PSYCHOLOGICAL PREDICTORS OF COMPENSATORY RESPONSES TO A STRUCTURED EXERCISE PROGRAM

by

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(Under the Direction of Michael Schmidt)

ABSTRACT

The purpose of this study was to identify possible psychological predictors of compensation to structured exercise. 20 subjects participated in an 8-week exercise intervention, where diet and outside activity were objectively measured at three time points (baseline, Week 5, Week 8). Results indicated no significant differences between energy intake (EI) and energy expenditure (EE) at baseline and Week 8; however, changes in both EI and EE were associated with large amounts of inter-individual variability. Self-motivation was significantly correlated to change in EI ($r = -.61$). Positive urgency, a construct related to trait impulsivity, was significantly correlated with EE change ($r = -.70$). Measures of fatigue and reward responsiveness were not strongly correlated with EI or EE in this sample. Further research is warranted to investigate the extent to which these psychological constructs can predict compensatory responses to a structured exercise program.

INDEX WORDS: physical activity; compensation; exercise intervention; psychological predictors; compensatory responses; self motivation; trait impulsivity

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CHAPTER 1

INTRODUCTION

Two thirds of adults in the United States are currently classified as overweight or obese, and evidence clearly associates these conditions with increased relative risk of cardio-metabolic diseases and a decreased quality of life (CDC, 2011). Regular physical activity is protective against hypertension, type II diabetes mellitus, coronary heart disease, and many other disease conditions. Research has also identified regular physical activity as a preventative mechanism against obesity. Consequently, a multitude of physical activity interventions encourage participants to increase energy expenditure (EE) and/or decrease energy intake (EI) to both facilitate weight loss and to maintain healthy weight status (Caudwell et al., 2011; ACSM, 2012). However, the average adult who participates in a structured exercise program loses only 30% of his/her predicted weight loss (Ross & Janssen, 2001). Researchers believe that compensatory responses to structured exercise are responsible for limiting the effectiveness of such intervention programs. In this sense, compensation can be defined as increasing EI and/or decreasing non-exercising activity thermogenesis (NEAT) in response to structured physical activity, thus counteracting the negative energy balance of the exercise.

Within individuals, the type and magnitude of compensatory responses will predict the success of an exercise intervention to produce weight loss as desired. Compensatory responses to physical activity include both metabolic and behavioral adaptations. The involuntary, metabolic adaptations to exercise include small changes in the resting metabolic rate, energy expenditure associated with exercise, and energy expenditure associated with NEAT (King et al., 2007).

Since these metabolic responses occur very slowly over time, behavioral responses are identified as the largest barrier to weight loss (King et al., 2007). These behavioral responses, like increasing EI after an exercise bout, can offset the increased EE achieved with exercise and may be either volitional or non-volitional in nature.

Clinical researchers have begun to quantify the volitional behavioral changes that occur in response to structured exercise participation, focusing specifically on changes in EI with the addition of exercise. Less explored are the compensatory changes associated with decreased EE resulting from exercise interventions; but, it is plausible to expect that introducing a moderate-to-vigorous intensity exercise program leads to a reduction in physical activity EE during non-exercising periods, known as non-exercising activity thermogenesis (NEAT). Further and more-controlled research is needed to better quantify volitional and non-volitional changes in behavior as related to compensation to exercise.

Results from recent literature suggest a significant decrease in NEAT during an 8-week intervention with obese women (Colley et al., 2007). The average decrease in NEAT was equivalent to 175 kilocalories, or 22% of the baseline NEAT measurement (Colley et al., 2007). Similarly, a study by Manthou et al. 2010 provided further confirmation of a significant decrease in NEAT with an added dose of structured exercise. Specifically, "compensators" decreased NEAT by an average of -0.62 + 0.39 MJ, and "non-compensators" increased NEAT by 0.79 + .50 MJ ($p<0.05$) (Manthou et al., 2010). This evidence suggests that changes in NEAT may partially explain the differences in weight loss between individuals during exercise interventions.

Few studies have yet to determine if psychological factors predict these behavioral and compensatory changes that cause inter-individual variability in weight loss in response to exercise. Existing research in this area focuses primarily on eating behavior traits such as disinhibition and dietary restraint (Stunkard & Messick, 1985). Specifically, women with higher disinhibition have been found to increase EI with chronic exercise (Keim et al., 1996; Visona & George, 2002). This pilot study will extend the body of research to include additional psychological factors plausibly linked to compensation.

For example, sensitivity to reward (STR) is a psychobiological trait rooted in the dopamine system, and research shows that exercise may influence eating behavior by changing the hedonic response to certain foods (Davis et al., 2002; King et al., 2007). STR can be defined as the ability to receive pleasure from both natural and pharmacological reinforcers, like food and drugs, respectively (Davis et al., 2002). Specifically, exercise may increase the amount of pleasure induced by eating and/or exercise may make certain individuals more sensitive to a reward such as food (King et al., 2007). This implies that STR is a characterological trait, where some individuals are more tuned to reward than others; therefore, research investigating STR with regard to compensation to physical activity is warranted.

Secondly, the term trait impulsivity covers a wide range of actions that are poorly thought-out and often result in undesirable outcomes (Evenden, 1999). Whiteside et al. 2005 partitioned impulsivity into distinct traits, including positive and negative urgency, delay of gratification, and sensation-seeking. Research has shown these distinct traits to be associated with reduced weight loss during obesity treatment and self-regulation failures in terms of alcohol and other substances; consequently, trait impulsivity may contribute to compensation to exercise (Stice et al., 2009).

Self-motivation is defined as the tendency to engage in behaviors regardless of extrinsic reinforcement, and it has been strongly linked to adherence to exercise intervention programs in adults (Dishman & Ickes, 1981). Lack of self-motivation has also been widely cited as a primary reason for not obtaining adequate levels of physical activity in one's daily routine (Annesi, 2002). Based on this evidence, it is warranted to further explore self-motivation in relation to compensation to physical activity during an exercise intervention.

Lastly, current research relates facets of fatigue and energy to obesity and physical activity. In this sense, fatigue and energy can be defined as multi-faceted psychological constructs that reflect feelings of both mental and physical capacity to perform tasks of daily living. For example, researchers found lower vitality scores among obese individuals when compared to normal weight adults (Katz et al., 2000). Likewise, increased structured physical activity and weight loss are associated with decreased feelings of fatigue and increased feelings of energy and vitality (Fontaine et al., 1999; Puetz et al., 2006). Therefore, it is plausible that feelings of fatigue and energy are related to compensatory responses to exercise, and further research in this area is needed to ascertain the strength of this relationship.

Compensatory increases in EI and decreases in EE appear to be significant factors limiting the effectiveness of weight-related physical activity interventions in some individuals; however, few studies have attempted to pinpoint psychological traits and characteristics that may predict proneness to compensation. This pilot study attempted to fill the existing knowledge gap by investigating the extent to which psychological traits related to other health behaviors may relate to and predict compensation to physical activity.

Specific Aim and Corresponding Hypotheses

The purpose of this study was to investigate the extent to which psychological traits (self motivation, sensitivity to reward, trait impulsivity & fatigue) related to other health behaviors predict compensatory behaviors in response to initiating a structured exercise program in healthy, low-active, college-aged adults.

I. It was hypothesized that compensation via increase in energy intake would be most highly correlated with trait impulsivity and reward sensitivity.

II. It was hypothesized that compensation via decrease in outside energy expenditure would be most highly correlated with self-motivation and fatigue.

Significance

Increased physical activity is a primary recommendation for weight management and weight loss. However, the effectiveness of increased physical activity to actually result in desired weight loss varies substantially across studies and individuals. Therefore, from a public health perspective, it is imperative to further explore the cause of inter-individual variability in weight loss and weight management with structured exercise interventions. This pilot study aims to identify psychological factors that are helpful in predicting compensation to exercise. If replicated in larger studies, knowledge gained will help public health professionals by identifying specific psychological traits that increase proneness to compensation. Individuals who possess these traits may need a combination of individualized exercise prescriptions and behavioral modification counseling in order to achieve and maintain a healthy weight status.

Delimitations

I. All subjects willingly volunteered to participate in the research study and are students at the University of Georgia.

II. All subjects were between ages 18 and 30.

III. All subjects were enrolled in a PEDB course and did not have physical and/or mental limitations that prohibited participation in walking/jogging.

Limitations

I. The ActiGraph accelerometers used throughout the study to objectively measure energy expenditure are associated with small amounts of error in quantifying non-ambulatory physical activity. For example, energy expenditure due to weight training was not accounted for in accelerometer data output.

II. Energy intake was measured via online 24-hour diet recalls throughout the intervention. Subjects may have underreported the intake of food and beverages consumed, which would then alter the energy intake estimates used in data analysis.

III. The relatively low dose of structured physical activity (150 minutes per week) produced through this intervention may not have been sufficient to elicit compensatory behaviors.

IV. Small sample size (N=20) limited both statistical power and generalizability to the population at large.

Assumptions

I. Subjects honestly and accurately answered the questionnaires that will be used to assess psychological factors.

II. Subjects honestly and accurately completed the ASA24 dietary recall measure.

Defined Terms

- Compensation: increasing EI and/or decreasing NEAT in response to structured physical activity, thus creating a state of positive energy balance
- Non-exercising activity thermogenesis: NEAT; unstructured physical activity outside of the 8-week exercise intervention of PEDB 1990
- Disinhibition: lack of mental restraint; in relation to diet, the tendency to overeat in response to emotional cue (Stunkard & Messick, 1985)
- Sensitivity to Reward: STR; the ability to receive pleasure from both natural reinforcers like food and pharmacological reinforcers like drugs (Davis et al., 2002)
- Trait Impulsivity: a broad term defining actions that are poorly conceived, risky, or inappropriate to the situation and that often result in undesirable outcomes (Evenden, 1999)
- Sensation-seeking: those individuals labeled as "sensation-seekers" thrive off of novel and stimulating experiences and situations (Whiteside et al., 2005)
- Positive and negative urgency: an individual's proneness to react adversely to negative and positive emotional states (Whiteside et al., 2005)
- Delay of gratification: individuals who are unable to delay gratification are highly oriented to smaller immediate awards (Whiteside et al., 2005)

CHAPTER 2

REVIEW OF LITERATURE

Importance of Physical Activity and Recommendations

Two thirds of adults in the United States are currently classified as overweight or obese, and evidence clearly associates these conditions with increased risk of cardio-metabolic diseases and a decreased quality of life (Centers for Disease Control and Prevention, 2008). Regular physical activity is protective against obesity, hypertension, type 2 diabetes mellitus, coronary heart disease, and many other chronic disease states (CDC, 2008). Despite the convincing and long-term benefits associated with a habitually active lifestyle, however, many individuals fail to adhere to current physical activity guidelines and recommendations.

The World Health Organization (WHO) recommends that adults aged 18-64 engage in the equivalent of 150 minutes of moderate aerobic physical activity or 75 minutes of vigorous aerobic physical activity each week to maintain a healthy weight (WHO, 2012). The WHO recognizes a dose-response relationship with physical activity, meaning that increased amounts of physical activity offer additional health benefits. To accrue these additional health benefits, adults should increase weekly expenditure to the equivalent of 300 minutes of moderate aerobic physical activity or 150 minutes of vigorous aerobic physical activity. Additionally, the WHO recommends that muscle strengthening be incorporated at least 2 days per week to improve muscular fitness and bone health (WHO, 2012).

Similarly, the American College of Sports Medicine (ACSM) offers specific recommendations in regard to weight loss and weight management. In order to prevent weight gain and promote a state of modest weight loss, the ACSM recommends 150-250 minutes of moderate intensity physical activity weekly. Exceeding this recommendation and participating in greater amounts of physical activity provides clinically significant weight loss (ACSM, 2012). Additionally, ACSM states that performing more than 250 minutes of moderate activity weekly can prevent weight re-gain following initial weight loss (ACSM, 2012). Strengthening the public's adherence to the ACSM's recommendation of using physical activity to promote weight loss and weight management is of primary importance.

While it is certainly important for adults of all ages to engage in regular physical activity, establishing health behaviors in college-aged young adults is of particular concern for public health professionals. The incidence of obesity in U.S. college-aged adults increased from 12% in 1991 to 36% in 2004, and research has shown that 81 to 85% of adults continue the same physical activity patterns that they establish during their senior year of college into later adulthood (Ogden et al., 2006; Sparling et al., 2002). In fact, only 40-45% of college students engage in sufficient, regular physical activity to receive the psychological and physiological benefits associated with exercise (CDC, 1997). Removing perceived barriers to physical activity and providing health and wellness education to college students could have a significant benefit from a public health perspective.

Evidence of Compensation to Physical Activity

Physical activity is an integral component of weight loss and weight management; thus, most individuals seeking to lose weight and/or maintain a healthy weight status include increased physical activity as part of their approach. For many people, however, incorporating additional doses of structured physical activity does not result in the expected amount of weight loss. In fact, one study estimated that the average adult who participates in a structured exercise program loses only 30% of his/her predicted weight loss (Ross & Janssen, 2001). Researchers believe that compensatory responses to structured exercise are responsible for limiting the effectiveness of such intervention programs. In this sense, compensation can be defined as increasing EI and/or decreasing non-exercising activity thermogenesis (NEAT) in response to structured physical activity, thus counteracting the negative energy balance of the exercise.

In a 1980 study of aerobic exercise and weight loss, Epstein and Wing were among the first to express variability in weight loss between individuals as compensation. This compensation to exercise was loosely defined as a behavioral or metabolic disturbance to the body's homeostatic, energy balance state (King et al., 2007). Involuntary, metabolic adaptations to exercise include small changes in the resting metabolic rate, energy expenditure associated with exercise and energy expenditure associated with non-exercise activity (King et al., 2007). Volitional, behavioral responses to an increased dose of activity include changes in energy intake and the amount of energy expended during the intervention (King et al., 2007). Since the metabolic adaptations that occur are relatively small in magnitude, it is highly likely that behavioral changes account for the majority of compensation in individuals.

Scientists have previously identified compensatory increases in energy intake and/or decreases in non-exercise physical activity as major obstacles of successful weight loss; consequently, recent research has focused on pinpointing the timing and magnitude of these compensatory responses to structured physical activity (King et al., 2007; Manthou et al., 2010). For example, Blundell et al. 2003 examined the responses to short (1-2 days) and medium (3-16 days) duration physical activity interventions. The research team found no evidence of an immediate or automatic effect of physical activity increasing energy intake (Blundell et al., 2003). They did, however, determine that subjects later emerged as "compensators" and "non-compensators." The food intake of compensators gradually increased over the 16-day period to negate approximately 30% of energy expended through physical activity (Blundell et al., 2003). Though the measured compensation was relatively small in magnitude, it poses a significant hindrance for successful weight management.

To examine the effects of longer-term interventions on compensatory behavior, King et al. 2008 performed a 12-week physical activity intervention exposing subjects to a high dose of exercise that burned approximately 500 kilocalories, 5 days per week. Researchers found that energy intake increased significantly among those who failed to achieve the expected weight loss ($p<.05$) (King et al., 2008). In fact, those who lost less weight than expected increased energy intake by an average of 268.2 ± 455.4 kilocalories daily (King et al., 2008). Again, participants were labeled as "compensators" or "non-compensators" based on actual versus expected weight loss and, therefore, their responsiveness to the high-dose exercise intervention.

As previously mentioned, non-exercising activity thermogenesis (NEAT), or non-structured physical activity throughout the day, has been identified as a possible explanation for compensation to exercise (King et al., 2007). Results from recent literature suggest a significant decrease in NEAT during an 8-week, moderate intensity walking intervention in a small sample of obese women (Colley et al., 2010). In fact, NEAT decreased by an average of 175 kilocalories per day, or about 22%, from baseline to week 8. Data from Manthou et al. 2010 provided further confirmation of a decrease in NEAT with an added dose of structured exercise. Specifically, overweight and obese women were exposed to an 8-week cycling intervention with an exercise dose equivalent to 150 minutes/week. (Manthou et al. 2010). Changes in NEAT of "compensators" and "non-compensators" differed significantly between groups ($p<0.05$), with "compensators" decreasing NEAT by an average of -0.62 + 0.39 MJ, and "non-compensators" increasing NEAT by 0.79 + .50 MJ ($p<0.05$) (Manthou et al., 2010). This suggests that compensators were less active outside of the intervention (Manthou et al., 2010).

Increasing total daily energy expenditure is the primary purpose of many physical activity interventions targeting weight loss. However, automatic and volitional compensatory responses seem to convincingly disrupt the change in energy balance needed to elicit substantial weight loss (Blundell et al., 2003; Manthou et al. 2010). Identifying the psychological and environmental triggers of volitional compensation to exercise has the potential to improve the likelihood of successful weight loss in overweight and obese individuals, thus benefiting the public at large.

Evidence of Gender Differences in Physical Activity and Compensation to Physical Activity

In general, women tend to self-report less physical activity than men. This is particularly true for participation in vigorous, recreational sports and exercise; however, it is important not to discount the moderate intensity household and childcare activities performed daily by many adult women (Sternfeld et al., 1999). In college students, motivation for engaging in physical activity also differs between males and females (Egli et al., 2011). Specifically, males are motivated by intrinsic factors like challenge, competition and strength ($p<0.05$), and females are primarily motivated by extrinsic factors like appearance and weight management ($p<0.05$) (Egli et al., 2011).

It is well documented that men and women display different patterns of, and motivation for, habitual physical activity. Likewise, current research suggests that the magnitude of compensatory changes to structured exercise may also differ by gender. Acute bouts of exercise do not affect energy intake in males; however, women tend to increase energy intake following acute exercise bouts (Thompson et al. 1988; King et al. 1997). This increased energy intake in women decreases or negates the effects of physical activity on energy balance (Martins et al., 2008). Similarly, a series of exercise intervention studies by Stubbs et al. found that energy intake increased only in females. Interestingly, though, only about 30% of the exercise-induced energy expenditure was compensated for by an increased energy intake (King et al., 2007). This suggests that despite partial compensation, the women were still receiving some benefit from the exercise intervention.

It is imperative that public health professionals recognize the gender differences associated with physical activity and compensation to physical activity in college-aged adults. Catering to the motivational differences and providing students with strategies to better control their non-exercising physical activity may reduce the consequences of behavioral compensation to interventions.

Compensation via Increasing Total Energy Intake

An increase in total energy intake has been identified as the main form of volitional compensation to increased doses of physical activity (King et al., 2007). The psychological constructs of trait impulsivity and sensitivity to reward have both been extensively examined in relation to diet and addictive behaviors such as drug abuse; but, the relationships among these traits and physical activity compensation are less well documented. Each psychological construct, in relation to both addictive behavior and physical activity, is described more completely below.

Trait Impulsivity as Predictor of Compensation

The term trait impulsivity is loosely defined as a range of actions that are poorly thought-out and often result in undesirable outcomes (Evenden, 1999). Whiteside et al. 2005 dissected impulsivity into five distinct traits: 1) positive and negative urgency, 2) delay of gratification, and 3) sensation-seeking, 4) lack of perseverance, and 5) lack of premeditation. Two of these five traits are most plausibly linked to compensatory energy intake. Firstly, urgency refers to an individual's proneness to react to emotional situations in a positive or negative light. Participants in an exercise intervention who have high urgency to react to extreme mood states may do so by rewarding themselves with food. Secondly, sensation-seekers thrive off of novel and stimulating experiences, and they may be less likely to refuse food after exercise (Whiteside et al., 2005).

Research has shown these two distinct traits to be associated with reduced weight loss during obesity treatment and self-regulation failures in terms of alcohol and other substances; consequently, trait impulsivity may influence the likelihood of compensation to exercise (Stice et al., 2009). Specifically, studies suggest that obese individuals are unable to delay gratification and thus anticipate reward from food, which causes overeating (Pelchat et al., 2004). Further, researchers have proposed that sight and smells of food elicit physiological responses that trigger food craving post exercise, which may result in the need to splurge and increase total energy intake (Jansen, A. 1998).

This pilot study assessed trait impulsivity using a revised version of the original UPPS Impulsive Behavior scale developed by Whiteside & Lynam in 2001, called the UPPS+P

(Cyders & Smith, 2007). This updated version of the measure assesses positive urgency, in addition to negative urgency, lack of premeditation, lack or perseverance and sensation-seeking (Cyders & Smith, 2007). Whiteside and Lynam 2001 presented information on the internal consistencies for the four factors of premeditation (r=.91), urgency (r=.86), sensation seeking (r=.90) and perseverance (r=.82). The UPPS+P was created for use in adult populations ranging in age from 18 to 64 (Cyders & Smith, 2007).

Sensitivity to Reward as a Predictor of Compensation

Sensitivity to reward (STR) is a psychobiological trait that refers to an individual's ability to derive pleasure from both natural reinforcers like food and pharmacological reinforcers like drugs (Davis et al. 2004). STR has been identified as a normally distributed psychological construct within the population (Meehl et al., 1975). At one end of the spectrum is anhedonia, or the diminished capacity to experience naturally pleasurable reinforcers. Hedonia, or enhanced motivation to approach naturally pleasurable behaviors, lies at the opposite end of the spectrum (Meehl et al., 1975). Experts in the field of addictive research are now recognizing that natural rewards (i.e. food), like drugs, can greatly enhance mood in hedonic and anhedonic individuals (Davis et al., 2004). This suggests that persons at either end of the STR distribution may have an increased risk for over-indulgence in rewarding behaviors.

Studies also suggest that engaging in behaviors like physical activity, over-eating and smoking can reduce feelings of anhedonia; thus, some anhedonic individuals may seek out such behaviors (Davis & Woodside, 2002). For example, women diagnosed with clinical anorexia nervosa had significantly higher anhedonia scores than women with bulimia nervosa and women with normal eating patterns (Davis & Woodside, 2002). Additionally, anhedonia was higher in women defined as excessive exercisers. This evidence supports the hypothesis that individual differences in STR contribute to the respective avoidance and approach relationships to food and physical activity (Davis & Woodside, 2002).

Food has been long acknowledged as one of the body's natural reinforcers; so, STR has been studied extensively in relation to eating behaviors. Loxton and Dawe found that adolescent girls with inherently high STR were more prone to participate in binge eating than normal or low STR counterparts (2001). Likewise, Davis et al. found that adult women with high STR were more likely to engage in emotional eating and, therefore, had significantly higher body mass indexes than those with normal STR (2007). Since similar patterns in behavior follow both eating and exercise, it is reasonable to investigate the relationship between STR and exercise.

Recent research shows that exercise may influence eating behavior by changing the hedonic response of certain foods (Davis et al., 2004; King et al., 2007). Specifically important to this pilot study, exercise may increase the amount of pleasure induced by eating and/or exercise may make certain individuals more sensitive to natural rewards like food (King et al., 2007). Heightened sensitivity to food during an exercise intervention may affect one's ability to lose the predicted amount of weight. This implies that STR is a characterological trait, where some individuals are simply more tuned to reward than others; therefore, further research investigating the relationship between STR and compensation to physical activity is warranted.

This pilot study assessed sensitivity to reward using the Behavioral Inhibition System/Behavioral Activation System developed by Carver and White. Specifically, a 5-item component of the Behavioral Activation System scale provides a score for reward responsiveness (Carver & White, 1994). The BAS subscales, Reward Responsiveness, Drive and Fun Seeking, have satisfactory internal consistencies, with alphas ranging from .66 to .76, and strong two-month test-retest reliabilities with r=.59-.69 in undergraduate populations (Carver & White, 1994).

Compensation via Decreasing Total Energy Expenditure

Based on previous literature, it is plausible that individuals with higher levels of fatigue and lower levels of self-motivation will compensate when introduced to a structured exercise program by decreasing total energy expenditure. In other words, when participating in a structured exercise program, individuals with high self-reported fatigue or low self-reported motivation may reduce activity levels outside of the program, so that the proportion of their day defined as sedentary by accelerometry increases. Or, these individuals may replace moderate activity with light activity in response to exercise. If inactivity displaces physical activity outside of the intervention, a decrease in total energy expenditure would occur.

Self-motivation and fatigue have well-established relationships with physical activity; however, relationships between these psychological constructs and compensatory behavior are not well documented to date. Determining the extent to which these constructs are predictive of compensation by decreasing total energy expenditure could provide insight into more successful approaches to weight loss in the college population.

Fatigue as a Psychological Predictor of Compensation

Research shows that approximately 25% of populations self-report regular feelings of fatigue, and fatigue is associated with physical inactivity in college-aged students (Lewis et al., 1992; Soyeur et al., 2010). Students who self-reported strong feelings of fatigue performed significantly less physical activity than their non-fatigued counterparts ($p<0.05$) (Soyeur et al., 2010). A study by Lee et al. in 2007 found a high prevalence of fatigue in 1,806 college-aged students, with 45.8% of males self-reporting fatigue and 48.9% of females identifying themselves as regularly fatigued. The intensity of regularly performed physical activity was identified as protective against fatigue, with subjects in the top quartile of intensity having an odds ratio of 0.36 when compared to the lowest quartile of intensity ($p < 0.001$) (Lee et al., 2007). This suggests an inverse relationship between self-reported feelings of fatigue and habitual physical activity intensity; individuals who regularly exercise at a high intensity have lower self-reported levels of fatigue.

Similarly, findings by Katz et al. in 2000 reflect an inverse relationship between fatigue and obesity status. Using the Medical Outcomes Study Short-Form Health Survey (SF-36), a vitality scale that measures physical and mental well-being, Katz et al. (2000) found lower vitality scores among obese individuals when compared to normal weight adults. The research team sampled approximately 3,000 adults with chronic illnesses and concluded that overweight and obese status had a significant association with physical and mental well-being.

Likewise, increased structured physical activity and weight loss were associated with decreased feelings of fatigue and increased feelings of energy and vitality (Fontaine et al., 1999). Fontaine et al. recruited 38 mildly-to-moderately overweight, sedentary adults to participate in a 13-week exercise intervention. Subjects were either assigned to a program of lifestyle physical activity (which intended to increase NEAT) or a traditional aerobic exercise routine to meet the ACSM's physical activity guidelines for weight loss. As measured by the SF-36, all participants reported significantly lower levels of fatigue and higher vitality scores ($p<0.05$) post-intervention. Additionally, the intervention produced an average weight loss of 8.6 ± 2.8 kg. This suggests that increased physical activity and weight loss are associated with improvement in self-reported energy levels (Fontaine et al., 1999).

It has been well established that habitually physically active individuals report lower levels of fatigue; however, current research that directly links fatigue to physical activity compensation is lacking. Assuming fatigue is inversely related to the amount of physical activity performed, it is plausible to assume that individuals with high self-reported fatigue during a structured exercise intervention may respond by decreasing EE outside of the intervention. This study seeks to understand whether or not fatigue and energy levels are predictive of compensation to physical activity.

There is no consensus on whether fatigue is best captured as a mood, a symptom, or a measure of quality of life; consequently, researchers have created a multitude of instruments that measure fatigue in different ways (O'Connor, 2003). A mood is a transient feeling that is self-reported, and the mood of fatigue refers to feelings of having a reduced ability to complete mental and/or physical activities (O'Connor, 2003). Visual analogue scales (VAS) are rapid, sensitive, and reliable subjective measures that have been used to assess moods, including fatigue and vigor (Luria et al., 1975).

Researchers have used VAS to assess mood in various populations since the 1960's, and advantages include ease in administration, acceptance by respondents, and validity coefficients commensurate with those of more time-consuming scales (Little & McPhail, 1973; Stewart, 1977). VAS measures use a 100 millimeter line, with polar mood statements at the "0" and "100" millimeter points. The participant is instructed to draw a vertical line corresponding to where their current mood falls on the continuum. Additionally, VAS models have been utilized in exercise studies in adult populations to measure rate of perceived exertion, pre-exercise energy, and post-exercise fatigue (Wilson & Jones, 1989; Tseng et al., 2010).

This pilot study used one, 12-item section of the *Mental and Physical State and Trait Energy and Fatigue Scales* that measures four energy and fatigue mood states: Physical Energy State, Physical Fatigue State, Mental Energy State, and Mental Fatigue State (O'Connor, 2006). Evidence of reliability for the state scales of this measure were determined from a telephone survey of 202 adult residents of the United States and range from alpha=0.89-0.91 (O'Connor, 2006). Additionally, a second section of the *Mental and Physical State and Trait Energy and Fatigue Scales* was used to evaluate the energy and fatigue mood traits for descriptive purposes. Evidence of reliability for the trait scales of this measure were also determined from a telephone survey of 202 adult residents of the United States and range from alpha=.82-.85 (O'Connor, 2006).

Self-Motivation as a Psychological Predictor of Compensation

Lack of self-motivation is a common reason given for omitting adequate levels of physical activity from one's daily routine (Annesi, 2002). Self-motivation is defined as the tendency to engage in behaviors regardless of extrinsic reinforcement, and it has been strongly linked to adherence to exercise intervention programs in adults (Dishman & Ickes, 1981). As previously mentioned, it is plausible to assume that individuals with low levels of self-motivation may be more likely to decrease total daily energy expenditure during a structured exercise intervention than individuals with high levels of self-motivation.

Exercise adherence studies to date have reported unequivocal findings on the effect of self-motivation on physical activity behaviors. In one study, self-motivation scores accurately classified undergraduate students and student-athletes according to their adherence status in approximately 80% of all cases and accounted for nearly 50% of the variance in exercise adherence behavior (Dishman, 1980). Similarly, a study by Steinhardt and Young in 1992 found that the adherence status of 646 non-active and high active participants in a workplace health center could be classified solely using self-motivation measures with an accuracy of 40.1%. Additionally, other studies have used attendance records as a measure of activity, and have reported even higher predictability from self-motivation measures (Merkle et al., 2002).

A recent review by Trost et al. examined correlates of adults' participation in physical activity and identified self-motivation as having a repeatedly documented positive association with physical activity (Trost et al., 2002). In one 9-month intervention study among 105 older adults, for example, the indirect measure of perceived behavioral control and self-motivation accounted for 27% of the variance in exercise behavior during month 1 and 10% of the variance at month 3 (Brenes et al., 1998). In another study of 5000 women, lack of self-motivation for exercise accounted for 18% of the variance in total physical activity (Sternfeld et al., 1999). Although self-motivation alone does not determine exercise behavior, evidence suggests it may play a key role in one's likelihood to perform the recommended amount of daily physical activity.

Given the current obesity epidemic in the United States, a major practical issue in health promotion lies in facilitating adherence to regular exercise (Dishman et al., 1985). It has been well established that individuals with high levels of self-motivation are more likely to adhere to exercise programs and interventions; so, better understanding this psychological construct will prove beneficial from a public health perspective. This study aims to contribute to the small existing body of research directly linking self-motivation to physical activity compensation in college-aged students, with the use of the Self Motivation Inventory (SMI).

The SMI is a 40-item questionnaire on which respondents indicate the degree to which each statement is characteristic or uncharacteristic of them, using a 5-point Likert scale format. The SMI consists of several correlated facets of self-motivation including commitment, lethargy, drive, persistence, reliability, and discipline (Merkle et al., 2002). The SMI is strongly correlated with well-established behavioral measures like the Thomas-Zander Ego Strength Scale ($r=0.63$). Additionally, the SMI has strong internal consistency ratings ($r=0.91$) and a high degree of scale stability ($r=0.86$-0.92)(Dishman et al., 1981).

As previously noted, motivation for structured exercise differs significantly by gender in college-aged adults. Specifically, males are motivated by intrinsic factors like challenge, competition and strength ($p<0.05$), and females are primarily motivated by extrinsic factors like appearance and weight management ($p<0.05$) (Egli et al., 2011). Determining the extent to which self-motivation is predictive of compensation to structured exercise in college-aged students could prove helpful in compelling a larger percentage of college-aged students to meet the WHO's physical activity recommendations. As suggested by Colley et al. 2010, potential alterations in non-exercising energy expenditure should be considered when exercise is prescribed. Additionally, offering suitable education on how to monitor daily activity outside of structured exercise may attenuate the effects of compensation (Colley et al. 2010).

24-Hour Diet Recall to Measure Energy Intake

Total energy intake has been recognized as a predictor of the nutrient content of the diet and chronic disease development; therefore, obtaining precise estimates of energy intake has been a primary focus of many research studies (Ma et al., 2001). Additionally, accurate estimation of energy intake is crucial for assessing the effectiveness of weight loss and physical activity interventions (Ma et al., 2009). Nutritional data in large-scale epidemiological studies are often self-reported or interviewer administered 24-hour dietary recalls (Ma et al., 2009).

Research shows that energy intake varies substantially from day to day, and that weekday intakes are often different from weekend intakes; however, much debate exists around the number of 24-hour recalls needed to accurately capture energy intake (Basiotis et al., 1987; Ma et al., 2009). A study by Ma et al. 2009 sought to calculate the number of 24-hour recalls needed to accurately describe an individual's energy intake. A sample of 79 middle-aged, white woman completed 7, 24-hour dietary recalls over a two-week period. During this time, the research team also objectively measured energy expenditure of the women using doubly labeled water. Researchers determined that participants underreported energy intake on the first 24-hour recall and that three 24-hour recalls appeared optimal for accurately estimating energy intake (Ma et al., 2009).

The National Cancer Institute (NCI) sponsors a free, online dietary recall program called the ASA24 Automated Self-Administered 24-hour Recall (ASA24). The format and design of ASA24 mimic an interviewer-administered 24-hour recall, and the ASA24 is comprised of both a respondent website and a researcher website. The researcher website allows the research team to set the study parameters, create usernames and passwords for all research subjects, and view collected diet data in Microsoft Excel format. The respondent website is interactive in nature, as a small penguin mascot prompts subjects to enter all food and drink consumed on specified days.

The ASA24 is based on the United States Department of Agriculture's Automated Multiple Pass Method (AMPM) (Kipnes et al., 2003; Moshfegh et al., 2008). The AMPM is the dietary interview component of the National Health and Nutrition Examination Survey, and it has been validated to accurately report energy intake in normal-weight subjects (Moshfegh et al., 2008). Preliminary analyses of diet recall data from the ASA24 are consistent with results from the National Health and Nutrition Examination Survey. (NCI, 2011). Additionally, the developers of ASA24 conducted multiple pilot tests to ensure comprehension and user-friendliness of the program (NCI, 2011). Since the ASA24 is a relatively new program, further validation studies are currently underway by the NCI, and supporting data has an expected release date in late 2012 (NCI, 2011).

This pilot study sought accurate estimates of energy intake to quantify changes in energy intake of college-aged students with the addition of structured physical activity into their daily routines. The ASA24 was employed for this purpose. Based on previous research, it was determined that three, 24-hour diet recalls were sufficient to produce an accurate estimation of habitual energy intake.

Accelerometry to Measure Energy Expenditure

Accelerometers are small devices that measure body movements in terms of acceleration, which can then be used to estimate the intensity of physical activity over time (Chen & Bassett, 2005). Accelerometers are cost efficient, relatively user-friendly, small in size, convenient to wear during exercise, and are associated with low subject burden (Chen & Bassett, 2005). Therefore, accelerometers have become an important component in many physical activity surveys and interventions. Considered a gold standard for accelerometry, the ActiGraph accelerometer has been used in measuring physical activity for over twenty years and is associated with high reliability and validity (Chen & Bassett, 2005).

Triaxial accelerometers use piezoelectric sensors to provide body acceleration estimates in three orthogonal planes: vertical, anterior-posterior, and medial-lateral (Chen & Bassett, 2005). Triaxial accelerometers provide better assessments of non-ambulatory and sedentary activities than single-axis vertical accelerometers (Boutan et al., 2004). This pilot study used ActiGraph GT3X and AcitGraph GT3X+ triaxial accelerometers to objectively estimate energy expenditure at specified time periods throughout the intervention. ActiGraph GT3X+ is the newest version of the GT3X model, and the manufacturer guarantees that the internal mechanisms are identical. No research comparing the validity and reliability of the GT3X and the GT3x+ is currently available.

Actigraph GT3X triaxial accelerometers, as well as other brands of accelerometers, have been widely used in exercise intervention studies to estimate energy expenditure. Thus, generalized prediction equations have been created to easily calculate energy expenditure. The three most commonly used generalized equations are as follows:

1. Work-Energy Theorem:

   Kcals (for a single epoch) = counts (for a single epoch) * 0.0000191 * Mass (kg)

2. Freedson Equation:

   Kcals = Scale (epoch length in seconds/60) * (0.00094 * counts + (0.1346 * Mass (kg) – 7.37418))

3. Combination Work Energy Theorem/Freedson Equation:

   Kcals = (Work-Energy Theorem for Counts <1952; Freedson Equation for Counts ≥1952)

A study by Freedson et al. in 1998 created generalized calibration equations from a sample of 50 college-aged men and women who performed treadmill exercise at three speeds (4.8, 6.4, 9.7 km/hr) in 6-minute bouts. Steady-state oxygen consumption values were measured during each 6-minute bout, and energy prediction equations were developed. Authors reported a strong correlation, r=0.88, between ActiGraph counts and oxygen consumption readings (Freedson et al., 1998). The generalized equations provide satisfactory estimates of group energy expenditure; however, some limitations exist when quantifying energy expenditure in individuals (Bassett, 2010). For example, the Freedson Equation has been shown to underestimate moderate intensity activities by approximately 50% in some individuals (Bassett, 2010). Additionally, both the Work-Energy Theorem and the Freedson Equation have misclassified moderate activity as light activity in some cases (Bassett, 2010).

In order to avoid such limitations and increase the accuracy of using accelerometry to predict energy expenditure during specified bouts, individual calibration equations can be generated using metabolic systems that measure breath-by-breath values of oxygen consumption and carbon dioxide production. Commonly, participants perform a standardized treadmill protocol that increases from low to high intensity, and the results are used to derive both prediction equations for energy expenditure and cut-points for intensity thresholds. The current pilot study employed a similar protocol to that of Freedson et al. 1998, capturing steady state oxygen consumption and accelerometer counts at each of three treadmill speeds, to generate individual calibration equations for each subject.

Although ActiGraph accelerometers provide reliable, valid, objective estimates of energy expenditure, limitations do exist and must be taken into account when analyzing raw data. For example, accelerometers do not accurately capture load-bearing activity, upper body activity, cycling, swimming, and up-hill walking; thus, total energy expenditure may be underestimated by accelerometry for some individuals (Chen & Bassett, 2005). Additionally, participant compliance has historically been an issue with meeting wear-time requirements.

The Big Picture

Participation in 150-250 minutes of moderate and vigorous physical activity is a recommended strategy for weight management for U.S. adults (ACSM, 2012). However, volitional and automatic compensatory adjustments to structured exercise appear to limit the effectiveness of weight loss interventions for many individuals. Deciphering the relationship between psychological constructs known to predict other addictive behaviors and the proneness to compensate to physical activity could pose a huge benefit to society. This pilot study aims to identify psychological factors that are helpful in predicting compensation to exercise. If replicated in larger studies, knowledge gained will help public health professionals by identifying specific psychological traits that increase proneness to compensation.

CHAPTER 3

METHODS

Subjects

Subjects were 20 males and females enrolled in PEDB 1990 during Spring 2012 at the University of Georgia between the ages of 18 and 30.

Recruitment & Screening

At the University of Georgia, all students are required to participate in 1 credit hour of basic physical education (PEDB) in order to graduate. A special course number of PEDB, PEDB 1990, was designated for the specific purposes of this pilot study. The course description of PEDB 1990, as posted in the University of Georgia's undergraduate course directory, included basic information about the research study and is displayed below:

> **Course ID:** PEDB 1990
>
> **Course Description:**
>
> This is a research study evaluating behavior changes
> with structured exercise. Students will be randomly assigned
> to either a PEDB walking or jogging class. Contact researchers at
> uga.pe.study@gmail.com.

After receiving approval from the Institutional Review Board at the University of Georgia, the research team posted approximately 200 recruitment flyers in dorms and common areas around campus. Flyers contained a brief description of the research study, as well as contact information for the research team.

Students enrolled in PEDB 1990 were first contacted via e-mail prior to the start of the Spring 2012 semester. At this time, students were provided with more detailed information on the scope of the research study. The course syllabus and a self-screening form were attached to this e-mail (Appendix A). The syllabus outlined both the requirements inherent to the PEDB general curriculum and those requirements specific to the research study. The self-screening form contained a series of 'yes or no' questions pertaining to the inclusion and exclusion criteria of the study, as well as instructions to drop the course if deemed ineligible. Subjects were excluded if they had orthopedic limitations that inhibit ambulation. Additionally, female subjects were excluded if they were pregnant, lactating, or attempting to become pregnant. Lastly, subjects were excluded if they self-reported chronic physical or mental health conditions or medications that adversely affected participation in physical activity or disrupts diet.

Since enrollment for PEDB 1990 was below target levels, instructors for other walking and jogging PEDB sections were contacted and asked to provide study information to students enrolled in their courses. Appendix E illustrates the recruitment and enrollment pattern for the pilot study.

Obtaining Informed Consent

The informed consent for this pilot study received approval by the Institutional Review Board at the University of Georgia. Students were given two copies of the original informed consent on the first day of class, Tuesday 1/10/12. The researchers verbally explained the form, and students were then given ample time to read the document and ask questions. Students were asked to sign both copies. Researchers kept 1 copy in a locked file cabinet, and students kept the second copy for their personal records. On Wednesday, 1/11/12, the Institutional Review Board recommended three minor amendments to the original informed consent. Therefore, students were provided with two copies of the revised informed consent on Thursday, 1/12/12. Researchers stapled the revised form to the original form, and the copies were stored in a locked file cabinet.

Study Design

Students enrolled in the PEDB 1990 course were randomized, within strata of gender and body composition, to an 8-week structured physical activity program of either moderate intensity walking or vigorous intensity jogging. These courses were intended to be similar to the existing PEDB 1930 jogging class and the PEDB 1950 walking class offered at the University of Georgia. The 10-week total duration of PEDB 1990 allowed for completion of study testing before and after the actual 8-week exercise program. Since compensation can only occur in response to an imposed change in physical activity, no control group was included in the study design.

Each PEDB 1990 class met twice weekly from 11:00-12:15 (Tuesday/Thursday) for a duration of 75 minutes. The walking class consisted of 60 minutes of moderate intensity walking, with 15 minutes allowed for administrative and warm-up activities. The jogging class aimed to include 30 minutes of vigorous intensity jogging, 30 minutes of moderate intensity walking, with 15 minutes allotted for administrative and warm-up activities. If students could not meet these target activity levels, modifications were made on an individual basis. For example, some members of the jogging class needed to intersperse walking with jogging (i.e. jog for 3 minutes, walk for 2). Additionally, undergraduate research assistants acted as peer motivators and physical activity monitors throughout the exercise class duration. Students were instructed to wear proper exercise clothing to each class meeting, and each student wore his/her assigned accelerometer for the duration of each class meeting.

Table 1: Study Timeline

Weeks	**1**	**2-4**	**5**	**6-7**	**8**	**9-10**
INSTRUMENTS						
SubMax Test & Treadmill Test	X					
DXA	X					
DXA Risk Form	X					
3-day Diet Recall	X		X		X	
3-day Accelerometer	X		X		X	
Visual Analogue Scale	X		X		X	
3-Factor Eating Questionnaire	X					
Self-Motivation Inventory	X					
NEO Five Factor	X					
Reward Responsiveness	X					
UPPS-P	X					
Monetary Choice	X					
Accelerometers During Class		X	X	X	X	

As illustrated in Table 1, baseline testing was completed during Week 1 of the PEDB 1990 course and included a height and weight measurement, a PWC 170 sub-maximal cycle ergometry exercise test, a dual-energy X-ray absorptiometry (DXA) body composition assessment, individual calibration of accelerometer counts to energy expenditure via treadmill test, and a battery of psychological assessments. During Week 1, students were also required to complete a three-day dietary recall (for two weekdays and one weekend day) and to wear accelerometers throughout the week. During Week 5, students completed a second three-day dietary recall (for two weekdays and one weekend day), wore accelerometers throughout the week, and also completed the Visual Analogue Scale (VAS). Week 8, the final week of the intervention period, followed the same protocol outline as Week 5. Each component of the protocol is described in detail below.

Measurement Protocols

Anthropometric Data Collection

After obtaining informed consent during the first class meeting, researchers escorted subjects to the Exercise Physiology laboratory to obtain anthropometric measurements. One at a time, students entered a small intake room and removed their shoes and outerwear. Students were instructed to stand against the goniometer, with their hands on their hips, and feet flat against the wall. Height was measured and recorded in centimeters. Weight was then measured on an electronic scale by A & D Company (San Jose, CA), and was recorded to the nearest 0.1 kilogram.

Dual X-Ray Absorptiometry Protocol

Dual X-ray absorptiometry is widely recognized as the gold standard for estimating body composition (Treuth et al., 1994). Total body or estimated total body scans using DXA provide information about body composition, including bone mineral content, bone mineral density, lean tissue mass, fat tissue mass, and percent fat results. During Week 1 of PEDB 1990, subjects were provided with two copies of the University of Georgia's Kinesiology Department's DXA Risk informed consent. Researchers verbally described the risks and benefits associated with receiving a DXA scan and provided subjects with ample time to read the form, ask questions and provide written consent. Researchers kept one copy of the DXA Risk informed consent form, and students kept the second copy for their personal records. The researchers' copy of the form was available for the certified DXA technician to review at the time of each subject's scan. Subjects then registered for an appointment time, outside of class, in which they would receive a DXA scan by a certified member of the research team.

Each subject was instructed to wear exercise clothing to his/her DXA appointment and to avoid wearing any clothing/accessories containing metal. If the subject failed to conform to this request, he/she was provided with medical scrubs to change into for the DXA scan. Upon arrival to the DXA appointment, the certified DXA technologist of the research team greeted each subject. Each subject was then given the opportunity to take a pregnancy test if he/she indicated that desire on the DXA Risk informed consent. The certified DXA technologist then properly positioned the subject on the DXA table and performed one total body scan. The scan lasted approximately 8 minutes, and the subject was then dismissed. A member of the research team analyzed total body scan results for each subject, and subjects received their results during Week 2 of PEDB 1990. The total body percent fat, from the total body scan, was the only DXA output used for this study.

Sub-maximal Test Protocol

The basic aim of sub-maximal exercise testing is to determine an individual's heart rate (HR) response to various sub-maximal workloads and use those values to predict the individual's maximal oxygen uptake. The Physical Work Capacity (PWC) 170 sub-maximal cycle ergometer test is recommended for normal and high-risk university students and involves an increase in resistance at four-minute intervals (Pihl et al., 1997). The sub-maximal exercise tests were performed by research staff in the Exercise Physiology lab at the University of Georgia.

Prior to the subject arriving to the laboratory for testing, Monark cycle ergometers were calibrated using a 3 kp weight, and a metronome was set to a pace of 60 beats per minute, to facilitate a pedaling cadence of 60 rotations per minute. Upon arrival, each subject was instructed to place a wetted Polar Heart Rate (Lake Success, NY) monitor below the sternum and directly against the skin. Researchers wore the receiving Polar watch on their wrists, for ease of reading throughout the protocol. The subject was then seated at the laboratory table for a three-minute period while researchers explained the PWC 170 protocol (see Table 2). Resting heart rate and blood pressure were obtained and recorded on the appropriate data collection forms. The cycle seat height was then adjusted to properly fit the subject, and the warm-up portion of the protocol began.

Table 2: PWC 170 Cycle Ergometer Sub-maximal Exercise Protocol

			Workload (kp)			
Length (min)	Stage	**(HR goal)**	Male	Female	Male*	Female*
2	Warm-up		1.5	0.5-1	0.5-1	0.5
4	1	**(HR≥115-130)**	2	1	1	0.5
4	2	**(HR≥130-145)**	2.5	1.5	1.5	1
4	3	**(HR≥145-160)**	3	2	2	1.5
4	4 - if required	**(HR≥145-160)**	3.5	2.5	2.5	2.0

**used for overweight or very sedentary subjects*

The two-minute warm-up stage allowed subjects to familiarize themselves with the cycle and the cadence of 60 rotations per minute. Researchers used this warm-up time to gauge the subject's heart rate response to a low resistance. During each 4-minute stage, it was the goal of the researcher to elicit a target heart rate response in the subject by increasing his/her workload appropriately. For example, the target heart rate response for Stage 1 is 115-130 beats per minute; so, the workload (kp) during Stage 1 varied across subjects from 0.5 kp to 2.0 kp to produce the desired heart rate response. The subject's workload and heart rate were recorded during each minute of the protocol on the PWC 170 data collection sheet. Stage 4 was completed only if the subject failed to reach the target heart rate response range in Stage 3. The criteria for terminating the sub-maximal test were as follows: 1) the subject requested to stop; 2) the subject reached ≥85% of his/her age-predicted maximum heart rate; 3) the subject failed to conform to the exercise protocol; 4) the testing environment became unsafe for any reason.

Treadmill Accelerometer Calibration Protocol

During weeks 1 and 2 of PEDB 1990, students also completed a treadmill accelerometer calibration test. The purpose of this calibration test was to estimate EE at three distinct walking speeds using a physical activity measurement device. Specifically, this protocol involved a walking exercise test on the treadmill, while wearing an ActiGraph GT3X (Pensacola, FL) accelerometer and being connected to a metabolic cart for respiratory gas analysis. It should be noted that the ActiGraph GT3X accelerometer is associated with high intra-instrument reliability estimates of r=0.99 in lean and overweight adults (Aljaloud et al., 2011). Prior to beginning testing each day, the pneumotach of the TrueMax 2400 Metabolic System (Salt Lake City, UT) was calibrated by following the prompts on the computer screen and properly using a 3-liter syringe with room air. Data on barometric pressure, room temperature and humidity were obtained and entered into the system. Researchers also assembled a Hans Rudolph (Shawnee, KS) mouthpiece for each subject, wearing rubber gloves and using standard sanitary conditions.

Upon the subject's arrival, researchers instructed him/her to place a Polar heart rate monitor around the sternum and directly against the skin. The TrueMax 2400 Metabolic System receives signals directly from the Polar heart rate monitor, so it was not necessary for researchers to wear the Polar receiving watch throughout the protocol. The subject then placed his/her assigned ActiGraph GT3X accelerometer on his/her right hip. The subject was then seated at the laboratory table for a three-minute period while researchers explained the treadmill accelerometer calibration protocol. Resting heart rate and blood pressure were obtained and recorded at the end of this three-minute period. Researchers then explained the Borg scale of perceived exertion to the subject, ensuring he/she felt comfortable reporting a rating of perceived exertion (RPE) at standardized time points throughout the protocol.

The subject was then asked to stand on the treadmill, place the mouthpiece in his/her mouth, and Stage 1 of the exercise protocol began. The subject was instructed to walk normally and to avoid grabbing onto the handrails of the treadmill. Table 3 below illustrates the protocol used for this test. During each three-minute stage, the following measures were recorded: VO_2 at 1:00, 2:00 & 3:00; RPE at 2:00; HR at 1:45 and 2:45. The subject was notified prior to any stage change and corresponding increase in speed. The criteria for terminating the treadmill accelerometer test were as follows: 1) the subject requested to stop; 2) the subject reached $\geq$85% of his/her age-predicted maximum heart rate; 3) the subject failed to conform to exercise protocol; 4) the testing environment became unsafe for any reason; 5) the subject's rate of perceived exertion was $\geq$18.

Table 3: Treadmill Accelerometer Calibration Protocol

Stage	**Length (min)**	**Grade**	**Speed**
1	3	0	1.7
2	3	0	3.0
3	3	0	4.2
Active Recovery	3	0	1.7

During completion of the treadmill accelerometer calibration protocol, each participant wore an ActiGraph GT3X accelerometer on his/her right hip. The epoch length on each accelerometer was set to 30 seconds by the research team. Similarly, the TrueMax 2400 Metabolic Cart was set to summarize respiratory gas analyses in 30-second increments.

Accelerometer counts during the treadmill accelerometer calibration protocol were then plotted against oxygen consumption values from the TrueMax 2400 Metabolic Cart to generate individualized prediction equations of oxygen consumption for each participant. For data analysis purposes, the volume of oxygen consumption was converted to kilocalories.

Estimation of Energy Expenditure with Accelerometry

Each student wore his/her assigned accelerometer during class time from week 2 through week 8. Accelerometer counts during class were then input into each student's individualized calibration equation estimate the student's energy expenditure (in kilocalories) during class time. Each student also wore his/her assigned ActiGraph GT3X accelerometer for seven consecutive days during all waking hours during week 1, week 5, and week 8. The accelerometer counts for these seven-day periods were entered into the individualized calibration equations to provide estimates of weekly energy expenditure. Seven-day wear periods included all EE performed during class periods for the structured exercise intervention. For all analyses presented here, a valid day was defined as having 8 or more hours of monitor wear. Based on a recent literature review from Trost et al (2005), it was determined that subjects needed four valid days of 8-hour wear-time to be included in these data analyses.

ActiGraph GT3X accelerometers connected directly to the Exercise Physiology Lab's desktop computer through a USB interface. ActiLife Software (Pensacola, FL) allowed researchers to download .CSV files of the recorded data to the appropriate master spreadsheet for each designated wear-time.

Dietary Recall Protocol

The National Cancer Institute (NCI) sponsors a free, online dietary recall program called the Automated Self-Administered 24-hour Recall (ASA24). The format and design of the ASA24 mimic an interviewer-administered 24-hour recall, and the ASA24 is comprised of both a respondent website and a researcher website. Prior to beginning PEDB 1990, a request was submitted to register this pilot study and to set the study parameters (i.e. number of recalls allowed, time to complete a recall), generate usernames and passwords for all study participants, and grant members of the research team access to dietary analysis files.

On the first day of PEDB 1990, students received written and verbal instructions regarding the ASA24 online program. Each student was provided a unique username and password which granted him/her access to the respondent website. Students were instructed to follow the prompts and enter all food and drinks consumed for the previous day. Students were asked to report their dietary intakes for at least two weekdays and one weekend day during Week 1, Week 5, and Week 8 of the intervention. Students were reminded frequently via e-mail and during exercise sessions to submit their online diet records.

The researcher website component of the ASA24 generates summary variables of food and drink intake for all subjects upon request by the researcher. For the purposes of this study, macronutrient intake and total caloric intake were evaluated at each of the three collection time points (Weeks 1, 5, 8). The primary goal for quantifying the dietary intake was to quantify differences in intake throughout the intervention. For data analysis purposes, the two reported weekday intakes during each time point were averaged together. This generated one typical weekday intake and one typical weekend day intake per subject during each time point. From these two values, a weighted average ((5/7*weekday)+(2/7*weekend day)) was then calculated to represent a typical daily intake.

As previously mentioned, the ASA24 is based on the United States Department of Agriculture's Automated Multiple Pass Method (AMPM) (Kipnes et al., 2003; Moshfegh et al., 2008). The AMPM is the dietary interview component of the National Health and Nutrition Examination Survey, and it has been validated to accurately report energy intake in normal-weight subjects (Moshfegh et al., 2008). Preliminary analyses of diet recall data from the ASA24 are consistent with results from the National Health and Nutrition Examination Survey (NCI, 2011). Since the ASA24 was only recently created, further validation studies are currently underway, and the NCI expects to release this data in late 2012 (NCI, 2011).

Psychological Assessments Protocol

During Week 1 of the semester, students completed a battery of psychological assessments including the Three-Factor Eating Questionnaire, Self-Motivation Inventory, Mental and Physical State and Trait Energy and Fatigue Scales (EFS), NEO Five-Factor Inventory, Assessment of Impulsivity-related Traits (UPPS+P), Reward Responsiveness Scale, and the Monetary Choice Questionnaire (MCQ). At week 5 and week 8, students also completed additional EFS questionnaires to assess changes in symptoms of energy and fatigue throughout the 8-week period. The approximate time associated with completion of all surveys/questionnaires was 2 hours. Table 4 includes a brief description of each psychological measure.

Table 4: Psychological Assessments Summary

Instrument	Brief Description	Completion Time (minutes)	Data Entry & Scoring Time (minutes)
TFEQ	51 items; measures cognitive restraint of eating, hunger & disinhibition	10	10
SMI	40 items; measures general self-motivation	5	10
EFS	12 items; measures transient mood states of fatigue and vigor	5	15
NEO-FF	60 items; measures Neuroticism, Extraversion, Openness to Experience, Agreeableness & Conscientiousness	10	10
UPPS-P	59 items; measures urgency, premeditation, perseverance, and sensation seeking	10	10
RRS	24 items; measures reward sensitivity	5	5
MCQ	27-items; measures reward sensitivity and delayed discounting	7	10

The Three-Factor Eating Questionnaire (TFEQ) is a 51-item instrument designed to measure cognitive restraint of eating, hunger, and disinhibition. The questionnaire is comprised of two parts: Part I contains 36 true/false items, and Part II contains ten 4-point scales, one item reflecting eating restraint, and one open-ended question. Completion of the self-report measurement takes approximately 10 minutes in healthy populations (Stunkard & Messick, 1985). Research suggests that the cognitive restraint scale is robust across different samples, while disinhibition and hunger are less stable but still satisfy minimum psychometric requirements (Karlsson et al., 2000). Multiple validation studies have been carried out in samples of normal weight and obese men and women (Karlsson et al., 2000). For example, Karlsson et al (2000) sampled over 4,000 men and women from the Swedish Obesity Study and found reliability estimates with Cronbach's alpha ranging from .77 to .84, which is indicative of acceptable internal consistency.

The Self-Motivation Inventory (SMI) is a 40-item questionnaire that measures general self-motivation and has been shown to predict adherence to physical activity. In fact, self-motivation scores accurately classified undergraduate students and student-athletes according to their adherence status in approximately 80% of all cases and accounted for nearly 50% of the variance in exercise adherence behavior (Dishman et al., 1980). The SMI is strongly correlated with well-established behavioral measures like the Thomas-Zander Ego Strength Scale (r=0.63). The SMI also has strong internal consistency ratings (r=0.91) and a high degree of scale stability (r=0.86-0.92)(Dishman et al., 1981). Dishman et al. 1981 established predictive validity by observing subjects in a variety of settings and quantifying their behaviors.

The EFS was developed and validated by Dr. Patrick O'Connor at the University of Georgia. This pilot study used one, 12-item section of the measure that measured four energy and fatigue mood states: Physical Energy State, Physical Fatigue State, Mental Energy State, and Mental Fatigue State. Completion of the self-report instrument took approximately five minutes in this college-aged, healthy population. Raw scores for all 12 items were determined by using a ruler to measure the distance in millimeters from the left edge of each horizontal line to the vertical mark made on the line by the subject. Scoring took approximately 5 minutes per survey. Specifically, this pilot study focused on assessing the four energy and fatigue mood states at Week 1, Week 5, and Week 8 of the intervention. Evidence of reliability for the state scales of this measure were determined from a telephone survey of 202 adult residents of the United States and range from alpha=0.89-0.91 (O'Connor, 2006).

This pilot study also used a 12-item section of the EFS to measure four energy and fatigue trait scales: Physical Energy Trait, Physical Fatigue Trait, Mental Energy Trait, and Mental Fatigue Trait. These 12 items were scored on a Likert-type scale, and scoring took approximately 2 minutes per survey. Evidence of reliability for the trait scales of this measure were determined from a telephone survey of 202 adults residents of the United States and range from alpha=0.82-0.85 (O'Connor, 2006). Discriminant validity in this same sample of 202 adults was assumed because the item-total scale correlations were higher than the correlations found between items and scales measuring other related constructs, r=-0.23-0.62 (O'Connor, 2006).

The NEO Five-Factor Personality Inventory is a 60-item version of the 240-item Revised NEO Personality Inventory, which assesses the personality traits of Neuroticism, Agreeableness, Extraversion, Conscientiousness, and Openness to Experience (Goldberg, 1990; McCrae & Costa, 1987, 1989). Each of these five factors houses a number of more specific and narrowly defined states (Schmukle et al., 2008). For example, the Neuroticism category is comprised of trait spectrums like calm to worrying and self-satisfied to self-pitying (McCrae & Costa, 1990). The NEO Five-Factor Inventory scale accounts for about 75% as much variance in personality traits as the 240-item Revised NEO Personality Inventory from which it was designed (McCrae & Costa, 1989). Estimated time to completion in healthy populations is approximately 10 minutes. Additionally, the NEO Five-Factor Inventory has average scale-score reliabilities of 0.78 (McCrae & Costa, 1992).

The UPPS+P Impulsive Behavior Scale is a 59-item questionnaire that assesses urgency, premeditation, perseverance and sensation seeking. The estimated time to completion in healthy subjects is approximately 10 minutes. Whiteside and Lynam 2001 presented information on the internal consistencies for the four factors of premeditation (r=0.91), urgency (r=0.86), sensation seeking (r=0.90) and perseverance (r=0.82). Additionally, convergent corrected item totals had a mean of r=0.58, and divergent item totals had a mean of r=0.17, which can be considered average (Whiteside & Lynam, 2001). The UPPS+P was created for use in adult populations ranging in age from 18 to 64 (Cyders & Smith, 2007).

The Reward Responsiveness Scale (RRS) is a 24-item questionnaire measuring sensitivity to reward. It is a primary component of Carver and White's BIS/BAS scale, and this study assessed sensitivity to reward using the 10-item Sensitivity to Reward – Short Form. The BAS subscales, Reward Responsiveness, Drive and Fun Seeking, have satisfactory internal consistencies, with alphas ranging from 0.66 to 0.76, and strong two-month test-retest reliabilities with r=0.59-0.69 (Carver & White, 1994). Estimated time to completion is 5 minutes in healthy subjects, and the scale took approximately 2 minutes to enter and score for each subject.

The Monetary Choice Questionnaire (MCQ) is a 27-item instrument measuring sensitivity to reward and delayed discounting (Kirby & Marakovic, 1996). Participants were presented with a fixed set of 27 choices between smaller, immediate rewards (SIRs) and larger, delayed rewards (LDRs). Estimated time to completion was 7 minutes. The temporal stability of the MCQ is fairly strong in undergraduate students, with a 5-week test-retest stability of discount rates at 0.77 (95% confidence interval = 0.67-0.85) and a 1-year stability of 0.71 (95% confidence interval =0.50-0.84) (Kirby, 2009).

Psychological Assessment Data Entry Protocol

Scoring documents for all psychological measures were created in Microsoft Excel prior to the intervention. After completion of psychological measures during week 1, an undergraduate research assistant entered each item into the appropriate Microsoft Excel spreadsheet. A member of the research team then double-entered each item for quality assurance. Any discrepancies in data entry were triple-checked by a third member of the research team and corrected accordingly. This pilot study focused specifically on the following four psychological measures: Self Motivation Inventory, UPPS+P, Mental and Physical State and Trait Energy and Fatigue Scales, and the Reward Responsiveness Scale.

Statistical Analyses

All data was gathered and entered into Microsoft Excel and SPSS 19.0 (Armonk, NY) for analysis. Descriptive statistics were run on all subjects for each of the 4 psychological measures used in this pilot study. Descriptive statistics are presented in the form of means $\pm$ standard deviations. The alpha level was set to *a priori* at 0.05 for the analysis of the physical activity intervention and for analyses concerning the psychological questionnaires. Paired-samples t-tests were run to compare energy intake at baseline and Week 8, energy expenditure at baseline to Week 8, and VAS data at baseline to Week 8. Pearson's correlations were then found between each psychological construct and energy intake. This process was repeated to find correlations between each psychological construct and change in energy expenditure.

CHAPTER 4

RESULTS

Subjects

This study included 20 male (n=7) and female (n=13) undergraduate students at the University of Georgia with a mean age of 20.6 ± 1.51 years. Average body mass index (BMI), as calculated from weight (kg) and height (cm), was 24.12 ± 4.55 kg/m^2. BMI was significantly higher in females than in males ($p<0.05$). Body fat percentage, as determined through dual x-ray absorptiometry, was also significantly higher in females than in males ($p<0.05$). Subjects were categorized as having average levels of fitness for their age group, as evident in the mean estimated VO^2max of 41.77 ± 8.67 ml/kg/min (ACSM, 2010). Subject baseline characteristics are shown in Table 5.

Table 5: Subject Characteristics at Baseline

	Total	**Males**	**Females**
N	20	7	13
Age (years)	20.6 ± 1.51	21.3 ± 0.6	20.3 ± 1.7
Height (cm)	170.3 ± 14.6	187.0 ± 8.6	162.0 ± 2.8
Weight (kg)	68.7 ± 12.9	75.4 ± 4.6	65.1 ± 14.6
BMI (kg/m^2)	24.1 ± 4.6	22.9 ± 1.7	24.8 ± 5.5
Body Fat (%)	32.4 ± 9.6	23.2 ± 5.1	37.3 ± 7.5
VO_{2max} (ml/kg/min)	41.8 ± 8.7	48.8 ± 2.6	37.7 ± 8.3

Dose of PEDB 1990 Exercise Intervention

The goal of PEDB 1990 was to provide a dose of 60 minutes of aerobic exercise twice weekly. Students were block randomized by gender and baseline BMI into two exercise groups:

moderate intensity walking and vigorous intensity jogging. Based on accelerometer measurements, the walking group participated in an average of approximately 50 minutes of moderate activity, with the remaining time spent in vigorous activity. In contrast, the jogging class spent an average of 34 minutes in moderate activity, 15 minutes in vigorous activity, and 6 minutes in very vigorous activity. Overall, 86% of PEDB 1990 classes were attended, and each subject attended at least 11 of the 15 structured exercise sections. PEDB 1990 was successful in providing approximately 120 minutes of structured exercise each week.

Determining Change in Energy Intake

To quantify change in total energy intake (EI) throughout the intervention, baseline caloric intake from week 1 was compared with diet recall outcomes at week 8. To be included in the dietary analysis for week 1, subjects were required to have completed 1 weekday day recall and 1 weekend recall; participants with incomplete diet records were excluded from this section of data analysis. A weighted average was then calculated in Microsoft Excel to produce a single, baseline estimate of daily EI for each subject. The same weighted average procedure was repeated for week 8 diet recalls, provided subjects satisfied the minimum inclusion requirement of diet recalls on the National Cancer Institute's ASA24 website. Five subjects were excluded due to missing diet records.

A matched pairs t-test was run to compare EI during week 1 and week 8 for the 15 subjects with complete data at both time points. When examining the group as a whole, there was no significant difference between EI during week 1 and week 8 ($p=0.19$). The 15 subjects were then separated based on gender to detect possible differences. For the 10 females, there was no significant difference between EI during week 1 and week 8 ($p=0.10$). Similarly, no significant change was detected in EI for the five males between baseline and week 8 ($p=0.69$). Mean ± standard deviation values for EI at each time point are presented in Table 6.

Although changes in EI were not significant in these statistical analyses, the individual variability between subjects should not be ignored. Specifically, the mean EI change score for the group overall was -239.6 ± 667.1 kilocalories, meaning that the group did decrease EI in response to the PEDB 1990 exercise intervention. This same trend of decreased EI over the 8-week period was evident when the group was separated by gender (see Table 6).

Table 6: ASA 24 Estimated Daily Energy Intake Descriptive Statistics (kcals)

	N	Mean EI Week 1	Mean EI Week 8	Mean EI Change Score
Overall	15	1994.3 ± 582.0	1754.7 ± 819.6	-239.6 ± 667.1
Male	5	2530.2 ± 619.0	2325.2 ± 1166.3	-257.0 ± 440.5
Female	10	1726.4 ± 342.5	1469.4 ± 411.4	-205.0 ± 1057.7

Determining Change in Energy Expenditure

Accelerometry was used to objectively measure the weeklong EE of each subject at three points during the intervention: baseline, week 5 and week 8. Weeklong EE estimates included EE performed during PEDB class meetings. Raw data output from the ActiGraph GT3X accelerometers was reported in total counts, and researchers converted this into counts per valid hour and counts per 30-second epoch. Individualized regression equations were then used to estimate VO_2 per 30-second epoch length. These oxygen consumption values were then converted into kilocalories (kcals) per 30-second epoch length, which allowed researchers to calculate average kcals expended per hour. This value (kcals/hour) was then multiplied by 14, as it was assumed by the research team that 14 hours of the 24-hours period were active. Rest was assumed for the remaining 10 hours of the day, so 1 kcal/kg/hour (3.5 mlO_2/kg/min) was added for each of the 10 remaining hours. An EE change score was then calculated for each subject with complete data for both baseline and week 8. Subjects were excluded if they did not satisfy the wear time requirements for either baseline or week 8. Nine subjects were excluded due to insufficient wear time.

A matched pairs t-test was run to compare EE during week 1 and week 8 for the 11 subjects with complete data at both time points. When examining the group as a whole, there was no significant difference between EE from week 1 and week 8 ($p=0.56$). The 11 subjects were then separated based on gender to detect possible differences. For the 8 females, there was no significant difference between EE during week 1 and week 8 ($p=0.21$). Similarly, no significant change was detected in EE for the 3 males between baseline and week 8 ($p=0.43$).

Although changes in EE were not significant in these statistical analyses, the individual variability between subjects should not be ignored. Specifically, the mean EE change score for the group overall was 73.0 $\pm$ 112.3 kilocalories per day, meaning that the group did increase EE slightly in response to the PEDB 1990 exercise intervention. This same trend of increased EE over the 8-week period was evident when the group was separated by gender (see Table 7).

Table 7: Accelerometer Estimated Daily Energy Expenditure Descriptive Statistics (kcals)

	N	Mean EE Week 1	Mean EE Week 8	Mean EE Change Score
Overall	11	2205.1 $\pm$ 588.8	2265.1 $\pm$ 585.7	73.0 $\pm$ 112.3
Males	3	2389.9 $\pm$ 140.0	2508.8 $\pm$ 333.1	119.0 $\pm$ 209.7
Females	8	2135.8 $\pm$ 685.2	2173.7 $\pm$ 650.7	55.7 $\pm$ 65.0

Relationships between Energy Intake, Energy Expenditure & Psychological Constructs

The relationship between each psychological construct and the change in EE and EI was then examined using Pearson's correlations (see Appendix C). Change in EI was calculated by finding the difference between the weighted average (kcals) for week 1 and week 8. 15 subjects had sufficient diet recall data to be included in all analyses regarding EI. Change in EE was calculated by finding the difference between EE estimates from accelerometry for week 1 and week 8. Only 11 subjects had sufficient accelerometer data to be included in analyses regarding EE. Descriptive statistics for each psychological construct at baseline are presented in Table 8, and bivariate Pearson's correlations between each psychological construct and EI, EE are presented in Table 9. Results of these analyses are described below.

Table 8: Psychological Measures Descriptive Statistics

Instrument	**Psychological Construct**	**N**	**Mean ± St. Dev**	**Min**	**Max**
SMI	Self Motivation	20	147.0 ± 25.7	108	184
EFS	Physical Fatigue State_Baseline	20	103.3 ± 46.6	18	193
EFS	Physical Energy State_Baseline	20	165.5 ± 42.6	76	224
EFS	Physical Fatigue Trait	20	3.9 ± 1.8	3	11
EFS	Physical Energy Trait	20	6.8 ± 2.4	3	10
BIS/BAS	Reward Responsiveness	20	17.7 ± 1.8	14	20
UPPS+P	Positive Urgency	20	22.5 ± 4.9	15	33
UPPS+P	Negative Urgency	20	27.5 ± 6.1	18	47
UPPS+P	Sensation-Seeking	20	32.6 ± 8.1	18	47

Table 9: Bivariate Pearson's Correlations between Psychological Constructs and EI, EE

Psychological Construct	**Energy Intake Δ (N=15)**	**Energy Expenditure Δ (N=11)**
Self Motivation	0.61*	-0.33
Physical Fatigue State Change	-0.04	0.23
Physical Energy State Change	-0.28	0.10
Physical Fatigue Trait	0.14	-0.17
Physical Energy Trait	0.06	-0.22
Reward Responsiveness	-0.19	-0.34
Positive Urgency	-0.10	-0.70*
Negative Urgency	-0.18	-0.26
Sensation-Seeking	0.03	-0.15

* indicates significance, $p<.05$

Self-Motivation

The Self Motivation Inventory (SMI) was administered at baseline and provides a summary measure of motivation for physical and mental activities. The descriptive statistics for the SMI are presented in Table 8. Subjects had a mean score of 147.0 ± 25.7 and scores (out of 200 possible points) ranged from 108 to 184. A histogram of scores for the SMI is available in Appendix C and shows a relatively normal distribution. These descriptive statistics are consistent with normative values from the literature (Dishman et al., 1980).

A Pearson's correlation was run to examine the relationship between EI change and Self Motivation score. A positive, significant correlation of $r = 0.61$ was observed, suggesting that variance in self motivation accounted for 37.0% of the variance in EI change in our sample of 15 college-aged students. Those with higher levels of self-motivation were more likely to increase EI over the course of the exercise intervention.

A Pearson's correlation was then run to examine the relationship between EE and self-motivation score. A small, negative correlation of $r = -0.33$ indicates that variance in self Motivation accounted for only 10.8% of the variance in EE change in our sample of 11 college-aged students. Self-Motivation did not appear to predict EE change in this sample.

Mental and Physical State and Trait Energy and Fatigue Scales

The Mental and Physical State and Trait Energy and Fatigue Scales (EFS) was taken at 3 time points during the physical activity intervention: baseline, Week 4 & Week 8. Scores for both subscales are calculated out of 300 total points. The mean score for the Physical Fatigue State was 103.3 ± 46.6, and scores ranged from 18 to 193. The mean score for the Physical Energy State was 165.5 ± 42.6, and scores ranged from 76 to 224. Baseline values were consistent with normative averages of 126.4 ± 64.7 for Physical Fatigue State and 159.5 + 56.4 for Physical Energy State as established in a population of over 200 adults (O'Connor, 2006).

Paired samples t-tests were run to detect differences in Physical Fatigue State and Physical Energy State throughout the intervention. There was a significant change in Physical Fatigue State (p=.001); however, Physical Energy State did not change significantly throughout the intervention (p=.24). Table 10 displays the mean change values for both Physical Energy State and Physical Fatigue State.

Table 10: Mental and Physical State and Trait Energy and Fatigue Scale Results

	N	**Week 1 Mean**	**Week 8 Mean**	**Mean Change Score**
Physical Fatigue State	20	103.3 ± 46.6	174.1 ± 45.0	70.9 ± 73.6
Physical Energy State	20	165.5 ± 42.6	159.9 ± 33.2	-5.6 ± 42.8

The change scores in Physical Fatigue State and Physical Energy State throughout the intervention were calculated by subtracting baseline scores from Week 8 scores for each subject. A non-significant, negative correlation of -0.04 was observed between EI and Physical Fatigue State change, suggesting no relationship between those two variables in this sample. The bivariable correlation between EI change and Physical Energy State was slightly larger in magnitude (r = -0.28). This suggests that individuals with lower scores on the Physical Energy State scale were slightly more likely to increase EI in response to the PEDB 1990 exercise intervention.

The bivariate correlation between EE change and Physical Fatigue State change was r = 0.23. This suggests a small, potential relationship between EE change and change in Physical Fatigue State. The bivariate correlation between EE change and Physical Energy State was r = 0.10, suggesting that EE change was not significantly related to Physical Energy State.

To further investigate the relationship between state measures and EI at specific time points, the bivariate correlation between baseline EI and baseline Physical Fatigue State score was calculated (r = -0.35). Similarly, the correlation between baseline EI and baseline Physical Energy State score was r = 0.35. This suggests a potential relationship between baseline EI measurements and both Physical Fatigue State scores and Physical Energy State Scores. The same process was repeated with measures collected at week 8. The correlation between week 8 EI and Physical Fatigue State score at week 8 was r = -0.38, suggesting a moderate relationship between the two variables. The correlation between week 8 EI and Physical Energy State score at week 8 was r = -0.15.

Likewise, the relationship between state measures and EE at specific time points was investigated (see Table 11). The bivariate correlation between baseline EE and baseline Physical Fatigue State score was r = 0.01. Similarly, the correlation between baseline EE and baseline Physical Energy State score was r = -0.17. This suggests no significant relationships between baseline EE and baseline state measures in the PEDB 1990 sample. The correlations between week 8 EE and Physical Fatigue State score and Physical Energy State score were r = 0.16 and r = -0.30, respectively.

Table 11: Bivariate Pearson's Correlations between EI, EE & EFS State Measures Over Time

	EI Baseline	EE Baseline	EI Week 8	EE Week 8
Physical Fatigue State Baseline	-0.35	0.01	xx	xx
Physical Energy State Baseline	0.35	-0.17	xx	xx
Physical Fatigue State week 8	xx	xx	-0.38	0.16
Physical Energy State week 8	xx	xx	-0.15	0.30

It is important to note, from a descriptive perspective, that the EFS also contains a component assessing Fatigue and Energy Traits. The Fatigue and Energy Trait data was collected at baseline from all 20 subjects and contextualizes the results of the Physical Fatigue State and

Physical Energy State measures taken throughout the intervention. Subjects had a mean Physical Energy Trait of 6.8 ± 2.4, which is consistent with the normative value of 7.3 ± 2.0 (O'Connor, 2006). The mean score for Physical Fatigue Trait was 3.9 ± 1.8, which was also consistent with normative data of 4.9 ± 2.3 from literature (O'Connor, 2006). Subjects had normal levels of Trait Physical Fatigue and Trait Physical Energy when measured at baseline.

Bivariate correlations between EI change and both Trait Physical Fatigue and Trait Physical Energy were r = 0.14 and r = 0.06 respectively. This suggests that EI change was not strongly related to these trait measures in the PEDB sample. Bivariate correlations between EE change and both Trait Physical Fatigue and Trait Physical Energy were r = -0.17 and r = -0.22 respectively. This suggests that Trait Physical Fatigue and Trait Physical Energy were not helpful in predicting EE change in this sample.

Reward Responsiveness

Reward Responsiveness (RR) is a component of Carver and White's BIS/BAS scale, which was administered during Week 1 of the physical activity intervention. Out of 20 possible points, scores ranged from 14 to 20 with a mean score of 17.7 ± 1.8. A small, negative Pearson's correlation of r = -0.19 indicated no significant relationship between EI change and RR score. A second Pearson's correlation was then run to compare EE change and RR score. A moderate, negative correlation of r = -.34 indicated that 11.6% of the variance in EE change could be attributed to the variance in RR in our sub-sample of 11 subjects. This suggests that those with lower RR scores were more likely to increase EE in response to the PEDB 1990 exercise intervention.

UPPS+P Impulsive Behavior Scale

The UPPS+P has five subscales, three of which are most plausibly related to compensation to physical activity: Negative Urgency, Positive Urgency, and Sensation-Seeking. Descriptive statistics for each of the three subscales are available in Table 6. Negative Urgency was scored out of 48 possible points, and scores ranged from 18 to 47 with a mean of 27.5 $\pm$ 6.1. Positive Urgency was scored out of 56 possible points, and scores ranged from 15 to 33 with a mean of 22.5 $\pm$ 5.0. Sensation-Seeking was scored out of 48 possible points, and scored ranged from 18 to 47 with a mean of 32.6 $\pm$ 8.1.

Negative Urgency, Positive Urgency, and Sensation-Seeking had bivariate Pearson's correlations of $r = -0.18$, $r = -.01$, and $r = 0.03$ respectively with EI. This suggests that EI was not strongly related to any facets of UPPS+P in this sample. Negative Urgency, Positive Urgency, and Sensation-Seeking had bivariate correlations of $r = -0.26$, $r = -0.70$, and $r = -0.15$ respectively with EE. Negative and Positive Urgency were both strongly correlated to EE change in this sample. This suggests that individuals with higher scores for Negative and Positive Urgency were less likely to change their EE in response to the PEDB 1990 exercise intervention.

Relationships between Psychological Measures

Pearson's correlations were determined between psychological measures (see Table 12). Physical Fatigue Trait and Physical Energy Trait were significantly related, $r = 0.58$, $p = .01$. None of the remaining measures were significantly related to one another; however, it is imperative that future studies increase the sample size to investigate the many potential relationships between psychological measures.

Table 12: Bivariate Correlation Matrix between Psychological Measures

	SMI	PFS Δ	PES Δ	PFT	PET	RR	+Urgency	-Urgency	SS
SMI		0.21	-0.09	0.15	-0.01	0.16	0.11	-0.24	0.01
PFS Δ			-0.24	-0.43	0.39	0.21	-0.11	-0.09	-0.05
PES Δ				0.15	-0.28	-0.25	-0.17	-0.23	-0.03
PFT					0.58*	-0.18	0.32	0.12	0.01
PET						0.20	-0.09	0.09	-0.19
RR							0.24	0.11	-0.39
+Urgency								0.33	0.21
-Urgency									-0.24
SS									

* indicates $p<0.05$

CHAPTER 5

DISCUSSION

Physical activity is a primary component of many weight loss and weight management programs; however, many individuals achieve only a fraction of the predicted weight loss. Existing research indicates that volitional and automatic responses often occur when structured exercise is introduced into the daily routine. Understanding the potential causes and predictors of these compensatory responses to physical activity is highly important for public health practitioners seeking to combat the current obesity epidemic. The purpose of this study was to investigate the extent to which psychological constructs previously linked to lifestyle behaviors such as exercise, diet and addictive behavior, were related to compensation to physical activity.

Twenty undergraduate students at the University of Georgia voluntarily registered for a special section of basic physical education to participate in this research project. Students received an average dose of approximately 120 minutes of moderate and/or vigorous physical activity weekly during the 8-week intervention. This weekly increase in physical activity facilitated subjects' abilities to meet the World Health Organization's recommendation to accumulate 150 minutes of at least moderate intensity physical activity weekly for weight management. Diet and physical activity outside of the intervention were measured at three time points: baseline, week 5, and week 8 to quantify changes in energy expenditure (EE) and energy intake (EI). The relationships between theses changes with a number of psychological constructs were investigated.

Despite variability between subjects, no significant changes in EI were identified in the 15 subjects with complete diet recall data. This was also true when subjects were separated by gender; EI did not differ significantly in women or in men from baseline to Week 8 (see Tables 6 & 7). Previous research suggests that doses of added exercise may trigger compensatory EI responses in women. As discussed in Chapter 2, acute bouts of exercise do not appear to affect energy intake in males; however, women have been observed to significantly increase energy intake following acute exercise bouts (Thompson et al. 1988; King et al. 1997). This increased energy intake in women often decreases or negates the effects of physical activity on energy balance (Martins et al., 2008). Similarly, a series of exercise intervention studies by Stubbs and colleagues found that energy intake increased in response to acute exercise only in females. Interestingly, only about 30% of the exercise-induced energy expenditure was compensated for by an increased energy intake (Stubbs et al., 2002; Stubbs et al., 2002). This suggests that despite partial compensation via energy intake, the women were still receiving some benefit from the exercise intervention.

Only four subjects in this study increased EI throughout the structured exercise intervention; the remaining 11 subjects either decreased or maintained EI throughout the eight-week measurement period (see Graph II). Previous research examining the effects of an 8-week structured exercise program found that EI increased 9.7% overall, and this increase in EI was detected in both "compensators" (n=23) and "non-compensators" (n=11) (Manthou et al., 2010). This suggests that the ASA 24, used to estimate EI change throughout PEDB 1990, may not have been sensitive enough to detect EI changes in this sample. External factors, such as the timing of the third EI assessment in relation to the university's spring break, may have also contributed to the overall trends in EI that were observed in this study.

Existing research suggests that we should have expected a compensatory increase in EI among women, with no significant change in EI in men when structured physical activity was added to their weekly routine. The lack of increased EI in women during this study may be attributed to the fact that only 10 females had sufficient diet recall data to be included in the analysis. Additionally, those who did have adequate amounts of data (at least one weekday and one weekend day) may have not accurately reported all food and drinks consumed in the National Cancer Institute's ASA24 online recall program. A different method/program for diet recall is recommended for future studies attempting to objectively measure changes in energy intake during an exercise intervention.

It was expected that overall EE would increase when a substantial dose of physical activity was added to the weekly routine. Change in EE throughout this intervention was objectively quantified using ActiGraph accelerometers. In order to be included in data analyses regarding EE, subjects were required to wear the activity monitor for at least 8 hours a day for 4 days during each one-week wear period; only 11 subjects met these specifications for both baseline and week 8 time points. Despite variability between subjects, a non-significant change in EE of 73.0 ± 112.3 kilocalories per day occurred throughout the intervention from baseline to week 8 in the group overall, nor were meaningful changes observed when subjects were examined separately by gender (see Table 7). This suggests that, despite the added dose of physical activity during exercise sessions, overall EE in the group remained relatively steady throughout the 8 weeks of this study.

Using the ActiGraph to estimate EE throughout the PEDB 1990 structured exercise intervention has several broad limitations. Specifically, ActiGraph accelerometers do not accurately capture non-ambulatory activities such as household chores, gardening and upper-body weight lifting (Chen & Bassett, 2005). Similarly, ActiGraph accelerometers cannot be worn in the water; any physical activity done in the swimming pool is not measured with this type of accelerometer. Thus, total daily physical activity may have been under-estimated in individuals engaging in such behaviors. Secondly, some error is associated with the individualized calibration equations implemented by the research team to quantify EE with data from ActiLife and MeterPlus software. For example, the treadmill calibration test was conducted with 0% incline at three walking speeds (see Table 3); however, subjects likely were walking/running on slight inclines and at different speeds during the free-living, week-long wear periods. Thirdly, differences in wear time between subjects poses a potential problem. Some subjects wore the device during all waking hours as instructed, while some only wore the device for 8 hours of waking time. Thus, EE estimates may be more accurate for some subjects than for others. Due to such limitations with accelerometry, a different method of measuring EE may have provided more accurate results. For example, the use of doubly labeled water is recognized as a gold standard for quantifying energy expenditure in free-living environments (Kazuko et al., 2011).

The purpose of this study was to investigate the relationship between psychological traits and the change in both EE and EI in response to increased amounts of structured exercise in a college population. Understanding the potential causes and predictors of compensatory responses to physical activity is highly important for public health practitioners seeking to combat the current obesity epidemic. Each psychological trait, as related to EE and EI in this sample, is described more completely below.

Self-Motivation

Given the current obesity epidemic in the United States, a major practical issue in health promotion lies in facilitating adherence to regular exercise (Dishman et al., 1985). Existing literature linking self-motivation to adherence to physical activity and, therefore, successful weight management has had unequivocal findings. In one study, self-motivation scores accurately classified undergraduate students and student-athletes according to their adherence status in approximately 80% of all cases and accounted for nearly 50% of the variance in exercise adherence behavior (Dishman et al., 1980). Another study, however, found that lack of self-motivation for exercise accounted for only 18% of the variance in total physical activity in adult women (Sternfeld et al., 1999). Although self-motivation alone does not determine exercise behavior, evidence suggests it may play a key role in one's likelihood to perform the recommended amount of daily physical activity.

Though self-motivation has been widely examined in relation to physical activity and adherence to exercise interventions, a small body of literature to date has examined self-motivation in relation to compensation to physical activity. This study used the Self Motivation Inventory (SMI) to assess self-motivation in college-aged students at the University of Georgia. After noting that self-motivation is likely a predictor of exercise behavior, it was hypothesized that self-motivation would be strongly related to compensation via change in EE; however, only a weak negative relationship between SMI summary scores and EE change was observed ($r = -0.33$). This suggests that subjects with higher SMI scores had lower EE changes in response to the intervention, which seems counter-intuitive. The scatterplot (see Graph IV) for this relationship illustrates that most subjects experienced only a very small change in EE, and this lack of variability between individuals have made it more difficult to detect relationships with psychological measures. Increasing the sample size in future studies may alter the magnitude and direction of the relationship.

In contrast, a strong, positive relationship was identified between EI and the SMI summary score (r = 0.61). This result indicates that 37.0% of the variance in EI change could be attributed to variance in SMI summary score in this sample. Individuals in this sample with higher SMI scores were more likely to increase EI in response to the PEDB 1990 intervention. This suggests that self-motivation, or lack thereof, may be helpful in predicting compensation via volitional change in EI. It is important to recognize, however, that Graph III indicates that approximately half of the subjects had no change or very little change in EI throughout the intervention.

Based on prior literature, we assumed a relationship between EE change and self-motivation would be observed; however, the relationship between EI change and self-motivation was significantly stronger in this pilot study. Specifically, individuals with higher levels of self-motivation (as measured via SMI) were more likely to increase their EI throughout the intervention than individuals with lower levels of self-motivation. These surprising results may be partially attributable to the small sample size of 15 students, as any one subject's score may highly influence the observed correlations. Alternatively, the large amount of variability seen in EI change (-239.6 $\pm$ 667.1 kcals/day) may have influenced the direction of this relationship. Lastly, environmental and social factors, such as upcoming vacations during Spring Break, may have impacted EI change scores in these subjects. Future studies examining compensation to structured exercise in this population should aim to collect qualitative data on seasonal weight loss goals and social desirability.

Mental and Physical State and Trait Energy and Fatigue Scale

The relationship between fatigue and physical activity is well established in the literature. Fatigue is associated with physical inactivity in college-aged students, and existing research indicates that approximately 25% of the general population self-reports regular feelings of fatigue (Lewis et al., 1992; Soyeur et al., 2010). A study by Lee et al. in 2007 found even higher rates of fatigue in college-aged students, with prevalence estimates of 45.8% and 48.9% in males and females, respectively. This same study showed that the intensity of regularly performed physical activity was identified as protective against fatigue (Lee et al., 2007). Similarly, Soyeur et al. 2010 reported that students with strong feelings of fatigue performed significantly less physical activity than their non-fatigued counterparts (Soyeur et al., 2010). This suggests an inverse relationship between self-reported feelings of fatigue and habitual physical activity intensity; individuals who regularly exercise at a high intensity have lower self-reported levels of fatigue.

Less well documented is the relationship between fatigue and compensation to physical activity. Based on the existing literature, it was hypothesized that fatigue would be most highly correlated with changes in EE throughout the intervention. To assess levels of fatigue, this study employed the Mental and Physical State and Trait Energy and Fatigue Scale, which provides measures of both fatigue traits and fatigue states. Information on fatigue traits was gathered at baseline to describe levels of fatigue and energy present in the sample. Trait physical fatigue and trait physical energy levels were consistent with normative values from the literature, suggesting that this sample was neither more fatigued nor less energized than the general population (O’Connor, 2006).

Transient state measures of physical fatigue and physical energy were collected at three time points during the study: baseline, week 5, and week 8. A significant increase of 70.9 ± 73.6 points between physical fatigue state at baseline and week 8 was observed, suggesting that students felt more physically fatigued at the end of the intervention than they did at the beginning. From a practical standpoint, this is a logical result. The intervention began during the first week of the Spring 2012 semester, after students had a long break, and the intervention ended right before spring break, during a week full of mid-term exams. Therefore, factors outside of the intervention, rather than the increased dose of physical activity, may have led to the increase in state physical fatigue that was observed.

In contrast to physical fatigue state, a non-significant mean change of -5.6 ± 42.8 points in physical energy state was observed from baseline to week 8. This was unexpected as physical energy and physical fatigue states typically have an inverse relationship; if physical fatigue increased, we would expect physical energy to have decreased.

The relationships between these transient state measures and EI change were examined among the 15 subjects with complete diet recall data. Change in EI was not significantly related to change in physical fatigue state ($r = -0.04$), and only slightly more predictive of physical energy state change ($r = -0.28$). These results are consistent with previous literature, which suggest that EE change is more highly related to fatigue than EI change. Weak correlations were also observed between EE change and physical fatigue state and physical energy state ($r = 0.23$ and $r = 0.10$, respectively).

To further investigate the relationship between state measures and EI at specific time points, the correlations between baseline EI and both baseline Physical Fatigue State and Physical Energy State were observed ($r = -0.35$ and $r = 0.35$, respectively). This suggests a potential relationship between baseline EI measurements and both Physical Fatigue State scores and Physical Energy State scores. Individuals with higher Physical Fatigue State scores were likely to report lower EI at baseline, and subjects with higher Physical Energy State scores were more likely to report higher EI at baseline. The same process was repeated with measures collected at week 8. The correlation between week 8 EI and Physical Fatigue State score at week 8 was r = -0.38, suggesting a moderate negative relationship between the two variables. Subjects in this sample with lower EI during week 8 reported higher levels of Physical Fatigue State. Week 8 EI and Physical Energy State score were less strongly related (r = -0.15), suggesting that Physical Energy State was not predictive of EI during week 8 in this sample.

Likewise, the relationship between state measures and EE at specific time points was investigated (see Table 11). The correlation between baseline EE and baseline Physical Fatigue State score was near null (r = 0.01), suggesting no relationship between the two variables. Similarly, the correlation between baseline EE and baseline Physical Energy State score was r = -0.17. This suggests no significant relationships between baseline EE and baseline state measures in the PEDB 1990 sample. The correlations between week 8 EE and Physical Fatigue State score and Physical Energy State score were r = 0.16 and r = -0.30, respectively. Week 8 EE was inversely related to Physical Energy State in this sample; subjects with higher EE were more likely to have lower scores for Physical Energy State during the last week of the PEDB 1990 intervention.

Based on prior findings regarding physical activity and fatigue, it was hypothesized that fatigue would be highly related to EE throughout the intervention. In general, however, fatigue and energy states were more strongly related to EI in this sample. The weaker correlations between state measures and EE may be explained by differences in the methodology and timing of when the EFS questionnaires were administered. The EFS was distributed at baseline along with the other six questionnaires used for this project. The estimated time to complete all seven questionnaires was approximately 1 hour; it is possible that baseline EFS data was inaccurate due to attention loss or boredom of the participants. Additionally, the EFS state scales were distributed at the beginning of PEDB 1990 class during week 5 and week 8. Students completed the scales sitting on the gymnasium floor prior to beginning exercise. Having the students complete this measure in a more formal setting may have changed the responses. These errors in survey administration may have affected the estimates of association to EI and EE change.

Reward Responsiveness

Research relating reward responsiveness to EI is well established in the literature. Reward responsiveness loosely refers to an individual's ability to derive pleasure from both natural reinforcers like food and pharmacological reinforcers like drugs (Davis et al. 2004). As explained in Chapter 2, experts in the field of addictive research are now recognizing that natural rewards (i.e. food), like drugs, can greatly enhance mood in some individuals (Davis et al., 2004). This study attempted to capture reward responsiveness using a component of Carver and White's BIS/BAS scale (Carver & White, 1994). Out of 20 possible points for the reward responsiveness component, scores ranged from 14 to 20 with a mean of 17.7 $\pm$ 1.8. The mean for this sample is very close to the maximum possible score, and the variability is relatively small. This suggests that in general, all of our subjects were highly sensitive to reward and would be expected to have an increased risk for over-indulging in rewarding behaviors (i.e. change their EI) during the intervention.

The correlation between EI change and reward responsiveness was r = -0.19, suggesting that there was no significant relationship between EI change and reward responsiveness in this sample. In this sample, those with higher levels of reward responsiveness were slightly more likely to decrease their EI in response to the intervention. This result did not support our hypothesis and contradicted existing literature, which suggests a positive and direct relationship between reward responsiveness and EI. It is possible that adding a physical activity dose of 120 minutes per week was not a large enough stimulus to elicit the need for a reward. Additionally, some students verbalized their need to ‘get in shape’ before spring break; so, the social desirability to fit in may have overpowered their desire to increase EI in response to exercise. Lastly, the lack of variability within reward responsiveness scores in this sample likely made it difficult to identify associations with EI change.

Interestingly, EE change was more strongly related to reward responsiveness in this sample (r= -0.34). EE change and reward responsiveness were inversely related in this sample; subjects with high scores on the reward responsiveness scale were more likely to decrease EE throughout the intervention. The lack of variability between subjects on the reward responsiveness scale may have masked some associations with EE change. Increasing the sample size may produce different associations in future research.

These results suggest that reward responsiveness was not highly related to EI changes in our population. Conversely, reward responsiveness was a potential predictor of EE change in this sample. Future research investigating this area should focus on better quantifying the changes in EI with food frequency questionnaires and interviewer-administered diet recalls and EE with doubly labeled water. It may also be favorable to investigate the extent to which social desirability and other environmental factors influence the relationship between reward responsiveness and EI and EE change in this population.

UPPS+P Impulsive Behavior Scale

The term trait impulsivity is loosely defined as a range of actions that are poorly thought-out and often result in undesirable outcomes (Evenden, 1999). Though trait impulsivity has been widely examined in relation to self-regulation failures with diet and other addictive behaviors, its relationship with physical activity compensation is incompletely described in the literature. Research has hinted that two components of trait impulsivity, urgency and sensation-seeking, may be linked to compensatory changes in diet (Whiteside et al., 2005). Literature has also shown these two distinct traits to be associated with reduced weight loss during obesity treatment and self-regulation failures in terms of alcohol and other substances; consequently, trait impulsivity may contribute to volitional compensation to exercise (Stice et al., 2009). Based on this research, we hypothesized that these two subcomponents of trait impulsivity (urgency and sensation-seeking) would be highly related to changes in EI throughout the exercise intervention.

Urgency was separated into positive urgency and negative urgency for analytical purposes. Unexpectedly, positive urgency and negative urgency were only weakly related to EI ($r = -0.10$, $r = -0.18$, respectively). Rather, both positive and negative urgency were more strongly correlated with EE change ($r = -0.70$, $r = -0.26$). The negative correlation indicates that individuals with higher levels of positive urgency were more likely to decrease their overall EE over the course of the study. Likewise, subjects with higher levels of negative urgency were more likely to have a decrease in EE change. From a psychological perspective, this suggests that an impulsive reaction to increased structured physical activity was to decrease total EE in those with higher urgency scores.

The second component of trait impulsivity most plausibly related to compensation is sensation-seeking. Based on previous literature, it was hypothesized that sensation-seekers, who thrive off of novel and stimulating experiences (Whiteside et al., 2005), would be less likely to refuse food after exercise and would therefore be more likely to increase EI over the course of the intervention. However, between sensation-seeking and EI or EE, no relationship was observed ($r = 0.03$, $r = -0.15$, respectively). This suggests that sensation-seeking is unlikely to predict an individual's behavioral response to increased structured exercise.

Strengths and Limitations

Strengths

1. A primary strength of this study was the novelty behind exploring the ability of selected psychological traits to predict compensatory responses to structured exercise. If this same model is replicated in large-scale intervention studies, researchers may be able to shed light on which types of individuals would benefit most from specific types of exercise interventions. For example, individuals identified as having high levels of trait impulsivity may respond better to a combination of cognitive behavioral therapy and structured physical activity.
2. An additional strength of this study was the setting in which it was conducted. A special section of basic physical education at the University of Georgia was created for this study, which provided a built-in avenue for subject recruitment. Since students at the University of Georgia are required to take and regularly attend a

physical education class in order to graduate, the retention rate for study participants was very high. Only one subject withdrew from the course, and therefore the study, over the course of the intervention.

3. This study also employed the use of multiple 24-hour diet recalls, which likely provided a better estimate of EI than past studies regarding compensation to physical activity. Prior studies have generally used food frequency questionnaires to estimate EI, which are widely considered to be less precise than multiple 24-hour recalls (Ma et al., 2001).

Limitations

1. This study only had 20 subjects, which was a primary limitation, as this sample size may not have been sufficient to detect clinically meaningful relationships between study variables. Repeating this study with a larger sample and some methodological modifications (more frequent and user-friendly diet recalls, larger dose of physical activity) may prove beneficial in determining the link between compensation and psychological constructs. The small sample size and university setting also limit the generalizability of these research findings to the population at large. Lastly, the low sample size did not allow the research team to explore the independence of associations via multiple regression modeling.
2. Additionally, as mentioned in Chapter 1, the ActiGraph accelerometers used throughout the study to objectively measure EE are associated with error in quantifying non-ambulatory physical activity. For example, EE due to weight training and other upper-body activities was not accurately accounted for in

accelerometer based estimates. Likewise, EI was measured via online 24-hour diet recalls throughout the intervention. Subjects may have underreported the intake of food and beverages consumed, which would then alter the EI estimates used in data analysis. Subject burden associated with completing online dietary recalls and wearing accelerometers may have influenced the accuracy of EI and EE estimates.

3. Thirdly, the relatively low dose of structured physical activity (120 minutes per week of moderate to vigorous physical activity) produced through this intervention may not have been sufficient to elicit compensatory behaviors in this sample. Baseline fitness testing of study participants suggested that subjects were at an average or above average fitness level for age and gender (ACSM, 2010). This suggests that subjects were already fairly active prior to enrolling in PEDB 1990. Using more sedentary subjects in the future and/or increasing the physical activity dose may increase the magnitude of compensatory changes and their relationship with psychological factors.

Recommendations for Future Research

The following are recommendations for future research related to psychological predictors of compensation to physical activity:

1. Investigating independent effects of psychological measures: Increasing the sample size in future studies would allow researchers to investigate the independent effects of the psychological measures on compensation to physical activity. It is likely that some of the psychological measures examined in this study were related to other

psychological measures, which may have masked some of the associations with EI and EE in data analysis (see Table 12).

2. Increasing the length of the intervention: Increasing the duration of the structured exercise intervention, and increasing the weekly dose of exercise, may provide the stimulus needed to elicit compensatory responses to exercise.
3. Measurement of EI: The National Cancer Institute's ASA24 website is relatively new, and fairly user-friendly; however, it only allows individuals to complete the diet recall for the day previous to the day on which they log into the site. Individuals may have forgotten food and drink consumed the previous day. Asking students to complete the diet recall more frequently and/or to keep a written log of food consumed may increase the likelihood of them accurately reporting their intakes. Alternatively, having a nutritionist administer and/or quality control the food recalls in person may improve the accuracy and completeness of the reported intake.
4. Measurement of EE: The ActiGraph accelerometers used throughout the study to objectively measure EE are associated with error in quantifying non-ambulatory physical activity. For example, EE due to weight training and/or household activities were not accurately accounted for in accelerometer data output. Using solely accelerometer data to estimate EE in individuals engaging in such behavior may have resulted in an under-estimation of total daily EE. Future research studies should consider adding a questionnaire about habitual physical activity to account for those activities not accurately captured through accelerometry.
5. Sample: This sample included 20 males and females of average and above average fitness level, as evident by a mean estimated VO_2max of 41.8 ± 8.7 ml/kig/min. This

suggests that our sample was relatively active prior to the beginning of the PEDB 1990 intervention. Therefore, the added dose of 120 minutes of moderate to physical activity daily may not have provided an adequate stimulus to elicit compensatory responses in all individuals. Future studies should consider restricting samples to non-exercisers or sedentary adults to better understand compensatory responses to structured exercise.

Conclusion

The purpose of this study was to identify possible psychological predictors of compensatory responses to structured exercise. Results of this study suggest that psychological constructs such as self-motivation and trait impulsivity may help predict compensatory responses in college-aged students. Specifically, it appears that urgency may be helpful in predicting an individual's change in EE when structured exercise is introduced into the daily routine. Additionally, self-motivation and measures of fatigue were related to change in EI throughout the intervention.

From a public health perspective, it is beneficial to understand the relationships between self-motivation, fatigue and trait impulsivity and behavioral responses to physical activity. Further research on a larger sample size is needed to clarify these relationships; however, knowledge gained from larger-scale studies examining this topic has the potential to influence the development and implementation of structured exercise interventions and programs. Providing a more complete understanding of how exercise affects an individual, both psychologically and physically, is instrumental in light of the current obesity epidemic.

CHAPTER 6

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APPENDIX A

Course Syllabus

UNIVERSITY OF GEORGIA
College of Education
Department of Kinesiology

Spring 2012
Behavioral Responses to Exercise
PEDB 1990 – 80-815
TR 11:00 – 12:15 – First 10 weeks of semester
Ramsey Center 117

Instructors:	Ms. Amanda Gipson & Ms. Rachelle Acitelli Office: Ramsey Center/109 I Phone: (219) 712-0816 OR (704) 488-7586 (Emergencies Only) Email: uga.pe.study@gmail.com
Office Hours:	Monday and Wednesday, 10:00-11:00am Other office hours are available by appointment
Department Webpage:	http://www.coe.uga.edu/kinesiology/
eLearning Commons:	http://elc.uga.edu/
Required (online) book**:**	ISBN is 0078032008: **"**UGA Physical Education & Fitness Activities Access Card" (available at the bookstore) OR online through McGraw-Hill: http://www.mhprofessional.com/mhhe_product.php?isbn=0078032008&cat=108

Course Description:

This course has been created for the purpose of a research project. There are additional assignments in this course that are not present in other PE courses. However, these measurements provide valuable information regarding your health and wellness. For example, you will receive a DXA scan (body composition measurement) and a submaximal fitness test. The standard assignments are the same as other PEDB courses (attendance, online textbook, fitness log, participation), and will fulfill the University's PE requirement. The additional research-specific assignments will require 2-3 hours of your time outside of class. These include:

Questionnaires (completed during class)
- Visual Analogue Scale
- Eating Q
- Self-Motivation
- NEO
- UPPS-P
- Reward Responsiveness
- Monetary Choice Questionnaire

Activities (completed outside of class)
- Wear Accelerometer (9-days total)
- Diet Recall (9-days total)
- DXA (30 minutes in lab)
- Fitness Test (40 minutes in lab)

Students will be randomly assigned to either FFL Walking or FFL Jogging. The activity portion of this class will be equivalent to PEDB 1950 or PEDB 1930.

In *FFL Walking,* students will be taught walking techniques to incorporate higher levels of physical activity, and to track their physical activity in their daily lives with the goal of promoting fitness throughout the lifetime. Physical activity is a large part of this course, and students will be expected to participate in moderate to vigorous activity when they are in class.

The *FFL Jogging* class focuses on individual improvement in cardiovascular fitness by regular and progressive jogs. Distance and times for jogs are gradually increased as the semester progresses. Flexibility and muscular strength and endurance exercises are also incorporated into the class' activity.

Course Objectives:

After successfully completing this course, students will be able to:

1. Examine one's personal attitude toward exercise.
2. Understand the role of physical activity in human health.
3. Develop a value for exercise as an integral part of life.
4. Understand the principles for development and maintenance of aerobic fitness, muscular strength, muscular endurance, flexibility, and for controlling and maintaining a healthy body weight.
5. Design a personal exercise program to promote better health, physical fitness, and increased quality of life.

Class Policies:

1. Students will abide by the standards as stated by the University Honor Code (see below) and Academic Honesty Policy. These standards can be found in *A Culture of Honesty*, the University's policy and procedures for handling cases of suspected dishonesty. Detailed information can be viewed at http://www.uga.edu/honesty to help you understand how the term "academic dishonesty" is defined on this campus.

   As a University of Georgia student, you have agreed to abide by the University's academic honesty policy, "A Culture of Honesty," and the Student Honor Code. All academic work must meet the standards described in "A Culture of Honesty" found at: www.uga.edu/honesty. Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation. Questions related to course assignments and the academic honesty policy should be directed to the instructor.

2. Students requesting classroom accommodation must first register with the Disability Resource Center (DRC). The DRC will provide documentation to the student, who must then provide this documentation to the instructor when requesting an accommodation. Students with documented disabilities that affect their ability to participate fully in the course or who require special accommodations are encouraged to speak with the instructor, so that appropriate accommodations can be arranged.

3. Attendance and timeliness is required. (See attendance policy below)

4. Students are responsible for the information provided in class along with the readings from the online textbook and/or supplemental resources. If you are absent when materials are distributed, it is your responsibility to obtain the information from another student.

5. Students desiring to withdraw from this class must do so by the deadline (March 22).

6. Students should read the "Clearance for Safe Exercise Participation" form provided by the instructor. Students with medical conditions should discuss them with the instructor. The instructor will determine whether medical conditions require a waiver or physician clearance.

7. Poor sportsmanship and the use of inappropriate language will not be tolerated. If this occurs, the student will be asked to leave, will be counted as absent, and will need to meet with the instructor. If the student refuses to leave, it is at the instructor's discretion to reduce the student's grade.

8. Class begins at 11:00am. If you arrive late to class, you must check in with the instructor.

9. Appropriate attire must be worn – comfortable exercise wear and tennis shoes.

10. ***The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary.***

Course Requirements:

1. This course will consist of discussions, demonstrations, in-class assessments, and written assessments. All updates or changes to the schedule will be announced in class. It is your responsibility to keep up with changes to the syllabus and calendar.

2. Readings, assessments and assignments will be assigned throughout the semester and due dates will be posted by the instructor on eLC. It is your responsibility to keep up with the due dates.

3. Students are required to purchase a textbook for the online fitness component of the course. A total of seven assignments will be due throughout the semester. **Students who have already met the PE graduation requirement should turn in a Degree Audit Report (DAR) with the PEDB course listed to the instructor as proof that they have already meet the graduation requirement These students will be given 40 pts credit for the online fitness knowledge portion of their grade.**

4. Students are required to use eLearning Commons (eLC) for this course. Syllabus, class information, the course schedule, exercise tips, the clearance for safe exercise participation, and a link to the online fitness content will be available through eLearning Commons. To access eLearning Commons you will need your MyID, as well as a current password.

Attendance Policy:

Regular attendance and class participation are required and are vital factors into your final grade. The first two absences (including excused and unexcused) will be without penalty. The third absence will have a 10 points grade penalty and the fourth absence will have a 20 point grade penalty. More than four absences will result in a grade of Unsatisfactory.
Arriving on-time to class is also part of your attendance grade. Students will lose 1 point of their participation grade for every time they are 5 or more minutes late to class. However, arriving more than 15 minutes late to class will result in an absence. Unless the class time has ended, if a student leaves before/without being dismissed, s/he will be marked absent that day.

The following is a list of occurrences that will deem the student as absent:
1. Inappropriate attire
2. Poor sportsmanship
3. Arriving to class late (after 15 minutes of the start of class)

Grading:
This course is graded as an "S" (Satisfactory) or "U" (Unsatisfactory). In order to determine what grade a student will be awarded, a percentage system will be sued. There are 100 possible points to be earned and **70 points are required to earn an "S" in this course**.

Attendance	**40 pts**	**70% - 100%: S**
Online Fitness Component	**40 pts**	**Below 70%: U**
• Assessments (6 total)	5 pts each (only earned if 80% score)	
• Jogging-specific assessment	10 pts	
Fitness Log	**10 pts**	
Participation	**10 pts**	
	Total 100 pts	

Special Note

We thank you for being a part of our thesis project. It is very helpful to us to have so many willing participants! We are hoping that the results from this study will help open the doors to future research in the area of exercise physiology. Thank you again and way to go for being a part of UGA research!

APPENDIX B

Informed Consent

UNIVERSITY OF GEORGIA

INFORMED CONSENT FORM

Psychological predictors of compensatory responses to a structured exercise program

I, __________________________________, agree to participate in a research study entitled "Psychological predictors of compensatory responses to a structured exercise program" which is being conducted by Michael Schmidt, Ph.D. at the University of Georgia.

My participation is voluntary. I can refuse to participate or withdraw my consent at anytime without penalty or loss of benefits to which I am otherwise entitled and will in no way influence my relation to the University of Georgia. I can have the results of my participation that can be identified as mine removed from the research records or destroyed. If I decide not to participate at a later date, or withdraw my consent at any time, I will not be required to withdraw from PEDB 1990 and my course grade in PEDB 1990 will not be affected. In addition, my PEDB 1990 course grade will not be affected by my participation, or lack thereof, in the research-specific activities of this project.

The purpose of the study is to:
Learn more about how participation in a structured exercise program can change dietary intake and non-exercise physical activity levels and to identify psychological traits that may be associated with these changes.

The procedures are as follows:
In this study I enroll in a special section of PEDB 1990 for which I will receive 1 credit hour. Once enrolled, I will be randomly assigned to either a walking exercise program (similar to PEDB 1950) or to a jogging exercise program (similar to PEDB 1930). During the first week of the study I will complete tests of body composition (height, weight, and dual-energy X-ray absorptiometry) and aerobic fitness (10-15 minute treadmill test) and will complete a battery of psychological pen-and-paper tests. In addition, at the beginning, middle, and end of the study I will be completing a 3-day recall of my food intake and wear a small waist-mounted activity monitor for 3 consecutive days. My weight will be re-measured at the end of the study.

Regardless of whether or not I participate in the research project, I will be expected to attend the 75 minute class sessions as scheduled and my course grade may be affected by the number of classes I miss (as is the policy for most basic physical education courses). If I am assigned to the walking exercise program I can expect to spend 60 minutes in walking activity. If I am assigned to the jogging exercise program I can expect to spend 30 minutes in jogging activity with an additional 30 minutes spent in walking activity. However, if I am unable to meet these activity goals I will be allowed to take rests as needed and to gradually increase my activity participation over time.

The benefits that I may expect from it are:
The potential benefits of my participation include a free structured physical activity program that will provide health benefits for disease risk and general well-being. In addition, health information regarding my risk of obesity from the DXA scan and my dietary intake information will be provided to me. Humankind may benefit because the data collected will be used to help better understand how participation in exercise can influence other behaviors important for weight management. This may help in the development of more effective interventions to prevent the development of overweight or obesity.

The risks and discomforts include:
I understand that there are some risks associated with this study. These may include:

- The occurrence of exercise-related events including the development of ventricular arrhythmia, myocardial infarction, cardiac arrest, and death as well as the less serious problems of injury to tendons, ligaments, joints and muscles. However, these risks are no greater than those from participation in similar basic physical education classes offered at UGA. Further, the risk of serious events is extremely small in healthy younger adults and the amount of activity I will participate in will be similar to current physical activity recommendations for improved overall health.
- Elevated radiation exposure during my body composition scan by dual energy x-ray absorptiometry. While this dose is very low it does present some risk. This is particularly true if I am pregnant, as the x-rays could harm my unborn child. For this reason I should not participate in this study if I am currently pregnant or plan to become pregnant during this study. (Please review and sign the separate Acknowledgement of Risk from DXA Exam form.)

Research-Related Injury:
The researchers will exercise all reasonable care to protect me from harm as a result of my participation. In the event of an injury as an immediate and direct result of my participation, the researcher's sole responsibility is to arrange for my transportation to an appropriate facility if additional care is needed. The researchers are not able to offer any financial compensation or payment for medical care. As a participant, I do not give up or waive any of my legal rights.

Confidentiality:
The results of this study will not be released in any individually identifiable form without my prior consent unless otherwise required by law. In other words, I will not be personally identified if the results of this study are published and my participation will be kept confidential. The data will be coded with my identification number and the list linking the code to my identity will be kept separately in the researcher's locked office. This list will be destroyed after my participation in the study has been completed.

I have read this document and it has been explained to me. I have had an opportunity to ask questions and they have been answered to my satisfaction.

The primary investigator will answer any further questions about the research, now or during the course of the project, and can be reached by email or telephone at:

The University of Georgia, Department of Kinesiology:
Michael Schmidt, PhD., schmidtm@uga.edu, 706-542-6577

If there is an emergency related to this study I should first contact my personal physician or go to the emergency room. I understand that I should also notify the study investigator (above) as soon as possible.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_________________________	___________________________	____________
Name of Participant	Signature	Date
_________________________	___________________________	____________
Name of Researcher	Signature	Date

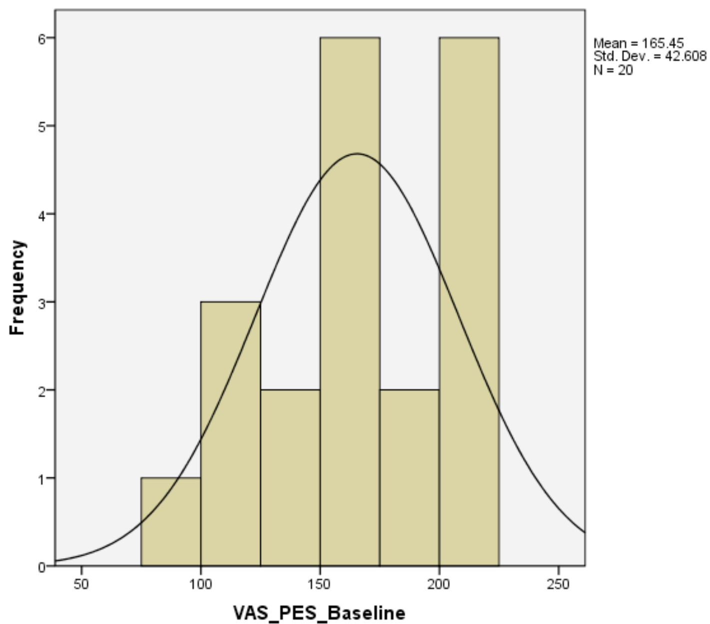
Telephone: _________________ Email: ______________________________

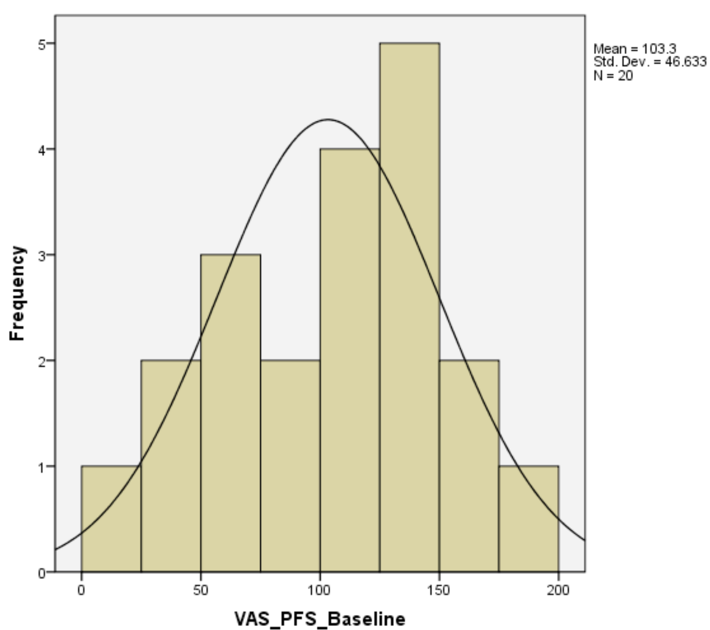
Please sign both copies, keep one and return one to the researcher.
Additional questions or problems regarding your rights as a research participant should be addressed to the Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-mail Address IRB@uga.edu.

APPENDIX C

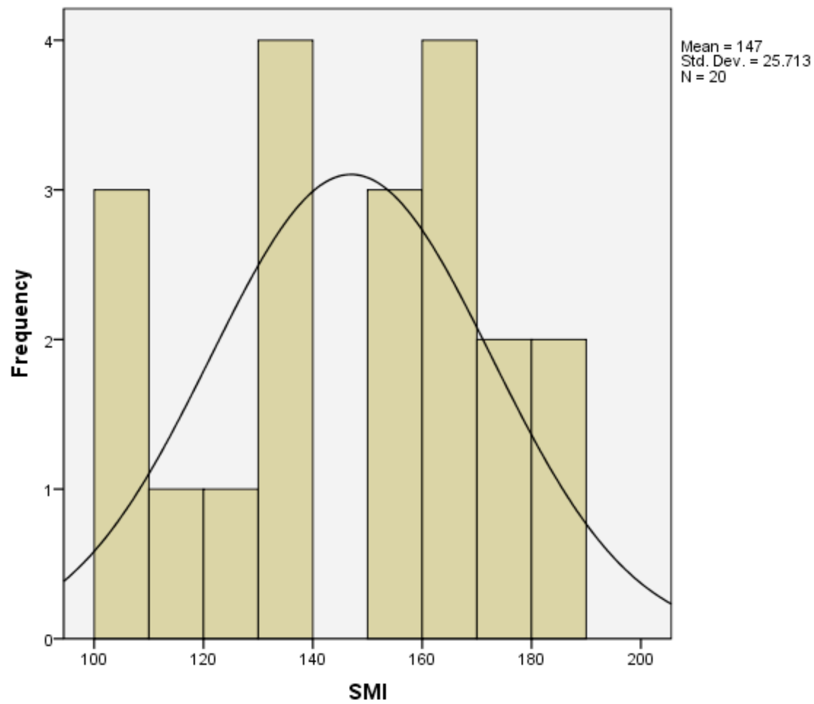
Graphs

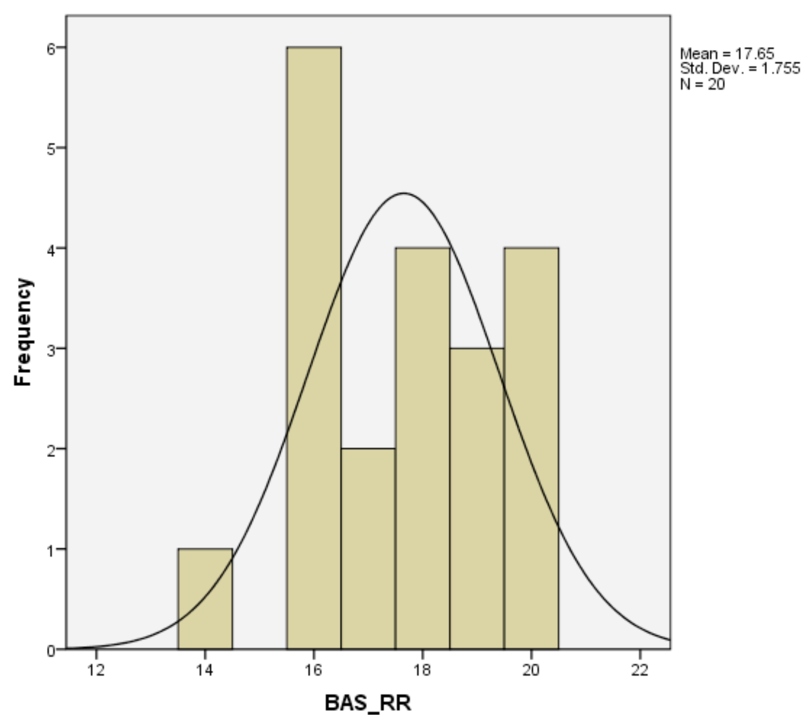
Graph I: Psychological Construct Histograms



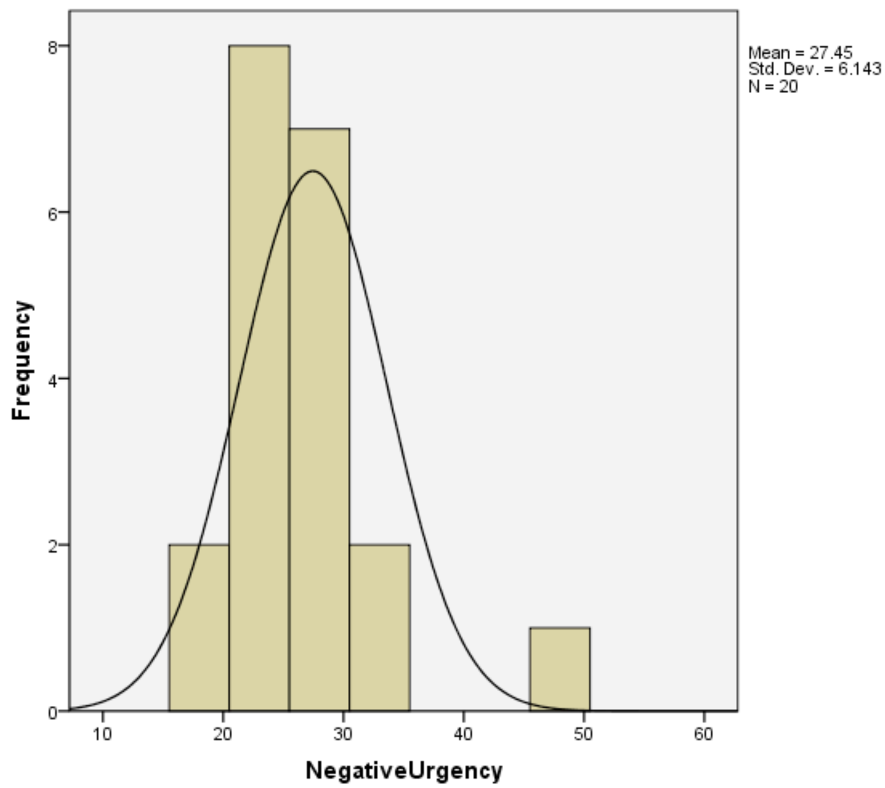


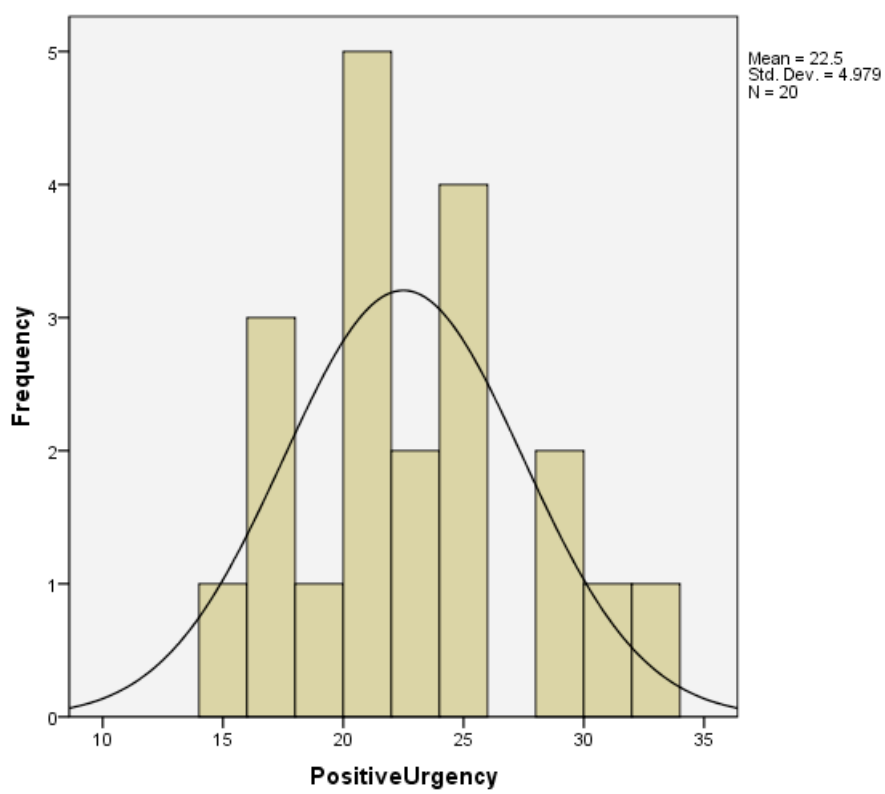
Graph I: Psychological Construct Histograms (Continued)



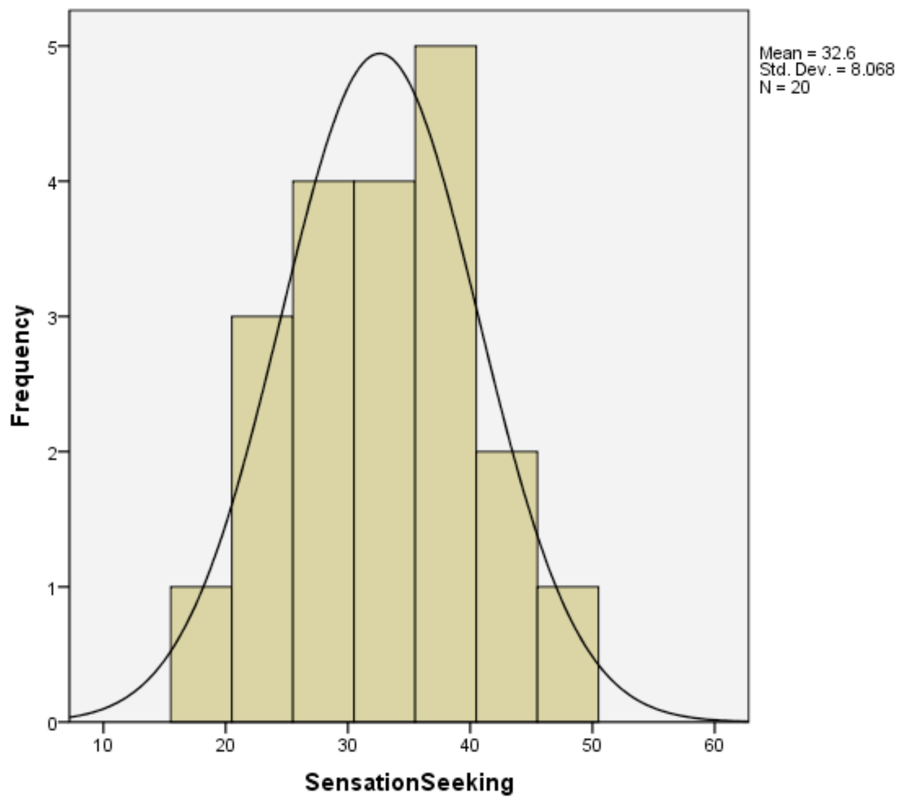


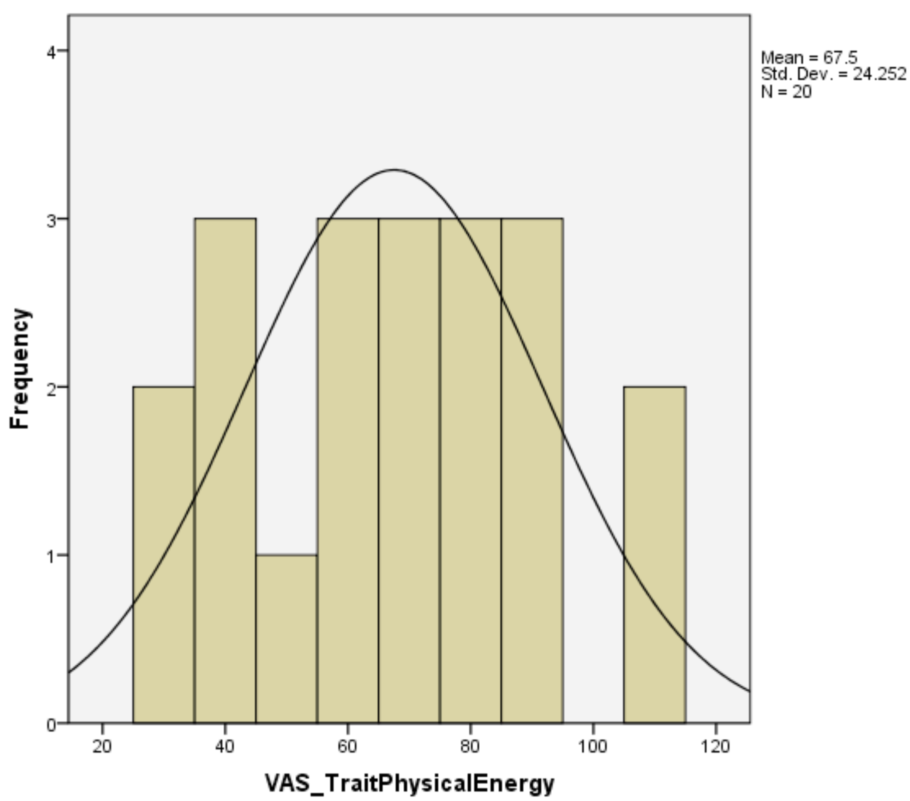
Graph I: Psychological Construct Histograms (Continued)



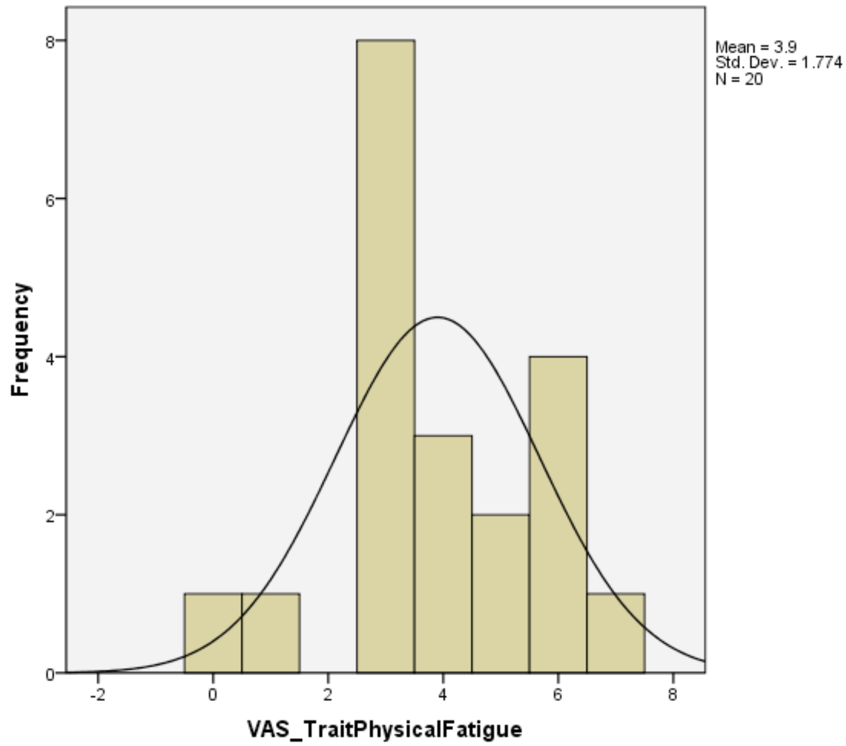


Graph I: Psychological Construct Histograms (Continued)





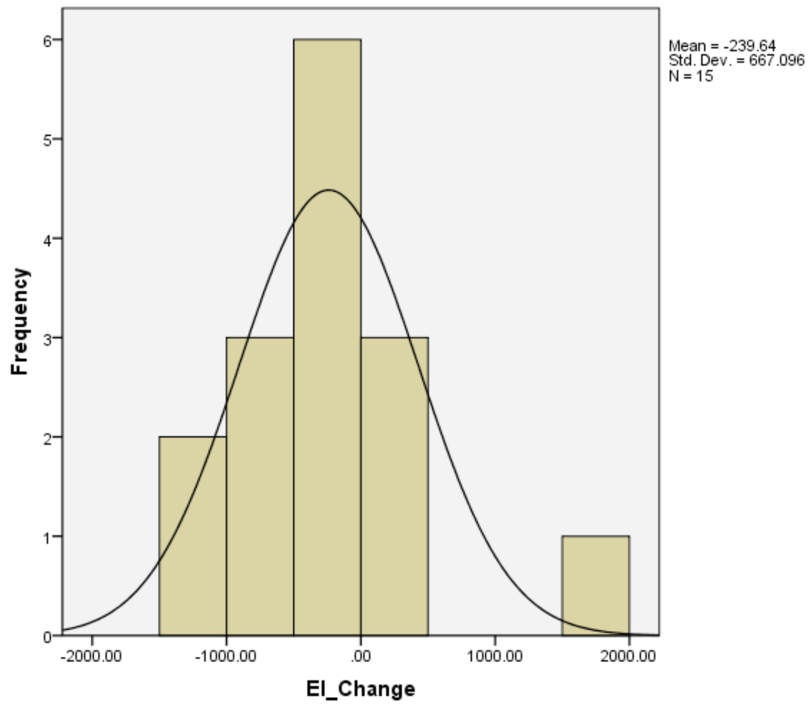
Graph I: Psychological Construct Histograms (Continued)

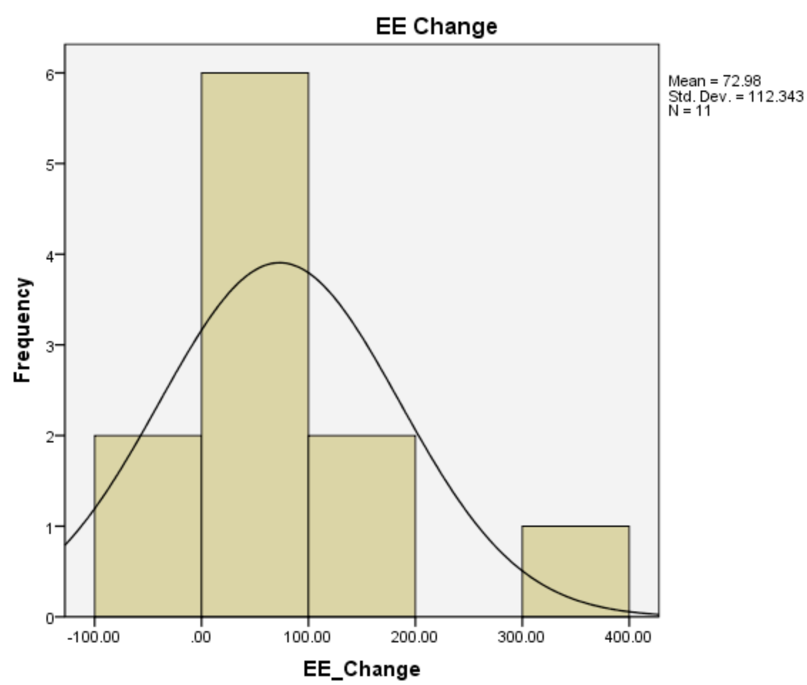


Graph I Key:

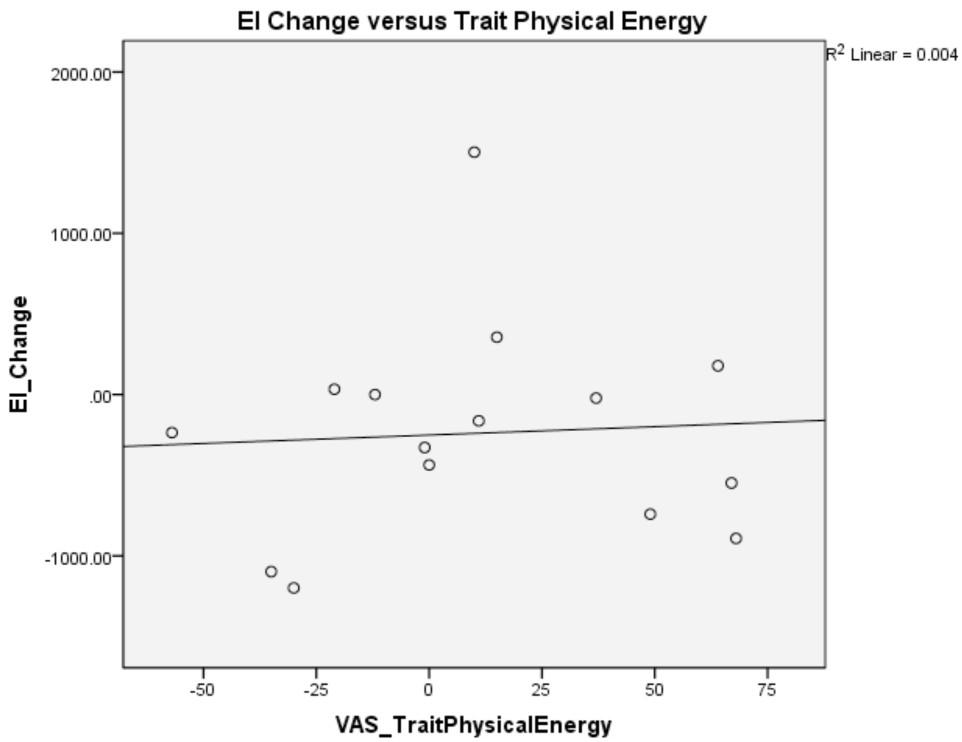
VAS: Visual Analogue Scale
PES: Physical Energy State
PFS: Physical Fatigue State
SMI: Self-Motivation Inventory
BAS: Behavioral Activation System
RR: Reward Responsiveness

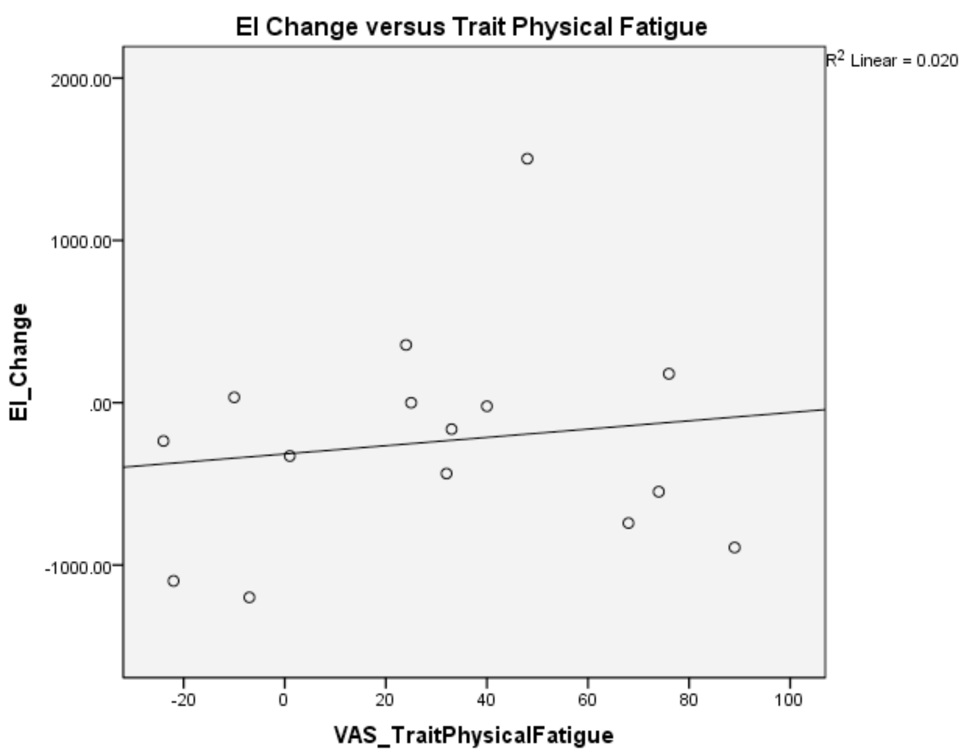
Graph II: Histograms for Change in EI (kcals/day) and Change in EE (kcals/day) during PEDB 1990



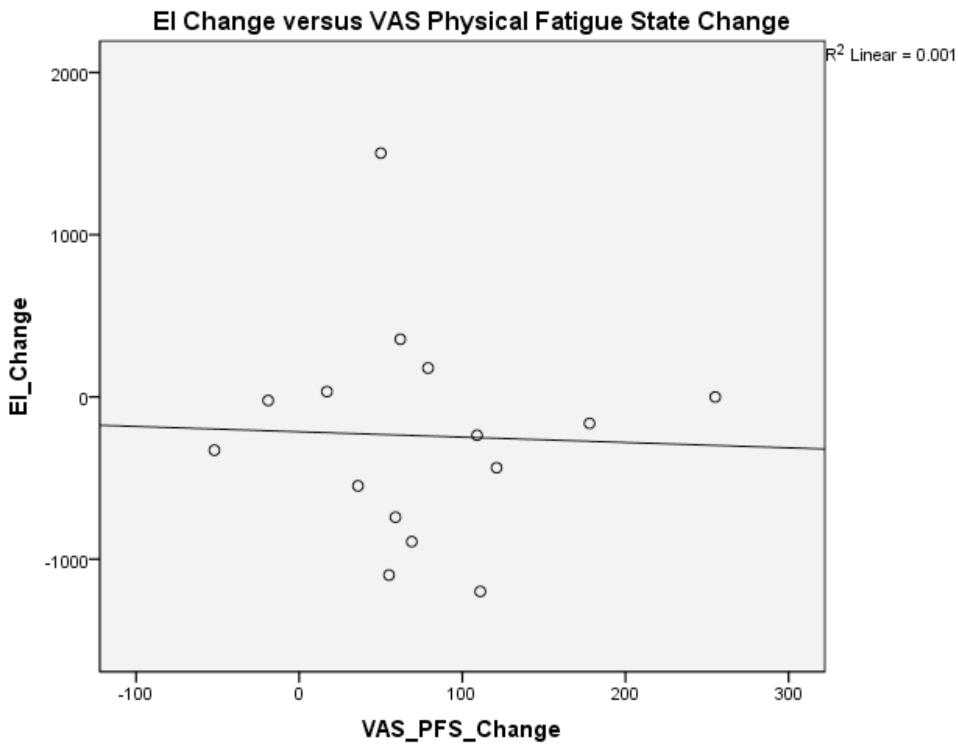


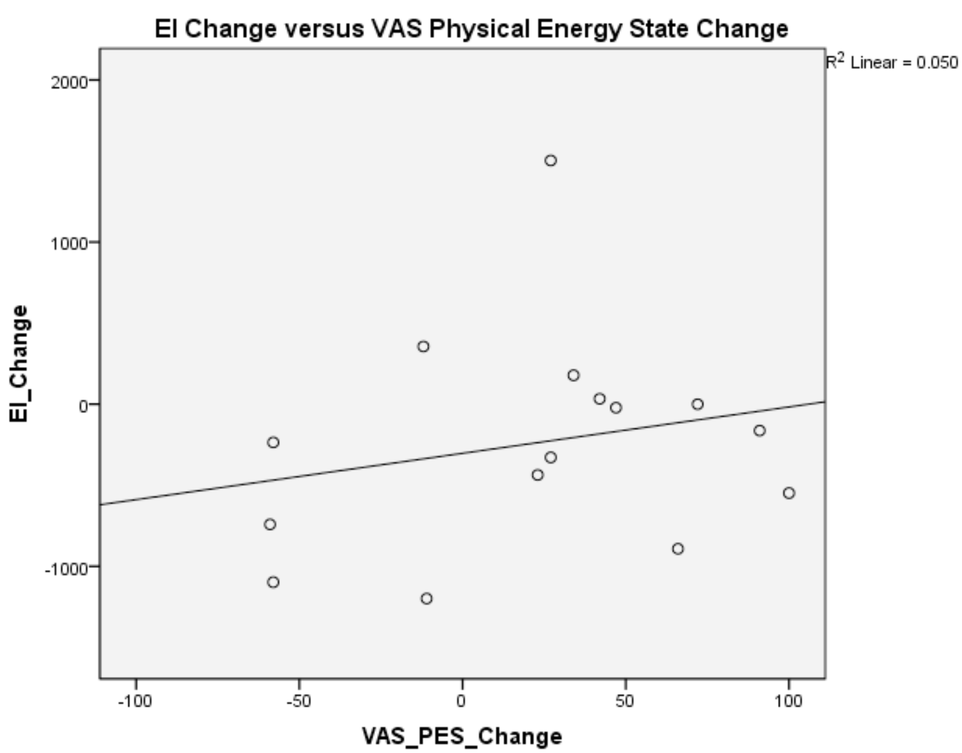
Graph III: Scatterplots for Change in EI (kcals/day) and Psychological Construct Scores



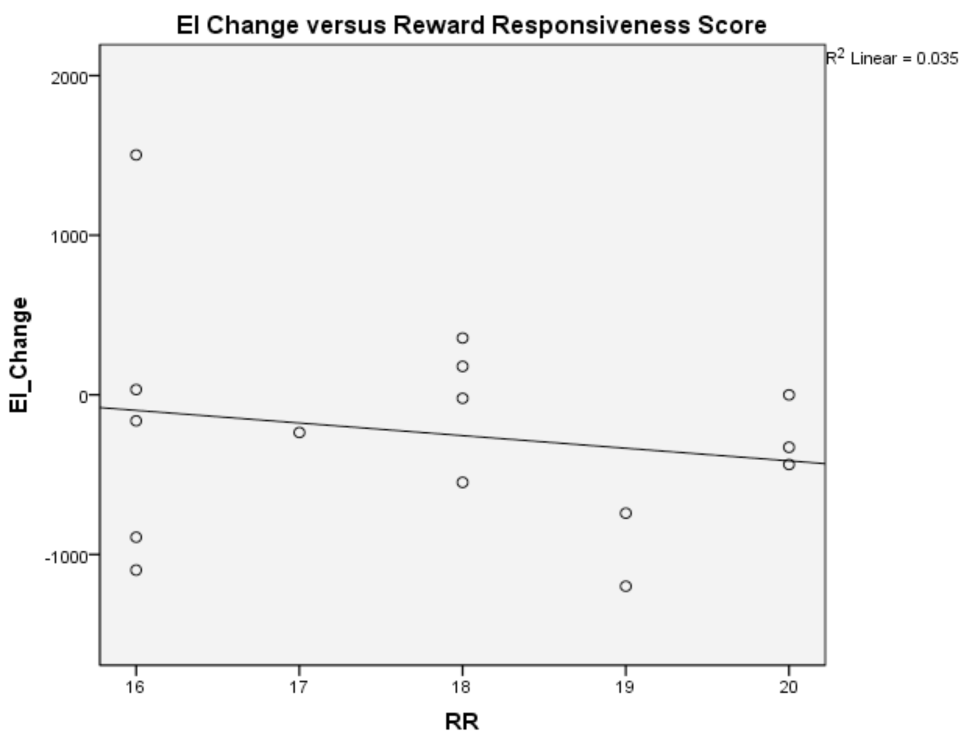


<u>Graph III</u>: Scatterplots for Change in EI (kcals/day) and Psychological Construct Scores (Continued)

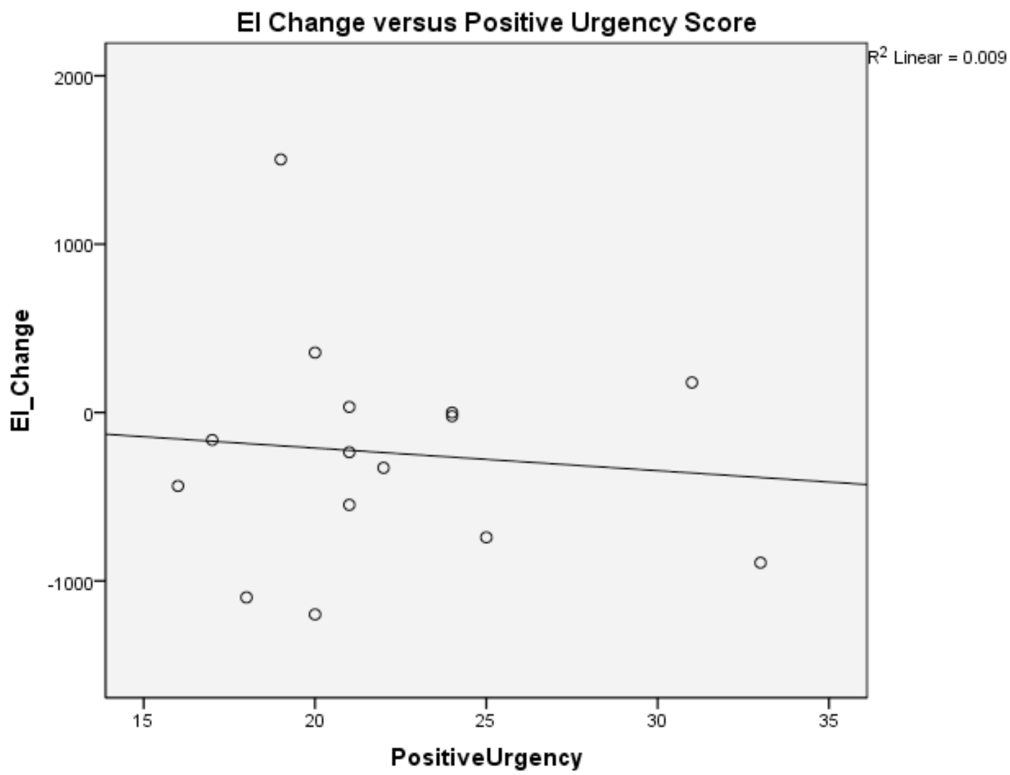


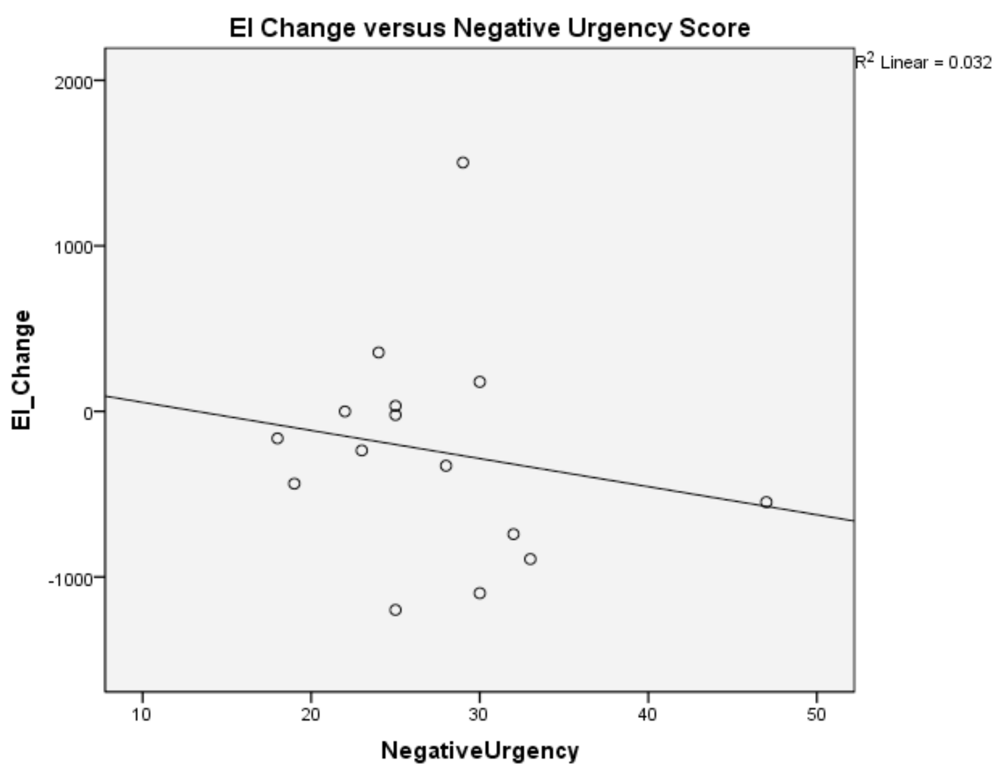


Graph III: Scatterplots for Change in EI (kcals/day) and Psychological Construct Scores (Continued)



Graph III: Scatterplots for Change in EI (kcals/day) and Psychological Construct Scores (Continued)



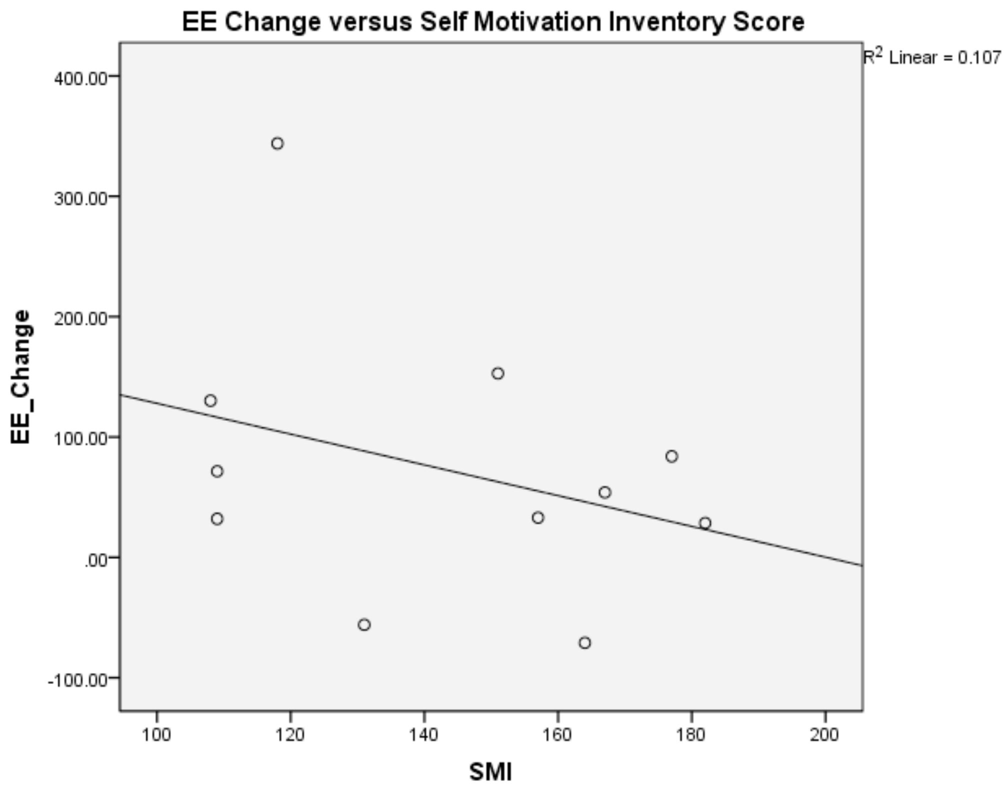


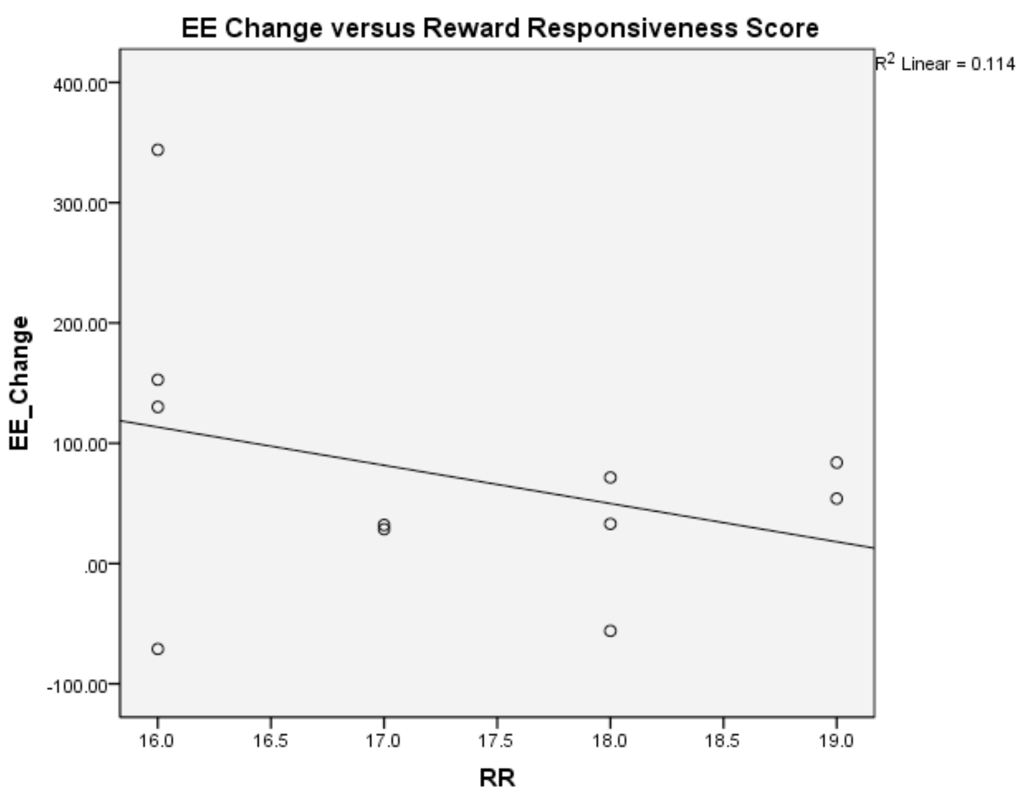
Graph III: Scatterplots for Change in EI (kcals/day) and Psychological Construct Scores (Continued)

Graph III Key:

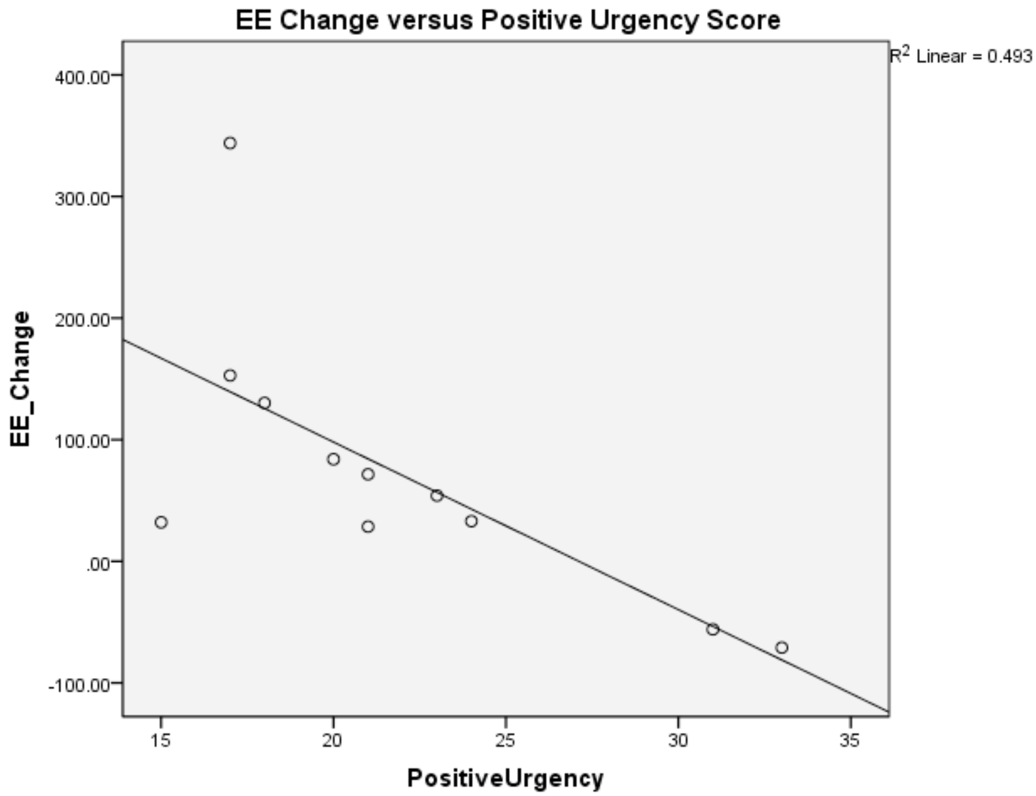
VAS: Visual Analogue Scale
PES: Physical Energy State
PFS: Physical Fatigue State
SMI: Self-Motivation Inventory
BAS: Behavioral Activation System
RR: Reward Responsiveness

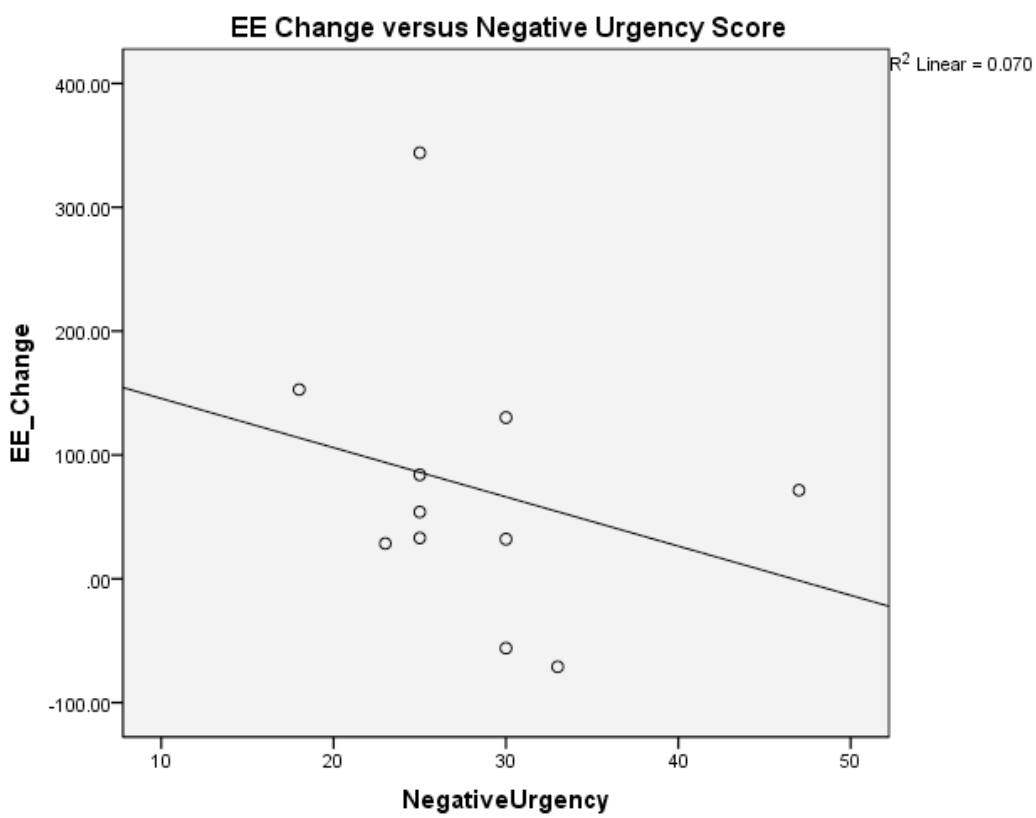
Graph IV: Scatterplots for Change in EE (kcals/day) and Psychological Construct Scores



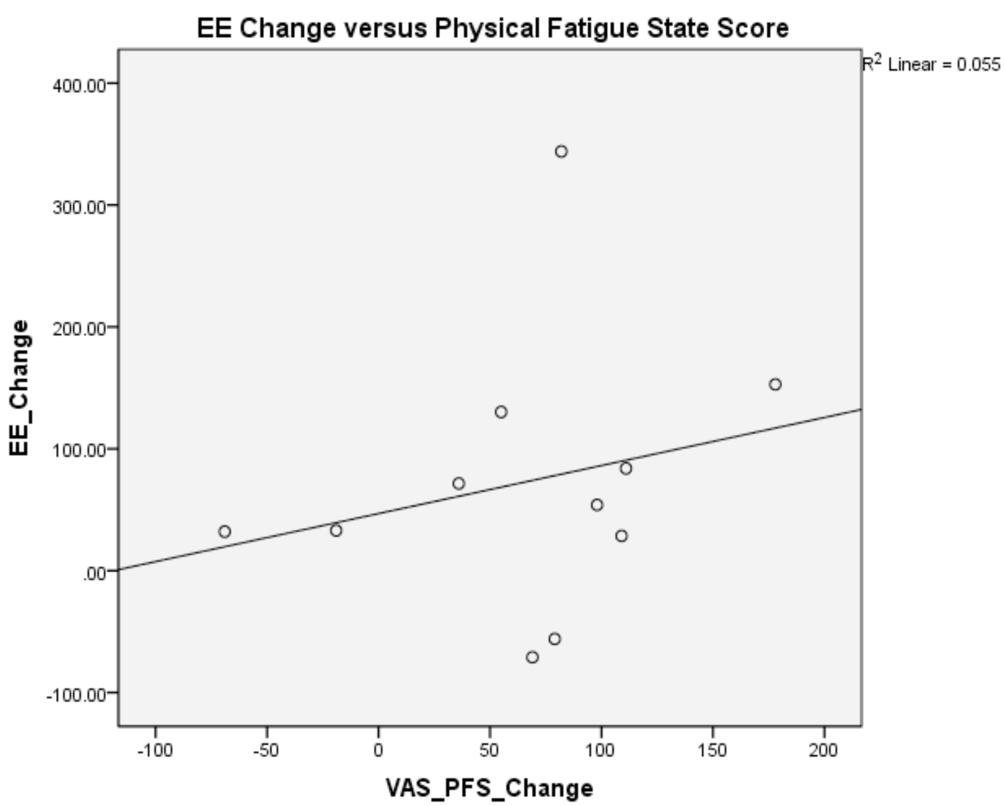


Graph IV: Scatterplots for Change in EE (kcals/day) and Psychological Construct Scores (continued)

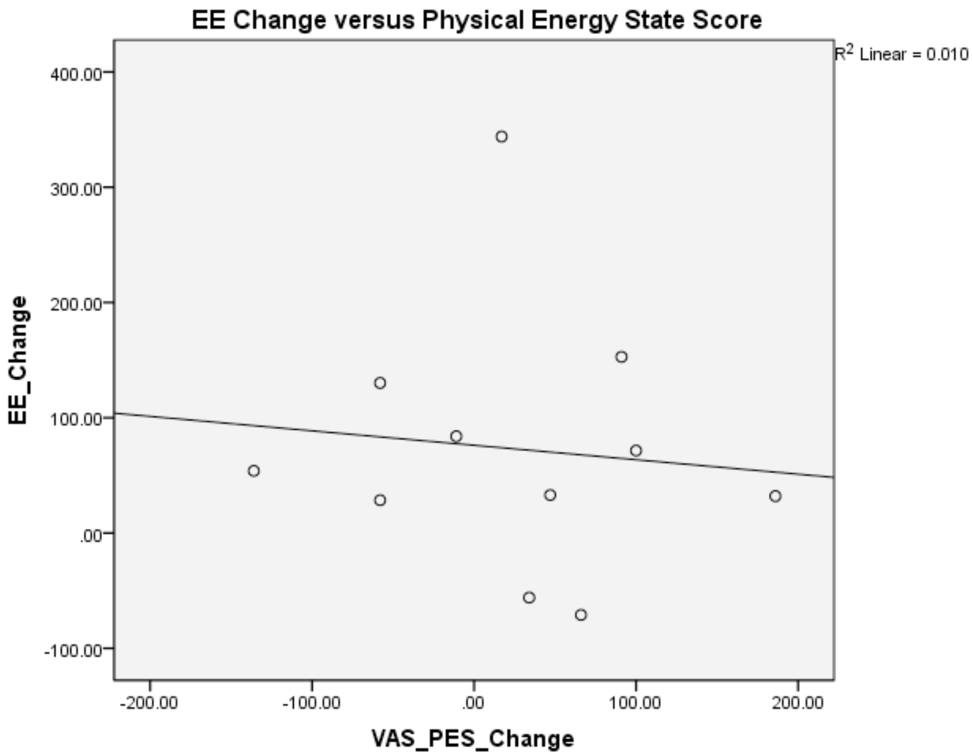


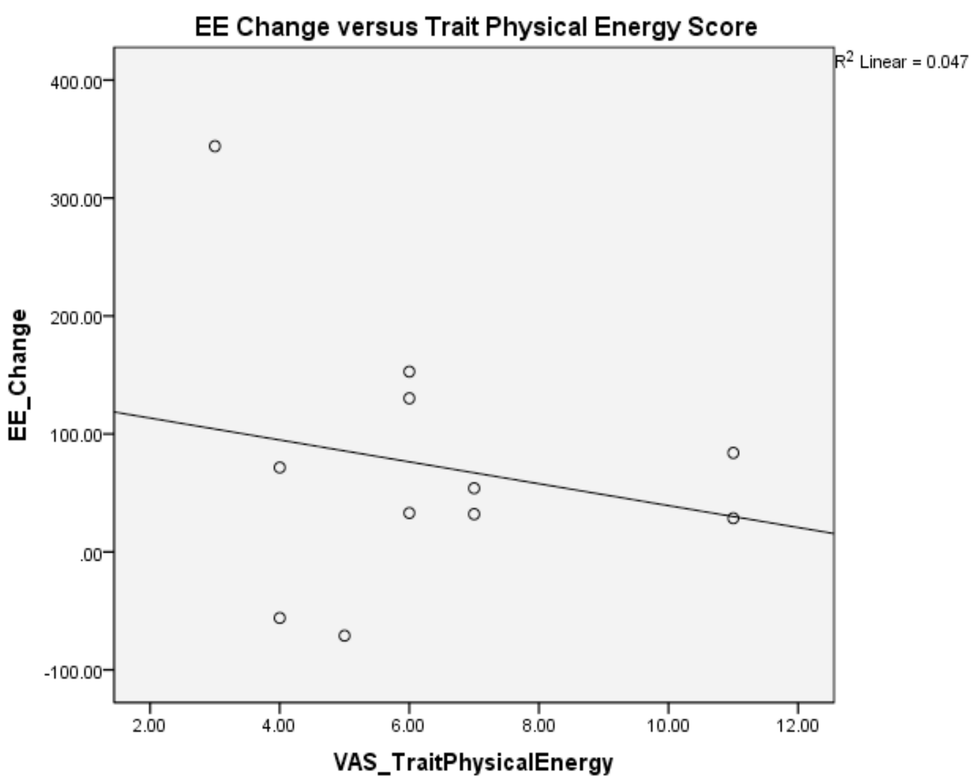


Graph IV: Scatterplots for Change in EE (kcals/day) and Psychological Construct Scores (continued)

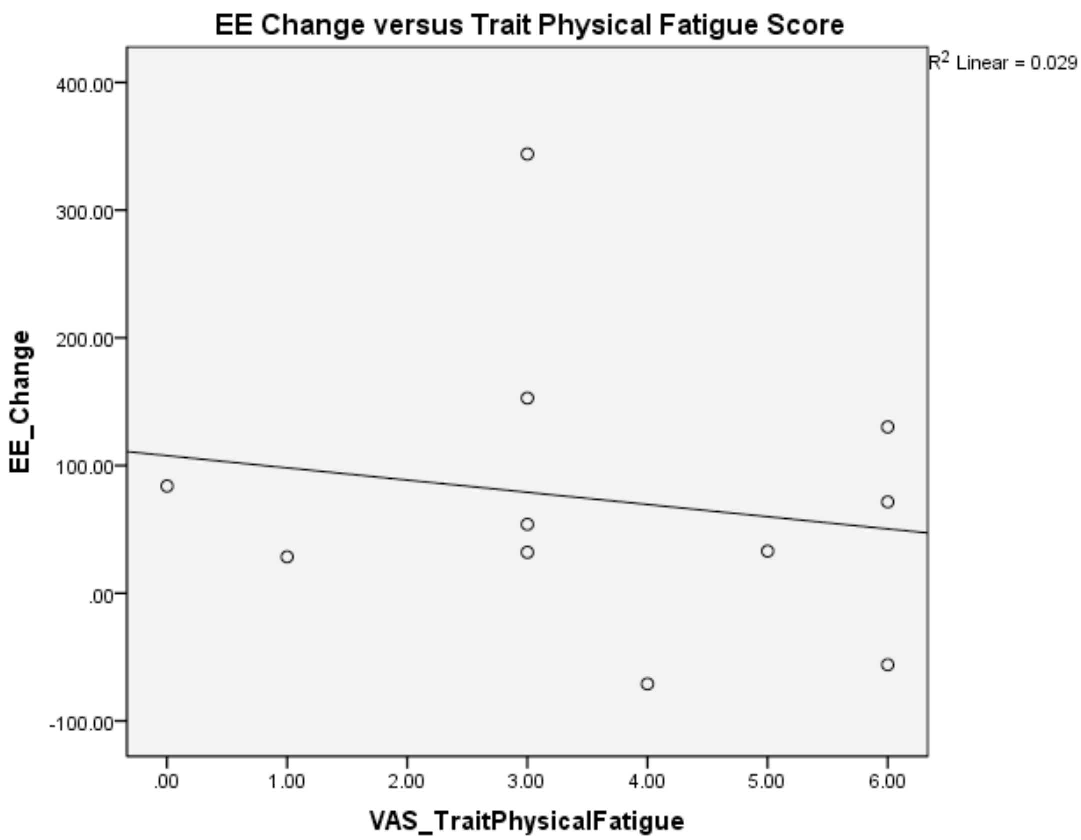


Graph IV: Scatterplots for Change in EE (kcals/day) and Psychological Construct Scores (continued)





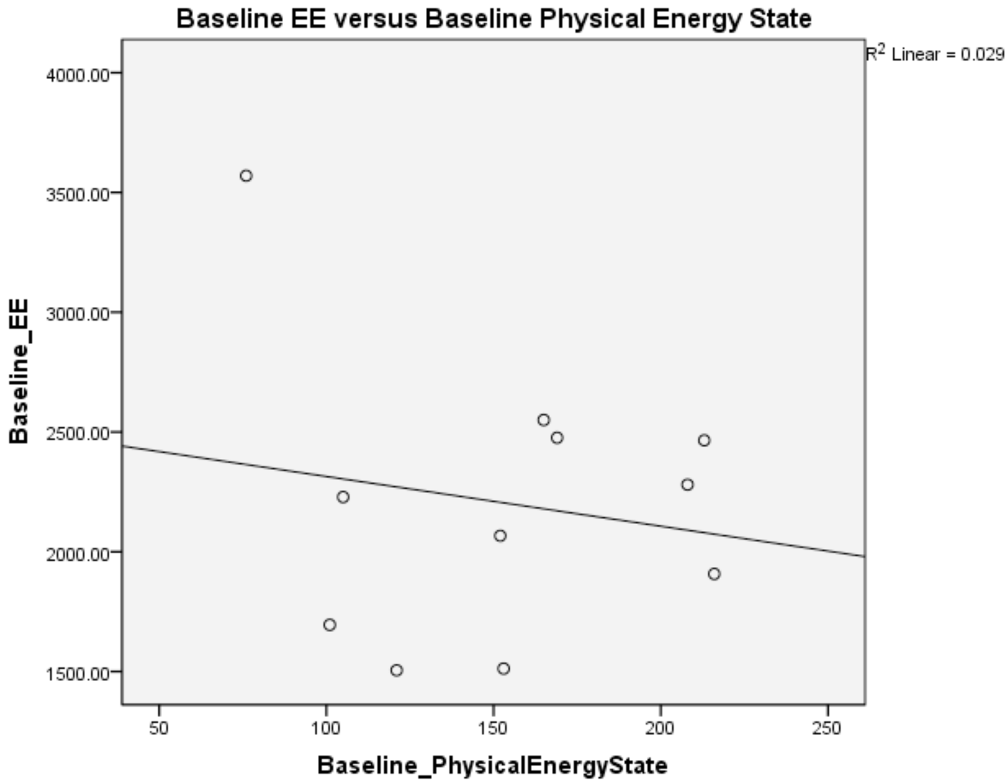
Graph IV: Scatterplots for Change in EE (kcals/day) and Psychological Construct Scores (continued)

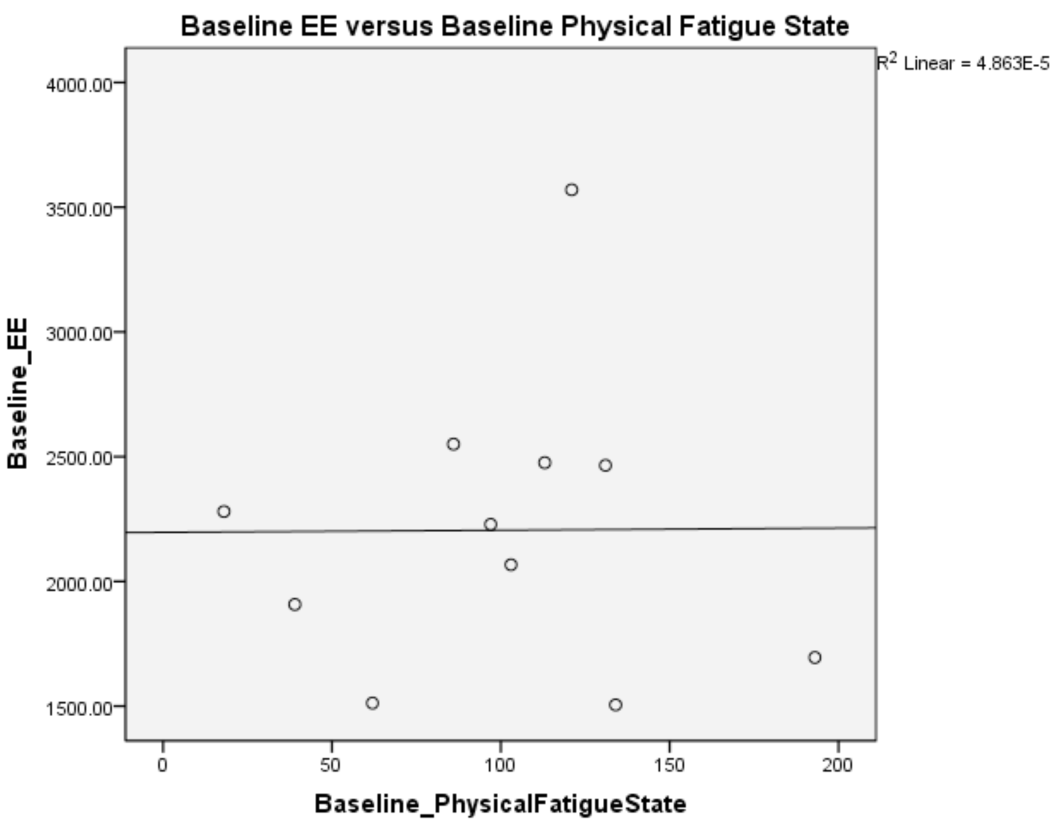


Graph IV Key:

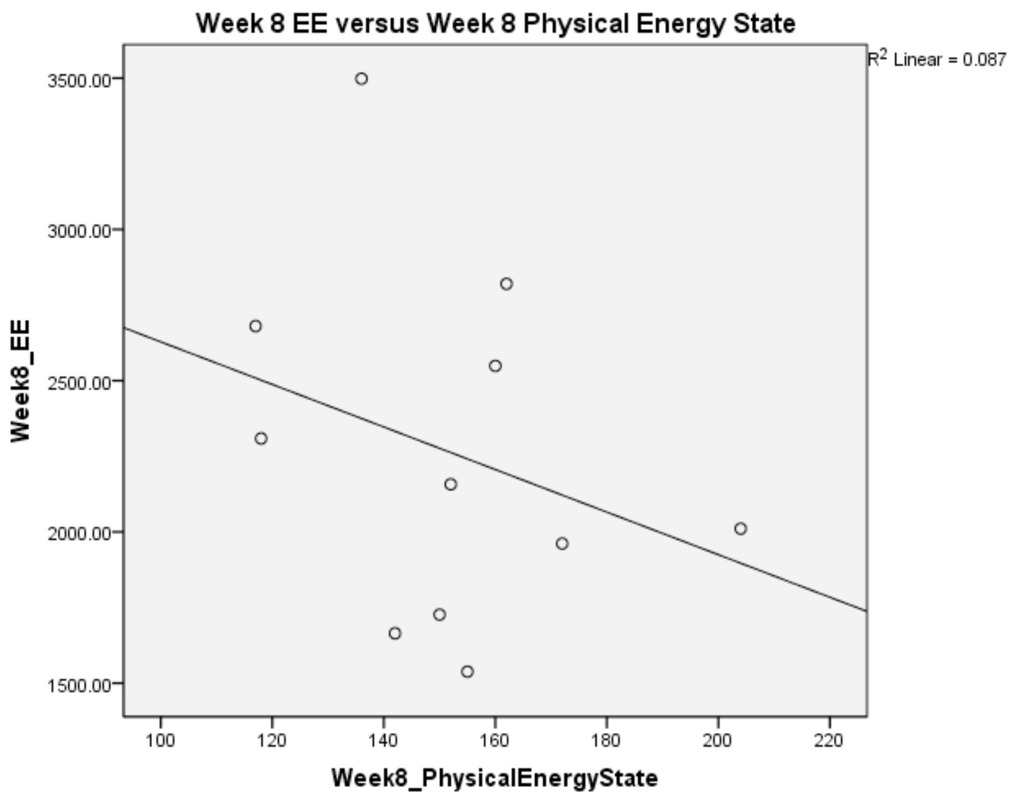
VAS: Visual Analogue Scale
PES: Physical Energy State
PFS: Physical Fatigue State
SMI: Self-Motivation Inventory
BAS: Behavioral Activation System
RR: Reward Responsiveness

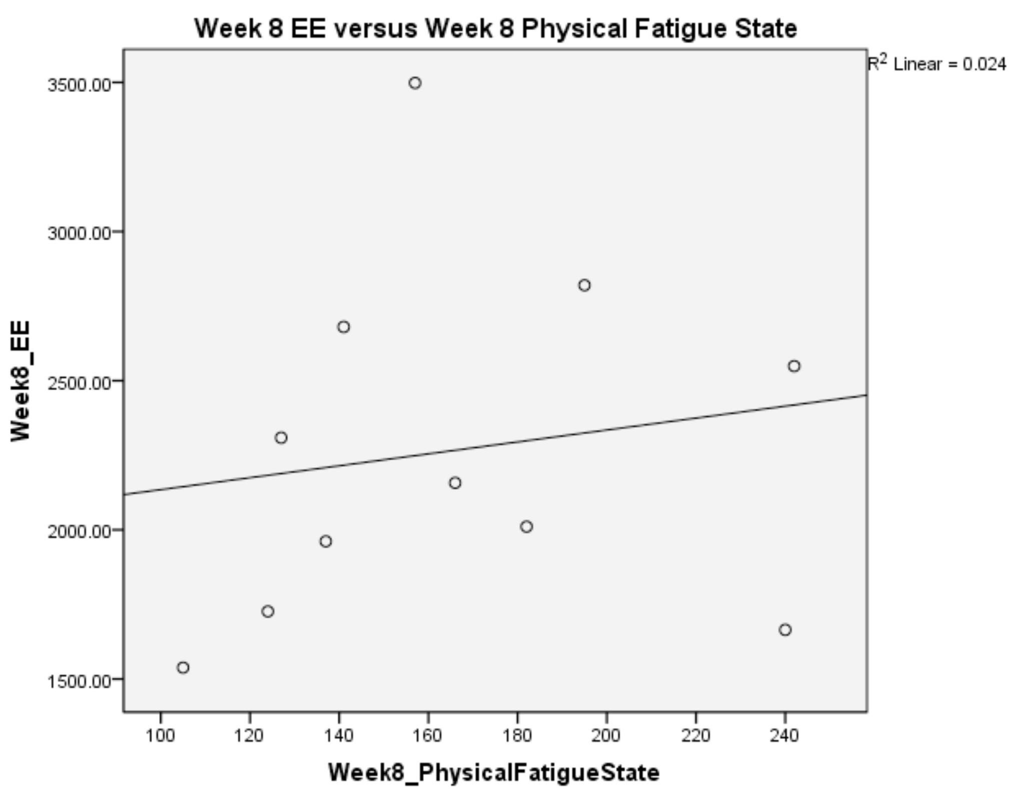
Graph V: Scatterplots for Baseline and Week 8 EE and EFS State Scales



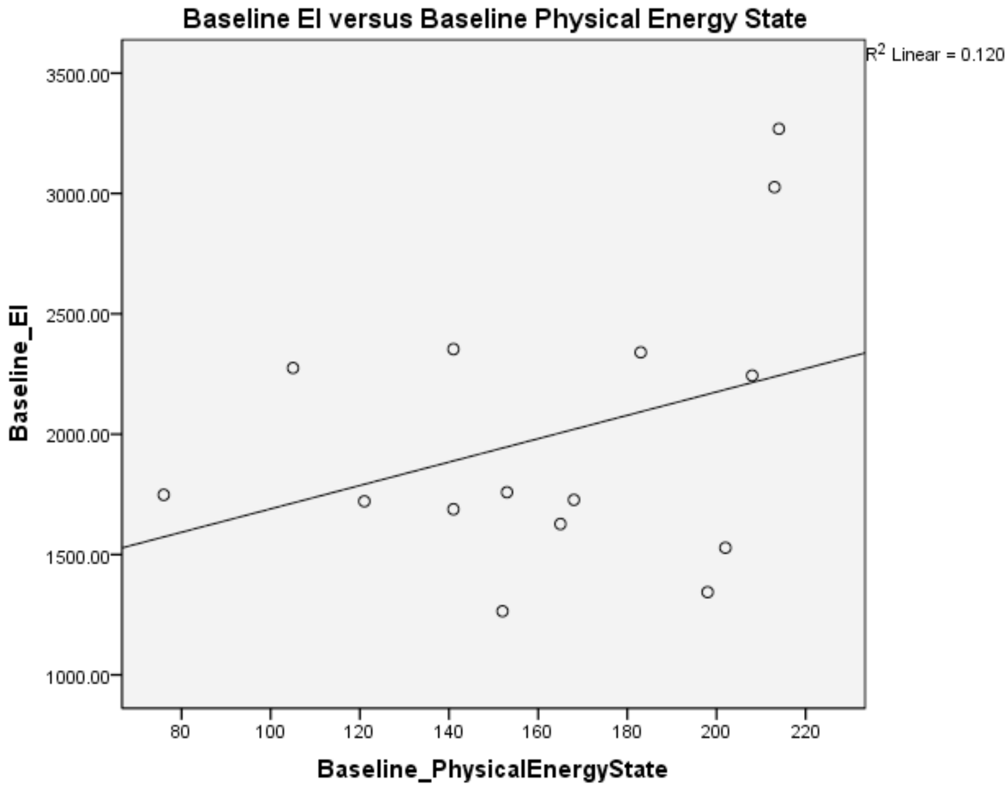


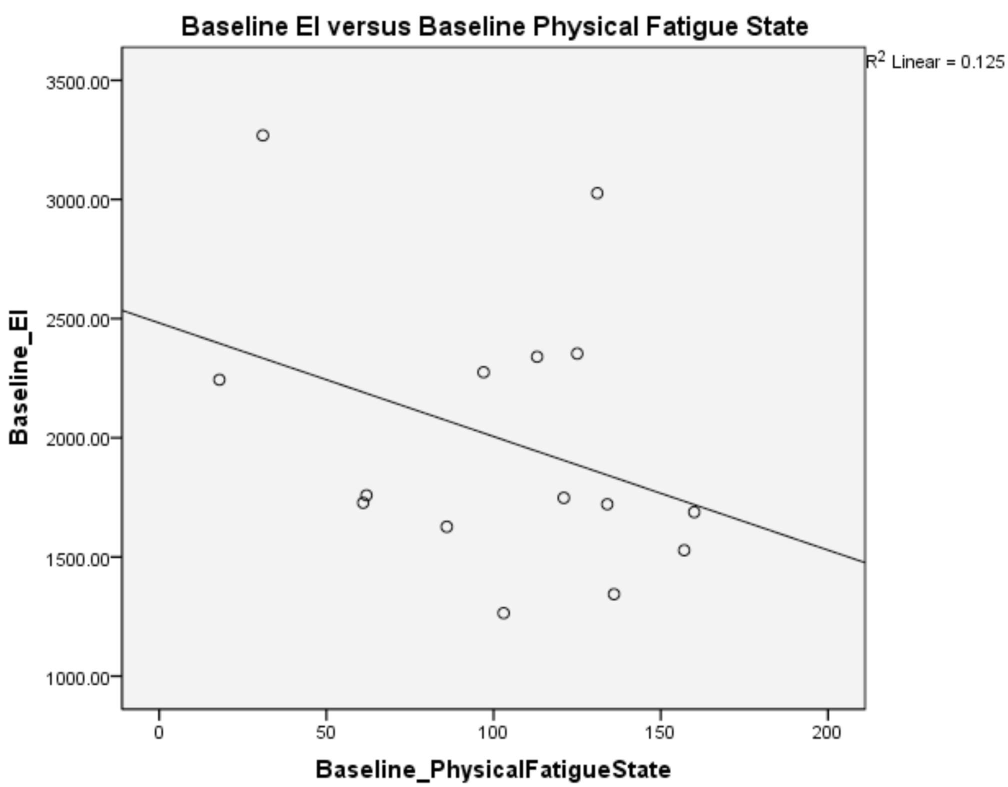
Graph V: Scatterplots for Baseline and Week 8 EE and EFS State Scales (continued)



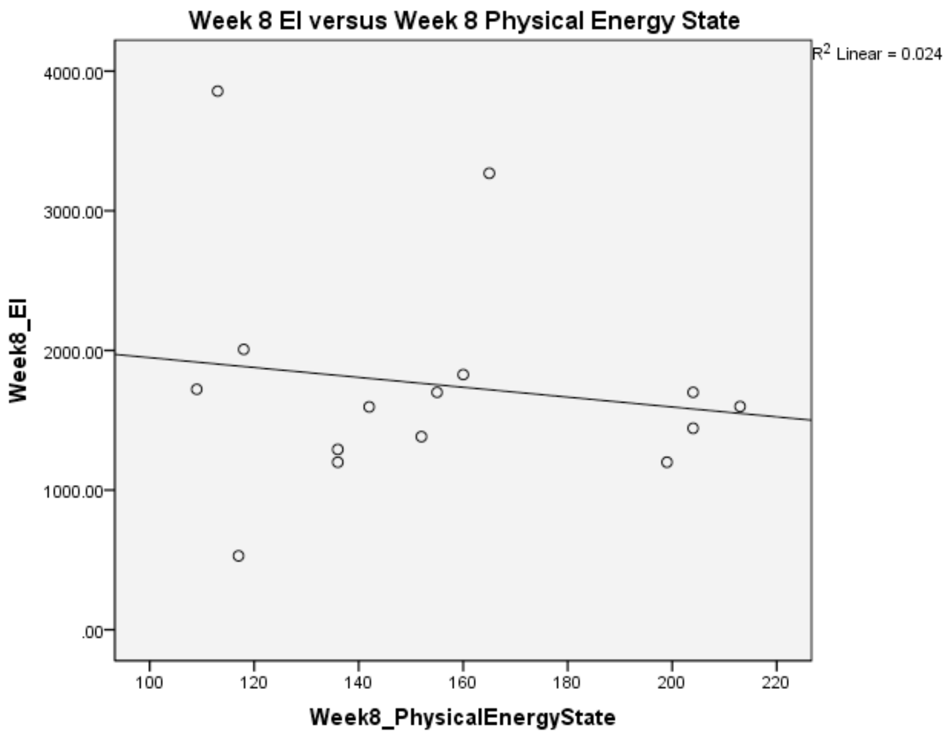


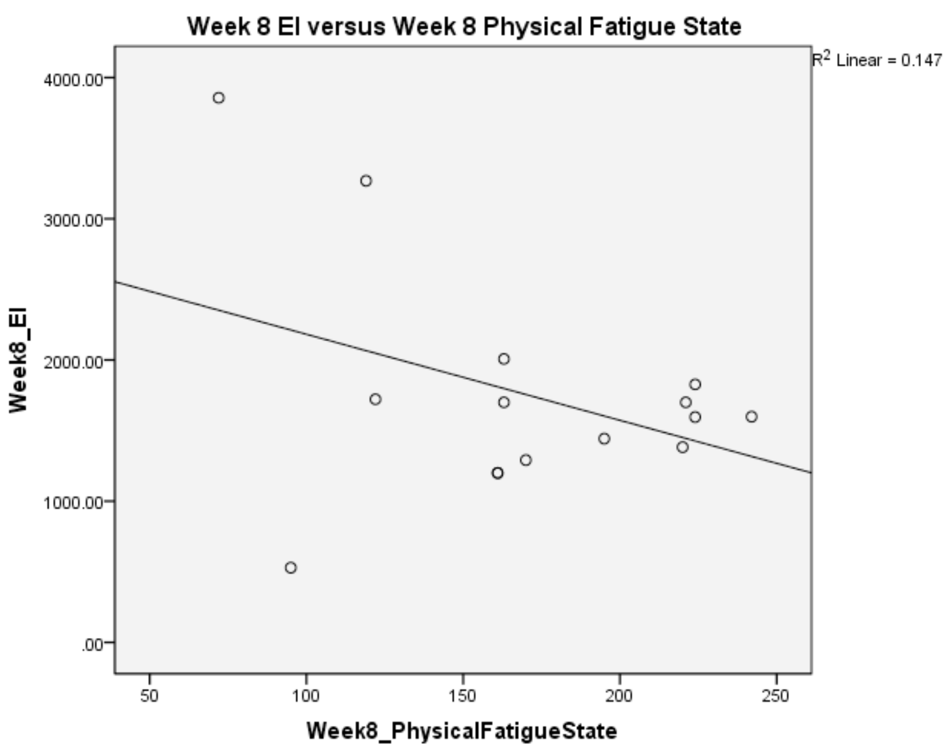
Graph VI: Scatterplots for Baseline and Week 8 EI and EFS State Scales





Graph VI: Scatterplots for Baseline and Week 8 EI and EFS State Scales (continued)





APPENDIX D

Visual Analogue Scale

Subject Number | | | |

Mental and Physical
State and Trait Energy and Fatigue Scales

Part I - How you feel right now.

Directions. This part of the questionnaire asks about your current feelings of energy and fatigue. We are interested in how you feel right now, even if it is different than how you usually feel. Therefore, it is important that you focus on how you feel right now at this moment in responding to each item. There are no right or wrong answers. Please be as honest and accurate as possible in your responses. Make a vertical line through each horizontal line below to indicate the intensity of your current feelings. If you have a complete absence of the feeling described then place a vertical mark at the left edge of the horizontal line. If your feelings are the strongest intensity that you have ever experienced then place a vertical mark at the right edge of the horizontal line. If your feelings are between these two extremes, then use the distance from the left edge to represent the intensity of your feelings.

Example:

I feel I have no energy — Strongest feelings of energy ever felt

______________________________________|____________

How do you feel right now with regard to your capacity to perform your typical *PHYSICAL ACTIVITIES*....

1. I feel I have no energy — Strongest feelings of energy ever felt

____

2. I feel no fatigue | Strongest feelings of fatigue ever felt

3. I feel I have no vigor | Strongest feelings of vigor ever felt

4. I feel no exhaustion | Strongest feelings of exhaustion ever felt

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5. I feel I have no pep | Strongest feelings of pep ever felt

6. I have no feelings of being worn out | Strongest feelings of being worn out ever felt

How do you feel right now with regard to your capacity to perform your typical *MENTAL ACTIVITIES*....

7. I feel I have no energy Strongest feelings of energy ever felt

8. I feel no fatigue Strongest feelings of fatigue ever felt

9. I feel I have no vigor Strongest feelings of vigor ever felt

10. I feel no exhaustion Strongest feelings of exhaustion ever felt

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11. I feel I have no pep Strongest feelings of pep ever felt

12. I have no feelings of being worn out | Strongest feelings of being worn out ever felt

____

Part II - How you usually feel.

Directions. This part of the questionnaire asks about how you usually feel. Therefore, it is important that you focus on how you usually feel in responding to each item. There are no right or wrong answers. Please be as honest and accurate as possible in your responses. Circle the response that best represents how you usually feel.

With regard to your capacity to perform ***PHYSICAL ACTIVITIES*** how often do you usually feel....

13. ENERGETIC
never
a little bit of the time
sometimes
most of the time
always

14. FATIGUED
never
a little bit of the time
sometimes
most of the time
always

15. VIGOROUS
never
a little bit of the time
sometimes
most of the time
always

16. <u>EXHAUSTED</u>
never
a little bit of the time
sometimes
most of the time
always

17. <u>FULL OF PEP</u>
never
a little bit of the time
sometimes
most of the time
always

18. <u>WORN OUT</u>
never
a little bit of the time
sometimes
most of the time
always

With regard to your capacity to perform <u>*MENTAL ACTIVITIES*</u> how often do you usually feel…..

19. ENERGETIC
never
a little bit of the time
sometimes
most of the time
always

20. FATIGUED never
a little bit of the time
sometimes
most of the time
always

21. VIGOROUS never
a little bit of the time
sometimes
most of the time
always

22. EXHAUSTED never
a little bit of the time
sometimes
most of the time
always

23. FULL OF PEP never
a little bit of the time
sometimes
most of the time
always

24. WORN OUT never
a little bit of the time
sometimes
most of the time
always

APPENDIX E

Enrollment Report