Do differing levels of physical activity influence markers of appetite?

by

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The student author and the program of study committee are solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

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ABSTRACT

Background: An epidemic of overweight and obesity has become a leading public health concern worldwide. In developed countries, people live in an obesogenic environment, which encourages minimal physical activity and the overconsumption of food. With more than two-thirds of Americans being overweight or obese, a rise in healthcare costs and a suggested decline in lifespan is occurring. Non-invasive lifestyle interventions are being developed to achieve weight loss and decrease the associated health risks. Anti-obesity strategies involve increasing physical activity and/or reducing energy intake, resulting in a negative energy imbalance. The increase in physical activity impacts the malleable part of energy expenditure. Some studies suggest that increasing physical activity is not an effective means for weight loss as it increases appetite and energy intake. However, other studies report a causal relationship between physical activity and appetite regulation, which may be a solution to decreasing the prevalence of overweight and obesity.

Purpose: The primary objective of this study was to determine if changes in physical activity alter appetite measured by energy intake at an ad lib meal and appetite questionnaires. The hypothesis is that an increase in physical activity will increase subjective appetite ratings and therefore energy intake at an ad lib meal.

Methods: Twelve males (31 ±3 years) with a BMI between 25.0 and 35.0 kg/m² took part in a randomized control study. The participants completed three
treatment conditions: control, decreased activity (sedentary), and increased activity (active). Subjective appetite ratings were measured using visual analogue scales (VAS) and energy intake was calculated at the end of a test meal during the measurement session after each two week period. Energy expenditure was measured using activity monitors and compliance to prescribed exercise regimens. Additional questionnaires were used to measure eating restraint, disinhibition, food cravings, stress, sleep quality, and mood states.

**Results:** Ad lib energy intake did not differ between control (313.2±128.1 kcals) and active (358.1±201.1 kcals) treatments (p=0.62), or sedentary (434.0±225.2 kcals) and active (358.1±201.1 kcals) treatments (p=0.12). There was a statistical significant difference in energy intake at the ad lib meal between control and sedentary treatments (p=0.02). There was a statistically significant interaction between the subjective appetite rating of hunger at time point 180 (before ad lib meal) and energy intake between treatments, but no significant interaction in satisfaction, fullness, or perceived food consumption ratings. There was no significant difference in energy expenditure or steps between control and sedentary treatments (p=0.27 and 0.70, respectively). There was a significant increase in steps per day in active treatment versus control and sedentary treatments (p<0.001 for both). Other questionnaires reporting food cravings, eating restraint and disinhibition, sleep, mood, and stress were measured and showed no statistically significant changes between the treatments (p>0.05).

**Conclusion:** These data indicate that under laboratory conditions, there was no statistically significant change in energy intake between active and control
treatments, and active and sedentary treatments. There was however an unexplained significant difference in energy intake in between control and sedentary treatments, regardless of no change in steps or energy expenditure between the two treatments. These findings did not support our hypothesis that appetite is upregulated by an increase in physical activity.
CHAPTER 1: INTRODUCTION

The thesis begins with a review of literature on obesity and the confounding health risks and problems associated with it, as well as energy balance and appetite regulation and physical activity’s influence on these. The next section consists of methods done during this research study, followed by the outcomes found. Last is the conclusion of the data and a summary of what was found and limitations that could be corrected by further research.

Purpose of study

An aim of this pilot study was to measure appetite following changes in physical activity. The primary objective was to examine the effects of three levels of physical activity and energy expenditure on the subjective response to food consumption. There is a lack of evidence showing a short-term habitual increase and decrease of physical activity, and the appetite response associated with that change. The hypothesis is that an increase in physical activity will upregulate appetite and therefore energy intake during a test meal.
Obesity

Due to the rising number of overweight and obese individuals, research concerning body fat regulation has received increased attention. In 2010, 68.8% of U.S. adults were overweight or obese\(^3\). Moreover, 17% of children and adolescents were obese\(^54\). Overweight and obesity are internationally classified by the World Health Organization (WHO) as a body mass index (BMI) of 25-29.9 kg/m\(^2\) and 30 kg/m\(^2\) and higher, respectively, with obese class I as 30-34.9 kg/m\(^2\), class II as 35-39.9 kg/m\(^2\) and class III as 40 kg/m\(^2\) and greater\(^94\). Obesity increases the risk of chronic diseases such as coronary heart disease\(^55\), type 2 diabetes\(^56\), many types of cancer\(^57\) and liver disease\(^58\). Over the last couple of decades, the average lifespan has increased globally from 77 years old to 83 years old in some parts of the world\(^71\), but some have suggested that life-expectancy may begin to decline due to the obesity epidemic\(^97\). Obesity is associated with a decrease in lifespan by 13-20 years for men and 5-8 years for women, with minorities being at the upper end\(^59\). The estimated number of annual deaths per year attributed to obesity is roughly 280,000 deaths\(^60\). This means about 15% of deaths per year in the U.S. are correlated with obesity\(^61\), however lower estimates of 111,909 excess deaths per year in the U.S. have also been shown when adjusted for more variables using data from National Health and Nutrition Examination Surveys\(^98\). The implications of overweight and obesity may become more pronounced as the projected prevalence of obesity among men by year 2020 is 40.2% and for women 43.3%\(^62\). Another study by
Finklestein et al. reports 51% of the American population projected to be obese by 2030 using the Behavioral Risk Factor Surveillance System (BRFSS) and a linear time trend including variables known to influence obesity\textsuperscript{14}. Consequently, effective interventions are required to halt this epidemic.

Obesity is not evenly distributed over socioeconomic status or ethnic groups. For instance, low socioeconomic groups have a higher incidence of obesity\textsuperscript{65}, as do lower educated individuals\textsuperscript{70}, women and minorities\textsuperscript{66}. African Americans and Mexican Americans are at highest risk of developing obesity followed by Caucasians\textsuperscript{82}. Females are at the highest risk of being obese in every category of ethnic group\textsuperscript{82}. The obesity epidemic is not only a public health concern, but also a financial challenge as well. An estimated 9.1% of annual medical expenses are spent on the treatment of disease associated with excess body fat\textsuperscript{4}. The direct costs of obesity are comparable to the indirect costs, together estimating $73.1 billion, which include health care costs, weight loss programs, work absenteeism, and presenteeism\textsuperscript{74}. Our BMI as a nation has increased\textsuperscript{64} in concert with our lives becoming more sedentary\textsuperscript{99}. With modern day conveniences like cars, computers, and televisions influencing our sedentariness, there is room for an energy imbalance. Moore\textsuperscript{1} and Stubbs\textsuperscript{72} demonstrate that when a sedentary lifestyle is implemented, energy intake is not accordingly reduced causing a positive energy imbalance. Consequently, it has been hypothesized that the inability to downregulate food intake may be a contributory factor to the obesity epidemic\textsuperscript{2,36,75}. An obesogenic environment has been suggested to be associated with higher rates of obesity. In a study
conducted among children, it was found that for every hour a child is sedentary in front of a television, it increases their risk of obesity by 12% \(^6\). On the other hand, one hour of moderate-to-vigorous physical activity decreases their risk of obesity by 10% \(^6\). The social and obesogenic environment appear to override the internal physiological factors when strongly influenced \(^9\). It has been suggested that humans have an increased sensitivity to the external environment than internal physiological cues \(^2\). Altering the external environment or human interactions with environmental factors rather than changing their internal environment through medication, may curb or even reverse the prevalence of obesity \(^2\). Other strategies that have been suggested for alleviating the obesogenic environment include mandatory physical education classes, stricter food policies for school lunch and vending machines, and building parks and bike paths to promote safe environments for natural physical activity. If the same idea was applied for adults in the work setting, there may be a decrease in prevalence of obesity, however long-term effects are still unclear. Barriers to these improvements exist through commercial companies selling energy dense foods for cheap, schools allowing beverage companies to put soda machines in contact with children, real estate development being more lucrative than parks and open spaces, and budget cuts to physical education in schools \(^8\). The causation of these rising obesity rates among both adults and children are debated, including the environmental and behavioral factors promoting overconsumption, genetic predispositions \(^8\) to obesity and increased sedentariness \(^8\). The latter is being debated due to a study done in a hunter-gatherer population compared to Western lifestyle \(^8\). The
body fat percent was higher in the western population, as well as a lower physical activity level. There was no significant difference in total energy expenditure (TEE) in the two populations, however, the hunter-gatherer population spent less percent of TEE on basal metabolic rate than western population. The results from this study suggest that a difference in physical activity may not be the cause to the difference in obesity prevalence, rather an increased energy consumption due to diet change over time. While there are many proximate causes of obesity, the ultimate cause must be an energy imbalance.

*Energy Balance*

Energy balance is based on the first law of thermodynamics, which states that energy can be transformed from one form to another, but cannot be created nor destroyed, therefore, the energy balance equations exists as rate of change in energy storage (ES)= energy input (EI)- energy output (EO)\(^69\). Energy input is comprised of the food and drink we consume. After the absorption of macronutrients (carbohydrates, protein, and fat), they are either oxidized to produce fuel for our body, or stored\(^69\). Daily energy expenditure is made of three primary variables: basal metabolic rate (~65%), diet induced thermogenesis (~10%), and physical activity (~25%)\(^73\). Basal metabolic rate (BMR) can be increased by increases in lean tissue, but is very limited, and most often will not result in significant change. This was shown in a 9-week exercise program where volunteers gained 1.5 kg of fat-free mass, but resulted in a nonsignificant (p>0.05) change in BMR expressed as per kg fat-free mass\(^81\). Dietary induced
thermogenesis (DIT) is the obligatory energy required to digest and process food, and could increase from a rise in energy intake. Significant changes are not commonly seen, due to limitations including variability in diet composition with protein and carbohydrate being the greatest contributors, variability in compensatory responses between individuals- which was evidenced by 14 women having an increase in energy intake of 50% above normal for 14 days but the result of no significant change in total energy expenditure, and variability in decreased energy expenditure after the cessation of overfeeding. Physical activity is the most variable of the three components of energy balance and could potentially be manipulated to facilitate weight loss. Increasing physical activity has been advocated as one of the key methods of influencing weight gain and prevention of obesity. However, studies provide conflicting evidence regarding the effectiveness of this approach because of possible compensation of activity through increased sedentariness or increased energy intake. Energy balance may also eventually be achieved by reducing expenditure through BMR and DIT reduction, resulting in less weight loss than desired. Low adherence to exercise programs also remain a challenge for individuals to see the desired weight loss or maintenance. In a study measuring self-reported adherence to exercise concluding a 20 week program and after, the adherence dropped from 89.2% to 73.4% at an 18-month follow-up. There was, however, an increase in adherence seen in the group that had a maintenance program including the support of a group and interactions with a therapist. This group’s adherence also deteriorated at the end of the maintenance program. Higher adherence to
exercise programs, than what currently are evident, are required to see a lifestyle change and its effect on body fat regulation.

Individuals change eating patterns and physical activity bouts day to day, thus variability exists in energy balance. However, an energy balance could be seen when averaging over several days. When a person begins exercising and/or restricts their intake, a negative energy imbalance would occur. It has been proposed that the U.S. population should reduce energy intake by 100 calories per day to prevent weight gain\textsuperscript{5}, or reduce energy intake by 500 calories per day to promote weight loss\textsuperscript{6}. Studies conducted that changed behavior or used pharmacotherapy observed that overweight or obese individuals that lost weight, regained at least half of the weight after a year, and in 3-5 years all or an excess of weight loss was regained\textsuperscript{10}. Furthermore, a diet restriction compared to exercise regimen of weight loss showed an increased appetite and food consumption at the time of an ad lib meal\textsuperscript{11}. Although increases in physical activity can improve risk factors for CVD, little evidence exists that these regimens, without caloric restrictions, promote significant long-term weight loss\textsuperscript{12}. Why physical activity does not decrease body weight long-term independently from caloric restriction, requires further elucidation.

In a review by Swift et al.\textsuperscript{12} it was reported that different studies have used methods of promoting weight loss such as pedometer-based step goals, aerobic exercise training, resistance training, combined aerobic and resistance training, and energy restriction with aerobic training. The pedometer-based study, without caloric restriction, showed that increasing physical activity by 2,000-4,000 steps
per day only led to minimal weight loss\textsuperscript{15}. A daily step count of less than 5,000 is categorized as a sedentary lifestyle, while 5,000-7,499 is low active. Insufficiently active is seen at the level of 7,500-12,500, and highly active takes place when a person is getting more than 12,500 steps/d\textsuperscript{15}. A meta-analysis conducted by Bravata et al. found participants using pedometers increased their physical activity overall by 26.7%. The statistically significant, although not clinically significant, physiological effects seen included decreases in body mass index (-0.38 kg/m\textsuperscript{2}) and systolic and diastolic blood pressure (-3.8mmHg, -0.3mmHg)\textsuperscript{16}. Apart from weight loss, physical activity is thought to improve eating behavior through changes in appetite.

\textit{Appetite Regulation}

Appetite is the motivation or desire to eat. Evidence suggests three main approaches for methods of weight loss, exercise, energy restriction, and a combination of the two. Energy restriction results in a greater chance of compensation of energy intake following the restriction, which was seen in a study that was conducted comparing four treatments of low energy breakfast with and without exercise, and high energy breakfast with and without exercise\textsuperscript{17}. The participants ate significantly more at an ad lib lunch meal in both the low energy breakfast groups, regardless of exercise, than the high energy breakfasts groups. The need to compensate for that energy deficit produced by exercise is not present, suggesting that the relationship between energy expenditure by physical
activity and energy intake is not tightly coupled over the short-term\textsuperscript{17}. However, other evidence shows that when lean women\textsuperscript{110} and men\textsuperscript{111} were assigned to three treatment conditions of differing levels of exercise, energy intake was significantly increased to partially (~30%) compensate for the exercise-induced energy deficit. Similarly, moderately active women were assigned to 2 treatment conditions, exercise or control, and results showed that energy intake was significantly increased in the exercise condition\textsuperscript{109}. This conflicting evidence suggests that further evidence is needed to verify if compensatory increases in energy intake are prevalent.

Although a wide variability of weight loss has been shown in different individuals with exercise, there remains another relationship between exercise and health, appetite regulation\textsuperscript{13}. Appetite regulation is the physiological and psychological regulatory processes that underpin feeding behavior\textsuperscript{13}. There is conflicting evidence regarding the effect of exercise on energy intake. Unick et al.\textsuperscript{26} found that when obese participants were subject to exercise prior to an ad lib meal, 58% of them ate less ($-71.5 \pm 65.4$ kcals) than their resting counterparts. Apart from one, the 42% that ate more post-exercise were analyzed, and after calculating for relative energy intake, were seen as having a net negative energy imbalance. With this evidence, it could be hypothesized that those who are sedentary, and engage in an exercise program, could in turn have a net negative energy imbalance with decreased energy intake if adherence is maintained over long-term. In a study done by Rosenkilde et al.\textsuperscript{27}, they found that after a 12 week regimen of moderate and intense exercise, measurements
of appetite were not changed in previously sedentary overweight individuals, but rather ratings of fullness were increased. King\textsuperscript{28} suggests the likelihood of a short-term transition period following an increase in exercise, where EI and EE are uncoupled. Hill et al.\textsuperscript{9} proposed a model where coupling between energy intake and expenditure would be modified by body weight and eating behavior. This model suggests that compensatory energy intake in response to physical activity differs with unrestrained, restrained and disinhibited eaters. Unrestrained eaters would fully or partially compensate in energy intake depending on body weight, while restrained eaters would have a negative energy imbalance. If restrained eaters had high disinhibition, the result would be an increase in energy intake. It is still unclear as to how connected energy intake and energy expenditure are to appetite regulation with evidence showing intense bouts of exercise having short-term suppression on hunger and delay of eating\textsuperscript{67}, while long-term effects on appetite vary. It has been hypothesized that PA can increase sensitivity to appetite regulation. King et al.\textsuperscript{29} have shown that the effect of exercise on appetite regulation in obese and overweight men and women involves an increase in appetite stimulant as well as fasting and total daily hunger. The compensation of energy intake for energy expenditure varies between individuals. Long et al.\textsuperscript{30} provides evidence that lean individuals who habitually exercise, can compensate better than their sedentary counterparts for high-energy dense pre-loads prior to an ad lib meal. Moreover, after a 6-week duration of exercise, formerly sedentary men were better able to differentiate energy intake after high and low energy dense preloads at an ad lib meal\textsuperscript{31}. The
sensitivity of appetite regulation after exercise seems to improve. The posed question then is, is there a difference between lean and overweight/obese individuals in compensatory energy intake? The idea of exercise-induced anorexia was studied in human subjects that participated in exercise on three nonconsecutive days, where obese women showed no significant difference in energy intake when involved in both strenuous and moderate exercise\textsuperscript{32}. Non-obese individuals however, had a significantly less energy intake following the strenuous exercise condition\textsuperscript{32}. Similar results were seen by George and Morganstein\textsuperscript{33}, who observed the effect of exercise and sedentariness on separate days in 12 lean and 12 overweight women. On both occasions, the overweight women consumed more than the lean individuals. It is unclear if the study was randomized to which condition the individuals participated in first which may have biased the results. The results may stem from a higher energy need for overweight individuals, or it could be a cognitive effect. It has been suggested that sedentary individuals have less of a connection between energy intake and energy expenditure, compared to individuals who expend more energy displaying a strong coupling between energy intake and energy expenditure. Sedentary individuals, or “non-regulated” individuals (they aren’t maintaining an energy balance), can move into the physiologically “regulated” zone by increasing their physical activity, thus creating a homeostatic balance between energy intake and energy expenditure. This underscores the importance of promoting physical activity for weight management, and its association with an increased sensitivity in appetite regulation. Sedentariness
and it’s interaction with overconsumption, produces obesity. This hypothesis of sedentary individuals having a high energy intake due to the dysregulation of appetite resembled by a J-shaped curve in which the anchored end populations have a higher energy intake, was introduced by Mayer et al. and reiterated by Shook et al. It was also shown that the sedentary population has the highest risk of gaining fat mass in one year’s time due to the dysregulation of appetite. It has been shown that the adoption of a sedentary lifestyle from an active one produces a state of positive energy imbalance, as the physiological system is unable to compensate adequately by decreasing energy intake to compensate for the low PA.

McNeil et al. found that after acute exercise, both isocaloric regimens of resistance and aerobic, relative preference for high fat versus low fat foods is decreased. Compared to a sedentary group, explicit liking of high fat foods was lower after resistance exercise. However, these ratings of liking and wanting had no predictive effect of energy intake. This is similar to findings by Farah et al., where a bout of moderate intensity exercise was followed by an anorexigenic effect. Participants preferred a significantly smaller ideal portion size and diminished hunger rating, compared to those in the resting condition. Despite this, no significant decreases in food liking measurements were seen between the two conditions. In two experiments done by Panek et al., participants were randomized to exercise 3 days a week, exercise at different frequencies, or no exercise at all. They found that in both exercise groups, the reinforcing value of high-energy dense foods were reduced, and in the group who exercised 5 days a
week, the reinforcing value of low-energy dense foods was increased\textsuperscript{41}. Furthermore, sedentary, obese women participated in a 16-week walking program of at least 3 bouts a week of walking. The women who lost the most body weight showed a reduction in consumption of fruits, sweet foods, fatty foods, and sugar, however the weight loss was contributed to the increased energy expenditure\textsuperscript{42}. Using this evidence, it could be argued that an adoption of increasing physical activity as a lifestyle change for at least 5 days a week, decreases the appeal of high-energy dense foods.

Eating behavior involves a number of inputs including size and frequency of meals, food choices, social and physical environment, and physiological mechanisms. A reward system contributes to the consummatory food reward. It is the attractive property that stimulates appetitive behavior, resulting in food intake and pleasure. In studies using functional MRI scans, obese individuals had an altered sense of food reward than lean individuals\textsuperscript{93}. They were seen to have a higher activation of the region that processes palatability (anticipatory reaction), and had a lower activation in brain reward circuits in response to food consumption (consummatory reward)\textsuperscript{92,93} suggesting that overconsumption may be a way to overcome a reward deficit\textsuperscript{96}. These responses may also interplay with some physiological cues. The physiological mechanisms behind appetite are comprised by the brain, with a complex signaling system in the hypothalamus integrating hormones found in various organs (the main being the gastrointestinal tract\textsuperscript{18}), energy substrates, and neuropeptides. The system works to send and receive signals to communicate nutritional and energy status from the
gastrointestinal tract to the brain to regulate energy intake. Ghrelin is the only gastrointestinal hormone that has been identified as an appetite-stimulator, others such as cholecystokinin (CCK), peptide YY (PYY) and glucagon-like peptide-1 (GLP-1) promote satiety. The hypothalamus has opposing neuronal populations of hormones: the agouti-related protein (AgRP) and neuropeptide Y (NPY) both stimulating energy intake, and proopiomelanocortin (POMC) and cocaine- and amphetamine-regulated transcript (CART), which is stimulated by circulating leptin, suppress energy intake. When PYY was administered intravenously to both lean and obese patients, appetite and food intake was reduced suggesting that obese individuals maintain sensitivity to PYY, unlike leptin. In obese individuals, circulating levels of PYY are lower, and a postprandial release is blunted, which may be associated with impaired satiety.

GLP-1 is co-secreted with PYY, and is found in the gastrointestinal tract, brain, and pancreas. It has been suggested to have a suppressive effect on food intake, however, it is controversial because the precise mechanism involved is still unclear, and long-term effects are not evident. CCK is secreted by the small intestine and decreases food intake through activated receptors in the brain stimulated primarily by fats and proteins. CCK may also enhance gastric distension signals. When stomach capacity increases, ghrelin also increases, and the satiety hormones decrease. Ghrelin, secreted by the stomach and small intestine, surges pre-prandial and decreases post meal. In obese subjects, plasma levels of ghrelin are not markedly decreased postprandial like they are in lean subjects. This reduced suppression of appetite may augment
obesity\textsuperscript{90}. Other hormones such as leptin and insulin are regulators of energy balance\textsuperscript{86}, and can indirectly regulate body weight by effecting the appetite suppressant neuropeptides in the central nervous system, causing an anorexigenic effect and altering the total amount and frequency of energy intake\textsuperscript{19,20}. Insulin decreases the expression of NPY\textsuperscript{103} and increases the expression of POMC\textsuperscript{104}, both decreasing food intake, although evidence existing from human studies is less prevalent. In a previous study, insulin showed an appetite suppressant effect in lean men, but not in obese individuals\textsuperscript{113}. In a study conducted measuring the effect of brain selective deletion of insulin receptors in mice, the outcome was hyperphagia, obesity and insulin resistance\textsuperscript{102}. Similarly, high leptin levels cause a reduction in energy intake, and is predominantly synthesized in the adipose tissue, in which the circulating levels indicate the level of adiposity in humans, which correlate with fat mass found in the body\textsuperscript{21}. However, some individuals have shown resistance or deficiency in leptin, leading to hyperphagia, ultimately resulting in obesity\textsuperscript{91}. In a study that compared 9 women and 9 men, ghrelin, insulin, and leptin were measured to observe any biological changes in appetite, along with energy intake\textsuperscript{22}. Two conditions were established, exercise with added energy to maintain a balance and exercise without added energy to produce a deficit. Although leptin levels were unchanged in both conditions for both groups, women had higher levels of ghrelin after both conditions, as well as lowered insulin. This demonstrates a promotion of energy intake after exercise regardless of energy status in women, for men however, the need to increase energy after exercise was eliminated
when energy balance was maintained. Exercise size also has an impact on these appetite hormones. A study subjected 9 obese girls to a control or aerobic exercise condition, leptin and PYY were evaluated to assess changes\textsuperscript{114}. The group that exercised was shown to have an increase in PYY levels and leptin was unchanged, whereas the control condition had an increase in leptin levels compared to baseline. Another study was conducted on 15 healthy males that were subjected to exercise or control and their ghrelin, leptin and PYY was assessed\textsuperscript{115}. The ghrelin and leptin levels were unchanged between conditions, while their PYY levels were increased during the exercise condition. Other evidence is needed to clarify these mechanisms of action and the effects of exercise on other appetite hormones.

The coordinated relationship of appetite hormones and environmental and behavioral factors contribute to energy intake and potentially body weight. Food intake is influenced by several environmental factors including hunger\textsuperscript{17}, palatability\textsuperscript{78}, stress\textsuperscript{79}, form of energy\textsuperscript{80}, social facilitations\textsuperscript{77}, environment and perceived expectations. Since appetite is a behavior it is difficult to measure, therefore, it takes on the requirement of measurement in multiple ways\textsuperscript{43}. A common method for measuring changes in appetite ratings in within-participant studies, to see different effects between treatments, is a visual analogue scale, which observes the behavior change over time\textsuperscript{44,45}. The validity of this questionnaire has been established as a reliable source\textsuperscript{45,64}. The use of visual analogue scales have been studied to verify the prediction of energy intake. After reviewing 64 papers, Holt et al.\textsuperscript{52} found that in 51% of the studies reviewed,
there was no statistical correspondence of appetite rating responses to energy intake. With only half of the studies showing no predictive intake, this leaves room to question if appetite responses do in fact sometimes predict energy intake.

Individuals will respond differently to both exercise regimen and caloric restrictions since there is some genetic predispositions of obesity. Appetite stimulants are often driven upwards in an exercise–induced deficit state, while some individuals have better satiety signaling, which aids in the increased weight loss\textsuperscript{24}. For those who are capable of tolerating the energy deficit encountered by exercise, hunger and energy intake may be attenuated compared to those who are not. This diversity and variability can make it difficult to promote a one-size-fits-all answer. The concept of an ‘energy gap’ has been proposed, where a constant state of positive energy imbalance occurs\textsuperscript{25}. This can be closed, or shrunk by increasing physical activity and decreasing daily food intake. If appetite is regulated by exercise, and there is no association of an increased energy intake after the induced deficit, then in time, these changes could lead to a negative energy imbalance. It has been hypothesized that a reason physical activity does not have a higher decrease in weight loss is due to a possible compensatory increase in energy intake. The purpose of the current study is to study the effects of physical activity and sedentariness on energy intake. Our hypothesis is that increased physical activity will have an increase in energy intake, but with an increase in energy expenditure, it will result in an energy balance.
CHAPTER 3: MATERIALS & METHODS

A randomized crossover study design was used to investigate the effect of altered physical activity on appetite. The study included three treatment groups: control, active, and sedentary. Each testing period lasted two weeks with a washout period of at least 14 days between the active and sedentary periods.

Potential participants were informed about the study through a mass email sent to Iowa State University faculty and staff, a local newspaper advertisement, and flyers posted near and around the Iowa State University campus. Interested individuals were initially screened by phone through self-report measures to determine eligibility. After the pre-screening, eligible participants were brought to the laboratory to confirm measurements met standards for the study.

Participants were recruited subject to the following inclusion criteria: male, age 25-35 years old, body mass index (BMI) between 25-35 kg/m², and were available for a three month period to attend test sessions. Potential participants were excluded if they: used tobacco products, had the presence of any chronic disease, were regular exercisers (> 3 times a week for > 20 minutes during the past 6 months) or were unable to complete the exercise protocol.

Height was measured using a calibrated stadiometer (Ayrton model S100) and weight using a calibrated scale (Detecto model 758C). Blood pressure was measured using an Omron digital upper arm blood pressure monitor (Intellisense HEM-907XL). If participants met the eligibility criteria, they were invited to sign an informed consent document to enroll in the study. Before beginning the study,
participants completed a 5-7 day run-in period to estimate their normal activity using a Sensewear armband.

All eligible participants were required to complete the three test periods. The participants completed the control period first before completing the active and sedentary test periods in a random order. The participants were randomly assigned to a test period order using Excel RANBETWEEN function to generate a random number between 1 and 2, prior to which number 1 was assigned sedentary and number 2 was assigned the active condition.

Before starting test sessions, participants completed a fitness test while walking on a treadmill. The fitness test measured oxygen consumption while reaching their VO2 maximum. Bruce Protocol\textsuperscript{105} was used during the fitness test to determine energy needing to be expended by each individual in one week’s time prior to the start of their active period. During the fitness test the individual’s heart rate (using Polar Electro T31 monitor), blood pressure, and Rate of Perceived Exertion (RPE) were monitored. The RPE was measured using Borg’s\textsuperscript{106} scale ranging from 6 (no exertion at all) to a 20 (maximal exertion).

For each treatment condition participants wore three monitors recording steps and activity, along with other parameters. Close to 24 hours were recorded for each participant during the two-week periods of sedentariness, increased activity, and normal activity. The SenseWear Professional 7.0 Armband (Bodymedia Inc. Pittsburgh, PA), activPAL 7.2.32 version (PAL Technologies Ltd 2013), and a FitBit Charge were given to participants to keep track of their steps and activity.
throughout the study. During each treatment period, participants were also called at random by different registered dieticians on three occasions (2 weekdays and 1 weekend day) to estimate food consumption. The participants were given a portion size manual to use as a reference when called, and the dietitians used a 24 hour dietary recall to assess normal dietary intake. The participants began their baseline period of two weeks, maintaining their normal activity (approximately 7,000 steps/d). After the two week baseline period, participants reported to the laboratory for an appetite measurement session.

For each appetite measurement session, participants reported to the laboratory first thing in the morning following a 12 hour overnight fast. Participants were also asked to avoid exercise for the 24 hours before each test session. During each session the participant's height and weight was measured. Body composition was also measured using Hologic Dual-energy X-ray Absorptiometry (DXA) and handheld bioelectrical impedance analysis. Each participant completed a questionnaire on an iPad determining their baseline appetite sensations. Questions asked were: “How hungry do you feel right now?” “How satisfied do you feel right now?” “How full do you feel right now?” “How much do you think you can eat right now?” “Would you like to eat something sweet?” “Would you like to eat something salty?” Would you like to eat something savory?” Would you like to eat something fatty?” Responses were measured using a visual analogue scale anchored with opposing statements at each end (e.g. not hungry at all or as hungry as I have ever felt). Each response was stored on an iPad with a time and date stamp to check for protocol compliance.
Participants also completed the 51-item Three Factor Eating Questionnaire (TFEQ)\textsuperscript{46}, and the evaluation of food cravings by the Control of Eating Questionnaire (CEQ)\textsuperscript{47}. After completion of the questionnaires, participants had an indwelling catheter inserted into their arm by a trained nurse. After a 5 minute period to acclimatize to the indwelling catheter, a baseline blood draw (t0) was taken. A spaghetti and sauce meal that provided 500 kcal, (Barilla spaghetti, Barilla regular pasta sauce, and shredded low-fat mozzarella cheese) (55% CHO, 20% protein, and 25% fat) and 240ml of water was then provided to participants, which they were required to eat, in its entirety, within 15 minutes. After the meal was consumed another blood sample was collected and a new appetite questionnaire was completed (t15). Further blood samples were collected and appetite questionnaires completed at t0+30, 45, 60, 90 120, 150 and 180 minutes. At minute 60, additional surveys were given including the Perceived Stress Scale (PSS)\textsuperscript{48}, Profile of Mood States (POMS)\textsuperscript{49}, and Pittsburg Sleep Quality Index (PSQI)\textsuperscript{50}. Two-hundred and forty milliliters of water was also given at 60 and 120 minutes. Following the final blood draw, the indwelling catheter was removed. Participants were then invited to eat an ad lib pizza (Hy-Vee Three-cheese) buffet, containing a total of 1,770 calories per pizza with 8g fat, 12g protein, and 41g CHO in each serving. There was no time limit on this meal, although the length of the meal was recorded. The amount eaten was determined by weight of the plate of food before and after serving, and was conducted without the knowledge of the participant. Each plate of pizza was measured by weight prior to and after consumption to evaluate calories.
consumed using an equation that took the grams consumed divided by total grams in pizza (250 grams), then multiplied by the calories in the whole pizza (1770 calories). After this test meal was completed, the participant completed a final appetite questionnaire.

During the active treatment period, participants completed 3 to 6 bouts of exercise per week on a treadmill (Precor USA 966i) in the laboratory. The bouts of walking included a warm-up and cool-down, and lasted between 30 to 70 minutes at a brisk pace at an incline chosen by the participant. The length of time, speed, and incline were dependent on participant's predetermined energy expenditure goal from the calculation 17.5 kcal/kg/body weight. Participants' heart rates (HR) were measured throughout this activity and kept between 40% and 60% of their VO2 maximum that was determined during the fitness test. A calculation was done to determine the energy expended per session using HR, speed/incline of treadmill, and time spent exercising. In addition to the laboratory exercise sessions, participants were required to take at least 12,500 steps per day. The number of steps were self-monitored using the FitBit Charge, and evaluated upon completion of the period by staff using the data from the Sensewear armband (Bodymedia version 7.0) and activPal (software version 7.3.32). Compliance was also measured using the prescribed caloric energy needs and the length of time the activPal and armband monitors were worn, which was 24 hours only removed for water activities. Non-compliance was defined as meeting less than 90% of their prescribed caloric expenditure requirement.
The sedentary period consisted of taking a maximum of 4,500 steps per day, using the same tools to measure as the active and control treatment periods. During this period, participants were called to give a self-report of compliance, and again, this data was assessed by staff upon completion of the period.

Compliance for steps was calculated using the steps achieved divided by the step goal multiplied by 100, resulting in a percent compliance. For the compliance in the active condition, the number of calories they expended divided by the calorie goal determined the percentage compliance.

JMP Statistical software version 12.0.1 (2015 SAS Institute Inc.) was used for all statistical analysis. Data is presented as mean ± standard deviation and statistical significance is defined as $\alpha < 0.05$. A one-way analysis of variance (ANOVA) and post hoc Tukey HSD were used to test the differences in energy expenditure and steps per day via Sensewear Armband between treatments using ID as a random effect variable to account for the individuals repeating treatments. Analysis on energy intake between treatments during the ad lib meal and estimated by the 24 hour recalls were done using a Tukey HSD analysis and ordered details report. A Student’s t-test was run to determine if the differences in active and sedentary from the control treatment was significant for energy consumption from the 24 hour recalls. A fixed effects analysis was run to determine whether the sequence or period order had any effect on results. An ANOVA test was used to analyze the interactions between the appetite ratings and the energy intake at the ad lib meal between each treatment. Lastly, the
visual analogue scale responses used an ANOVA analysis to determine difference in responses between treatments.
CHAPTER 4: RESULTS

Twelve overweight and obese males age ranging from 25-35 years old (31 ±3), and with a BMI of 25-35 kg/m² (27.6 ±3.1) participated in this study. For the active treatment, the males met greater than 95% compliance of prescribed energy expenditure. Those on the sedentary treatment had a 79.4% compliance of steps achieved. Table 1 shows the characteristics of the sample group, along with the steps per day on average.

Table 1: Sample characteristics of the study group (mean ±SD)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men (n)</td>
<td>12</td>
</tr>
<tr>
<td>Age (y)</td>
<td>31 ±3</td>
</tr>
<tr>
<td>VO2 max (ml/kg/min)</td>
<td>32.9 ±4.7</td>
</tr>
<tr>
<td>Average steps during run-in (steps/d)</td>
<td>6,816 ±1,611</td>
</tr>
</tbody>
</table>

There was no statistically significant changes in body weight or percent body fat over the course of the study. Table 2 shows the average body composition measurements over each treatment condition.
Table 2: Body composition characteristics of the study group (mean ±SD)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Control Treatment</th>
<th>Sedentary Treatment</th>
<th>Active Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>87.4 ±10.1</td>
<td>87.1 ±10.3</td>
<td>87.2 ±10.0</td>
</tr>
<tr>
<td>% body fat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DXA</td>
<td>34.4 ±2.7</td>
<td>34.5 ±2.7</td>
<td>34.3 ±2.4</td>
</tr>
<tr>
<td>BIA</td>
<td>22.9 ±3.6</td>
<td>22.7 ±3.6</td>
<td>23.1 ±3.8</td>
</tr>
<tr>
<td>In-Body</td>
<td>26.9 ±5.3</td>
<td>25.0 ±3.8</td>
<td>25.5 ±4.2</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.6 ±3.1</td>
<td>27.5 ±3.3</td>
<td>27.2 ±2.6</td>
</tr>
</tbody>
</table>

Energy Expenditure

The Senswear armband (SWA) compliance shows that for all three treatment periods, on average, the men wore their monitor for 23.00 ±0.13 hours. Table 3 shows the average steps during the control, active, and sedentary treatments were 6,784 ±1,515, 12,382 ±1,521, and 5,942 ±1,310, respectively. There were statistically significant differences in the number of steps taken between treatments F(2,22)=87.38 p<0.001, but not between subjects F(11,22)=1.85 p=0.11, or sequence F(1,22)=0.87 p=0.36. There was no statistically significant difference in average steps per day between the control condition and the sedentary condition (p= 0.27). There was a statistically significant difference in average steps per day between control and active (p<0.001), and sedentary and active conditions (p<.001). Energy expenditure using the Sensewear Armband was statistically significant between the active and sedentary treatments (F (2)=
3.65 $p=0.03$), but not between active and control ($p=0.18$), nor control and sedentary treatments ($p=0.70$). Mean energy expenditure in calories for control, sedentary and active were $2919 \pm384$, $2784 \pm361$ and $3221 \pm465$, respectively. Additionally, physical activity (METs 3.0) daily duration was statistically significant between active and control treatments ($F (2)= 12.78$, $p=0.006$), and between active and sedentary treatments ($p<0.001$), but no significant difference between control and sedentary treatments ($p=0.23$). The average daily duration of physical activity in hours per day for control, active and sedentary treatments was $1.6 \pm0.8$, $2.6 \pm0.9$ and $1.0 \pm0.6$, respectively.

Table 3. Energy expenditure differences between treatments using different measurements (mean ±SD).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Sedentary</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steps (average/d)</strong></td>
<td>$6,784 \pm1,515$</td>
<td>$5,942 \pm1,310$</td>
<td>$12,382 \pm1,521$</td>
</tr>
<tr>
<td><strong>Energy Expenditure (Kcals)</strong></td>
<td>$2919 \pm384$</td>
<td>$2784 \pm361$</td>
<td>$3221 \pm465$</td>
</tr>
<tr>
<td><strong>Duration of PA- 3.0 METs (hours)</strong></td>
<td>$1.6 \pm0.8$</td>
<td>$1.0 \pm0.6$</td>
<td>$2.6 \pm0.9$</td>
</tr>
<tr>
<td><strong>Average wear time for SWA (hours)</strong></td>
<td>$22.95 \pm0.61$</td>
<td>$23.13 \pm0.35$</td>
<td>$23.21 \pm0.29$</td>
</tr>
</tbody>
</table>

*Energy Intake*

The mean energy intake after the consumption of the ad lib pizza meal can be seen in Figure 1. Energy consumed with subject, group, and sequence as random effects found no significant effect of sequence on energy consumed
F(1,22)=0.77 p=0.39, but effects by treatment F(2,22)=4.67 p=0.02, and by subject F(10,22)=9.57 p<0.001. A significant difference in consumption between the control and sedentary groups (p=0.02) was seen, but no difference in consumption between the active and sedentary groups (p=0.12), nor was there a difference in consumption between the control and active (p=0.62). There is a correlation between mean energy consumed at the ad lib meal and energy consumed during the control treatment and the energy consumed in active and sedentary treatments using ID as a random effect, with a p< 0.001. As the energy consumed during control treatment increased, the energy consumed in sedentary (95% CI, 17-225) and active (95% CI, -59-149) treatments increased.

![Mean Intake at Ad Lib Meal](image)

**Figure 1.** Mean calories consumed ad lib at a lunch meal 3 hours after a standardized breakfast meal was given for control, sedentary, and active treatments. Letters not connected by the same letter are significantly different.
The data from the dietary assessments included up to 9 dietary recalls for each individual. The data showed no significant difference in energy consumption between treatments $t(1) = 0.006$, $p=0.99$. Data was collected on total energy intake, macronutrients, and micronutrients. Table 4 shows there was also no significant difference in carbohydrate, protein and fat intake between each treatment.

Table 4. Average energy, carbohydrate, protein and fat intake in natural environment among all treatments and the p-values for differences between treatments.

<table>
<thead>
<tr>
<th></th>
<th>Control Treatment</th>
<th>Sedentary Treatment</th>
<th>Active Treatment</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (Kcal)</td>
<td>2232 ±576</td>
<td>2109 ±470</td>
<td>2270 ±585</td>
<td>0.995</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>261.9 ±73.4</td>
<td>268.6 ±64.3</td>
<td>271.3 ±70.2</td>
<td>0.652</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>86.2 ±26.4</td>
<td>75.8 ±20.1</td>
<td>86.8 ±25.7</td>
<td>0.974</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>89.7 ±30.2</td>
<td>75.2 ±28.9</td>
<td>86.2 ±29.6</td>
<td>0.298</td>
</tr>
</tbody>
</table>

*Appetite Questionnaires*

Figure 2-5 shows the response over the 3 hours for the appetite questionnaires and the area under the curve for each rating during each treatment condition. The AUC was determined using the responses for the time points between the 2 meals. There are missing responses for 5 time points, and 2 half-completed responses. We included the individuals with missing data points, but the responses that were missing were left null when running statistics.
Overall, the individual responses varied widely with one another, however, the mean of the data showed some trends. Between meals the responses showed an increase in hunger and decrease in satisfaction, until the ad lib meal was given, which was succeeded by another spike in responses data similar to the first meal. This is reflected in each treatment condition. A regression analysis was done to evaluate the effects of the VAS questionnaire on energy intake, while controlling for any effects of treatment and subject. One subject was missing their final VAS data in the control setting so the immediately prior survey (at 150 minutes) was substituted in our analysis. There was a statistically significant effect of treatment ($t=2.415$, $p=0.03$) and of hunger ratings ($t=-2.33$, $p=0.03$) on energy consumption, but no statistically significant effect from reported satisfaction ($p=0.07$), perceived food consumption ($p=0.07$), or fullness ($p=0.13$). Responses for sweet, salty, savory, and fatty are shown in figure 6, and there is no statistical significant difference ($p>0.005$) between each treatment.
Figure 2. Mean subjective appetite ratings over the 3-hour time points for hunger and the area under the curve (AUC) for control (C), sedentary (S) and active (A) treatments. Each error bar is constructed using 1 standard deviation.
Figure 3. Mean subjective appetite ratings over the 3-hour time points for satisfaction and the area under the curve (AUC) for control (C), sedentary (S) and active (A) treatments. Each error bar is constructed using 1 standard deviation.
Figure 4. Mean subjective appetite ratings over the 3-hour time points for fullness and the area under the curve (AUC) for control (C), sedentary (S) and active (A) treatments. Each error bar is constructed using 1 standard deviation.
Figure 5. Mean subjective appetite ratings over the 3-hour time points for perceived food consumption and the area under the curve (AUC) for control (C), sedentary (S) and active (A) treatments. Each error bar is constructed using 1 standard deviation.
Sweet

Salty
Figure 6. Responses from the VAS questionnaires over the 3-hour time point on wanting to eat something sweet, salty, savory and fatty for the control (c), sedentary (s) and active (a) treatments. Each error bar is constructed using 1 standard deviation.
Using an ANOVA analysis, all time points for all questions were reviewed, and any significant differences between treatment conditions were measured. Following a Bonferroni adjustment, there were no significant differences between treatment conditions for any of the time points, among all questions with p values shown in Table 5.

**Table 5**: P-values for treatment differences between appetite ratings over the 3 hour time points for each question in the visual analogue scale.

<table>
<thead>
<tr>
<th>Question</th>
<th>T0</th>
<th>T15</th>
<th>T30</th>
<th>T45</th>
<th>T60</th>
<th>T90</th>
<th>T120</th>
<th>T150</th>
<th>T180</th>
<th>Tfinal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hunger</strong></td>
<td>0.035</td>
<td>0.381</td>
<td>0.692</td>
<td>0.316</td>
<td>0.973</td>
<td>0.790</td>
<td>0.642</td>
<td>0.755</td>
<td>0.736</td>
<td>0.966</td>
</tr>
<tr>
<td><strong>Satisfaction</strong></td>
<td>0.656</td>
<td>0.707</td>
<td>0.840</td>
<td>0.712</td>
<td>0.450</td>
<td>0.747</td>
<td>0.945</td>
<td>0.912</td>
<td>0.999</td>
<td>0.688</td>
</tr>
<tr>
<td><strong>Fullness</strong></td>
<td>0.924</td>
<td>0.412</td>
<td>0.928</td>
<td>0.807</td>
<td>0.495</td>
<td>0.662</td>
<td>0.531</td>
<td>0.918</td>
<td>0.657</td>
<td>0.596</td>
</tr>
<tr>
<td><strong>Perceived Food</strong></td>
<td>0.629</td>
<td>0.722</td>
<td>0.842</td>
<td>0.991</td>
<td>0.243</td>
<td>0.670</td>
<td>0.728</td>
<td>0.638</td>
<td>0.140</td>
<td>0.254</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 6**: Average score for all three treatments for all questionnaires (mean±SD).

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Control Treatment</th>
<th>Sedentary Treatment</th>
<th>Active Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFEQ</td>
<td>33 ±16</td>
<td>30 ±16</td>
<td>30 ±19</td>
</tr>
<tr>
<td>CEQ</td>
<td>46 ±13</td>
<td>49 ±12</td>
<td>50 ±14</td>
</tr>
<tr>
<td>POMS</td>
<td>85 ±10</td>
<td>83 ±10</td>
<td>86 ±9</td>
</tr>
<tr>
<td>PSQI</td>
<td>5 ±2</td>
<td>5 ±2</td>
<td>5 ±2</td>
</tr>
<tr>
<td>PSS</td>
<td>14 ±6</td>
<td>14 ±7</td>
<td>14 ±7</td>
</tr>
</tbody>
</table>
The other questionnaires that were completed, including the TFEQ, CEQ, POMS, PSQI, and PSS are listed in Table 6 as average response from the sample population. There was no significant difference in responses between the three treatments ($p > 0.05$) for all questionnaires.
CHAPTER 5: DISCUSSION AND SUMMARY

In the context of this randomized crossover study involving three 2 week periods of different levels of activity, ranging from less than 4,500 steps per day to 12,500 steps per day, we measured changes in appetite regulation through subjective appetite rating questionnaires and energy consumption during an ad lib lunch meal.

These data show that the short-term exercise training bouts versus the control condition resulted in no significant difference in energy consumption between treatments. From this, we can conclude that there was no compensatory increase in food intake after the two weeks of increased physical activity under laboratory conditions. These results do not support our hypothesis of a compensatory increase in energy intake after increasing physical activity. There was however a statistically significant increase in food consumption during the ad lib test meal between sedentary and control treatments. When people were sedentary for two weeks, they ate a larger amount at the test meal. This result of increased energy intake is supported by the hypothesis that sedentariness is suggested to be a source of overconsumption\(^{35}\). There was a significant difference between steps per day during active versus control treatments and active versus sedentary, but no significant change in steps per day between sedentary and control treatments remains. The unchanged step counts and energy expenditure make this significant difference unexplainable. While other
research has found different conclusions\textsuperscript{107}, these results support other findings of no compensatory increase in energy intake after exercise\textsuperscript{67, 17, 108}.

When measuring the interaction between each appetite rating in the visual analogue scale at time point 180 and energy intake to see a predictive effect, there was a significant difference in hunger, but no difference in the other ratings. This conclusion of appetite rating being a moderate predictor of energy intake is reiterated in other literature. The visual analogue scale mean responses to hunger, perceived food consumption, fullness and satisfaction did not show a statistically significant difference over time, between treatments. As expected, there was a spike before and after the consumption of the breakfast meal, and also the ad lib meal. These data show that in response to change in physical activity, there is no change in appetite ratings, at least in a two week timeframe. The short-term duration of this lifestyle change could be a cause for the lack of change in appetite, but more evidence is needed to determine this. The lack of difference could also be due to measuring their appetite ratings at least 24 hours following their last activity session (during the active treatment). While other studies measured the appetite ratings immediately after an acute bout of exercise\textsuperscript{26, 32, 33}, we measured the following day. This coincides with the belief of a delay in appetite change from exercise\textsuperscript{28}. The other questionnaires displaying disinhibition and restraint of food intake, cravings, perceived stress, mood, and sleep quality showed no statistically significant changes between treatments.

Previous research has shown that of the three monitors given, all were shown to have an underestimation in step count\textsuperscript{51}. All three monitors used are seen as
common under estimators of steps at a slower pace, with the FitBit and activPal having the lowest mean percentage error\textsuperscript{51}. This may result from their purpose being created for an increased pace. Although Sensewear armband shows to have the highest mean percent error among the three\textsuperscript{51}, the underestimation is not pertinent since the data that is not in compliance (being too high) is the sedentary treatment step count. This indicates that although it may not have recorded exact amount of steps, it did not underestimate a specific condition more than others. There is room for error with these monitors, however the randomization of handing them out to individuals would result in random bias. Sensewear armband was chosen as the monitor for step analysis because the wear compliance was the highest among the monitors and there were no missing data. Overall, the control and sedentary conditions only differed by 842 steps per day, which was not significantly different. Although there was a low compliance in the sedentary condition, the higher accuracy of the FitBit monitoring the steps taken may indicate that the participants believed they were increasing their steps to a higher degree. This agrees with the participants’ self-report of more steps taken than what was shown on the armband. Regardless of accuracy, the monitors do show a consistent ratio of activity change.

Since the same timeframe and meals were provided at each measurement session, this may have resulted in a training effect in the participants, knowing their taste for the pizza and having the opportunity to consume what they wanted elsewhere after leaving the laboratory. Since we could not measure their intake immediately following the lab visits, we are unsure if they did in fact compensate
for the increased energy expenditure or increased sedentariness following the provided ad lib meal. The dietary recall data reflected their normal eating behaviors. Although this data does not give picture to what they ate directly following a measurement session, this method can give a better idea of what a normal diet consists of for each participant, in which no statistically significant differences between treatments were reflected. Energy intake at the ad lib meal, along with the VAS questionnaire allows us to better identify feeding behavior. This conclusion supports the idea that there are many factors influencing energy intake apart from physical activity such as stress, eating environment, social facilitations, and more. More research in which all these variables are accounted for is needed to see which factors represent the greatest influence on eating behavior.

**Limitations**

Some limitations for this study include the control treatment period being first for everyone, which was not included in randomization. The purpose of not including control in the randomization was to acclimate the participants to the study without immediately making them undergo a lifestyle change. This could lead to a recognition of protocol, and therefore a training effect. Brunstrom suggests that, since many of us are experts at eating, the selection process of portioning is practiced and learned instead of novel, leading to an expected satiation. A possible solution for further research would be to include a control
period between the two active conditions to have the participants resume their normal activity and monitor that instead of just a washout period, or to include the control period in the randomization.

Although the use of visual analogue scales have been validated by other studies\textsuperscript{45,64}, the responses could have been the result of priming from the questions. This may have influenced appetite as questions were directed towards making participants think about hunger. Participants were not told about the caloric content in either meal, however, the questionnaire could have made them think about the caloric intake and therefore cause a reduction in the amount they were eating. Again, since appetite is a behavior, it is difficult to measure, and should include various tools of measurement.

The initial rating of spaghetti meal was tested and approved by study staff, however, the participants never rated palatability. When participants ate it, there were some comments on their displeasure for it as a breakfast option. Other options of breakfast items that maintain the 500 calorie criteria could be used. Also, having the participants rate the palatability of the food prior to beginning the study is necessary, as palatability has been shown to greatly influence eating behavior\textsuperscript{78}.

Since this was a pilot for a larger study, a power calculated sample size of 40 was determined, being much larger than our sample size of 12. Additionally, the budget only allowed for a smaller sample size. With such a small sample size, the possibility of outliers may skew the results. A larger sample, more reflective
of the power calculation value, would give a better representation of the population and form a better picture for analysis. This study was only targeted to a certain population, young healthy men, which may not be universally appropriate. The purpose of the sample size only including men was for uniformity due to the small population. The fully powered study will include both men and women with a larger sample population.

Future research will include a larger sample, a more diverse population, and blood samples taken from this research sample will be analyzed and appetite hormones will be assessed. Future research should evaluate energy intake immediately following exercising or sedentary bouts, or participants should be given a diet diary to record intake following measured energy intake to evaluate any compensatory intake following exercise or sedentary bouts.
REFERENCES


77. de Castro JM, Brewer EM. The amount eaten in meals by humans is a power function of the number of people present. *Physiol Behav*. 1992 Jan;51(1):121-5.


Title of Study: Appetite and adiposity across a continuum of activity (The AAA Study)

Investigators: Laura Ellingson, PhD, James Hollis, PhD, Mark Lyte, PhD, Gregory Welk, PhD and Robin P. Shook, PhD

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

Introduction

The purpose of this study is to understand what happens when someone either becomes more active or more inactive. This study will measure your energy intake, energy expenditure, and body composition under normal conditions, when you become active, and when you become inactive.

You are being invited to participate in this study because you are a healthy adult between the ages of 22-40. You should not participate if you have any metal or food allergies, a current or past diagnosis of an eating disorder, are pregnant, trying to get pregnant, have given birth within the last 12 months or are within 6 months of post-lactation, or any self-reported significant cardiovascular diseases.

Description of Procedures

If you agree to participate, you will be asked to take part in an orientation session followed by three measurement sessions which will occur following two weeks of normal activity, two weeks of being active, and two weeks of being inactive. In between each activity period, there will be a two week period when you resume your normal level of activity. Your participation will last for approximately three months. All activities will take place at the Nutrition and Wellness Research Center (NWRC).
At the orientation session, your blood pressure, height, and weight will be measured. Following the orientation visit you will be emailed a link to a survey to answer questions about your medical history and other health-related behaviors.

Following the orientation session you will be asked to participate in a Fitness test where you walk/jog on a treadmill. This test will take 10-15 minutes and will involve exercising at increasing levels of intensity, until you reach maximal effort. Heart rate, blood pressure, and breathing will be monitored throughout the entire test.

Baseline period:

- During this two week period you will maintain your normal level of activity, accumulating between 5000-7000 steps per day.

Active period:

- Exercise training: You will be asked to participate in a physical exercise program. This will require attending 3-6 sessions per week at the NWRC during center hours. The program will consist of walking/jogging on a treadmill for a given amount of energy expenditure (calories burned) per week.

- You will also be asked to accumulate at least 12,500 steps per day for a two week period. This can be achieved by taking the steps at work or parking a little further away from the entrance at the store, in addition to the exercise training you will also be asked to do. The activity monitor you will be wearing will provide feedback so you know how many steps you have accumulated during the day.

Sedentary period:

- You will be asked to reduce the number of steps you take to less than 4,500 per day. This can be achieved by taking the elevator at work or parking a little closer to the entrance at the store. The activity monitor you will be wearing will provide feedback so you know how many steps you have accumulated during the day.

Measurement sessions:
At the end of each period described above, you will complete a measurement session. The following measures will take place during each measurement session. In preparation for the measurements conducted during this visit, you will be asked to stop eating and drinking (except for water) for 12 hours before coming for the laboratory visit. This session will last approximately 5 hours.

- **Body Scan** to evaluate your body composition and amount of fat (DXA scan and InBody). A DXA scan (dual energy x-ray absorptiometry scan) is a type of X-ray scan used to measure body composition (lean body mass and fat composition). DXA is a non-invasive procedure that involves approximately 1/10 the radiation in a normal X-ray. During the scan, you will be asked to lie on a table. A detector will be slowly passed over your body. The entire procedure should take approximately 10 – 20 minutes. This measurement will occur while you are wearing hospital scrubs and bare feet. An InBody scan will take approximately 30 seconds and will involve standing barefoot on a special scale that can measure the amount of water in your body.

- Because of the small amount of radiation you will be exposed to during the body scan, females will be required to take a pregnancy test that involves a urine measurement.

- Because the InBody involves a safe, small amount of electrical current, individuals with a pacemaker should not perform this test.

- **Resting Metabolic Rate** where we measure the amount of oxygen you use for 45 minutes while you are lying down. You will lie down on a bed and a canopy will be placed over your head to measure the amount of air you breathe in and out. The canopy has a hole in it to allow for you to breathe in normal room air during the entire test.

- **Blood draw** (approximately 2.5 teaspoons) to determine blood fats and other blood components.

- You will be provided two meals during the measurement session, one that is a specific amount and another where you can eat as much as you like.

- Prior to and after the meals, you will be asked to complete short questionnaires that ask you about your hunger and how full you feel.

- **Consume enriched water.** This is a non-radioactive, noninvasive, harmless technique that allows a precise measurement of energy metabolism. This water is the same as the water you drink out of a drinking faucet, and does not look or taste different. However, it has been filtered extensively to only include certain molecules, which makes it slightly heavier. This difference is very small and can be measured only with very specialized equipment.

- **Urine collection** to determine the amount of enriched water in your body. These collections will occur three times over a two week period; on the day you drink the enriched water, seven days later, and seven days after that.

- **Provide three self-collected fecal samples.** By analyzing these samples, we can determine different types of gut bacteria that live in all of us. You will be given a pre-labeled container and detailed instructions for collection and delivery to the NWRC for
storage. This assessment is optional, and will not prevent you from participating in other parts of the study.

- **During each activity period, participants will be asked to:**
  - Complete random 24-hour dietary recalls. Someone will call you and ask you to report everything you have eaten in the previous 24 hours. You will be asked to complete 3 random recalls during each period.
  - Wear a small armband on the back of your upper arm, a small monitor on your upper leg, and a monitor on your wrist, all which track your physical activity. You will be asked to wear the monitors for 14 days while awake and sleeping.

## Risks or Discomforts

While participating in this study you may experience the following risks or discomforts:

- You may experience temporary pain during the blood draw and finger stick, with later bruising at the puncture site. There is also a slight risk of infection at the blood draw site.
  
  o Only specially trained staff (nurses) will collect blood samples. Clean needles and sterile techniques will be used to reduce the risks associated with blood draws.

- Wearing activity monitors poses no known risks. However, you may feel some discomfort while initially getting used to wearing the monitors. Those with an allergy to nickel may experience a rash from the arm activity monitor, in addition, a small percent of participants have developed a rash associated with the adhesive from the leg activity monitor. If you experience any irritation, itching or redness while wearing either monitor stop wearing the monitor immediately and inform the study staff by phone or email.

- While the radiation used for the body fat scan (DXA scan) has no observable radiological or biological effect, there is always a risk associated with radiation exposure.

- Pregnant women can NOT take part in the body fat scan. Please tell the study technician if you are pregnant or if you think you might be pregnant. As mentioned above, all women will take a pregnancy test prior to this measurement.

- Because the InBody involves a safe, small amount of electrical current, individuals with a pacemaker should not perform this test.

- During the fitness test you will experience an increase in heart rate and blood pressure. Additionally, sweating will occur, you may become fatigued, all of which are to be expected with exercise training. It is also possible that abnormal responses may occur such as dizziness, unusually high increases in heart rate and blood pressure, and in rare instances, fainting. Trained personnel will be on hand during the fitness test. Emergency equipment is kept in the exercise testing room and all staff have been trained in its use. Following the fitness test, you may experience muscle soreness for a few days.
• Following participation in the exercise training program, you may experience some mild muscle or joint soreness from the exercise.

• During the study you will be asked to eat a pasta and pizza meal. Please let us know if you are allergic to noodles, tomato pasta sauce, or pizza.

Benefits

If you decide to participate in this study, there may be no direct benefit to you. It is hoped that the information gained in this study will benefit society by understanding what happens when someone becomes active or inactive.

At the end of the study you will also receive a personalized report and a free counseling session with study staff to discuss the results from the measures/tests you took part in during the study (blood pressure, cholesterol levels, body fat, etc.). All of these tests will provide you with important information about your health status at no cost to you. You will also receive a personalized exercise program from a certified exercise professional to complete on your own based on your goals.

Costs and Compensation

You will not have any costs from participating in this study. You will be compensated for participating in this study up to $450 ($100 for completion of activity period of the baseline period; $150 for completion of the sedentary or active period, whichever comes first; $200 for completion of the sedentary or active period, whichever comes last). You will need to complete a form to receive payment. Please know that payments may be subject to tax withholding requirements, which vary depending upon whether you are a legal resident of the U.S. or another country. If required, taxes will be withheld from the payment you receive. You will need to provide your social security number (SSN) and address on the form in order for us to pay you.

This information allows the University to fulfill government reporting requirements. Confidentiality measures are in place to keep this information secure. You may forego receipt of payment(s) and continue in the research study if you do not wish to provide your social security number and address. Information regarding documentation required for participant compensation may be obtained from the Controller’s Department: 294-2555 or http://www.controller.iastate.edu.
Participant Rights

Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. You can skip any questions that you do not wish to answer.

If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

Confidentiality

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken: Study data will be stored in locked filing cabinets and protected computer files at the Iowa State University. All data collected during the project will be strictly confidential. A random ID number will be assigned to each participant at the beginning of the project. Your ID number (not your name) will be used on project records. No one other than the study researchers will be able to link your information with your name. Your name will not be used in reporting the results of this study nor with the process of data collection. De-identified study records may be shared with other researchers, and the results of the study may be published or presented at seminars, but your identity will not be revealed. All researchers involved with this project have signed confidentiality statements saying that they will not reveal any information learned during this study. After the study is completed, all forms with your name will be destroyed.

Questions

You are encouraged to ask questions at any time during this study. For further information about the study, contact Laura Ellingson, PhD, 515-294-2552, ellingl@iastate.edu.
Consent and Authorization Provisions

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed)

________________________________________________________

________________________________________________________

Participant’s Signature       Date
APPENDIX B

AAA Study

Visual Analogue Scale

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Please make a vertical mark on each line at the point closest to how you feel right now

Questions to assess feelings of hunger, satiety, fullness, prospective food consumption, desire to eat something fatty, salty, sweet or savory

1) How hungry do you feel?
   I am not hungry at all                                                I have never been more hungry

2) How satisfied do you feel?
   I am completely empty                                                I cannot eat another bite

3) How full do you feel?
   Not at all full                                                        Totally full
4) How much do you think you can eat?
Nothing at all ___________ A lot ___________

5) Would you like to eat something sweet?
Yes, very much ___________ No, not at all ___________

6) Would you like to eat something salty?
Yes, very much ___________ No, not at all ___________

7) Would you like to eat something savory?
Yes, very much ___________ No, not at all ___________

8) Would you like to eat something fatty?
Yes, very much ___________ No, not at all ___________
APPENDIX C

Eating Attitude questionnaire

- This questionnaire contains a number of statements. Each statement should be answered either TRUE or FALSE. Read each statement and decide how you feel about it.
- If you agree with the statement, or if you feel that it is true about you then circle T next to the statement.
- If you disagree with a statement, or if you feel that it is false as applied to you, circle F next to the statement.

1) When I smell a sizzling steak or see a juicy piece of meat I find it very difficult to keep from eating, even if I have just finished a meal

2) I usually eat too much at social occasions, like parties and picnics.

3) I am usually so hungry that I eat more than 3 times a day.

4) When I have eaten my quota of calories I am usually very good about not eating any more

5) Dieting is so hard for me because I just get too hungry.

6) I deliberately take small helpings as a means of controlling my weight.

7) Sometimes things just taste so good that I keep on eating, even when I am no longer hungry.
8) Since I am often hungry, I sometimes wish that while I am eating an expert would tell me that I have had enough or that I can have something more to eat. T F

9) When I feel anxious I find myself eating. T F

10) Life is too short to worry about dieting. T F

11) Since my weight goes up and down, I have gone on reducing diets more than once. T F

12) I often feel so hungry I just have to eat something. T F

13) When I am with someone who is overeating I usually overeat too. T F

14) I have a pretty good idea of the number of calories in common foods T F

15) Sometimes when I start eating, I just can't seem to stop. T F

16) It is not difficult for me to leave something on my plate. T F

17) At certain times of the day I get hungry because I have gotten used to eating then. T F

18) While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it. T F
19) Being with someone who is overeating often makes me hungry enough to eat also. T F

20) When I feel blue I often overeat. T F

21) I enjoy eating too much to spoil it by counting calories or watching my weight. T F

22) When I see a real delicacy I often get so hungry that I have to eat it right away. T F

23) I often stop eating when I am not really full as a conscious means of limiting the amount I eat. T F

24) I get so hungry my stomach feels like a bottomless pit. T F

25) My weight has hardly changed at all in the last ten years. T F

26) I am always hungry so it is hard for me to stop eating before I finish the food on my plate. T F

27) When I feel lonely, I console myself by eating. T F

28) I consciously hold back at meals in order not to gain weight. T F
29) I sometimes get very hungry late in the evening or at night.  
   T      F

30) I eat anything I want, anytime.  
   T      F

31) Without even thinking about it I take a long time to eat.  
   T      F

32) I count calories as a conscious means of controlling my weight.  
   T      F

33) I do not eat some foods because they make me fat.  
   T      F

34) I am always hungry enough to eat at anytime.  
   T      F

35) I pay a great deal of attention to changes in my figure.  
   T      F

36) While on a diet, if I eat food that is not allowed, I often then 
    splurge and eat other high calorie foods.  
   T      F
bullet Please answer the following questions by circling the number above the response that is appropriate to you.

37) How often are you dieting in a conscious effort to control your weight?

1    2    3    4
rarely    sometimes    usually    always

38) Would a weight fluctuation of 5lbs affect the way you live your life?

1    2    3    4
not at all    slightly    moderately    very much

39) How often do you feel hungry?

1    2    3    4
only at    sometimes    often between    almost
meal times    between meals    meals    always

40) Do your feelings of guilt about overeating help you to control your food intake?

1    2    3    4
never    rarely    often    always

41) How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?
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<tr>
<td>42) How conscious are you of what you are eating?</td>
<td>easy</td>
<td>slightly</td>
<td>moderately</td>
<td>very</td>
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<td></td>
<td>difficult</td>
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<td>43) How frequently do you avoid 'stocking up' on tempting foods.</td>
<td>not at all</td>
<td>slightly</td>
<td>moderately</td>
<td>extremely</td>
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<td>44) How likely are you to shop for 'low calorie' foods?</td>
<td>almost never</td>
<td>seldom</td>
<td>usually</td>
<td>almost always</td>
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<td>45) Do you eat sensibly in front of others and splurge alone?</td>
<td>unlikely</td>
<td>slightly</td>
<td>moderately</td>
<td>very</td>
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<td></td>
<td>likely</td>
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<td></td>
<td>never</td>
<td>rarely</td>
<td>often</td>
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46) How likely are you to consciously eat slowly in order to cut down on how much you eat?

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<td>unlikely</td>
<td>slightly</td>
<td>moderately</td>
<td>very likely</td>
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47) How frequently do you skip dessert because you are no longer hungry?

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<td>never</td>
<td>seldom</td>
<td>at least</td>
<td>almost once a week</td>
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<td>every day</td>
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48) How likely are you to consciously eat less than you want?

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<td>unlikely</td>
<td>slightly</td>
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49) Do you go on eating binges even though you are not hungry?

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<td>never</td>
<td>rarely</td>
<td>sometimes</td>
<td>at least once a week</td>
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50) On a scale of 0-5 where 0 means no restraint in eating (eat whatever you want, whenever you want it), and 5 means total restraint (constantly limiting food intake and never 'giving in'). What number would you give yourself?
Eat whatever you want, whenever you want it.

Usually eat whatever you want, whenever you want it.

Often eat whatever you want, whenever you want it.

Often limit food intake, but often 'give in'.

Usually limit food, rarely 'ive in'

Constantly limiting food intake, never 'giving in'.

51) To what extent does this statement describe your eating behaviour?

'I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.'

1  2  3  4
not like me  little like me  pretty good  describes
description  me perfectly
of me
APPENDIX D

Control of Eating Questionnaire

Please answer all questions according to your experience over the last 7 days.

1. How often have you had food cravings?
   
   1  2  3  4  5  6  7  8  9  10
   
   Never                                Very often

2. How strong have any food cravings been?
   
   1  2  3  4  5  6  7  8  9  10
   
   Not at all                           Extremely
   strong                                strong

3. How difficult has it been to resist any food cravings?
   
   1  2  3  4  5  6  7  8  9  10
   
   Not at all                           Extremely
   difficult                            difficult

4. How often have you eaten in response to food cravings?
   
   1  2  3  4  5  6  7  8  9  10
   
   Never                                After every one

How often have you had food cravings for the following types of food/drink?
5. Chocolate or chocolate flavoured foods

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<td></td>
<td>Never</td>
<td>Very often</td>
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6. Other sweet foods (cakes, pastries, biscuits, etc)

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7. Fruit or fruit juice

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8. Savoury foods (french fries, crisps, burgers, pizza, etc)

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9. Which one food makes it most difficult for you to control eating?

........................................................................................................................................

10. How difficult has it been to resist eating this food during the last 7 days?

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11. In comparison with your usual eating habits, how difficult has it been during the last 7 days to control your eating?

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<td>Much easier</td>
<td>About the same</td>
<td>Much more difficult</td>
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APPENDIX E

Perceived Stress Scale- 10 Item

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a check how often you felt or thought a certain way.

1. In the last month, how often have you been upset because of something that happened unexpectedly?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

2. In the last month, how often have you felt that you were unable to control the important things in your life?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

3. In the last month, how often have you felt nervous and "stressed"?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

4. In the last month, how often have you felt confident about your ability to handle your personal problems?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

5. In the last month, how often have you felt that things were going your way?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

6. In the last month, how often have you found that you could not cope with all the things that you had to do?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

7. In the last month, how often have you been able to control irritations in your life?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

8. In the last month, how often have you felt that you were on top of things?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

9. In the last month, how often have you been angered because of things that were outside of your control?

   ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

    ___0=never   ___1=almost never   ___2=sometimes   ___3=fairly often   ___4=very often
APPENDIX F

PITTSBURGH SLEEP QUALITY INDEX

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

Please answer all questions.
1. During the past month, what time have you usually gone to bed at night?
   BED TIME ____________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?
   NUMBER OF MINUTES ____________

3. During the past month, what time have you usually gotten up in the morning?
   GETTING UP TIME ____________

4. During the past month, how many hours of actual sleep did you get at night?
   (This may be different than the number of hours you spent in bed.)
   HOURS OF SLEEP PER NIGHT ____________

For each of the remaining questions, check the one best response. Please answer all questions.
5. During the past month, how often have you had trouble sleeping because you:

   a) Cannot get to sleep within 30 minutes
      Not during the past month _____ once a week _____ a week_____ times a week_____

   b) Wake up in the middle of the night or early morning
      Not during the past month _____ once a week _____ a week_____ times a week_____

   c) Have to get up to use the bathroom
      Not during the past month _____ once a week _____ a week_____ times a week_____

   d) Cannot breathe comfortably
      Not during the past month _____ once a week _____ a week_____ times a week_____

   e) Cough or snore loudly
      Not during the past month _____ once a week _____ a week_____ times a week_____
f) Feel too cold
Not during the Less than Once or twice Three or more past month_____ once a week_____ a week_____ times a week_____

g) Feel too hot
Not during the Less than Once or twice Three or more past month_____ once a week_____ a week_____ times a week_____

h) Had bad dreams
Not during the Less than Once or twice Three or more past month_____ once a week_____ a week_____ times a week_____

i) Have pain
Not during the Less than Once or twice Three or more past month_____ once a week_____ a week_____ times a week_____

j) Other reason(s), please describe______________________________________
________________________________________________________________

How often during the past month have you had trouble sleeping because of this?
Not during the Less than Once or twice Three or more past month_____ once a week_____ a week_____ times a week_____

6. During the past month, how would you rate your sleep quality overall?
Very good ___________
Fairly good ___________
Fairly bad ___________
Very bad ___________

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?
Not during the Less than Once or twice Three or more past month_____ once a week_____ a week_____ times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?
Not during the Less than Once or twice Three or more past month_____ once a week_____ a week_____ times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?
No problem at all ___________
Only a very slight problem ___________
Somewhat of a problem ___________
A very big problem ___________
10. Do you have a bed partner or roommate?
No bed partner or room mate __________
Partner/roommate in other room __________
Partner in same room, but not same bed __________
Partner in same bed __________
If you have a roommate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring
Not during the Less than Once or twice Three or more
past month_____ once a week_____ a week_____ times a week_____

b) Long pauses between breaths while asleep
Not during the Less than Once or twice Three or more
past month_____ once a week_____ a week_____ times a week_____

c) Legs twitching or jerking while you sleep
Not during the Less than Once or twice Three or more
past month_____ once a week_____ a week_____ times a week_____

d) Episodes of disorientation or confusion during sleep
Not during the Less than Once or twice Three or more
past month_____ once a week_____ a week_____ times a week_____

e) Other restlessness while you sleep; please describe ____________________________________________
Not during the Less than Once or twice Three or more
past month_____ once a week_____ a week_____ times a week_____
APPENDIX G

Profile of Mood States

Subject’s Initials ______
Birth date ______
Date ______
Subject Code No. ______

Directions: Describe HOW YOU FEEL RIGHT NOW by checking one space after each of the words listed below:

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APPENDIX H
PARTICIPANT FLOW CHART

Total interested 87

Not Screened 30

Total screened 57

Not oriented 7

Eligible based on screener 30

Not eligible via email 8

Not interested 5

No follow-up response 17

BMI 20

Diabetic 3

Willingness 1

Smoking 3

Time commitment 4

Too active 1

Injury 1

New Dx 1

Dropped 7

Oriented 23

Completed Study 16

Decided to not participate 7
APPENDIX I
IRB APPROVAL FORM

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 7/21/2016
To: Dr. Laura Ellingson
    239 Forker
From: Office for Responsible Research
Title: Appetite and Adiposity Across a Continuum of Activity
IRB ID: 16-323

Approval Date: 7/21/2015 Date for Continuing Review: 7/18/2017
Submission Type: New Review Type: Full Committee

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.
- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.
- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.
- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.
- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.
- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 202 Kingland, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.