baseline mean ± SD (n)**	**3-Month Change from baseline**	**6-Month Change from baseline**
Weight, lbs			
Stretching	214 ± 52 (53)	-12 ± 12*** (53)	-13 ± 19*** (43)
Yoga	209 ± 41 (63)	-14 ± 10*** (63)	-16 ± 16*** (56)
Group Differences	p=.37	p=.17	p=.25
Perceived Stress			
Stretching	17 ± 7 (46)	-3 ± 7* (29)	-3 ± 6 (14)
Yoga	17 ± 7 (54)	-2 ± 6 (35)	-3 ± 7* (29)
Group Differences	p=.81	p=.53	p=.94
Emotional Eating			
Stretching	55 ± 22 (47)	-12 ± 16*** (30)	-3 ± 24 (15)
Yoga	54 ± 21 (57)	-13 ±17*** (41)	-16 ± 17*** (31)
Group Differences	p=.73	p = .62	p= .04
Uncontrolled Eating			
Stretching	52 ± 19 (47)	-10 ± 13*** (30)	-4 ± 10 (15)
Yoga	48 ± 14 (57)	-11 ± 13*** (41)	-12 ± 12*** (31)
Group Differences	p=.10	p=.89	p=.03
Cognitive Restraint			
Stretching	48 ± 21 (47)	14 ± 27** (30)	7 ± 22 (15)
Yoga	43 ± 19 (57)	17 ± 20*** (41)	14 ± 20*** (31)
Group Differences	p=.26	p=.64	p=.33

Significance of within group change: * P<.05; ** P<.01; *** P<.001

Table 4.4 Multiple Linear Regression Models Predicting Weight Change at 3 and 6 Months

	Coef.	β	SE	P
Weight change at 3 mo				Model r^2=.22
Intercept	12.6	--	5.2	<.001
Weight (baseline)	-0.089	-0.38	0.017	<0.001
Age	-0.20	-0.23	0.067	<0.01
Alcohol	1.5	0.20	0.56	<0.01
Caffeine	0.85	0.13	0.48	0.063
Weight change at 6 mo				Model r^2=.20
Intercept	45.1	--	13.8	<0.001
Age	-0.36	-.26	0.11	<0.01
≥40 hrs work/wk	6.3	.17	3.0	0.04
Weight (baseline)	-0.12	-0.34	0.03	<0.001
Sleep Hours	-2.21	-0.14	1.3	0.092
Female	-8.05	-0.14	4.7	0.087

Weight in pounds. Alcohol= number alcoholic drinks per week. Caffeine = number of beverages per day that contain caffeine. ≥40 hrs work/wk (1= yes; 0= no). Female (1= yes, 0= no). Sleep hours ranged from 4.0 to 9.0: females=6.9 ± 1.0 (mean ± SD), males= 6.7 ± 1.1.

CHAPTER 5

DISCUSSION AND OVERALL CONCLUSIONS

Finding ways to reduce emotional eating and uncontrolled eating and to increase cognitive restraint through modifiable variables such as perceived stress, sleep, food insecurity, and physical activity has the potential to improve weight control efforts and ultimately the potential to impact the obesity epidemic if knowledge gained is applied on a broad scale.

The first study presented in this paper (Chapter 2) found that higher emotional eating scores were associated with higher levels of perceived stress and tobacco use was associated with lower uncontrolled eating. Those who indicated that they used relaxation strategies had higher cognitive restraint. Reduced hours of sleep in freshmen was associated with lower cognitive restraint and freshmen with high perceived stress had higher cognitive restraint scores. Reduced hours of sleep and high perceived stress did not affect other students' cognitive restraint scores. These findings suggest that freshmen's eating behaviors may be vulnerable to stress and lack of sleep and efforts to help freshmen lower their stress and encourage adequate sleep may be beneficial.

The second study presented (Chapter 3) found that perceived stress levels, working 40 or more hours a week and reduced sleep were associated with higher levels of emotional eating and that those who met the recommendations for physical activity had lower emotional eating scores. Uncontrolled eating was higher in those with poor sleep when stress levels were low, but not when stress levels were high. Results of this study would suggest that interventions that help individuals lower stress and improve sleep quality (including getting adequate amount of sleep) may be able to improve eating behaviors associated with obesity. It is unlikely that reducing hours of work a week is a modifiable variable for most individuals, but for those that may be able to lower hours of work a week, this too might have the potential to improve eating behaviors.

The final study presented (Chapter 4) revealed that a yoga intervention was not able to lead to greater weight loss or reduce stress more than a stretching intervention. Both emotional eating and uncontrolled eating scores decreased among the yoga group three months after the completion of the study and were different from the stretching group at the six-month follow-up, but not at the end of the three month intervention. Cognitive restraint increased in both the yoga and stretching groups similarly. Although the yoga intervention was not delivered as originally designed, with only a few participants in the study participating in a yoga class, a yoga intervention utilizing a yoga DVD shows some potential promise as an intervention. More research is needed to compare a yoga DVD with an actual yoga class to determine effectiveness.

In conclusion, the three research studies added to the current knowledge on obesity prevention and treatment. Getting adequate sleep, minimizing stress, and getting the recommended amount of physical activity may positively impact eating behaviors associated with obesity and yoga also appears to have some benefit as an intervention to improve emotional and uncontrolled eating.