A Comparison of Effects Between Post Exercise Resting Metabolic Rate after Thirty Minutes of Intermittent Treadmill and Resistance Exercise

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A Comparison of Effects Between Post Exercise Resting Metabolic Rate After Thirty Minutes of Intermittent Treadmill and Resistance Exercise

By

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A thesis submitted to the Department of Nutrition, Food & Exercise Sciences in partial fulfillment of the requirements for the degree of Masters of Science

Degree Awarded: Summer Semester, 2007
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ABSTRACT

PURPOSE: The purpose of the present study is to evaluate the acute effects of resistance exercise (RE) and intermittent anaerobic treadmill (IT) exercise matched for relative exercise intensity and duration on 14 hour post-exercise metabolic rate (MR) and 24 hour post-exercise resting metabolic rate (RMR) in healthy females. METHODS: Seven aerobically (>46 ml/kg/min) and resistance trained female college students, 18-30 yrs, were recruited. Subjects completed a running maximal oxygen uptake (VO\textsubscript{2max}) test, and one repetition maximal (1RM) tests for 5 resistance exercises. These tests were conducted at least 7 days prior to the exercise protocols. Subjects slept overnight in the laboratory for two consecutive nights during their early follicular menstrual phase. Evening and morning metabolic measurements were taken (9:30 p.m and 6:30 a.m) by indirect calorimetry. The subjects underwent one control night and then completed one exercise bout following the control morning RMR. Following the exercise protocol MR and RMR were measured again at 14 and 24 hours respectively. The subjects returned during a following menstrual cycle to complete the second exercise protocol. The two exercise protocols that were randomly assigned were RE and IT. Exercise duration (30 min), interval:recovery time (30 sec:60sec) was constant between the two protocols. The intensity for the IT was >90% VO\textsubscript{2max} and the intensity of RE was 80% of 1RM lifts. Repeated measures analysis of variance was used to determine significance among the three conditions (control, RE, IT) for 14 hour MR and 24 hour RMR. Significance was accepted at \( p \leq 0.05 \). RESULTS: Kilocalories expended and heart rate during IT were significantly higher (298 ± 49 kcals; 169 ± 11 bpm) than RE (129 ± 29 kcals; 134 ± 18 bpm). At 14 hours post-exercise MR was significantly different among the three conditions (\( F_{(1.1,6.6)}= 6.03; p \leq 0.05 \), effect size (ES)=0.50). MR was 8.8 and 11.8% higher for the IT and RE, respectively compared to control conditions. At 24 hours post-exercise RMR was not significantly different among the three conditions (\( F(2,12)= 2.70; p>0.05 \), ES=.31). CONCLUSION: Both protocols demonstrated that 30 minutes of intermittent-high intensity exercise can increase energy expenditure for up to 14 hours after exercise. This may have important implications for weight loss programs.
CHAPTER I
INTRODUCTION

Exercise is an integral part of increasing energy expenditure when trying to lose or maintain weight loss (Donnelly et al., 2004; Jakicic 1999). An excess energy intake, positive energy balance, compared to energy expenditure results in weight gain, whereas a negative energy balance will result in weight loss. Exercise is one of the components of energy expenditure that is under voluntary control (Donnelly et al., 2004) and is a popular avenue used by many Americans to maintain or achieve weight loss. The prevalence of leisure-time physical inactivity declined significantly, from 29.8% in 1994 to 23.7% in 2004. Leisure-time physical activity is defined as participation in physical activity or exercise, outside of regular job-related activity. Although the level of leisure activity slightly increased, the majority of Americans do not meet the recommended levels of physical activity for health benefits or weight maintenance (Kruger et al., 2004).

Energy balance is altered by exercise in a variety of ways. This can include the energy expended during exercise, the energy expended post exercise, and any alterations in resting metabolism induced by the exercise over time (Donnelly et al., 2004). The increase in energy expenditure after exercise was defined by Gaesser and Brooks as “excess post exercise oxygen consumption” (EPOC) (Borsheim et al., 2003; Gaesser et al., 1984). This increase in energy expenditure following high intensity exercise could be a valuable component to a weight loss or weight maintenance program (Schuenke et al., 2002) if the level of EPOC is high and can be sustained.

The Center for Disease Control and the American College of Sports Medicine recommend that all individuals should exercise at a moderate intensity for at least 30 minutes on most days of the week for health benefits. Moderate intensity is defined as 3-6 METS or 3.5-7.0 kcal/min (CDC, 1999). However, the goal of an aerobic exercise program for overweight and obese individuals to achieve weight loss, prevent weight gain, or regain is an energy expenditure of ≥ 2000 kilocalories (kcal) per week, (Jackicic et al., 2001) or 60-90 minutes most days of the week (Saris et al., 2003). Therefore, these recommendations are significantly higher than the recommendations needed for health benefits.
Although the published guidelines for weight loss and weight re-gain prevention recommend aerobic exercise (Jackicic et al., 2001; Saris et al., 2003), the addition of resistance training to a weight loss program has clear advantages. Resistance training may be an important component of a successful weight loss program by maximizing fat loss while stimulating increases in lean body mass and muscular strength (Kraemer et al. 2002). The increase in metabolic rate post exercise following resistance training may have a significant effect on weight loss. Resistance training does not produce the same caloric expenditure during exercise that aerobic exercise does (Braun et al., 2005). However, the increase in metabolic rate may be sustained 24-48 hours (Schuenke et al., 2002; Dolezal et al., 2000) due to metabolic stress that resistance exercise can produce. It has been found that exercise is a prime factor for success in the maintenance of long-term weight loss (Donnelly et al., 2004). However, if the majority of Americans fail to meet even the 30 minutes of exercise recommended for health benefits requiring exercise sessions of 60-90 minutes to achieve weight loss, or prevent weight regain may be unrealistic. Perhaps, if the exercise prescription was changed to intermittent-high intensity exercise instead of continuous aerobic exercise or to a resistance exercise program, changes in body composition due to the increase in resting metabolic rate via EPOC may be attained in less exercising time.

**Purpose of the Study**

Therefore the purpose of the present study was to evaluate the acute effects of high intensity resistance exercise and high intensity intermittent treadmill exercise on post exercise 14 and 24 hour metabolic rates.

**Research Hypotheses**

**Hypothesis 1:** Both a 30 minute bout of intermittent high intensity resistance exercise and 30 minute bout of intermittent high intensity treadmill exercise will have an effect on 14 hour metabolic rate when exercise is matched for total time, duration of work, and recovery.

**Hypothesis 2:** Both a 30 minute bout of high intermittent intensity resistance and 30 minute bout of intermittent high intensity treadmill exercise will have an effect on 24 hour metabolic rate when exercise is matched for total time, duration of work, and recovery.
**Hypothesis 3:** The intermittent high intensity treadmill exercise will produce a greater caloric expenditure during exercise than the intermittent high intensity resistance exercise.

**Hypothesis 4:** The intermittent high intensity resistance exercise will produce a greater caloric expenditure at 14 and 24 hours compared to the intermittent high intensity treadmill exercise.

**Assumptions**

The following assumptions for this study included:

1. All subjects accurately reported their past and current exercise histories.
2. Subjects accurately reported their menstrual cycles.
3. Subjects followed instructions given to them regarding the maintenance of current lifestyle (e.g., diet and daily physical activity) outside of the prescribed program.
4. All laboratory equipment accurately recorded measurements over the course of repeated testing.

**Delimitations**

The delimitations for this study included:

1. Seven active, (resistance trained for >6 months and maximal aerobic capacity between 46.0-60.0 ml·kg⁻¹·min⁻¹) healthy, pre-menopausal females between the ages of 18-30 years were recruited from Florida State University.
2. Subjects were healthy, eumenorrheic, and did not have any underlying diseases or medical conditions that prevented them from performing exercise testing.
3. Subjects were non-smokers, not taking weight control or stimulant type supplements, and refrained from caffeine from day 2-5 of their menstrual cycle.
4. Subjects had a body mass index (BMI) ≤ 27 kg/m² and < 25 percent body fat.
5. During the study the subjects could not change their diets in any way or start any additional exercise programs outside the laboratory.
6. Subjects had one control test beginning the third day of menstruation, and completed the exercise sequence and metabolic measurements on days five and six of their menstrual cycle.
7. Subjects had their metabolic rates measured on ten different occasions over two menstrual cycles. The ten sessions included a control evening metabolic measurement on
day three, morning and evening metabolic measurements on day four, a morning RMR measurement on day five, followed by an exercise session, then a evening measurement, 14 hours post exercise, and finally a morning RMR measurement, 24 hours post exercise on day six, for the second exercise protocol the control evening and morning metabolic measurements were omitted. This sequence of testing occurred during day two for the first protocol and day three for the second protocol, during two separate menstrual cycles. The resistance exercise or intermittent anaerobic treadmill exercise bout occurred the morning of day five. Each exercise bout was designed to have similar durations of exercise intervals and recovery, equaling thirty minutes.

8. The order of exercise was randomized.

**Limitations**

The major limiting factors of this study included:

1. Subjects were recruited from the Tallahassee, FL area; the subjects were students from Florida State University. Subjects were from an active population. The subjects of this study were volunteers and therefore are already highly motivated and looking for exercise benefits. This type of self-motivated individual may not truly represent the entire population especially those individuals who are overweight and/or sedentary.

2. Bias also exists in this sample. There was geographical bias due to subjects being only from the Tallahassee, FL area. Increased motivation may have also lead to bias in this study.

3. Since subjects were healthy, exercised regularly, and highly motivated, the response variables might be higher than one would normally expect if an individual could have been randomly chosen from the population. Conclusions from this study must take into account the type of individual agreeing to participate in the study and living in this particular area.

4. Diet, sleep and other out-of-laboratory activities could not be controlled throughout the remainder of the subject’s menstrual cycle. Subjects did however sleep in the laboratory during testing, completed dietary recalls leading up to and during testing days, and were advised to follow a similar diet and activity level leading up to and during testing days the following menstrual cycle.
Definition of Terms

**Resting Metabolic Rate (RMR):** The lowest rate of energy expenditure that can sustain life, measured after an overnight sleep in a laboratory under optimal conditions of quiet, rest, and relaxation. (Wilmore et al., 1994)

**Nighttime Metabolic Rate (MR):** The lowest rate of energy expenditure that can sustain life, measured in a laboratory under optimal conditions of quiet, rest, and relaxation.

**Excess Post Exercise Oxygen Consumption (EPOC):** An increase in oxygen consumption above resting levels for a period of time after exercise (Gaesser et al., 1984).

- Fast EPOC component – EPOC occurring < 1 hour post exercise. (Borsheim et al., 2003).
- Slow EPOC component – EPOC that occurs at or beyond 1 hour post exercise. (Borsheim et al., 2003).

**High Intensity Aerobic Exercise:** > 75% VO$_2$ max. (Wilmore et al., 1994)

**Intermittent Exercise:** Intense short bouts of exercise followed by bouts of recovery. (Wilmore et al., 1994)

**High Intensity Resistance Exercise:** ≥ 75% of the one repetition maximum (1RM), ≥ 4 repetitions leading to muscle failure.
CHAPTER II
LITERATURE REVIEW

Components of Daily Energy Expenditure

Perhaps one of the biggest challenges in both researching and understanding the beneficial effects of the increase in resting metabolic rate (RMR) caused by excess post exercise oxygen consumption (EPOC) is the challenge of accurately measuring energy expenditure. Once a system to measure RMR has been established the challenge is to then understand how these various components interact as well as possible subject variability in daily RMR. In order to understand how EPOC affects a persons 24 hour daily caloric needs and energy expenditure, first we must understand what contributes to total daily energy expenditure (TDEE) and then look at factors that could effect RMR when studying the effects of EPOC in a laboratory setting.

There are three main components that contribute to the body’s TDEE; RMR; diet-induced thermogenesis, also called the thermic effect of food (TEF); and physical activity thermogenesis, (Donahoo et al., 2004; Speakman et al, 2003; Donnelly et al. 2004; Lemmer et al., 2001) which can be divided into non-exercise activity thermogenesis (NEAT) and exercise thermogenesis (Donahoo et al., 2004; Speakman et al, 2003). Together these components represent the amount of energy (calories) that a person expends on a given day. These components of energy balance are interactive and a change in one component may cause changes in other areas of energy expenditure (Donnelly et al., 2004). In order to understand how one area of energy expenditure could affect another area, it is necessary to first define and explain how exercise or other lifestyle factors affects each of these three components.

Resting Metabolic Rate.

Resting metabolic rate is the largest part of total daily energy expenditure. Resting metabolic rate accounts for approximately 60-75% of TDEE and represents the energy requirements of vital body functions. Seventy five to eighty percent of the variability in RMR is predicted by fat-free mass (Ravussin et al., 1992; Donahoo 2004; Illner et al., 2000; Speakman et al, 2003) and when comparing individual organs, it is the skeletal muscle and the liver that significantly contribute to resting energy expenditure (Illner et al., 2000). Many women have
fluctuations in RMR throughout their menstrual cycle (Webb 1986; Solomon 1982; Donahoo et al., 2004). Genetics and the ageing process also affect RMR.

Since skeletal muscle has been shown to significantly impact individual RMR (Illner et al., 2000), the impact of chronic exercise, especially resistance training on RMR has been investigated by many researchers (Broeder et al., 1992; Lemmer et al., 2001; Pratley et al. 1994; Ryan et al., 1995). The increase in RMR with training is thought to be due to an increase in lean body mass, as well as increased activity of the sympathetic nervous system (Lemmer et al., 2000; Pratley et al. 1994). Lemmer et al (2001) evaluated the age and gender effects of 24 weeks of resistance training on RMR, in 10 young men (20-30 yr), 9 young women (20-30 yr), 11 older men (65-75 yr), and 10 older women (65-75 yr). The researchers reported that resistance training increased absolute RMR by 7% in both young (6302 ± 1458 vs 6719 ± 1617 kJ/day) and older (5614 ± 916 vs 5999 ± 973 kJ/day) subjects, with no significant interaction between the two age groups. In contrast, men increased absolute RMR by 9% (6645 ± 1073 vs 7237 ± 1150 kJ/day), whereas women showed no significant increase (5170 ± 884 vs 5366 ± 692 kJ/day). Additionally, there was still a gender effect and no significant age effect with only the men showing a significant elevation in RMR. One possible explanation for the attenuated increase in RMR is a possible difference in sympathetic nervous system activity response to resistance training in women. This conclusion is in agreement with earlier studies that report RMR in women to be lower than men and may be related to sympathetic differences (Ferraro et al., 1992). Although results concerning the effects of resistance training on RMR are mixed, there is more agreement about the ability of resistance training programs to maintain RMR by preserving lean body mass (Andersen et al., 2003; Broeder et al., 1992; Bryner et al., 1999; Ryan et al., 1995)

Menstrual cycle is another factor that can affect RMR on a daily basis. Resting metabolic rate often shows a biphasic pattern during the menstrual cycle with a greater RMR observed in the luteal phase (Solomon 1982; Webb 1986). Although a recent study by Henry et al (2003) did not show any discernable biphasic pattern there was still considerable variability of RMR throughout the menstrual cycle. Webb (1986) concluded that eight of ten women showed an average RMR increase of 9% during the 14th day of the luteal phase following ovulation. In addition, Solomon et al (1982) reported that RMR decreased to its lowest point one week prior to ovulation. Progesterone from the corpus luteum was attributed to these changes, as it is said to
act as a metabolic stimulant by increasing body heat production and the changing progesterone levels coincide with the observed changes in RMR (Solomon 1982; Webb 1986). Although some researchers chose not to control for menstrual cycle (Maehlum et al., 1986; Sedlock, 1991a; Turley et al., 1993) it is generally accepted that validity is increased by controlling for the menstrual cycle when measuring RMR.

**Thermic Effect of Food.**

The TEF accounts for 10-15% of TDEE and represents the energy requirement associated with digestion, absorption, and storage of food. The magnitude of TEF can be altered by a number of factors (Donahoo et al., 2004; Donnelly et al., 2004). For example, TEF increases with a decrease in ambient temperature, is effected by over and under feeding, weight gain increases TEF and weight loss decreases TEF (Donahoo et al., 2004). Meals eaten a few hours post exercise noticeably increase the rate of oxygen (O$_2$) consumption (VO$_2$) compared to a rested state (Maehlum et al., 1986). Lean body mass is a strong determinant of diet-induced thermogenesis (Donahoo et al., 2004; Reed et al., 1996; Segal et al., 1985) and is significantly higher in lean men when compared to obese men of the same body size. This observation indicates that TEF is greater in lean individuals (Segal et al., 1985).

The TEF is also proportional to the energy and protein content of food (Donahoo et al., 2004, Donnelly et al., 2004, Belko et al., 1986). Belko et al., (1986) reported that a meal consisting of 45% of daily energy requirement produces a three hour TEF of 10.8 ± 0.79L O$_2$ compared with 4.0 ± 0.83 L O$_2$ for a meal consisting of 15% of daily energy requirement and a meal with a protein content of 30-45% of daily energy requirement had a higher TEF at 150-270 minutes following the meal compared with a 15% protein meal, but at 5 hours-post, O$_2$ consumption was unaffected by protein consumption. This study concluded that the energy content of a meal has the greatest effect on TEF.

**Physical Activity Thermogenesis.**

Physical activity is a key component of energy balance (Donnelly et. al., 2004). As technology advances and daily living becomes more sedentary, there is a decline in the energy expenditure of occupation, leisure activities and ambulation that comprise NEAT. The obesity
trend in western populations may not necessarily be an increase in energy consumption, but a
decrease in the activities of daily living that comprise NEAT (Speakman et al., 2003). Data
suggest that overweight individuals often show lower levels of activity than their lean
counterparts (Donahoo et al., 2004). So although food consumption remains stable, NEAT has
decreased, resulting in a positive energy balance (Speakman et al., 2003).

Excess Post Exercise Oxygen Consumption.

During exercise, VO$_2$ is increased to support the demands placed on the body. The
cellular and physical changes that occur in the cells during exercise carry over into recovery,
causing VO$_2$ levels to stay elevated for a period of time. This elevation in VO$_2$ after exercise is
called EPOC. EPOC can be divided into two separate phases (Gaesser et al., 1984), a rapid
component and a prolonged component (Bahr 1992; Borsheim et al., 2003).

The rapid component of EPOC includes the “oxygen debt hypothesis” and describes all
the components that expire within approximately 1 hour (Bahr, et al., 1991). The mechanisms
thought to be responsible for the rapid component of EPOC include: replenishment of oxygen
stores in blood and muscle; resynthesis of the phosphagen system; restoring hemoglobin and
myoglobin; lactate removal; increased body temperature; and increased circulatory and
ventilatory function (Bahr 1992; Borsheim et al., 2003; Gaesser et al., 1984; Tomlin et al., 2001).

The prolonged mechanisms responsible for EPOC are more complex and controversial, but
include: an increase in the rate of the triglyceride/fatty acid (TG/FA) cycling; carbohydrate to fat
substrate shift; the effects of potential hormonal stimulants; increased sensitivity to
catecholamines (Bahr et al., 1991; Borsheim et al., 2003); elevated protein breakdown; protein
synthesis; and sustained increase in ventilation, circulation, and body temperature (Borsheim et
al., 2003).

Mechanisms Explaining the Rapid Component of EPOC:

The basis for an increase in VO$_2$ post exercise stems from the understanding of how the
chemical and physical changes occurring during exercise carry on into recovery (Gaesser et al.,
1984). Although VO$_2$ by exercising muscle increases rapidly, and by more than 30 fold,
(Bangsbo et al., 1998) there is still a decrease in mixed venous blood O$_2$ content related to
exercise intensity (Bahr 1992).
At the onset of aerobic exercise, resting $O_2$ concentration of 120 ml/L falls to a concentration of about 40 ml/L with an $VO_2$ of 3 L/min at 75% $VO_{2\text{max}}$ and decreases to 20 ml/L at maximal exercise. This de-oxygenation amounts to a total hemoglobin desaturation of about 0.2L at submaximal exercise and 0.3L at maximal exercise. After exercise, the $O_2$ must be restored to the blood and tissues. The “oxygen debt” created by myoglobin-bound $O_2$ being used during exercise is related to exercise intensity. Oxygen store replenishment after supramaximal exercise is 0.5L and 0.3L after submaximal exercise (Bahr 1992).

Regarding resistance exercise, muscle blood flow during recovery is also dependent on the type and duration of exercise. Intensity also plays a factor in post exercise hyperemia. Blood flow is greatest and lasts longer following exercise of longer duration and higher tension suggesting that local metabolites play a dominant role in initiating and controlling the hyperemic response during and following exercise (Bangsbo et al., 1998). During exercise there is a reduction in muscle creatine phosphate concentration. The resynthesis of the ATP/creatine phosphate system is restored within a few minutes (Bahr 1992) and the amount of $O_2$ necessary for rephosphorylation need may not exceed 1.5 L and only account for less than 10% of total EPOC (Gaesser et al., 1984.)

Lactate is the end product of anaerobic metabolism of glucose, but it can also be produced in oxygenated muscle as a result of muscle contractions stimulating glycolysis and glycogenolysis. Oxidation is the end product of lactate metabolism post exercise. At the end of exercise, 55-70% of the lactate present will be oxidized and less than 20% will be converted to glycogen. The oxidation process takes about 60 minutes or longer and may require 14-26 L of $O_2$ while the conversion from lactate to glycogen occurs during the first four hours post exercise (Gaesser et al., 1984 p.37).

The rate at which, heart rate, ventilation, and body temperature return to resting levels impacts $O_2$ consumption. The estimated $O_2$ cost of increased circulation during the first hour after both submaximal and supramaximal exercise is 0.3 L (Bahr 1992). Excess pulmonary ventilation is estimated to contribute < 0.1 L to the rapid EPOC component after submaximal and supramaximal exercise (Bahr 1992). The increase in body temperature caused by exercise diminishes the phosphorylative coupling efficiency of the mitochondria which, results in more $O_2$ being required for a given amount of ATP to be synthesized (Brooks et al., 1971a; 1971b).
Mechanisms Explaining the Prolonged Component of EPOC

An increase in the TG/FA cycling after prolonged exhaustive exercise occurs because fatty acids released during lipolysis are re-esterified into TG rather than oxidized. Since ATP is needed for re-esterification, the energy cost associated with TG/FA cycling increase is thought to account for a significant part of EPOC after prolonged steady-state exercise (Bahr 1992). The shift from carbohydrate oxidation to lipid oxidation after high-intensity exercise may be due to increased fat utilization as a glycogen sparing mechanism as carbohydrate is spared to be used for glycogen re-synthesis (Binzen et al., 2001). Since the energy equivalent of O$_2$ is only ~4.7 mol ATP/mol O$_2$ compared to glucose which has ~5.1 mol ATP/mol O$_2$, this substrate shift has been calculated to account for 10-15% of EPOC (Borsheim et al., 2003) but, the extra energy cost associated with increased TG/FA cycling may account for up to half of EPOC (Bahr 1992).

Catacholamines released by the sympathoadrenal system have a lesser influence on EPOC directly although they may help with the regulation of other components such as heart rate; respiration; blood circulation; glycogenolysis; gluconeogenesis; and lipolysis. There is a linear relationship between exercise duration, intensity and plasma concentrations of catecholamines (Borsheim et al., 1998), and an increase in adipose tissue sensitivity after exercise helping to stimulate lipolysis and TG/FA cycling (Bahr 1992).

Exercise can have a dramatic effect on the rate of muscle protein synthesis (Rennie 2000). Since protein synthesis is energetically expensive it would make sense that the energy cost related to an increased rate of protein synthesis post exercise would contribute to a higher rate of energy expenditure (Borsheim et al., 2003). The rate of resynthesis depends on factors like intensity and mode (Rennie 2000) and it seems that the energy used to repair muscle damage after intense exercise, especially eccentric-type exercise such as high intensity resistance exercise, downhill running, or high intensity sprinting could positively affect EPOC (Dolezal et al. 2000).
Factors Influencing the Magnitude of EPOC

Exercise Intensity

There is a strong relationship between exercise intensity and EPOC (Borsheim 2003; Bahr et al., 1991; Bahr 1992). The magnitude of EPOC is related to the stress placed on the metabolic processes during exercise, like anaerobic metabolism, oxidation of fatty acids, and sympathetic activation. Exercise intensity near 50% of VO_{2max} may correspond with the lactate threshold (Bahr et al., 1991; Bahr 1992) in untrained individuals. It seems that only after exercise above 50% VO_{2max} does the duration of EPOC last more than one hour (Bahr, 1991) and only after strenuous exercise (>70% VO_2 max) is there a prolonged EPOC that contributes significantly to total energy expenditure (Maehlum et al., 1986; Bahr et al., 1991). If the magnitude of EPOC is related to the stress placed on the metabolic processes during exercise, like anaerobic metabolism, how does EPOC after supramaximal exercise compare to submaximal exercise? Research done by Laforgia et al., (1997) concluded that supramaximal intervals indeed produce significantly greater EPOC than submaximal exercise. In their study eight male middle-distance runners, age 21.1 ± 3.1 years, weight 67.8 ± 5.1 kg; with VO_{2max} of 69.2 ± 4.0 ml/kg/min completed two similar exercise sessions. One session was continuous treadmill running for 30 min at 70% of VO_{2max} and the other was interval running: 20 x 1-min intervals at 105% of VO_{2max} with 2-minute rest periods between intervals. At nine hours post exercise EPOC values were 6.9 ± 3.8 L for the submaximal and 15.0 ± 3.3 L for the supramaximal exercise. However the supramaximal exercise EPOC represents only 13.8% of the net total O_2 cost, so although there was an extended EPOC effect at this intensity, the majority of caloric expenditure came during the actual exercise. However a total EPOC of 16 L was shown after only three two-minute supramaximal exercise bouts, in men of similar age but a lower VO_2 (49.9 ± 1.4 ml/kg/min; Bahr et al., 1992). From the previous studies it could be assumed that the supramaximal exercise will have a more pronounced EPOC effect on moderately trained individuals compared with highly trained individuals. Although Laforgia et al., (1997) concluded that most of the caloric expenditure occurs during supramaximal exercise in highly trained men, perhaps low or moderately trained individuals would have a greater caloric expenditure during EPOC.
Exercise Duration

The question of what intensity and duration of exercise will produce an EPOC effect that lasts 24 hours still remains unknown. In a well-controlled study, Maehlum et al. (1986) measured EPOC after exercise in eight subjects. The effects of environment, dietary history, and excess daily movement was minimized by having the subjects complete 24 hours of bed rest immediately after a control session and an exercise session. The subjects consisted of four males and four females with a mean age of 22.1 years, and VO$_{2\text{max}}$ of 3.3 L/min. The subjects exercised on a cycle ergometer at 70% of VO$_{2\text{max}}$ for intervals of 10-30 minutes with a rest period of five minutes between each exercise period. The exercise was complete when the subjects had exercised for 90 minutes or were unable to complete a 10-minute work period. Mean exercise time was 79.8 minutes. After completing the exercise the subjects rested in bed for 24 hours. Their meals were measured during the first experiment (either control or exercise) and replicated for the second experiment. Heart rate, temperature, and VO$_2$ were measured hourly for the first 12 hours post exercise and again at 24 hours post exercise. Mean total VO$_2$ was 26 L/12 hr higher after the exercise session than the control session. Oxygen consumption 24 hours post exercise was also significantly higher compared to the control session. It appears from this study that 80 minutes of exercise at 70% of VO$_{2\text{max}}$ will produce a 12-hour and a 24 hour EPOC effect in both men and women. However exercising for 80 minutes at 70% VO$_{2\text{max}}$ is unrealistic for many individuals who are struggling with their weight.

Exercise Mode

The majority of studies investigating the relationship between exercise intensity, duration, and EPOC have used male subjects (Schuenke et al., 2002; Haltom et al., 1999; Bahr et al., 1991; Maehlum et al., 1986; Laforgia et al., 1997; Bahr et al., 1992) or a male/female combination (Sedlock 1991b; Scott et al., 2006). The effect of exercise intensity on EPOC specific to the female population was investigated by Sedlock (1991a). Seven normal-weight females participated in the study. The 7 women were in their 20’s and were reported to be moderately trained (mean VO$_2$ not reported). Subjects performed a cycle ergometer exercise at 40 and 60% of VO$_{2\text{peak}}$. They exercised until an energy expenditure of 850 kJ was achieved, which was 41.1±5.2 minutes at 40% and 27.3±3.6 minutes at 60%. There was no significant difference in the duration of EPOC, 27±15 and 18±8 minutes, respectively and the magnitude was similar for
both the exercise intensities. This study failed to produce a prolonged EPOC effect suggesting that an exercise intensity of 50% of VO\(_{2\text{max}}\) requires a longer duration to significantly effect EPOC in women. At this intensity, a minimum of one hour of exercise may be needed to effect the duration of EPOC (Sedlock 1991a). When comparing intense intermittent running to prolonged walking in women, Brockman et al (1993) reported that intermitted running has a greater effect on EPOC than either prolonged walking or a short duration run. In this study five highly trained (VO\(_{2\text{max}}\): 61.8 ml/kg/min) females (age: 22.4 ± 1.6 yrs) performed three separate exercise protocols. The women walked at 24.5% VO\(_2\) for two hours, ran at 80% VO\(_2\) for 10 minutes, or completed an interval run consisting of seven 2-minute bouts at 90% followed by 2 minutes active recovery. After each protocol VO\(_2\) was measured for 60 minutes post exercise and totaled. Both running protocols had significantly greater VO\(_2\) than the walking protocol (intermittent: 22.4 ± 1.5 L; 10-min run: 19.09 ± 0.09; walking: 17.4 ± 0.7). It should be noted that only the rapid portion (one hour) of EPOC was examined in this study. The VO\(_2\) of both running protocols were both greater than baseline and the walking protocol. At 60 minute post exercise VO\(_2\) was still elevated above the walking protocol and the control in both running programs. The authors estimated that VO\(_2\) would return to resting levels by 100-120 minutes. However, these were highly trained women and perhaps the EPOC duration would be much longer in low or moderately trained women. These two studies did not control for menstrual cycle so it is unknown whether variation in RMR associated with sex hormone levels would have had an effect on rapid EPOC.

The magnitude of EPOC depends on both the duration of the exercise and the intensity at which the exercise is performed. Both long duration (>1 hour) moderate intensity (50-70%) (Bahr et al., 1991; Maehlum et al., 1986; Sedlock 1991a), and short duration < 1 hour supramaximal (Laforgia et al., 1997; Bahr et al., 1992) exercise can produce a prolonged EPOC effect as long as intensity is adequate. Based on this evidence, the type of exercise whether continuous or intermittent, could be utilized as long as the minimum intensity or duration requirements are met to have a significant impact on EPOC.

Extensive research has been done on the EPOC effect of various modes and intensities of aerobic training. Both treadmill and cycling exercises show a similar linear relationship between intensity, duration and EPOC (Borsheim et al., 2003). Research has also been done to compare
treadmill exercise with cycling exercise, as well as upper body vs. lower body cycling ergometer exercise and the magnitude of EPOC.

Scott et al (2006) evaluated the differences in VO$_2$ of equal energy expenditure between brief, but intense cycling and uphill running exercise bouts. Fourteen well-trained subjects (VO$_2$ max 57.0 ± 12.9 ml/kg/min cycle; 59.3 ± 13.7 ml/kg/min run) were evaluated. The subjects performed 1-minute bout exercise protocols designed to elicit a 250 W power output. For the cycle exercise, the subjects pedaled at 60 rpms at a work rate of 250 W. For the treadmill exercise the subjects ran at a 10% grade and at a speed that elicited 250 W based on the subjects weight. Perceived exertion (14.0 ± 2.3 cycle; 13.2 ± 2.1 run) and EPOC did not differ between the exercise modes, yet exercise VO$_2$ was significantly greater for running (41.4 ± 6.9 kJ) compared to the cycling (31.7 ± 7.7 kJ). Exercise VO$_2$ + EPOC was greater for running, but anaerobic energy expenditure was greater for cycling creating total energy expenditure (including EPOC) that was similar between cycling (118.0 ± 21.8 kJ) and running (125.4 ±19.1 kJ). Therefore, EPOC is similar when different modes of aerobic exercise have similar work-equivalent exercise bouts.

To evaluate EPOC on upper body vs. lower body exercise, Sedlock (1991b) had four women and four men perform both a 20-minute arm crank and 20-minute cycle exercise at 60% mode-specific VO$_2$peak. There was no significant difference between the magnitude of EPOC (9.2 ± 3.3 kcal arm crank; 10.4 ± 5.8 kcal cycle). The duration of EPOC was also similar for both exercises (22.9 ± 13.7 min arm crank; 24.2 ± 19.4 min cycle). This suggests that EPOC is more related to the relative metabolic rate of the active musculature as opposed to the absolute VO$_2$ of the exercise or the amount of active muscle mass used during exercise (Sedlock 1991). It seems there is fairly good evidence that the mode of exercise has a negligible effect on the EPOC produced as long as exercise intensity and duration are within the appropriate parameters to elicit a sustained EPOC.

**Resistance Exercise and EPOC**

When studying the effects of resistance exercise and EPOC, most research compares aerobic exercise to resistance exercise matching either VO$_2$ or energy expenditure, or compares different types of resistance exercise equating workload. Understanding the effects of resistance
exercise on EPOC is difficult due to the diversity of protocols used (i.e. circuit training or multiple sets, number of sets, intensity, and rest period duration). Protocols that have relatively low or moderate work loads show little sustained EPOC beyond the first few hours following exercise (Burleson et al., 1998; Thornton et al., 2002; Haltom et al., 1999), however research using higher intensity training protocols that are designed for strength and hypertrophy, have shown significant EPOC values lasting as long as 48 hours (Dolezal et al., 2000; Schuenke et al., 2002).

If a high-intensity protocol has additional benefits relating to EPOC and energy expenditure over low intensity programs than perhaps a high-intensity program would be more beneficial to people looking to achieve weight loss. However, if EPOC is a reflection of total work done, than a low intensity and a high intensity program of equal work may have similar results. Thornton et al (2002) attempted to answer this question by investigating the effects of resistance exercise bouts of different intensities but equal work on EPOC. Fifteen females (age: 26.8±5.0 years; height: 1.64.5 ± .07. m; body mass: 63.1 ± 4.2 kg; body fat: 17.6 ± 2.8 %; \( \text{VO}_{2\text{max}} \): 2.87 ± 0.39 L/min) who were eumenorrheic and had been weight training for at least 6 months were used in the study. The women performed two exercise sessions on day 3-11 of their menstrual cycle and used dietary journals to replicated eating patterns on testing days. The protocols consisted of 2 sets of 9 resistance exercises either as 8 repetitions at 85% of 8RM (HI) or 15 repetitions at 45% of 8RM (LO). The biggest difference in EPOC was immediately post exercise but the HI protocol EPOC was still significantly greater than LO at 20 minutes (HI:1.72 ± 0.70 L \( \text{O}_2 \), vs. LO:0.9 ± 0.65 L of \( \text{O}_2 \), 60 minutes (HI:0.35 ± 0.25 L \( \text{O}_2 \), vs. LO:0.14 ± 0.19 L of \( \text{O}_2 \), and 120 minutes (HI:0.22 ± 0.22 L \( \text{O}_2 \), vs. LO:0.05 ± 0.11 l of \( \text{O}_2 \) post exercise. Although at 120 minutes post exercise, \( \text{VO}_2 \) was not significantly different than control \( \text{VO}_2 \), the researchers concluded that high-intensity exercise will produce greater EPOC when compared to low-intensity exercise, even when total work is the same. They attributed these results to the high intensity exercise causing greater metabolic disturbances, which is in agreement with a previous report (Burleson et al., 1998).

Thus far the evidence points to high intensity protocols as a means to significantly influence caloric expenditure during EPOC. Schuenke et al. (2002) conducted a study that resulted in caloric expenditure via EPOC that could definitely impact TDEE. Seven subjects with an average age of 20 years who were advanced weight lifters (3-4 times/wk for a minimum
of 6 months) were recruited for their study. Subjects had their resting VO$_2$ measurements taken 1 day prior to the exercise sessions at three separate times throughout the day. The subjects VO$_2$ were measured after 30 minutes of rest at 7:00 am, 12:00 noon, and 5:00 pm. On the exercise day, subjects had VO$_2$ measurements taken at 7:00 am and 12:00 noon. The subjects exercised for 30 minutes prior to the 5:00 pm measurement instead of resting supine. Post exercise, VO$_2$ was taken at the same time-points and under the same resting conditions. The resistance exercise protocol consisted of only 3 exercises (bench press, power cleans, and squats), at 70-85% 1 RM for 8-12 reps. The subjects performed 4 times in a circuit routine with two minutes rest between sets. The whole exercise session lasted about 30 minutes. VO$_2$ was significantly elevated above baseline values immediately following exercise and at 14, 19, and 38 hours post exercise. Exact data were not reported, but the average number of calories burned per subject above baseline estimated from the percent increase in VO$_2$ was 404 kcal the first 24 hours and 369 kcal for the second (48 hr) day following exercise. This increase in calorie expenditure over the 48 hours could have a significant effect on weight loss.

Since exercises that involve eccentric contractions induce more muscle damage than concentric contractions (Friden et al., 1992; Clarkson et al., 2002), post exercise metabolic rate after this mode of exercise may produce different results than concentric exercise (Gillette et al., 1994). Dolezal et al. (2000) examined whether muscle damage caused by eccentric resistance exercise would influence RMR. Eighteen college aged men participated in the study. Nine of the men had been weight training a minimum of 2 yrs with lower body exercise at least 2 days/wk and 9 other men were untrained. After completing RMR measurements on the day of the exercise protocol, subjects performed 8 sets of an eccentric leg press at 6-RM. Baseline RMR and 72 hour post exercise RMR were not significantly different between the trained and untrained groups. Both groups showed a significant increase in RMR at 24 hours and 48 hours post exercise compared to baseline measurements. The untrained group had a RMR of 9705.4 ± 204.5 kJ/day at 24 hours and 8930.9 ± 104.4 kJ/day at 48 hours. The trained group RMR measurements were 9209.3 ± 535.3 at 24 and 8601.7 ± 353.7 kJ/day and 48 hours post exercise. When RMRs were converted to caloric expenditure the average number of calories burned above baseline levels during the 48 hours were approximately 725 kcal/day for the untrained group, and 528 kcal/day for the trained group.
Both Dolezal et al (2000) and Schuenke et al (2002) confirmed that resistance exercise at 70-85% of 1RM can increase RMR above baselines values for over 48 hours. They also showed that not only can an elevation in RMR persist, but also the magnitude of EPOC could have a considerable positive impact upon weight loss by increasing TDEE. It appears evident that it is the metabolic impact of the exercise and not necessarily the workload (Thornton et al., 2002) that effects the duration and magnitude of EPOC. A resistance protocol of 70-85% 1RM can elicit an EPOC beyond 1 hour (Thornton et al., 2002) and even up to 48 hours (Dolezal et al., 2000; Schuenke et al., 2002) and could most positively affect weight loss through a sustained EPOC (Schuenke et al., 2002).

Comparing the Effects of Endurance Exercise and Resistance Exercise on RMR

Evidence suggests that exercise intensity has a greater effect on EPOC than duration due to a greater alteration in homeostasis (Melby et al., 1993; Laforgia et al., 1997). Since high-intensity intermittent exercise may have the greatest impact on the magnitude of EPOC researchers have investigated whether resistance exercise alone or combined with aerobic exercise would be a better mode for controlling weight. When studies comparing aerobic and resistance exercise of similar energy expenditure are conducted, the resistance exercise produces a greater EPOC response (Borsheim et al., 2003). An explanation for this may be due to the aerobic protocol used. In order to achieve equal energy expenditure, the aerobic exercise has to be done at a low intensity, approximately 50% of VO_{2max}, which has been established as the minimum intensity that produces a prolonged EPOC.

Burleson et al. (1998) evaluated the acute effects of resistance exercise and aerobic exercise. The purpose of the study was to compare the duration and total energy requirements of recovery after a circuit exercise and a steady state aerobic exercise session performed for the same duration at a matched VO_{2}. Fifteen males (age:22.7±1.6 years; body weight: 82.0±14.3 kg; body fat:13.1±7.6 %, VO_{2max}: 3.57±0.61 L/min) performed a 27-minute bout of circuit weight training at 60% of each subject’s 1RM and a 27-minute bout of treadmill exercise at a speed that obtained the same VO_{2} produced during the weight training session (approximately 45% of VO_{2max}). EPOC was measured at 30, 60 and 90 minutes post exercise. The resistance exercise produced the highest total VO_{2} during the first 30 minutes after exercise (19.0 L for circuit training vs. 12.7 L for aerobic training). Yet at 60 and 90 minute there were no significant
differences in VO₂. The researchers concluded that resistance exercise at the same VO₂ produced higher EPOC values than the aerobic exercise. However it is not surprising that there were no differences in EPOC after the aerobic exercise session since aerobic exercise intervention in this study was at a low intensity, approximately 45% of VO₂max, and for a relatively short duration, only 27 minutes. A study investigating EPOC response to circuit training and treadmill exercise in women reached similar conclusions (Braun et al., 2005). By controlling for aerobic energy cost, Braun et al. (2005) investigated whether circuit training (CT) or steady state treadmill running (TM) would lead to a higher EPOC response. Eight pre-menopausal females (age: 31.3 ± 9.1 years; estimated VO₂max: 2.04 ± 0.26 L/min; BMI: 24.6 ± 3.9 kg/m²) completed the exercise sessions. Subjects were tested on days 1-7 of their menstrual cycle and dietary records were used to replicate dietary habits for both exercises protocols. Resting metabolic rate measurements were taken, then the subjects completed an eight-exercise weight training session consisting of 3 sets of 15 repetitions at 65% 1 RM in a circuit fashion, with 30 seconds rest between exercises and a 2 minute recovery between each set. For the treadmill exercise session baseline measurements were again taken and during exercise, the duration and aerobic energy expenditure were matched to the circuit training session. Post exercise data were collected from 0-60 minutes. The circuit training resulted in a significantly higher VO₂ during the first 30 minutes post exercise (0.27 ± 0.01 L/min CT vs. 0.23 ± 0.01 L/min TM). The 60-minute VO₂ was not significantly different between the exercise protocols, VO₂ was significantly higher (VO₂: 0.231 ± 0.01 L/min) than pre-exercise baseline measure (VO₂: 0.193 ± 0.01 L/min). Heart rate, RPE, and ventilation were also significantly greater during the circuit training session, which the authors concluded to be evidence of greater metabolic disturbances and O₂ cost and greater aerobic energy expenditure during recovery from exercise.

One weakness of the experimental designs of the above studies is that the aerobic exercise protocol they used to compare with the resistance protocol was at an intensity that would hardly produce an EPOC effect beyond the rapid component. High intensity intermittent treadmill exercise produces higher EPOC than a low intensity continuous aerobic exercise with the same energy expenditure (Burleson et al., 1998 Borsheim et al., 1998; Braun et. al, 2005). Therefore, it would be interesting to compare the acute effects of high intensity resistance exercise with high intensity intermittent treadmill exercise that are of same duration of work and rest intervals.
**Effect of Training Status on EPOC**

Both aerobic (Short et al., 1997; Tomlin et al., 2001) and resistance (Dolezal et al., 2000) training status can influence EPOC since the physiological adaptations of trained individuals alter many aspects of exercise metabolism (Short et al., 1997). When performing high intensity intermittent exercise, the metabolic consequence is an increase in hydrogen ion (H+) and a depletion of ATP/CrP. Hydrogen ion accumulation is responsible for slowing the metabolic pathways and slowing the rate of recovery. Trained individuals have increased concentrations of aerobic enzymes, increased number and size of mitochondria, increased capilaritization, and improved vasodilatation. These adaptations not only increase the rate of VO$_2$ during exercise, they also result in less lactic acid accumulation which means less energy has to be devoted to clearing H+ and lactate during the recovery period.

As discussed previously, after high intensity intermittent exercise trained individuals had an EPOC of a lower magnitude (Laforgia et al., 1997) compared with less trained individuals (Bahr et al., 1992). When comparing exercise protocols using trained vs. untrained individuals, at the same percent VO$_2$ trained individuals consume more oxygen. This is because they are at a higher workload, so at the start of recovery VO$_2$ is elevated resulting in a greater extent of the rapid EPOC component (Tomlin et al., 2001). Although the initial EPOC is greater in trained individuals, these individuals also have a faster recovery back to post exercise metabolic rate (Borsheim et al., 2003; Short et al., 1997).

The training status after resistance exercise also effects the duration of EPOC. The variance in the protein muscle synthesis from muscle damage caused by resistance training is increased in untrained persons resulting in a higher EPOC. Resistance trained individuals show an attenuated response to RMR compared with untrained subjects (Dolezal et al., 2000) possibly due to muscular adaptations that result in less muscle damage (Clarkson et al., 2002).

The obesity rate is on the rise in America and although the level of leisure activity has slightly increased within the last decade, the majority of Americans do not meet the recommended levels of physical activity (Kruger et al. 2004). One of the reasons for this increase in obesity may be due to the decrease in TDEE. As daily living becomes more sedentary, there is a decline in the NEAT component of TDEE (Speakman et al., 2003). Since energy expenditure associated with physical activity is the most variable component of the TDEE, and under voluntary control, it has the greatest potential for increasing TDEE (Donnelly et
al., 2004) and consequently helping to reduce body weight. Although exercise is vital for weight loss success, the majority of Americans fail to meet the recommended energy expenditure of ≥ 2000 kilocalories (kcal) per week, (ACSM position stand 2001) or 60-90 minutes most days of the week (Salrs et al., 2003) that is recommended for overweight and obese individuals who want to achieve weight loss, prevent weight gain, or regain.

If the exercise prescription was changed to intermittent-high intensity exercise of a shorter duration of time instead of long duration continuous aerobic exercise, individuals could receive the additional benefits relating to EPOC and energy expenditure and perhaps this type of exercise intensity would be more beneficial to people looking to achieve weight loss. Even if EPOC only increases TDEE by 10%, for an individual with a 1,500 kcal RMR this would equate to about 1,000 calories a week. Creating a weekly caloric deficit of 1,000 kcals beyond what is expended during the exercise session (approximately another 1,000 kcals) would demonstrate that 30 minutes of high-intensity intermittent exercise could be an effective means of controlling weight gain and facilitating weight loss. It could be assumed that the extra caloric expenditure beyond that of the exercise session would able to evoke changes in body composition due to the increase in RMR via EPOC. Therefore the purpose of the present study is to evaluate the acute effects of intermittent high intensity resistance exercise and intermittent high intensity treadmill exercise matched for exercise duration on post exercise resting metabolic rate (RMR) by comparing the 14 hour and 24 hour post exercise EPOC and total net 24 hour energy expenditure.
CHAPTER III
RESEARCH METHODS

The purpose of this study was to compare the effects of intermittent high intensity treadmill and resistance exercise of equal exercise duration on EPOC. Recent data indicate that when resistance exercise and aerobic exercise are matched for energy expenditure, resistance training has a higher EPOC effect. However in these experiments, in order to match energy expenditure, the resistance exercise must be performed first so there is no randomization and the continuous aerobic exercise tends to be performed at 40-50% of \( \text{VO}_{2\text{max}} \) (Braun et al., 2005.; Thornton et al., 2002). When the interval of exercise and recovery are equalized, intermittent high intensity exercise may cause greater physiological changes during the exercise that will carry on throughout both the rapid and prolonged components of EPOC to induce a 24 hour increase in RMR. This chapter will provide information pertaining to the importance of controlling pre-testing conditions, accurate measuring of subject RMR and EPOC, and the research methodology that was used to conduct this study.

Methodological Considerations

There are several methodological aspects that need to be taken into consideration when studying EPOC. Differences in pre-experimental conditions across investigators may account for the variation in the results of EPOC duration and/or magnitude when similar protocols are used. It is necessary to control the pre-experimental conditions, and be able to reproduce the indirect calorimetry measurements to accurately measure the possibly small, but important differences in RMR pre and post exercise.

Study participants were of stable weight, and food and exercise were controlled during the research sessions. Subjects slept overnight in the laboratory to avoid excess movement in the morning before being measured for RMR (Borsheim et al., 2003). However there may be no significant difference between RMR when measured after subjects spend the night at home versus the laboratory (Turley et al., 1993). In a study by Turley et al (1993) subjects spending the night before measurement at home vs. at a clinic found no significant differences (\( p > 0.05 \)) in \( \text{VO}_{2} \, \text{ml/min} \), RMR (kJ/min, kJ.kg body wt-1.h-1, or kJ.kg fat-free mass-1.h-1), or RER between...
the home trial ($\text{VO}_2 = 216 \pm 41 \text{ mL/min}$, RER = $0.80 \pm 0.04$, heart rate = $51 \pm 3 \text{ beats/min}$, ventilation = $7.1 \pm 1.1 \text{ L/min}$) vs. the clinical trial ($\text{VO}_2 = 216 \pm 45 \text{ mL/min}$, RER = $0.80 \pm 0.04$, heart rate = $52 \pm 5 \text{ beats/min}$, ventilation = $7.0 \pm 1.1 \text{ L/min}$). In a study conducted by Bullough et al., (1993) RMR and RER were measured, using indirect calorimetry, in 9 male subjects under three conditions: (1) an inpatient, meal-controlled protocol (IPM) in which subjects were fed an evening meal and slept overnight in the laboratory prior to the morning test; (2) an outpatient, meal-controlled protocol (OPM) in which subjects were fed the same meal but slept at home prior to being transported to the laboratory for testing, and (3) and outpatient protocol (OP) in which the meal was not controlled, but subjects were instructed to fast for 12 h prior to testing. There were no statistically significant differences in RMR among protocols (IPM = 7,928 $\pm 360$, OPM = 8,015 $\pm 331$ and OP = 7,987 $\pm 315 \text{ kJ/day}$). Both studies concluded that under most circumstances it is not important that subjects spend the night before RMR assessment at the measurement facility. However, Berke et al, (1992) found RMR to measure higher after subjects spent the night at home and then transported themselves to the test facility but still concluded that exercise training-induced increase in RMR can be detected by using either an inpatient or an outpatient protocol (Burke et al., 1993). Although choosing to have subjects sleep overnight to avoid excess movement is to ensure a higher standard of control of subject and pre-testing condition, the previous research indicates that sleeping in a laboratory setting would not likely produce an overestimated RMR due to an unfamiliar bed or foreign environment (Turley et al., 1993).

**Subjects**

Pre-menopausal females from Florida State University with an exercise history of at least six months of resistance and aerobic training were recruited for this study (see Appendix A for subject recruitment form). The subjects were of normal weight (BMI < 27.0 kg/m$^2$ and percent body fat < 24 %) of moderate aerobic ability with a $\text{VO}_{2\text{max}}$ between 46.0-60.0 ml/kg/min, non-smokers, eumenorrheic, not taking any stimulant supplements, and did not have any medical conditions that would effect RMR measurements or prevent them from performing the exercise. Following pre-testing, subjects acted as their own controls and were randomly assigned to the order in which they completed the exercise protocols by drawing a folded slip of paper with either “weights” or “treadmill” written inside. Control measurements began on day 3 of their
menstrual cycle prior to the first protocol. The protocols ran from day 4 to day 6 on two separate menstrual cycles. The study was approved by the Institutional Review Board (Appendix B). All subjects were asked to sign a consent form (Appendix C), complete a medical and health status questionnaire (Appendix D), and an exercise history and menstrual history questionnaire (Appendix E).

**Pre-testing Data Collection**

Subjects reported to the lab 5-10 days prior to day 3 of their expected menstrual cycle. Subjects had their height and weight (in socks and gym cloths) measured on a Seca balance scale and percent body fat was estimated using Lange skin-fold calipers. When the subjects anthropomorphic measurements were complete, subjects became familiarized with the exercises for the protocols. Maximal oxygen consumption was tested using a running protocol to assess VO$_{2\text{max}}$ and 1RM were measured using Smith weight machines. A few days after the VO$_{2\text{max}}$ test the subjects came back to the laboratory to verify that there maximal speed obtained during the VO$_{2\text{max}}$ test would elicit >90% of their VO$_{2\text{max}}$. This speed was then used for the high intensity workload for the intermittent high intensity treadmill exercise protocol.

**Body Composition Measurement**

Subject’s body fat was assessed using the Jackson and Pollock three-site formula (triceps, iliac crest, thigh) for estimating body fat percentage. Measurements were performed using procedures outlined in the *ACSM’s Guidelines for Exercise Testing and Prescription (2004)*. Lange skinfold calipers were used for this procedure and two measures were made at each site unless they were not within 1 mm wherein an additional measurement was made.

**Measurement of Maximal Oxygen Consumption**

Subjects’ VO$_{2\text{max}}$ was determined by a graded exercise test to exhaustion on the treadmill. Prior to testing the metabolic system was calibrated according to manufacturer’s recommendations. First, a gas calibration was performed using a gas mixture of known concentrations of O$_2$ and CO$_2$ (16% O$_2$; 4% CO$_2$, Scott Medical Products, Plumsteadville, PA). The metabolic system was then flow calibrated with a 3L calibration syringe (no.5530, Hans Rudolph, Inc., Kansas City, MO). Environmental temperature, humidity and barometric pressure were measured using an indoor climate monitor (Perception II™, Davis Instruments, Hayward,
CA) and data were inputted into the metabolic cart system for internal adjustment of data. Subjects wore a nose clip and a mouthpiece (no. 112263 2700B and 666021, Hans Rudolph Inc., Kansas City, MO) connected to a nine foot plastic hose (no.1003, Vacumed, Ventura, CA), which was used to collect expired air from the subjects and deliver it to the metabolic cart system for analysis during the VO\textsubscript{2max} test. Heart rate was monitored using a polar heart rate monitor. The VO\textsubscript{2max} test began with a 5-min subject controlled walking warm-up period. The test began at a subject selected speed of 6.5 or 7.0 mph for three minutes, every minute thereafter the grade was increased by 1%. Once a grade of 5% was achieved, only the speed was increased until VO\textsubscript{2max} was reached. VO\textsubscript{2max} was defined as the point at which three out of four criteria were met 1) plateau of the oxygen consumption (\(< 2.0 \text{ mL/kg/min} \) with an increase in exercise intensity 2) attainment of a respiratory exchange ratio of 1.15 or greater 3) attainment of heart rate within \(\pm 10 \text{ beat/min} \) or age predicted maximal heart rate 4) and exhaustion or an RPE of 18 or higher (Howley et al., 1995). If three of the four criteria were not met the test was repeated within the next two days.

One Repetition Maximum Test

The following exercises were used for testing: chest press, squat, lat pull-down, shoulder press, and stationary lunges. Upon completion of the familiarization of the exercise protocol subjects had their 1RM determined for each exercise except the stationary lunge. The 1RM was determined by having the subject perform each of the exercises with a resistance that would produce muscle fatigue in one lift. Subjects estimated their approximate 10RM weight for each exercise. This weight was applied to a prediction table to determine the first weight attempted for their 1RM (Baechle et al., 2000). The load attempted was 10 pounds lighter than predicted to allow for a margin of error. Five to ten-pound increments were used until a weight was attempted that the subject could not lift. The last successful lift was recorded as the 1RM. The stationary lunge was measured for an 8 RM following the same sequence of events, with the last successful set of weigh lifted eight times recorded as the 8RM. Three-minute rest intervals were utilized as rest periods between lifts.

Dietary Record.

Starting 48 hours before the first evening metabolic measurement, the subjects were asked to keep a dietary record of the foods that they ate (Appendix F). The subjects were asked to consume foods they normally eat and could be easily replicated. Subjects were then asked to
replicate their diet 48 hours prior to the second exercise protocol so food intake could be controlled for the RMR measurements.

**RMR Measurements**

Resting metabolic rate was measured by indirect calorimetry using a metabolic cart. In order to get as accurate morning RMR as possible, subjects were instructed not to eat or drink anything except water after 6:00 pm and sleep overnight in the exercise physiology laboratory. The evening metabolic measurement was controlled by a four hour fast starting from 6:00 pm until their metabolic measurement was completed at 10:00 pm. The subjects rested in a supine position from 9:00 pm until 9:30 pm and metabolic measurement was taken from 9:30-10:00 pm with subjects wearing a ventilation mouthpiece and nose clip. For all metabolic measurements, the average \( O_2 \) over the 30-minute period was used as the criterion measure. Subjects had a familiarity night spent in the laboratory a day prior to the exercise sessions where morning RMR were measured. This was done to help familiarize subjects with sleeping in the laboratory and with the testing procedures. Morning baseline RMR was measured upon waking. After waking and using the restroom, subjects wore a ventilation mouthpiece and rested in the supine position for 30 minutes before having their baseline RMR measured. After the 30-minute rest period expired gases were collected over an additional 30-minute period. Upon completion of the control period RMR the subjects were allowed to go home and return to the laboratory at 9:00 pm to undergo the same protocol as they did the night before. After the RMR the following morning the subjects were randomized into one of the two exercise sessions.

After the morning RMR was measured, the exercise session began at 7:00 am. On completion of the exercise session subjects were allowed to leave the laboratory and return that night at 9:00 pm. They were again asked to stop eating after 6:00 pm and rest supine for 30 minutes beginning at 9:00 pm and have a 14 hour EPOC measurement at 9:30 pm and then a 24 hour EPOC measurement at 6:30 am. On completion of this measurement the subjects were asked to return to the laboratory on day four of their next menstrual cycle. Periodic calls were made over the next few weeks to remind subjects of their testing dates. On day 4 of the next menstrual cycle, the subject again reported to the laboratory at 9:00 pm for metabolic measurements.
<table>
<thead>
<tr>
<th>Menstrual Cycle 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet Log</td>
<td>Record all meals</td>
<td>Record all meals</td>
<td>Record all meals</td>
<td>Record all meals</td>
<td></td>
</tr>
<tr>
<td>6:00 A.M.</td>
<td></td>
<td></td>
<td>CM-RMR</td>
<td>CM-RMR</td>
<td>24-RMR</td>
</tr>
<tr>
<td>7:00 A.M.</td>
<td></td>
<td></td>
<td>Exercise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 P.M.</td>
<td>CE-MR</td>
<td>CE-MR</td>
<td>14-MR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Menstrual Cycle 2</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet Log</td>
<td>Replicate all meals</td>
<td>Replicate all meals</td>
<td>Replicate all meals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 A.M.</td>
<td></td>
<td></td>
<td>CM-RMR</td>
<td>24-RMR</td>
<td></td>
</tr>
<tr>
<td>7:00 A.M.</td>
<td></td>
<td></td>
<td>Exercise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 P.M.</td>
<td></td>
<td>CE-MR</td>
<td>14-MR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Example Research Protocol

CM-RMR: control morning resting metabolic rate; CE-MR: control evening metabolic rate; 14-MR: 14 hour post exercise metabolic rate; 24-RMR: 24 hour post exercise resting metabolic rate.

**Exercise Protocols**

The intermittent high intensity treadmill and intermittent high intensity resistance exercise protocols were 30 minutes in duration and were matched for exercise and recovery times. Both exercise protocols were designed to work the subjects out for 30 seconds until fatigue and then have the subjects recover for 60 seconds. The intermittent high intensity treadmill exercise bout consisted of a 1:2 work/rest ratio at a maximal intensity similar to that of other researchers (Laforgia et al., 1997) who used high intensity intermittent protocols (Bahr 1992; Laforgia et al., 1997).

Subjects were asked to refrain from resistance training and high intensity aerobic training starting day 3 of their menstrual cycle (48 hours) and any aerobic exercise day 4 (24 hours) prior to the morning exercise bouts. Following the morning RMR measurement on day five of menstruation, the subject performed either the intermittent high intensity resistance or the intermittent high intensity treadmill exercise wearing a mouthpiece and nose clip for VO₂ measurements. The resistance exercise session consisted of 5 exercises performed on a Universal Weight/Smith Machine. The exercises used were the chest press, squat, lat pull-down, shoulder press, and stationary lunges. These exercises were chosen because each exercise targets
a number of muscle groups and would hopefully create a large amount of metabolic stress. The
weight lifted for each set was set at 80% of subjects 1RM for 30 seconds, which was
approximately 6 repetitions. The rest period was 1 minute long and subjects performed 1 set
then moved on to the next exercise. The circuit was repeated 3 more times, for a total of 4 sets of
each exercise. The intermittent high intensity treadmill exercise session consisted of twenty 30
sec (>90% VO$_{2\text{max}}$) x 1 min (rest intervals). The grade and speed that was verified after the
subject VO$_{2\text{max}}$ test was used for each 30-second interval. Before exercise, immediately post
exercise, 14 hours post exercise and 24 hours post exercise, the subjects completed a soreness
assessment. (Appendix G)

**Statistical Analysis**

Statistical analysis was performed using SPSS for Windows 13.0. Sample size estimation
was determined a priori as a function of the significance criterion ($\alpha$), the statistical power and
effect size (ES). Effect size is calculated using the following formula:

$$\text{ES} = \frac{(\mu_1 - \mu_0)}{S_0}$$

Where $\mu_1$ is the mean of the experimental value, $\mu_0$ is the mean of the control value and
$S_0$ is the larger standard deviation of the two means (hence yielding the most conservative effect
size). For this experiment an effect size of 0.9 was used, based on a relevant literature review of
measured post exercise 16 hour RMR after 5 sets of circuit training, comprising 10-15 repetitions
of 10 exercises at 12RM in 7 young female subjects. Using the equation $\text{ES} = \frac{(\mu_1 - \mu_0)}{S_0}$, the
study by Osterberg et al (2000) had an effect size of $0.92 = \frac{[(1479-1419)/65]}{65}$. Statistical analysis
was set at an $\alpha = 0.05$, ES = 0.9, power of 70%, and a subject number of 8.

Values were presented as means ± standard deviations. Dependent measures of evening
metabolic rate and RMR was analyzed using a Repeated Measures Analysis of Variance
(ANOVA) (3 levels of treatment: control, resistance exercise, and treadmill exercise).
Dependent measures taken during the exercise bouts were measured using a One-Way ANOVA
(2 levels of treatment: resistance exercise and treadmill exercise). If there were significant
differences in data paired-t tests were used to determine where differences existed. When the
Mauchly's Test of Sphericity was violated, the Greenhouse-Geisser test was used to assess
significance. All significance was accepted at $p < 0.05.$
Nineteen women were initially recruited for the study. Three could not participate due to their VO\textsubscript{2}max (<45.0 ml/kg/min) being too low. One was unable to abstain from exercise on the required days due to another commitment. One developed an injury preventing her from finishing the study. Five others could not complete the entire protocol due to scheduling conflicts, and two had irregular menstrual cycles, which prevented them from completing the protocol. Therefore, seven active college age females completed the study. Subject characteristics along with their maximal measurements of VO\textsubscript{2} and strength are presented in Table 1. All subjects met the criteria for a physiological VO\textsubscript{2}max by meeting at least three out of following four conditions 1) plateau of the oxygen consumption (< 2.0 ml/kg/min) with an increase in exercise intensity 2) attainment of a respiratory exchange ratio of 1.10 or greater 3) attainment of heart rate within ± 10 beat/min or age predicted maximal heart rate 4) and exhaustion or a RPE of 18 or higher (Howley et al., 1995).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>23 ± 3</td>
<td>20 – 27</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.3 ± 11.0</td>
<td>152.4 - 182.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>60.2 ± 7.3</td>
<td>51.8 - 70.9</td>
</tr>
<tr>
<td>BMI (kg/m\textsuperscript{2})</td>
<td>22.6 ± 2.4</td>
<td>20.0 - 27.0</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>18.0 ± 3.5</td>
<td>13.0 - 23.2</td>
</tr>
<tr>
<td>Lean Body Mass (kg)</td>
<td>49.4 ± 6.5</td>
<td>43.3 - 61.7</td>
</tr>
<tr>
<td>VO\textsubscript{2}max (ml/kg/min)</td>
<td>50.9 ± 4.1</td>
<td>46.3 - 57.8</td>
</tr>
<tr>
<td>RER</td>
<td>1.17 ± 0.04</td>
<td>1.12 – 1.26</td>
</tr>
<tr>
<td>Maximal Heart Rate (b/min)</td>
<td>187 ± 12</td>
<td>168 – 199</td>
</tr>
<tr>
<td>Maximal RPE</td>
<td>19.7 ± 0.5</td>
<td>19 – 20</td>
</tr>
<tr>
<td>Chest Press (kg)</td>
<td>43 ± 9</td>
<td>31 – 56</td>
</tr>
<tr>
<td>Squat (kg)</td>
<td>71 ± 17</td>
<td>47 – 91</td>
</tr>
<tr>
<td>Lat Pull-down (kg)</td>
<td>34 ± 11</td>
<td>21 – 46</td>
</tr>
<tr>
<td>Shoulder Press (kg)</td>
<td>28 ± 5</td>
<td>22 – 33</td>
</tr>
<tr>
<td>Stationary Lunge (kg)</td>
<td>51 ± 12</td>
<td>38 – 67</td>
</tr>
</tbody>
</table>

BMI = Body Mass Index; VO\textsubscript{2}max = maximal oxygen uptake; RER = respiratory exchange ratio; RPE = rate of perceived exertion; Lat = Latissimus Dorsi
The Exercise characteristics are presented in Table 2. Total exercise time was similar for both protocols at 30 minutes, with twenty, 30 second exercise intervals followed by a 60 second recovery. For the intermittent high intensity resistance exercise subjects were encouraged to do 2-second concentric/3-second eccentric lifts. The actual number of repetitions completed in 30 seconds ranged from 5-8 repetitions and subjects lifted 4,478 ± 1,126 kgs during the resistance protocol. For the intermittent high intensity treadmill protocol the treadmill was set at 5% grade for the entire 30 minutes. Subjects completed each 30 second interval at 8.6 ± 0.3 mph, this was a previously determined set speed that produced an average work rate of 90% VO\(_2\)max or subject exhaustion (91.5 ± 2.6 % of VO\(_2\)max) within a 5 minute practice run completed before the metabolic measurements were taken. The subjects walked at a slow (~2.5 mph) speed at a 5% grade for their 60-second recovery. Both protocols produced near exhaustion for the subjects and constant verbal encouragement was provided. All subjects rated their exercise bouts at 18 or higher on the 20 point RPE scale during the last couple intermittent high intensity treadmill intervals and all subjects except one had to have weights periodically removed in order to finish the 30 second intervals during the intermittent high intensity resistance exercise protocol.

Although both exercise protocols were completed at a high intensity, average VO\(_2\), average heart rate, and kilocalories expended were significantly higher for the intermittent high intensity treadmill protocol. However, RER was significantly higher during the intermittent high intensity resistance training protocol.

Table 2 Exercise Characteristics (N=7)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intermittent Anaerobic</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Interval Speed (mph)</td>
<td>8.6 ± 0.3</td>
<td>X</td>
</tr>
<tr>
<td>Low Interval Speed (mph)</td>
<td>2.5 ± 0.4</td>
<td>X</td>
</tr>
<tr>
<td>Total Weight Lifted (kg)</td>
<td>X</td>
<td>4,478 ± 1,126</td>
</tr>
<tr>
<td>Kilocalories Expended</td>
<td>298 ± 49*</td>
<td>129 ± 29</td>
</tr>
<tr>
<td>Average VO(_2) (ml/kg/min)</td>
<td>32.4 ± 4.0*</td>
<td>13.4 ± 1.6</td>
</tr>
<tr>
<td>(\text{VO}_2) (%)</td>
<td>63.5 ± 5.0*</td>
<td>26.5 ± 3.0</td>
</tr>
<tr>
<td>Average Heart Rate(^b) (b/min)</td>
<td>169 ± 11*</td>
<td>134 ± 18</td>
</tr>
<tr>
<td>Respiratory Exchange Ratio</td>
<td>0.99 ± 0.06*</td>
<td>1.09 ± 0.06</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations; \(\text{VO}_2\) = oxygen uptake

\(^a\) Metabolic measurements were collected continuously and ten second averages were averaged over the entire protocol for mean values.

\(^b\) Peak heart rate for each interval and lowest heart rate during the recovery were averaged for mean values.

\(* p \leq 0.05, \text{significantly different between protocols}\)
The results of each exercise session at 14 hours and 24 hours post exercise are shown in Tables 3 and 4, respectively. Despite a practice overnight stay, the evening of the subjects’ third day of menstrual cycle, all subjects displayed their lowest evening and lowest morning resting metabolic measurements during the control evening and morning measurements of their second protocol visit to the laboratory. Since the protocols, treadmill exercise vs resistance exercise, were randomized and other factors that may have affected metabolic rate like diet, exercise, and menstrual cycle were controlled; it was assumed that the subjects felt more comfortable with the laboratory procedures on the second set of visits. As such, the third control evening and morning have been used as the baseline measures when comparing 14 and 24 hour post exercise metabolic measurements. There was a significant condition effect \( F(1,1.6,6) = 6.03; \ p \leq 0.05, \text{ effect size (ES)=0.50} \) among the measurements for the evening 14 hour post exercise on metabolic rate. When evaluating the individual exercises the evening metabolic rate after both the intermittent high intensity treadmill and intermittent high intensity resistance exercise protocols were significantly different from the control evening measurement. The intermittent high intensity resistance exercise protocol produced an 11.8% higher metabolic rate, and the intermittent high intensity treadmill protocol produced an 8.8% higher metabolic rate 14 hours post exercise compared to the control session. There was a significantly different condition effect for the 30-minute metabolic measurement of kilocalorie expenditure among treatments \( F(2,12) = 4.26; \ p \leq 0.05, \text{ ES=.42} \). There was a significant difference between the control measurement and the measurements of both the treadmill and resistance exercise protocols. The RER measurements for the treatments were not significantly different at the 14 hour post exercise measurement \( F(2,12)=0.04, \ p>0.05, \text{ ES=0.01} \). Kilocalories were calculated for the 14 hour period after the exercise bouts based on the 14 hour metabolic measurement. Calculations were made by taking the number of kilocalories expended during the 30-minute measurement and doubling the value for an hour then multiplying by 14 hours. The exercise protocols produced an approximately 85 kilocalorie increase in daily kilocalorie expenditure for the 14 hours post exercise compared to the baseline measurement and this was significantly different \( F(2,12)=4.18, \ p \leq 0.05, \text{ ES=0.41} \).
Table 3: 14 Hour Post Exercise Metabolic Measurements (N=7)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treadmill</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic Rate (ml/kg/min)(^a)</td>
<td>3.4 ± 0.3</td>
<td>3.7 ± 0.3*</td>
<td>3.8 ± 0.3*</td>
</tr>
<tr>
<td>Kcal(^b)</td>
<td>30 ± 3</td>
<td>33 ± 4*</td>
<td>33 ± 5*</td>
</tr>
<tr>
<td>Respiratory Exchange Ratio(^a)</td>
<td>0.86 ± 0.04</td>
<td>0.85 ± 0.03</td>
<td>0.86 ± 0.06</td>
</tr>
<tr>
<td>Kcal Expenditure</td>
<td>850 ± 89</td>
<td>931 ± 122*</td>
<td>935 ± 133*</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations; \(^a\)Metabolic measurements were collected continuously over 30 minutes and ten second averages were averaged over the entire protocol for mean values. \(^b\)kilocalories expended over 30 minutes measurement; Kcal Expenditure: kilocalorie expenditure over 14 hours using 14 hour metabolic measurements not including kilocalories expended during exercise.

* \(p \leq 0.05\), significantly different from control measurement

Shown in Table 4, at the 24 hour morning measurement there was no significant condition effects (\(F(2,12) = 2.70; p>0.05, \text{ES}=.31\)) among the three RMR. There was also no significant condition effects for the 30-minute RMR kilocalorie expenditure among treatments (\(F(2,12) = 1.60; p>0.05, \text{ES}=.21\)). The RER measurement for the treatments were not significantly different at the 24 hour post exercise measurement (\(F(2,12)=0.35, p>0.05, \text{ES}=0.06\)). Since gas measurements were not made continuously after completing the exercise protocols the calculations of kilocalorie expenditure at the 24-hour time period is conservative. In order to account for the 14 hour increases in RMR, both morning and evening resting metabolic measurements were combined to calculate daily caloric expenditure. Kilocalories were calculated for the 24 hour period after the exercise bouts. Calculations were made by taking the number of kilocalories expended during the 30 minutes of measurements doubling for an hour and multiplying by 14 hours, then adding this to the kilocalories calculated by taking the number of kilocalories expended during the 30-minute RMR measurement doubling and then multiplying by 10 hours. Values were compared to the control using data from both the 14 hour metabolic measurements and the 24 hour morning RMR measurements. Based on the 24 hour EPOC measurements, the intermittent high intensity resistance exercise increased kilocaloric expenditure by 8.5%. The control daily kilocalorie expenditure was 1417 ± 119 kcals. After the intermittent high intensity resistance exercise, kilocalorie expenditure increased to 1537 ± 168 kcals, and after the intermittent high intensity treadmill exercise kilocalorie expenditure was 1505 ± 154 kcals. This is a significant increase (\(F(2,12)=4.45, p\leq0.05, \text{ES}=0.43\)). Approximately
120 and 88 extra kilocalories daily were expended by the energy needed to recover from the intermittent high intensity resistance and intermittent high intensity treadmill exercise, respectively based on our method of calculation.

Table 4: 24 Hour Post Exercise Resting Metabolic Measurements

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treadmill</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic Rate (ml/kg/min)</td>
<td>3.2 ± 0.3</td>
<td>3.2 ± 0.3</td>
<td>3.4 ± 0.4</td>
</tr>
<tr>
<td>Kcal</td>
<td>28 ± 2</td>
<td>29 ± 2</td>
<td>30 ± 3</td>
</tr>
<tr>
<td>Respiratory Exchange Ratio</td>
<td>0.90 ± 0.03</td>
<td>0.91 ± 0.04</td>
<td>0.90 ± 0.06</td>
</tr>
<tr>
<td>Kcal Expenditure</td>
<td>1417 ± 119</td>
<td>1505 ± 154*</td>
<td>1537 ± 168*</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations; aMetabolic measurements were collected continuously over 30 minutes and ten second averages were averaged over the entire protocol for mean values. bKilocalories expended over 30 minutes measurement; Kcal Expenditure: kilocalorie expenditure over 24 hours using 14 hour metabolic measurements and 24 hour metabolic measurements not including kilocalories expended during exercise.

* p ≤ 0.05, significantly different from control measurement

Table 5 presents the soreness scores after the intermittent high intensity treadmill and intermittent high intensity resistance exercise protocols for different areas of the body. Subjects reported no soreness prior to exercise. There was a significant increase in the level of soreness after the resistance exercise in most of the muscle groups. At 24 hours post-resistance exercise, soreness for the chest, gluteals and hips and legs were all significantly greater than after the intermittent high intensity treadmill protocol.

Table 5: Assessment of Soreness (N=7)

<table>
<thead>
<tr>
<th></th>
<th>Chest</th>
<th>Back</th>
<th>Gluts/hips</th>
<th>Legs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-exercise Treadmill</td>
<td>0 ± 0.00</td>
<td>0 ± 0.00</td>
<td>0 ± 0.00</td>
<td>0 ± 0.00</td>
</tr>
<tr>
<td>Pre-exercise Resistance</td>
<td>0 ± 0.00</td>
<td>0 ± 0.00</td>
<td>0 ± 0.00</td>
<td>0 ± 0.00</td>
</tr>
<tr>
<td>14 hour Treadmill</td>
<td>1.14 ± 3.02</td>
<td>2.86 ± 3.08</td>
<td>5.71 ± 6.16</td>
<td>6.86 ± 6.39</td>
</tr>
<tr>
<td>14 hour Resistance</td>
<td>17.4 ± 16.8*</td>
<td>16.6 ± 17.8*</td>
<td>31.1 ± 14.0*</td>
<td>28.0 ± 15.9*</td>
</tr>
<tr>
<td>24 hour Treadmill</td>
<td>1.2 ± 4.5</td>
<td>4.6 ± 5.7</td>
<td>3.71 ± 4.1</td>
<td>13.7 ± 8.1</td>
</tr>
<tr>
<td>24 hour Resistance</td>
<td>29.1 ± 22.0*</td>
<td>31.4 ± 28.8*</td>
<td>45.4 ± 27.7*</td>
<td>41.7 ± 27.0*</td>
</tr>
</tbody>
</table>

Scale in mm; gluts/hips: gluteal area

* p ≤ 0.05, significantly different from the intermittent anaerobic at the same time-point
CHAPTER V
DISCUSSION

The present study is the first of our knowledge that has been completed comparing the EPOC effects of two types of intermittent high intensity exercise. In this study an intermittent high intensity treadmill and an intermittent high intensity resistance circuit were compared while the time of exercise was kept constant. The exercise duration was 30 minutes, since this is the minimum exercise time recommended by the American College of Sports Medicine and the Center for Disease Control. Since the goal of an aerobic exercise program for overweight and obese individuals to achieve weight loss, prevent weight gain, or regain is an energy expenditure of $\geq 2000$ kilocalories per week, (Jackicic et al., 2001) or 60-90 minutes most days of the week (Saris et al., 2003) we also wanted to investigate whether a short but intense 30-minute bout of mostly anaerobic type exercise could promote weight loss through the kilocalories expended during exercise and the kilocalories expended post-exercise via EPOC.

The results of the present study found that both 30 minutes of intermittent high intensity treadmill running and 30 minutes of intermittent high intensity resistance exercise significantly increased metabolic rate 14 hours after completing the exercise protocols. However, there were no significant differences on metabolic rate 24 hours after completing the exercise protocols. Therefore, based on the results of the present study either intermittent high intensity treadmill running or intermittent high intensity resistance exercise can help with kilocalorie expenditure over a 14 hour period. Twenty four hours after exercise, RMR was back to control measures after the intermittent high intensity treadmill protocol. After the intermittent high intensity resistance protocol, RMR was only elevated 0.2 ml/kg/min above control measures. While not statistically significant, the extra caloric expenditure resulting from this slight elevation may still be of some benefit for weight loss over the long term.

Data from the exercise sessions show that the intermittent high intensity treadmill protocol produced the greatest kilocalorie expenditure. This protocol expended 170 more kilocalories during the 30-minute exercise session than the intermittent high intensity resistance protocol. If this protocol was completed every other day for a month, a weight loss of nearly 1.5 lbs would result. If the intermittent high intensity resistance exercise protocol was completed every other day, after a month weight loss of half a pound would result. From these data, it may
be hypothesized that the kilocalorie expenditure just from the exercise session would favor the intermittent high intensity treadmill protocol as the more effective means of weight loss or weight maintenance. However, the changes in 14 and 24 hour resting metabolism due to EPOC need to be considered to determine total kilocalorie expenditure from the exercise.

The greatest changes in resting metabolism occurred at the 14 hour EPOC measurement, where both the intermittent high intensity treadmill and the intermittent high intensity resistance protocols produced similar increases in metabolism. Therefore, the first hypothesis stating that both a 30-minute bout of intermittent high intensity resistance exercise and 30 minute bout of intermittent high intensity treadmill exercise will have an effect on 14 hour metabolic rate when exercise is matched for total time, duration of work, and recovery is accepted. From these data it can be concluded that high intensity interval exercise whether running or lifting weights may produce a sustained EPOC effect. However, the intermittent high intensity treadmill protocol created an extra caloric expenditure of 170 kilocalories from the exercise session and did not produce the severity of muscle soreness produced by the resistance protocol. At 24 hours post exercise, only slight, non-significant changes in RMR were observed after the intermittent high intensity resistance protocol and no changes were observed after the intermittent high intensity treadmill protocol. Therefore, the second research hypothesis stating that both a 30-minute bout of intermittent high intensity resistance exercise and 30 minute bout of intermittent high intensity treadmill exercise will have an effect on 24 hour RMR when exercise is matched for total time, duration of work, and recovery is rejected. The third hypothesis stating that intermittent high intensity treadmill exercise will produce greater kilocalorie expenditure during exercise than resistance exercise is accepted. The fourth hypothesis stating that the intermittent high intensity resistance exercise will produce a greater kilocalorie expenditure at 24 hours compared to the intermittent high intensity treadmill exercise is rejected. Even though 24 hour post exercise RMR was elevated, it was not significant at p<0.05. However, this increase in metabolic rate could still have a substantial effect on daily kilocalorie expenditure when calculated over a 24 hour period.

When kilocalorie expenditure from the exercise sessions as well as the changes in metabolic rate over 24 hours are considered, intermittent high intensity treadmill protocol produced a kilocalorie expenditure of about 390 kcals (300 from exercise 90 from EPOC). Over a four week period, this raises the kilocalorie cost of this exercise from 4500 kcals to 5850 kcals.
The intermittent high intensity resistance protocol produced a total kilocalorie expenditure of 250 kcals (130 from exercise, 120 from EPOC). Over a four week period this raises the kilocalorie cost of this exercise from 1950 kcals to 3750 kcals. So even though the intermittent high intensity resistance exercise created a larger EPOC effect, the intermittent high intensity treadmill protocol still produced a 56% greater kilocalorie expenditure over the 24 hour period. Another benefit of intermittent high intensity treadmill exercise is it could be completed almost daily whereas it is recommended that total body resistance exercise be completed on nonconsecutive days (ACSM 2006) and only 2 to 3 times per week. For comparison sake, kilocalorie expenditure over a month was calculated assuming exercise was completed every other day. In practice, the intermittent high intensity treadmill exercise could be completed more frequently, possibly 20 times a month, while the intermittent high intensity resistance exercise is likely to be completed less frequently, possibly 12 times a month. A combination of both protocols would be recommended for a well rounded fitness routine.

To date, other EPOC research investigations comparing types of interval and aerobic exercise have matched exercise parameters like oxygen consumption and exercise duration (Braun et al., 2005 Burleson et al., 1998). However it is difficult to randomize protocols this way, and the result is the aerobic protocol is completed at a low intensity unlikely to produce a prolonged EPOC effect (Braun et al., 2005, Burleson et al., 1998). The VO$_2$ produced by the resistance protocol and replicated during the treadmill protocol in Burleson et al (1998) was 45% VO$_2$max. VO$_2$ during the resistance exercise was also matched during the aerobic protocol in Braun et al (2005). It is not surprising that the results of these two studies paralleled each other in that the researchers reported at 30 minutes post exercise the resistance protocol produced a greater post exercise VO$_2$ than the treadmill protocol. The present results do not contraindicate these earlier findings, rather they help to show that when done at higher intensities, interval exercise has a prolonged EPOC effect similar to a resistance exercise EPOC effect.

This study compared intense resistance exercise to intense interval exercise, as intensity seems to play a larger factor than duration when evaluating EPOC (Borsheim 2003; Bahr et al., 1991; Bahr 1992; Laforgia et al., 1997). Other studies that have examined EPOC have found a significant increase in RMR beyond 14 hours post-resistance exercise (Dolezal et al., 2000; Gillete et al., 1994; Melby et al., 1993; Osterberg et al., 2000; Schuenke et al., 2002). Using a study conducted on women for comparison, Osterberg et al., (2000) had subjects perform 5 sets
of 10 exercises at roughly 70% 1RM for 10-15 repetitions, with a 2-3 minute rest period between sets. At their 16 hour post exercise measurement RMR was elevated 4.2%. This is slightly lower than our 14 hour EPOC measurements. It is possible that the EPOC effect drops off between 14 and 16 hours, or that the difference in repetitions and load between the studies could have had an effect on sustaining EPOC. The studies that reported the longest duration of EPOC (>24 hours) used high intensity resistance protocols (Dolezal et al., 2000; Schuenke et al., 2002). Schuenke et al (2002) utilized a protocol that is very similar to the protocol used in the present study. They used a 31-minute resistance protocol using four circuits of three different exercises at 70-80% 1RM. It is unclear why the male subjects in this particular study were able to increase their RMR beyond 24 hours post exercise when the present study used a 30-minute protocol at 80% 1RM.

Gender differences including sympathetic nervous system activity, body mass, and muscle mass may play a factor in the different results. In a study by Lemmer et al (2001) after an identical 24-week strength-training program, young male subjects had a RMR of 7,726 ± 1,386 kcals, a body mass of 84 ± 15.6 kgs and a fat free mass of 64.9 ± 7.1 kgs whereas the young female subjects had a RMR of 5,423 ± 703 kcals, a body mass of 67.2 ± 13.7 kgs and a fat free mass of 44.8 ± 6.2 kgs. One explanation for the attenuated increase in RMR is the possible difference in sympathetic nervous system activity response to resistance training in women. Both Ferraro et al (1992) and Lemmer et al (2001) reasoned that a lower RMR (Ferraro et al., 1992) and an absence of any increase RMR after 24 weeks of resistance training (Lemmer et al., 2001) in women, compared to men may also be related to sympathetic differences between genders.

It could also be concluded that the greater body mass and fat free mass contributes to a greater daily kilocalorie expenditure. However Short et al (1997) examined EPOC duration after 30 minutes of exercise at 70% VO$_{2\text{max}}$ or 1.5 L/min in trained and untrained males and females and reported no significant differences between the genders within the trained and untrained groups during the EPOC trials despite the body mass differences between the trained males and trained females, 70.7 ± 7.1 kgs and 59.9 ± 5.0 kgs, respectively. It is possible that the gender difference between the subject pool is a factor and that a 10 kg difference between genders will not cause EPOC gender differences (Short et al., 1997) whereas a difference of 19 kgs (Lemmer et al., 2001) or the 23 kg difference between the 83 ± 10 kg males in Schuenke et
al (2002) to the 60.2 ± 7.3 kg females in the present study will cause a difference. The males used by Schuenke et al (2002) also had an average lean body mass of 74.7 kgs compared to 49.4 kgs in our females.

Since women often have a lower percentage of lean body mass than men they may not be able to create the same amount of protein breakdown. Protein synthesis is energetically expensive so it would make sense that the energy cost related to an increased rate of protein synthesis post exercise would contribute to a higher rate of energy expenditure (Borsheim et al., 2003; Rennie 2000). Since RMR accounts for approximately 60-75% of TDEE and seventy five to eighty percent of the variability in RMR is predicted by lean body mass (Ravussin et al., 1992; Donahoo 2004; Illner et al., 2000; Speakman et al., 2003), this may assist in explaining why females are not able to generate sustained EPOC the way male subjects do in most cases. Our subjects also reported moderate and high amounts of soreness at 14 and 24 hours respectably, indicating muscle damage. It appears that even though the females in the present study did not produce EPOC values as large as the male subjects in comparative studies done, after the resistance protocol, protein synthesis is still likely to be the major contributing mechanism at the 14 hour EPOC measurement after the intermittent high intensity resistance protocol.

The intermittent high intensity treadmill protocol also produced a sustained EPOC effect with an increase of 8.8% higher than the control at 14 hours post exercise. In addition, this type of exercise also created larger kilocalorie expenditure during the exercise. It has already been determined that exercise intensity has a greater effect on EPOC than duration, (Borsheim et al., 2003; Melby et al., 1993; Laforgia et al., 1997) and the present study supports this conclusion. The most likely mechanisms for the sustained EPOC is the increase in TG/FA cycling and resynthesis of glycogen storage. Our subjects were required to complete 20, 30 second intervals at >90% \( VO_2\max \), separated by 60 seconds rest, expending about 300 kcals after a 13 hour fast with an exercise RER of 0.99 ± 0.06. This cycling of TG/FA has been suggested to account for a significant part of EPOC after supramaximal exercise (Bahr 1991). Resynthesis of glycogen stores may have also acted to increase metabolic rate at 14 hours. The rate of muscle glycogen synthesis has a direct relationship to exercise intensity and is greater after short-term high intensity exercise at 100% of \( VO_2\max \) than prolonged low intensity exercise at 70% of \( VO_2\max \) or resistance exercise (15.1-33.6 mmol/kg/h vs. 1.5-2 mmol/kg/h vs. 1.9 – 11.1 mmol/kg/h respectively) (Pascoe et al., 1996). Our subjects had been fasting for 13 hours prior to
completing the protocols. Since the exercises were predominately anaerobic this could have depleted the subject’s glycogen stores to some extent. Various catecholamines released by the sympathoadrenal system may have had a lesser influence on EPOC directly by helping with the regulation of components such as heart rate; respiration; blood circulation; gluconeogenesis; and lipolysis (Bahr et al., 1991; Borsheim et al., 1998; Borsheim et al., 2003). It is likely that these mechanisms had an effect on 14 hour EPOC since the subjects had been fasting prior to exercise, enhancing the need for gluconeogenesis and lipolysis in the body post exercise. Although protein synthesis is energetically expensive and often a mechanism of EPOC, the subjects reported mild soreness suggesting that protein synthesis may have had a minor contributing factor to EPOC for the intermittent high intensity treadmill protocol.

These results are similar to those found by Laforgia et al (1997) and Brockman et al. (1993). Laforgia et al (1997) reported only a 9-hour elevation in metabolic rate in trained middle distance male subjects following 20, 1 minute intervals at 105% VO$_{2\text{max}}$ with 2 minute rest periods. Highly trained individuals have a faster return of VO$_2$ to resting levels, (Borsheim et al., 2003) so it is not surprising that these subjects returned to pre-exercise levels sooner than the female subjects in our study did. The only intermittent running study using females I could find was a study by Brockman et al (1993) who reported that an interval run consisting of seven 2-minute bouts at 90% VO$_{2\text{max}}$ followed by 2 minutes active recovery produced a higher VO$_2$ at 60 minutes post exercise than walking at 24.5% VO$_{2\text{max}}$ for two hours, or 10 minutes of continuous running at 80% VO$_{2\text{max}}$. To my knowledge there are no studies that utilize a similar exercise time and intensity completed on females and took 14 hour or longer EPOC measurements for comparison.

**Limitations**

As previously described, the subjects who volunteered for this study were healthy, of lean body weight, and highly motivated. This type of self-motivated individual may not truly represent the general population, especially those individuals who are overweight. A small sample of subjects completed the study, if there had been more subjects, we may have seen significant increases in RMR at 24 hour post exercise. Since the protocols were completed using high intensity exercise, it may not be applicable to individuals who are completely sedentary. Resistance training at 80% 1RM would not be recommend for a beginning resistance exerciser,
as this load would likely cause extreme soreness and would increase the risk of injury from muscle strain or injury. Untrained individuals may also be intolerant to the high lactate building up that was evident by our RER values. In addition, untrained people may not be able to recover adequately during the recovery periods. Finally our trained participants required a great amount of encouragement to finish the protocol and perhaps untrained or even some trained individuals may not have the motivation necessary to complete this type of intense workout.

The present study did not measure blood lactate during exercise or muscle enzymes during the recovery period. The only indicator of muscle damage was the muscle soreness assessment. Muscle damage has been shown to substantially increase metabolic rates (Dolezal et al., 2000). However it did not seem to be a factor since 24 hour soreness in most muscle groups was significantly higher 24 hours after the resistance protocol, even though RMR was not significantly higher than the baseline.

One of the biggest challenges with this study was getting a consistent baseline morning and evening metabolic measurement. Since it would be unreasonable for subjects to live in the laboratory over the entire testing protocol, dietary records and daily physical activity outside the laboratory relied on the subjects complying with the requested protocol. Since we controlled for menstrual cycle, controlling for day of the week was out of the scope of the research project, subjects who were in the laboratory during the weekday would have possibly been walking around more compared to a weekend day which may have altered the evening baseline metabolic measurements. There was also a trend with all the subjects to have their lowest morning and evening measurements on their second monthly visit to the laboratory. This may have indicated they were becoming more comfortable with the procedures and therefore RMR was lower and closer to a possible true resting rate.

**Future Research**

This study measured the effect of a single exercise session on 14 and 24 hour resting metabolic rate. Since this study used active females as subjects, future investigation should be conducted on different populations such as the non-active female populations, as well as male, elderly and overweight populations. Investigating females at different stages in their menstrual cycle may also be of interest since RMR is found to be lowest during the week before ovulation (days 7-14) and highest right before menstruation (Solomon 1982; Webb 1986).
accumulative effect of EPOC caused by intermittent high intensity exercise completed on consecutive days would also be of interest. Also, as was noted in our study, future researchers should make sure and have an adequate number of control days for subjects to become comfortable with the laboratory and the procedures. This will help ensure that control RMR measurements will not be elevated because of the test environment. It would also be recommended that the control measurements not be taken the morning before the exercise session as subjects may be nervous about the upcoming exercise.

**Conclusion**

Both exercise protocols demonstrated that 30 minutes of intermittent high intensity exercise can produce additional benefits relating to energy expenditure by the increases in metabolic rate by EPOC. At this intensity and duration, the intermittent high intensity treadmill protocol may be more beneficial to people looking to achieve weight loss since it requires a greater kilocalorie expenditure during the exercise and could be an effective means of controlling weight gain and facilitating weight loss with benefits both in terms of kilocalories expended during the exercise as well as kilocalories expended post-exercise. While not producing the same kilocalorie expenditure as the intermittent high intensity treadmill protocol during exercise, the intermittent high intensity resistance exercise protocol had the greatest increase in metabolic rate after exercise and is also a valuable component to a fitness routine and weight loss program. Over time a loss of body weight would still result from the kilocalories expended during exercise and the increase in metabolism from EPOC. These findings shows that both types of intermittent high intensity exercise are possible ways for individual’s to use exercise as part of a weight loss or weight management routine while committing only thirty minutes a day to exercise.
SUBJECTS NEEDED

Do you want to know how many calories your body burns at rest and learn how your metabolism responds to exercise?

Female subjects are needed to participate in a study that will investigate the effects of 30 minutes of both aerobic and weight training exercise to see if metabolism can be raised for 24 hours.

Women need to be between the ages of 18-38, non-smokers, and have participated in weight training and aerobic training for the past 6 months.

Contact Julie at jrm05e@fsu.edu for more information, research will begin in August!
APPENDIX B

INTERNAL REVIEW BOARD
HUMAN SUBJECTS APPLICATION
The Federal Government and University policy require that the use of human subjects in research be monitored by the Institutional Review Board (IRB). The following information must be provided when humans are used in research studies, whether internally funded, extramurally funded or unfunded. Research in which humans are used may not be performed in the absence of IRB approval.

Please complete and submit pages 1 and 2 plus your answers to the questions (on page 3) in typewritten form to: Human Subjects Committee, Mail Code 2763, or 2035 E. Paul Dirac Drive, Box 15 100 Sliger Bldg., Innovation Park Tallahassee, FL 32310

Researcher: Julie Rebecca Meuret Date: 06/23/06
Project Title: A comparison of the effects of post exercise resting metabolic rate after thirty minutes of intermittent aerobic and resistance exercise
Project Period (starting/ending dates): from August 2006 to Apr 2007
Position in University (faculty, etc.) If student, please indicate FSU Faculty Advisor:
Graduate student under the supervision of Dr. Lynn Panton
Department: Nutrition, Food and Exercise Sciences
Telephone: 720-280-7085 E-Mail Address: jrm05e@fsu.edu (where you can be reached in case of a problem with your application)
Mailing Address (where your approval will be mailed):
160 Crenshaw Dr. #9 Tallahassee, FL 32310

Project is (please check one): dissertation teaching thesis other
Project is: unfunded funded (if funded, please complete the following):
Funding Agency (actual/potential):
Contract/Grant No. (if applicable):
FOR EVALUATION OF YOUR PROJECT, PLEASE CHECK THE FOLLOWING WHICH APPLY:

<table>
<thead>
<tr>
<th>Mentally or Physically Challenged Subjects</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects studied at FSU</td>
<td>x</td>
</tr>
<tr>
<td>Subjects studied at non-FSU location(s)</td>
<td>x</td>
</tr>
<tr>
<td>Students as Subjects</td>
<td>x</td>
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<tr>
<td>Employees as Subjects</td>
<td>x</td>
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<tr>
<td>Questionnaires or Survey(s) to be administered</td>
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<tr>
<td>Review of Data Banks, Archives or Medical Records</td>
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<tr>
<td>Subjects’ major language is not English</td>
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<tr>
<td>Involves Deception (if yes, fully describe at Question No. 7)</td>
<td></td>
</tr>
<tr>
<td>Exclusion of Women or Children Subjects (must explain why they are being excluded)</td>
<td></td>
</tr>
</tbody>
</table>

Survey Techniques: Check applicable category if the only involvement of human subjects will be in one or more of the following categories:

| _________ | Research on normal educational practices in commonly accepted educational settings |
| _________ | Research involving educational tests (cognitive, diagnostic, aptitude, achievement) |
| x ________ | Research involving survey or interview procedures (if checked, please see below) |
| _________ | Research involving the collection or study of existing data, documents, records, specimens |

If research involves use of survey or interview procedures to be performed, indicate:

1. Responses will be recorded in such a manner that human subjects cannot be identified, by persons other than the researcher, either directly or through identifiers linked to the subjects.
   - x yes ___ no

2. Would subject’s responses, if they became known outside the research, reasonably place the subject at risk of criminal or civil liability or be damaging to the subject’s financial standing or employability.
   - yes _x__ no

3. The research deals with sensitive aspects of the subject’s own behavior, such as illegal conduct, drug use, sexual behavior, or use of alcohol.
   - ___yes _x__ no

Does Research Involve Greater Than Minimal Risk to Human Subjects? _________ Yes ___x____ No
(If yes, explain in full at Question No. 2)
“Minimal Risk” means that the risks of harm anticipated in the proposed research are not greater, considering probability and magnitude, than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

I HAVE READ THE FLORIDA STATE LETTER OF ASSURANCE FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH AND AGREE TO ABIDE BY IT. I ALSO AGREE TO REPORT ANY SIGNIFICANT AND RELEVANT CHANGES IN PROCEDURES AND INSTRUMENTS AS THEY RELATE TO SUBJECTS TO THE CHAIR, HUMAN SUBJECTS COMMITTEE, OFFICE OF RESEARCH.

RESEARCHER (signature) (Date)

FSU FACULTY ADVISOR (signature) (Date)
(Application will not be processed without Advisor’s signature)

Page 2 (rev. 11-99) Human Subjects Application
Questions
FOR RESEARCH INVOLVING HUMAN SUBJECTS

USE ADDITIONAL SHEETS FOR ANSWERING THE FOLLOWING QUESTIONS
PLEASE SUBMIT YOUR ANSWERS IN TYPEWRITTEN FORM

1. GIVE A COMPLETE DESCRIPTION OF YOUR RESEARCH PROCEDURES AS THEY RELATE TO THE USE OF HUMAN SUBJECTS.

Specific Aim.
The purpose of the study is to evaluate the acute effects of both resistance exercise and intermittent anaerobic exercise on post exercise resting metabolic rate (RMR).

Description of Study.
Ten healthy, non-smoking, female subjects between the ages of 18-39 years will be recruited by flyers and word of mouth from Florida State University and the surrounding community for this study. Subjects will be experienced in resistance and aerobic training, having at least 6 months of weight training experience, a maximal oxygen consumption (VO\textsubscript{2max}) between 40-49.9 ml/kg/min, with a body mass index \( \leq 25 \) kg/m\(^2\).

Five to ten days prior to day 4 of their menstrual cycle, subjects will arrive at the laboratory to sign informed consents and complete health, smoking, and exercise histories. Subjects will be measured on a Seca balance scale and percent body fat will be estimated using 3 body site skinfolds (triceps, iliac crest, and thigh) with Lange skin-fold calipers. When the subjects anthropomorphic measurements are complete, subjects will become familiarized with the exercises for the protocols. Maximal oxygen consumption will be tested using a running protocol to volitional failure (VO\textsubscript{2max}) and a 1 repetition maximum (1-RM) will be measured using Smith weight machines. Subjects’ VO\textsubscript{2max} will be determined by a graded exercise test to exhaustion on the treadmill. Heart rate will be monitored using a polar heart rate monitor. The test will begin with a 5-min subject controlled walking warm-up period. The subject will wear a nose clip and a mouthpiece connected by plastic tubing to a metabolic cart that will analyze expiratory gasses during the exercise test. The test will begin at a speed of 7.0 mph for three minutes then every minute thereafter the grade will increase by 1% and speed by 0.5 mph until VO\textsubscript{2max} is reached. VO\textsubscript{2max} will be defined as the point at which three out of four criteria are met 1) plateau of the oxygen consumption (< 2.0 ml/kg/min) with an increase in exercise intensity; 2) attainment of a respiratory exchange ratio of 1.15 or greater; 3) attainment of heart rate within \( \pm 10 \) beat/min or age predicted maximal heart rate; and 4) exhaustion or a rating of perceived effort (RPE) of 18 or higher. If the subjects do not attain three out of the four criteria they will have to come back another day to redo the VO\textsubscript{2max} test. There will be a 30 minute recovery period between the VO\textsubscript{2max} test and the 1RM testing. The following exercises will be used for testing maximal strength: chest press, squat, lat pull-down, shoulder press, and stationary lunges. After the recovery period subjects will have their 1RM determined for each exercise except the stationary lunge. For the stationary lunge an 8 RM will be determined. All of the exercises will be performed starting with the subjects estimated 10RM weight for each exercise. This weight will be applied to a prediction table to determine the first weight attempted for their 1RM. The load attempted will be 10 pounds lighter than predicted to allow for a margin of error. Ten-pound increments will be used until a weight is attempted that the subject cannot lift. The last successful lift will be recorded as the 1RM.
After the completion of testing subjects will be given a food diary log to record their diets on days 2 – 5 of their menstrual cycle, and subjects will be instructed to abstain from caffeine for this time period. This diet log will be returned to the subject before the second protocol so the diet can be replicated.

On the evening of the subjects third day of menstruation, they will arrive at the laboratory at 9:00 pm. They will have a baseline metabolic rate taken (all VO\(_2\) measurements will be taken using a TrueMax 2400 Metabolic Measurement System). Subjects will undergo a 30 minute period of supine quiet rest. Immediately following that period, VO\(_2\) samples will be collected for a 30 minute period beneath a ventilated hood to determine metabolic rate. This protocol will be used for all metabolic measurements. Subjects will then sleep overnight in the lab. Subjects will be told not to eat or drink anything after 6:00 pm except water. The next morning, (day four of menstruation) at 6:00 am, the subjects will have RMR measurements taken. They will then be asked to return again to the laboratory at 9:00 pm that evening and the same protocol will be followed. The next morning, a second RMR measurement will be determined and subjects will then be randomly assigned to complete one of the two exercise protocols. After exercising the subjects will return to the laboratory that evening at 9:00 pm to have their third metabolic measurements taken and then stay overnight to have their third RMR measurements taken in the morning. Approximately one month later subjects will return to the laboratory during their next menstrual cycle, subjects will repeat this schedule and complete the next exercise protocol, starting with diet replication on the second day of menstruation, and continuing with laboratory visits day two through four of menstruation. During their second visit they will only have two metabolic and RMR measurements taken.

Following RMR measurements on the exercise day subjects will perform either an acute bout of resistance exercise or a high intensity intermittent anaerobic running protocol, while wearing a mouthpiece and nose clip for VO\(_2\) measurements. Each exercise bout will last 30 minutes consisting of 30 seconds of work followed by one minute of recovery. The resistance exercise bout will consist of 5 free weight exercises performed on a non-counterbalanced Smith Machine. The exercises to be performed are the chest fly, squat, lat pull-down, upright row, and stationary lunges. The weight lifted for each set will be set at 85% of the subjects’ 1RM for 30 seconds which will allow for 6-8 repetitions. The rest period will be 1 minute long between sets and subjects will perform 2 sets before moving on to the next exercise then repeat the circuit for a total of 4 sets of each exercise. The high-intensity aerobic exercise will consist of 30 seconds of treadmill running at 100% VO\(_{2\max}\) followed by a 1 minute active walking recovery. The subjects will have their blood pressure measured before, during, and immediately after the exercise bout.

Subjects will be asked to stop eating after 6:00 pm prior to all evening metabolic measurements, then sleep overnight in the laboratory to ensure 7-8 hours sleep prior to baseline RMR. Subjects will be awakened at 6:00 pm to use the restroom then baseline measurements for morning RMR will be taken under a ventilated hood.

After completion of the two protocols, dependent variables will be analyzed using a repeated measures analysis of variance. Significance will be accepted at p < 0.05.

2. HAVE THE RISKS INVOLVED BEEN MINIMIZED AND ARE THEY REASONABLE IN RELATION TO ANTICIPATED BENEFITS OF THE RESEARCH, IF ANY, TO THE SUBJECTS AND THE IMPORTANCE OF THE KNOWLEDGE THAT MAY REASONABLY BE EXPECTED TO RESULT? WHAT PROVISIONS HAVE BEEN MADE TO INSURE THAT APPROPRIATE FACILITIES AND PROFESSIONAL ATTENTION NECESSARY FOR THE HEALTH AND SAFETY OF THE SUBJECTS ARE AVAILABLE AND WILL BE UTILIZED?
The risks will be minimized by using trained technicians and by teaching proper techniques in testing and training of subjects. All technicians will be certified in CPR and First Aid. They will also have extensive knowledge on testing and training procedures. Each subject will complete a health history, exercise history, and a smoking history. Subjects will be excluded if they are amenorrheic, smoking, on medication that prevents them from getting a monthly period, if they have any condition that may be contraindicated for exercise testing and training, if they have a VO$_{2\text{max}}$ of $\geq 50.0$ ml/kg/min or $< 40.0$ ml/kg/min, if they have a BMI $> 25.0$ kg/m$^2$, have a percent body fat of $> 27.9$ % and/or they have not been consistently weight training for at least six months.

During the resistance training session subjects may become fatigued. Subjects will be monitored by a spotter during their 1RM test and their resistance exercise sessions and all lifts will be performed on a Smith machine rack with safety bars. While performing the VO$_{2\text{max}}$ test the subjects may become extremely fatigued and/or short of breath. During this test subjects will be monitored by at least two spotters and heart rate and blood pressure will be measured during testing. During the high-intensity aerobic intervals, the subjects may become fatigued and/or short of breath and subjects will be monitored by at least one spotter.

There are minimal risks or discomforts with answering the enclosed questionnaires. Subjects who choose not to complete the questionnaires or do not feel comfortable disclosing their menstrual cycle status will be excluded from the study. The questionnaires are important in determining resistance training experience and disclosure of menstrual status is needed to determining the appropriate day to begin the testing protocol.

For the disinfecting process, saliva and expired air fluids will be thoroughly cleaned from the surfaces and lumen of the respiratory measurement equipment ie. breathing valves, mouthpieces and masks. The devices will be immersed in the CIDEX PLUS solution for at least 20 minutes then will be rinsed and left on a tray to dry. A respiratory tube will be rinsed and hung on a wall until completely dry before reusing.

3. **DESCRIBE PROCEDURES TO BE USED TO OBTAIN INFORMED CONSENT.** (See attached sample and tips on Informed Consent attached to this application.) Attach a copy of the informed consent you will use when submitting this application. ALSO, PLEASE ANSWER THE FOLLOWING:

   (A) **WHO WILL BE OBTAINING INFORMED CONSENT?**

       Julie Meuret will obtain informed consent.

   (B) **WHEN WILL THE SUBJECTS BE ASKED TO PARTICIPATE AND SIGN THE CONSENT FORM?**

       Subjects will not be asked to sign the informed consent until they have been screened and cleared for participation. Informed consent will be obtained before any testing occurs.

   (C) **IN USING CHILDREN, HOW WILL THEIR ASSENT BE OBTAINED?** (*"Assent" is an additional requirement. Please see attached sample regarding this procedure.)

       No children will be used as subjects.

4. **DESCRIBE HOW POTENTIAL SUBJECTS FOR THE RESEARCH PROJECT WILL BE RECRUITED.**
10 healthy college age female subjects will be recruited from Florida State University and surrounding communities through flyers.

5. WILL CONFIDENTIALITY OF ALL SUBJECTS BE MAINTAINED? HOW WILL THIS BE ACCOMPLISHED? PLEASE ALSO SPECIFY WHAT WILL BE DONE WITH ALL AUDIO AND/OR VISUAL RECORDINGS, IF APPLICABLE, PICTURES AND PERSONAL DOCUMENTATION OF SUBJECTS BOTH DURING AND AFTER COMPLETION OF THE RESEARCH.

Confidentially will be maintained by assigning each subject a code number and recording all data by code number. The only record with the subject’s name and code number will be kept by the principal investigator and Dr. Lynn Panton in a locked office in Sandels suite 100. No names, initials, or other identifying characteristics will be reported in publication. Data will be kept for 10 years and then destroyed.

6. IS THE RESEARCH AREA CONTROVERSIAL AND IS THERE A POSSIBILITY YOUR PROJECT WILL GENERATE PUBLIC CONCERN? IF SO, PLEASE EXPLAIN.

This research is not controversial and should not generate public concern.

7. DESCRIBE THE PROCEDURE TO BE USED FOR SUBJECT DEBRIEFING AT THE END OF THE PROJECT. IF YOU DO NOT INTEND TO PROVIDE DEBRIEFING, PLEASE EXPLAIN.

Following the completion of the study subjects will be provided with individual reports that will include their data that were collected over the one-year period. A presentation will also be given to describe the findings of the study that they participated in.

Informed Consent Forms MUST contain the following information:

- Researcher’s name and title of project
- Description of research
- Description of subjects’ involvement in the research
- Risks and Benefits to subjects participating in research
- That subjects have the right to not participate or withdraw from participation at anytime without prejudice, penalty or loss of benefits to which otherwise entitled.

IF AUDIO OR VIDEOTAPING PARTICIPANTS, the following information MUST be included on the Informed Consent:

- Purpose of taping and what tapes will be used for
- Where tapes will be stored
- How long tapes will be kept
- When tapes will be destroyed (i.e., Month/Date/Year)

Example:

Audio or videotaping participants:

I understand that I will be (tape recorded or videotaped) by the researcher. These tapes will be kept by the researcher in a locked filing cabinet. I understand that only the researcher will have access to these tapes and that they will destroyed by August 8, 2010.
Samples of additional language for informed consent:

If applicable, the following should be included in your informed consent:

<table>
<thead>
<tr>
<th>Administering nutritional supplement or other substance to participants:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;allergic reactions are possible from any product and although uncommon, cannot be predicted. You should stop taking the supplement if any rashes, difficulty breathing or other adverse/allergic symptoms occur and seek medical advice&quot;</td>
</tr>
</tbody>
</table>

Informed Consent Forms MUST contain the following information:

- Researcher’s name and title of project
- Description of research
- Description of subjects' involvement in the research
- Risks and Benefits to subjects participating in research
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<table>
<thead>
<tr>
<th>Administering nutritional supplement or other substance to participants:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;allergic reactions are possible from any product and although uncommon, cannot be predicted. You should stop taking the supplement if any rashes, difficulty breathing or other adverse/allergic symptoms occur and seek medical advice&quot;</td>
</tr>
</tbody>
</table>
APPENDIX C

CONSENT FORM
APPROVAL MEMORANDUM

Date: 6/18/2006

To: Julie Neuret
104 Crenshaw Dr #9
Tallahassee, FL 32310

Dept.: NUTRITION FOOD AND MOVEMENT SCIENCES

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects In Research
A comparison of the effects of post-exercise resting metabolic rate after thirty minutes of intermittent aerobic and resistance exercise

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Human Subjects Committee at its meeting on 7/12/2006. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If the project has not been completed by 7/11/2007 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. The principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to ensure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office of Protection from Research Risks. The Assurance Number is IRB00000446.

cc: Lynn Panton
HSC No. 2006.0564
A comparison of the effects of post exercise resting metabolic rate after thirty minutes of intermittent aerobic and resistance exercise: Proposition of alternate weight control methods of exercise

Informed Consent Form

I, ______________________, freely and voluntarily and without element of force or coercion, consent to be a participant in the research project entitled “A comparison of the effects of post exercise resting metabolic rate after thirty minutes of intermittent aerobic and resistance exercise.”

Please initial each paragraph indicating that you have read and understood it.

I will complete a health history questionnaire before I can participate in the study. I will not be able to participate in this study if I have any conditions that may be contraindicated for exercise testing and training. I will also not be able to participate if I have not been resistance training for at least 6 months, if my maximal oxygen capacity (VO2max) is not between 40 to 50 ml/kg/min, if my body mass index is over 25 kg/m², if I smoke, if I do not get monthly menstrual cycles and/or if I am taking any medications or drugs that may alter my metabolic rate.

I understand the majority of this research will be measuring my morning and evening metabolic rates. In order to do this accurately, I will come into the laboratory at 9:00 pm on the assigned testing days. I will rest in the supine position for 30 minutes then I will be asked to wear a ventilation mask that will collect my expired air so that my metabolic rate can be measured. I will wear the mask while I rest quietly for another 30 minutes. After this measurement I will spend the night in the laboratory. I will be awakened at 6:00 am to have my resting metabolic rate measured again. In order to accurately measure my resting metabolic rate, I will be required to stop eating after 6:00 pm and drink only water thereafter on the evenings I report to the laboratory. I will be making three consecutive overnight visits to the laboratory, during each of my two menstrual cycles.

All told, I will be asked to make seven visits to the laboratory. First, to undergo exercise testing, then six more visits divided equally between two of my menstrual cycles. I understand that each “research session” will consist of three consecutive visits to the Florida State University Exercise Physiology laboratory. These “research sessions” will be conducted beginning the evening of the third day of my menstrual period, and last through the morning of the sixth day of my menstrual period, for two separate cycles. I will complete an assigned exercise protocol the morning of day five of my menstrual cycle.
A comparison of the effect of post exercise resting metabolic rate after thirty minutes of intermittent aerobic and resistance exercise: Proposition of alternate weight control methods of exercise

I understand that the procedures will be as follows:

I will be asked to sign the informed consent and fill out questionnaires about my medical history, menstrual history, tobacco history, and family history. I will also be informed when my next menstrual cycle will begin and be scheduled for an exercise testing session.

I will be given a food diary log and be asked to record my dietary intake starting day two and lasting until five of menstruation during the first month that I will be tested. This four day dietary record will be replicated again day two through five of menstruation for the following months exercise protocol. I will also be informed that during the duration of each four day "research session" I will be asked not to eat anything after 6:00 pm and drink only water before reporting to the laboratory at 9:00 pm.

I will be asked to refrain from resistance training and high intensity aerobic training starting day one of my menstrual cycle, and any additional aerobic exercise outside of the laboratory day three, four, and five of my menstrual cycle.

Five to ten days before my expected menstrual cycle, I will report to the lab. My percent body fat will be estimated using a 3-site skinfold measurement. I will have then have a VO_2max test followed by 1-repetition (1-RM), and 8 repetition maximum (8-RM) testing. In order to determine my VO_2max I will be asked to perform a running test, after a self-controlled warm up, I will begin running at a speed of 7.0 mph. The speed and grade will gradually be increased every minute until I can not run any longer or meet the criteria for a maximal test. If I fail to complete a maximal test, I may be rescheduled to complete the test again, in no sooner than two days. I will be asked to wear a mouthpiece with a nose clip to collect my expired air to determine my VO_2max. I understand I am free to stop the test at any time.

Thirty minutes after completing the VO_2max test, I will then be asked to perform a 1-RM weight lifting test on the following exercises: chest press, squat, lateral pull-down, and shoulder press. I will be asked to perform an 8 RM test on a stationary lunge. I will estimate my 10-RM and that weight will be applied to a prediction table to determine a starting weight for my 1-RM. Ten-pound increments will be used until a weight is attempted that I cannot lift. The last successful lift will be recorded as the 1RM. The stationary lunge will be measured for an 8 RM following the same sequence of events, with the last successful set of weight lifted eight times recorded as the 8 RM. I will have three-minute rest periods between attempted lifts.

All of the morning and evening tests involve measuring my body's metabolic rate. In order to accurately measure my metabolic rate, on the third day of my menstrual cycle, I will be asked not to eat anything and drink only water after 6:00 pm, and report to the laboratory at 9:00 pm for a control session where evening metabolic rate will be measured. I will stay the night in the laboratory until 7:00 am for a morning resting metabolic rate measurement. This testing protocol will also be repeated day four and five of my menstrual cycle. I also understand that I will be required to avoid caffeine products during days two through five of my menstrual cycle.
A comparison of the effectiveness of post exercise resting metabolic rate after thirty minutes of intermittent aerobic and resistance exercise: Proposition of alternate weight control methods of exercise

When I arrive at the laboratory at 9:00 pm on day three, four, and five of my menstrual cycle, I will rest in the supine position for 30 minutes then I will be asked to wear a ventilation mask that will collect my expired air so that my metabolic rate can be measured. I will wear the mask while I rest quietly for another 30 minutes. After this measurement, I will spend the night in the laboratory. I will be awakened at 6:00 am to have my resting metabolic rate measured. I will be given the opportunity to use the restroom. I will walk slowly to the testing area and will rest in the supine position for 30 minutes then I will be asked to wear a ventilation mask and rest quietly for another 30 minutes.

The morning of day five of each menstrual cycle I will be asked to perform an exercise session. I will have my morning resting metabolic rate measured as described above, then I will put on a mouthpiece and nose clip and perform the bout of exercise while my VO2 samples are collected. My blood pressure will be measured before, during, and after the exercise bout. I will perform either the resistance exercise or the interval aerobic exercise protocol.

During the resistance training session I will be asked to perform resistance training consisting of chest flys, squats, lat pull-down, upright row, and stationary lunges. All exercises will be performed at approximately 85% of my maximal strength tests that were recorded previously. For each exercise, I will be asked to perform as many as repetitions as possible in 30 seconds followed by 60 seconds of rest. Exercise duration for the resistance exercise session will be fixed at 30 minutes allowing for four sets of each exercise. During the 30 minute bout of resistance exercise, I will be asked to wear a mouthpiece with a nose clip so that my oxygen consumption and calorie expenditure can be measured. I will be free to stop the test at any time.

During the intermittent aerobic exercise session I will be asked to perform 30 second intervals at 100% of my VO2max. I will be allowed to warm up, and then perform 30 second intervals followed by a 60 second active recovery where I will be allowed to choose my walking speed. The intermittent aerobic exercise session will last 30 minutes. During the 30 minute bout of intermittent aerobic exercise, I will be asked to wear a mouthpiece with a nose clip so that my oxygen consumption and calorie expenditure can be measured. I will be free to stop the test at any time.

I will return to the laboratory on day four of a following menstrual cycle after replicating my diet starting day two of my menstrual cycle to the dietary record that I completed the previous menstrual cycle. The same protocol as the previous "research session" will be followed.

I understand there is a possibility of a minimal level of risk involved if I agree to participate in this study. The risks will be minimized by using trained technicians and by teaching me proper techniques in testing and training.

The possible benefits of my participation in this research project include learning about my fitness levels, my body composition and how exercise affects my metabolism. I will also be given a number of tests free of charge and the results will be given to me.

The results of this research study may be published but my name or identity will not be revealed. Information obtained during the course of the study will remain confidential, to the extent allowed by law. My name will not appear on any of the results. No individual responses will be reported. Only group finding will be reported in publications. Confidentiality will be maintained by assigning each subject a code number and recording all data by code number. The only record with the subject's name and code number will be kept by Dr. Lynn Panton in a locked drawer in her office. Data will be kept for 10 years and then destroyed.

In case of an injury first aid will be provided to me by the laboratory personnel working on the research project any other treatment or care will be provided at my expense.

Any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by the investigators or they will refer me to a knowledgeable source. I understand that I may contact Julie Meuret (720-280-7085 or jrm05e@fsu.edu) for answers to questions about this research project or my rights. Group results will be sent to me upon my request.

In case of injury, or if I have questions about my rights as a subject/participant in this research, or if I feel I have been placed at risk, I can contact the chair of the Human Subjects committee, Institutional Review Board, through the Office of the Vice President for Research, at (850) 644-8633.

The nature, demand, benefits and risks of the project have been explained to me. I knowingly assume any risks involved. I have read the above informed consent form. I understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefits to which I may otherwise be entitled. In signing this consent form, I am not waiving my legal claims, rights or remedies. A copy of this consent form will be given to me.

(Subject) ___________________________ (Date) ___________________________

(Witness) ___________________________ (Date) ___________________________
APPENDIX D

MEDICAL HISTORY AND HEALTH STATUS QUESTIONNAIRE
Medical/Health Status Questionnaire

On this questionnaire, a number of questions regarding your physical health are to be answered. Please answer every question as accurately as possible so that a correct assessment can be made. Please place a "Y" in the space to the left of the question to answer "yes." Leave blank if your answer is "no." Please ask if you have any questions. Your responses will be treated in a confidential manner.

Date: __________ Your name: __________________________ Email: Address: __________________________
Home #: __________ Work #: __________ Mobile #: __________

Medical Screening - ACSM Medical Status Questionnaire

____ Do you have any personal history of heart disease?
____ Any personal history of metabolic disease (thyroid, renal, liver)?
____ Have you had diabetes for less than 15 years?
____ Have you had diabetes for 15 years or more?
____ Have you experienced pain or discomfort in your chest apparently due to blood flow deficiency?
____ Any unaccustomed shortness of breath (perhaps during light exercise)?
____ Do you have difficulty breathing while standing or sudden breathing problems at night?
____ Have you had any problems with dizziness or fainting?
____ Do you suffer from ankle edema (swelling of the ankles)?
____ Have you experienced severe pain in leg muscles during walking?
____ Do you have a known heart murmur?
____ Do you have any family history of cardiac or pulmonary disease prior to age 55?
____ Have you experienced a rapid throbbing or fluttering of the heart?
____ Have you been assessed as hypertensive on at least 2 occasions?
____ Has your serum cholesterol been measured at greater than 240 mg/dl?
____ Are you a cigarette smoker?
____ Would you characterize your lifestyle as "sedentary"?

Medical History

Are you currently being treated for high blood pressure? _____ Average blood pressure: ______/______

Please Check All That Apply:

____ Has a doctor ever found an abnormal EKG? _____ Limited Range of Motion? _____ Stroke?
____ Abnormal Chest X-Ray? _____ Arthritis? _____ Epilepsy or seizures?
____ Rheumatic Fever? _____ Bursitis? _____ Chronic/Migraine
____ Low Blood Pressure? _____ Swollen or Painful Joints? _____ Headaches?
____ Asthma? _____ Foot Problems? _____ Persistent Fatigue?
____ Bronchitis? _____ Knee Problems? _____ Stomach Problems?
____ Emphysema? _____ Shoulder Problems? _____ Hernia?
____ Other Lung Problems? _____ Recently Broken Bones? _____ Anemia?
____ Has a doctor imposed and activity restrictions? If so, please describe:
Family History

Has your mother, father, or siblings suffered from (please select all that apply):

____ Heart attack or surgery prior to age 55.
____ Stroke prior to age 50.
____ Congenital heart disease or left ventricular hypertrophy.
____ High cholesterol
____ Diabetes
____ Obesity
____ Hypertension
____ Osteoporosis
____ Asthma
____ Leukemia or cancer prior to age 60.

Medications

Please Select Any Medications You Are Currently Using

____ Diuretics    ____ Other Cardiovascular
____ Beta Blockers    ____ NSAIDS/ Anti-Inflammatories (Motrin, Advil)
____ Vasodilators    ____ Cholesterol
____ Alpha Blockers    ____ Diabetes/Insulin
____ Calcium Channel Blockers    ____ Other Drugs (record below).

Please list the specific medications that you currently take:

Lifestyle

Are you a cigarette smoker? ____ If so, how many per day: ____
Previously a cigarette smoker? ____ If so, when did you quit? ______
How many years have you smoked or did you smoke before quitting? ______
Do you/did you smoke: cigarettes?__ cigars?__ pipe? __

Please Rate Your Daily Stress Levels (select one):

____ Low
____ Moderate
____ High: often difficult to handle
____ High: sometimes difficult to handle
____ High: I enjoy the challenge

Do you drink alcoholic beverages? _____
How would you rate your daily alcohol consumption on a scale of 1 to 10? _____
1 = 1 glass of wine
10 = 1 liter bottle of wine
Other

Please Indicate Any Other Medical Conditions or Activity Restrictions That You May Have. It is important that this information be as accurate and complete as possible.

Is any of this information critical to understanding your readiness for exercise? Are there any other restrictions on activity that we should know about?

Emergency Contacts

Please List Your General Practitioner and Person to be Contacted in Case of Emergency

Doctor: ________________________________ Phone: ________________

Contact: _______________________________ Phone: ________________

Thank you for taking the time to complete this questionnaire!
APPENDIX E

EXERCISE HISTORY AND MENSTRUAL HISTORY QUESTIONNAIRE
Exercise History

1.) How many times a week do you participate in weight training?
   ___ 2-3 days a week
   ___ 3-4 days a week
   ___ 4 + days a week

2.) How long have you been consistently weight training?
   ___ Less that three months
   ___ Three to six months
   ___ Six months or more

   a.) In this time, how often have you taken more than a week off from weight training?

3.) How many days do you participate in aerobic exercise?
   ___ 2-3 days a week
   ___ 3-4 days a week
   ___ 4 + days a week

4.) How long does your typical workout session last? _____ minutes

Menstrual History

5.) How long is a normal menstrual cycle for you? _____ days

   How many days does your period last?
   ___ 2-3 days          ___ 3-4 days
   ___ 4-5 days          ___ 5-6 days

   What is the date of your next expected menstrual cycle? _____

6.) Do you have painful menstrual cramps lasting more that one or two days?
   ___ yes          ___ no

   If yes, would you be unable to participate in a 30 minute exercise session on the
   morning of day 5 of your menstrual cycle. ___ yes ___ no

7.) Are you taking oral contraceptives or similar hormone therapy?
   ___ yes          ___ no
   If yes, what kind? ____________________
APPENDIX F

FOOD LOG
Food Log Diary

Please record the time, amount, and food eaten on days 2-5 of menstruation. This log will need to be replicated during the second month of testing.

<table>
<thead>
<tr>
<th>DAY 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Food description</td>
<td>Quantity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DAY 3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Food description</td>
<td>Quantity</td>
</tr>
</tbody>
</table>

Stop eating by 6:00 p.m. today.
### DAY 4

<table>
<thead>
<tr>
<th>Time</th>
<th>Food description</th>
<th>Quantity</th>
</tr>
</thead>
</table>

Stop eating by 6:00 p.m. today.

### DAY 5

<table>
<thead>
<tr>
<th>Time</th>
<th>Food description</th>
<th>Quantity</th>
</tr>
</thead>
</table>

Stop eating by 6:00 p.m. today.
APPENDIX G

SORENESS ASSESSMENT SCALE
Visual Analog Scale

No Pain

Chest

No Pain

Back

No Pain

Gluts/Hips

No Pain

Legs

Unbearable Pain

Unbearable Pain

Unbearable Pain
REFERENCES


Scott CB, Littlefield ND, Chason JD, Bunker MP et al. Differences in oxygen uptake but equivalent energy expenditure between a brief bout of cycling and running. *Nutr Metab (Lond)* 2006;3(1)


BIOGRAPHICAL SKETCH

Julie Meuret received her Bachelors degree in Human Performance and Wellness from Mesa State College in Grand Junction, Colorado. After moving to Florida in 2004, she worked for a Corporate Fitness company before continuing her studies in the masters program at Florida State University. While collecting her research data she taught lab classes in Human Anatomy and Physiology. After receiving her M.S. in Exercise Physiology she will live in Palm Harbor Florida and pursue a career in Exercise Physiology.