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Exercise and time of day: Influence on hunger and caloric intake among overweight/obese adults

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Exercise and Time of Day: Influence on Hunger and Caloric Intake Among Overweight/Obese Adults

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ABSTRACT

The purpose of this study was to determine whether or not the time of day at which exercise was performed, morning compared to evening, influences acute daily caloric intake and hunger in overweight/obese sedentary adults. 8 overweight/obese (Age: 40 ± 4 yrs, Height: 170 ± 4 cm, Weight: 85.7 ± 6.4 kg, BMI: 29 ± 2 kg/m^2) sedentary adults completed 3 trials: control, morning, evening in a randomly counterbalanced cross over design. Caloric intake was assessed over three 4-day periods with subjects consuming ad libitum diets. Hunger was measured 15 minutes before exercise and 15 and 30 minutes following exercise. Exercise was performed on stationary bicycle ergometers at moderate intensity (40-60% of HHR) for 40 minutes. Average daily caloric intake was not different between morning and evening exercise ($p = 0.99$). However, average daily caloric intake during the exercise trials was greater than the control week ($p = 0.018$). Both morning and evening exercise sessions increased hunger but there was no differential between the two ($p = 0.42$). These data demonstrate that exercise performed at different times of the day, i.e. in the morning or evening, does not affect average daily caloric intake or hunger in overweight/obese sedentary adults, though more research needs to be conducted with a larger sample size.

CHAPTER ONE

INTRODUCTION

In February 2014, an investigation on body weight of the United State's population stated that the prevalence of overweight (defined as body mass index (BMI) of 25.0 to 29.9 kg/m^2) and obesity (obese defined as BMI of 30 or higher) between the years of 2011 and 2012 was 68.5% of the total population, 34.9% of whom were classified as obese (41). The rate of obesity among men increased from 27.5% in 1999-2000 to 31.1% in 2003-2004 to 35.5% in 2009-2010, whereas women remained stable from 1999-2000 (33.4%) to 2003-2004 (33.2%) but increased in 2009-2010 to 35.8% (40, 42). Obesity is accompanied by many health implications including but not limited to an increased risk of developing type 2 diabetes, hypertension, dyslipidemia, arthritis, asthma, coronary heart disease and some cancers (35). Obesity has also been linked to lower health-related quality of life, particularly in physical function but also in mental health (14). In addition to these individual consequences, the health implications also translate to an increased economic burden. An analysis of previous national surveys has predicted that by 2030 the annual health care costs associated with overweight and obesity will be 861 to 957 billion US dollars (56). Since obesity has become a public health crisis effective treatments like physical activity, exercise, and diet modifications have been emphasized in both research and practice to help alleviate the impact of this disease.

Weight loss occurs when energy expenditure exceeds energy intake; a sustained period of negative energy balance is required for weight loss. Various factors influence the energy balance equation, with exercise and diet emerging as two primary factors that can potentially be easily controlled. Exercise and diet as standalone weight loss tools have been studied and debated for years. Many studies have reported weight loss with both exercise (18, 19, 21, 44, 45) and diet modification alone (3, 8, 11, 27, 44, 45). Exercise contributes to weight loss through energy expenditure, with the magnitude of energy expenditure depending on exercise intensity and duration, body composition, and movement efficiency. These factors, and therefore weight loss, must be approached on an individual basis. Regardless of the nuances of the specific exercise program, weight loss should result if the additional energy expenditure through exercise does not lead to an equivalent increase in energy intake (i.e. compensatory eating). Interestingly, research indicates that exercise as a sole instrument for initial weight loss is not as potent as diet alone (6, 16, 22, 23). However, this may be due to energy expenditure of exercise not creating as much of an energy deficit as a dietary restriction does, although study design may have been a factor.

Dietary energy restriction can facilitate weight loss and like exercise, there are many ways to achieve an energy deficit through diet. Low carbohydrate diets (≤ 30 g/d) can lead to initial weight loss (≤6 months) (59), but it appears that variations in fat and carbohydrate distribution are inconsequential with longer interventions (≥12 months) when subjects consume foods ad libitum (6, 38, 46). Additionally, when diets are matched for calories, some studies have reported that the macronutrient distribution of carbohydrate and protein does not differentially influence weight loss either initially or long term (25, 37). For instance, a 12-week diet intervention comparing an isocaloric diet of either a high protein/low fat distribution (34% energy from protein, 20% energy from fat, 46% energy from carbohydrate) versus a high carbohydrate/low fat distribution (17% energy from protein, 20% energy from fat, 64% energy from carbohydrate) elicited similar weight loss between the two groups (37). Though some research finds that a diet higher in protein (greater than 30% of total calories) may increase satiety leading to lower ad libitum caloric intake thus resulting in greater weight loss than a lower protein diet (about 15% of total calories) (30, 32, 57). Finally, research has shown that initial weight loss through diet energy restriction has been very effective in the overweight/obese population, but it may be difficult to maintain long term (6, 22).

It is logical to suspect that higher rates of weight loss can be achieved with a combination of diet and exercise. Indeed, there is good evidence that combined interventions work to improve overall body composition more than either one alone (6 16, 20, 22), with some contention (9, 24, 55). A recent review of six investigations revealed that subjects who participated in a combination of diet and exercise intervention lost 20% more of their initial weight than with diet intervention alone for interventions lasting as short as 10 weeks to one year (6). Likewise, a separate review concluded that diet and exercise alone both lead to weight loss, and that diet and exercise combined led to better weight loss maintenance one year after initial weight loss (34). While concomitant modifications to dietary and exercise habits are recommended as not only part of the initial weight loss strategy but also long term weight maintenance, the acute relationship between exercise and diet is unknown (i.e. how does exercise influence dietary intake?). A better understanding of this relationship would allow practitioners to take better advantage of the complementary effects of diet and exercise together.

Energy intake of normal weight adults seems to remain the same or decrease following exercise (15 minutes to 4 hours following exercise) compared to non-exercise days (15, 29, 43, 50). In contrast, overweight/obese adults tend to increase energy intake following exercise (10 minutes to 4 hours following exercise), (13, 15, 28, 48, 52) although this finding is not universal (13, 28, 29, 53). The acute effect of exercise on energy intake is influenced by various factors such as body composition, sex, hunger, satiety, and exercise dynamics (intensity, duration, movement economy, and perception of exercise). The tendency for overweight/obese population to increase energy intake post-exercise may be precipitated by changes in hunger. There is evidence in short-term studies (2 days to 12 weeks) that the overweight/obese population experiences a greater hunger response following exercise, which may lead to compensatory eating though this relationship is poorly understood (13, 15, 28, 29, 48). Conversely, it appears that normal weight adults do not experience increased hunger to the extent that leads to compensatory eating after a short bout of exercise (40 to 60 minutes in length) (29, 43).

Satiety (perceived fullness) is another factor that has a reported impact on caloric intake. Satiety levels decrease throughout the day, which may precipitate greater food intake at night thus increasing total daily caloric intake (7). The changes in hunger following exercise and satiety throughout the day may have an effect on caloric intake following exercise performed at different times of the day. No difference between energy intake after exercise in the morning versus evening exercise sessions was observed in healthy normal weight males or females (31, 39). However, nothing is known about how the time of day when the exercise is performed may influence dietary intake in overweight/obese individuals. Because exercise elicits a greater hunger response in overweight/obese individuals (in both morning and evening) (13, 15, 28, 29, 48) and satiety (perceived fullness) levels decrease throughout the day (7), it is logical to speculate that overweight and obese adults who perform evening exercise may experience a marked increase in energy intake, thereby making it more difficult to lose weight (16, 29, 53). However, this hypothesis has not been examined. Therefore, the primary aim of this project is to determine whether or not the time of day at which exercise is performed will have an acute effect on hunger and daily energy intake in overweight/obese versus normal weight sedentary adults.

Aims and Hypotheses

Aim 1 - To determine if the hunger response to exercise, among overweight/obese adults, is impacted by the time of day that exercise is performed (morning vs. evening)

Hypothesis 1 – The hunger response to exercise, among overweight/obese adults, will not be impacted by the time of day that exercise is performed.

Aim 2 – To determine if energy intake following exercise, among overweight/obese adults, is impacted by the time of day that exercise is performed (morning vs. evening)

Hypothesis 2 – Energy intake following exercise, among overweight/obese adults, will be more elevated following evening exercise compared to morning exercise

Significance of the Study

Overweight and obesity is a serious health concern in the United States that affects two-thirds of the population. It is well known that the combination of exercise and diet interventions can lead to weight loss thus decreasing the prevalence of this condition. Although previous studies have shown no effect of the time of day that exercise is completed on energy intake in normal weight adults, this thesis will examine whether or not there is a difference in hunger levels and energy intake in overweight/obese compared to normal weight sedentary adults. The finding of this study could potentially provide professionals specializing in weight reduction with information on how exercise at different times of the day influences energy intake and could ultimately lead to more effectively designed weight loss programs.

CHAPTER TWO

METHODOLOGY

Subjects

Approximately 30 normal weight (n=15) and overweight/class 1 obese (n=15) adult males and females will be recruited to participate in this study. Subjects will be recruited through emails and flyers posted to James Madison University employees and local businesses. Subjects will have a body mass index (BMI) between 18.5 and 40 kg/m^2 (normal weight BMI of 18.5 to 24.9, Overweight 25.9-29.9, and Obese Class 1 30-34.9 Obese Class 2 35-39.9 kg/m^2), be 21-55 years old, and lead a sedentary lifestyle (performing physical activity/exercise < 3 times per week for 30 minutes or more in the last 3 months). Exclusion criteria will be: diagnosed cardiovascular, pulmonary or metabolic disease, signs and symptoms of cardiovascular, pulmonary, or metabolic disease, presence of any contraindication to exercise, use of medications affecting weight loss, and pregnancy or planning to become pregnant or breastfeeding. Prior to any testing, subjects will be required to read and sign informed consent forms detailing study procedures, risks and benefits of participation, and confidentiality standards. All procedures will be approved by the James Madison University Institutional Review Board.

Experimental design

During the initial week, subjects will complete 5 days of food records and visual analog hunger scales. Subjects will also report to the laboratory for basic anthropometric measurements (height and weight). Once the initial week is completed, a 2-week exercise intervention will be conducted in a randomly counterbalanced, cross over fashion (Figure

2.1). All subjects will exercise for two days one week during the morning and two days one week in the evening the another week. Each exercise session will be separated by one day, and the evening and morning phases will be separated by at least 3 days. During each phase subjects will record both energy intake throughout the day and hunger before and after each exercise session.

Exercise Intervention and Assessment

Basic anthropometric measurements will be obtained prior to the intervention. Specifically, body weight and height will be measured in light clothing and without shoes in the evening. Weight will be measured to the nearest tenth of a kilogram (kg) on a calibrated scale (Seca, United Kingdom). Height will be measured with a stadiometer to the nearest 0.1 centimeter (cm) (Chorder, Taichung, Taiwan). BMI will be calculated as weight in kilograms divided by height in meters squared. Resting heart rate will be recorded during this session, this will be done using heart rate monitors (Polar Kempele, Finland), and average heart rate over a 5-minute period will be taken as resting heart rate. Subjects will then receive a brief orientation to the facility and bicycle ergometers (Schwinn Evolution/Spinner, Chicago, Illinois US) that will be used during the exercise intervention.

Morning exercise (ME) will be performed between 6:00 and 8:00 am and evening exercise (EE) will be performed between 5:00 and 7:00 pm on stationary bicycle ergometers. Subjects will be encouraged to exercise at moderate intensity defined as 40-60% of heart rate reserve (Calculated: Target Heart Rate = (fractional intensity)(HR_{MAX} – HR_{REST}) + HR_{REST}, Fractional intensity being 0.4 and 0.6) (2) for 40 minutes, which will include a 5 minute warm up period and then a 5 minute cool down. Warm up and cool down will be completed on the stationary bicycle. During the warm up subjects will be instructed to get comfortable with the bike and to slowly increase heart rate. For the cool down subjects will be instructed to slowly decrease intensity of exercise, which will be done with a steady decrease in heart rate. During each exercise session, subjects, along with investigators, will utilize heart rate data to adjust workload to ensure proper exercise intensity. The primary investigator and/or research assistants will record heart rates at 5-minute intervals during all exercise sessions. All subjects will also be asked to rate their perceived exertion once during the exercise session (at 20 minutes in) and following the completion of exercise, using the 0-10 RPE scale (4).

Dietary and Hunger Assessment

All foods will be self selected and prepared by the subjects and no dietary supplements will be provided throughout the duration of the study. Subjects will be instructed to maintain normal eating habits during the study and to follow their normal diet.

All subjects will be required to keep a five-day food record each week of the study (total = 15 daily food records). A Registered Dietitian will train subjects on how to fill out food records. A food record will be completed for 5 days prior to the exercise intervention and will be used as baseline dietary measurement. During the exercise intervention, five-day food records will be recorded beginning the day prior to exercise and ending the day following the second exercise session of the week for both weeks involving exercise.

All subjects will be instructed to eat a 150 to 200 calorie snack 30 minutes prior to each exercise session. A handout will be provided to all subjects for examples of 150-200 calorie snack options. Only water consumption will be permitted during the exercise sessions. To ensure continuity, because morning exercise will be conducted after an overnight fast, subjects will be instructed to fast 2 hours prior to the evening pre-exercise snack. Subjects will also be asked to abstain from food during the initial 30 minutes following each exercise session. Subjects will be asked to eat meals and snacks at the exact same time each day throughout the study, matching the times recorded on the baseline food record.

Diet records will be reviewed using a nutrition database (University of Minnesota, Nutrition Data System for Research) to analyze total calorie and macronutrient intake. Analyzed diet records will be randomly selected and reanalyzed by a second investigator to ensure quality of diet records.

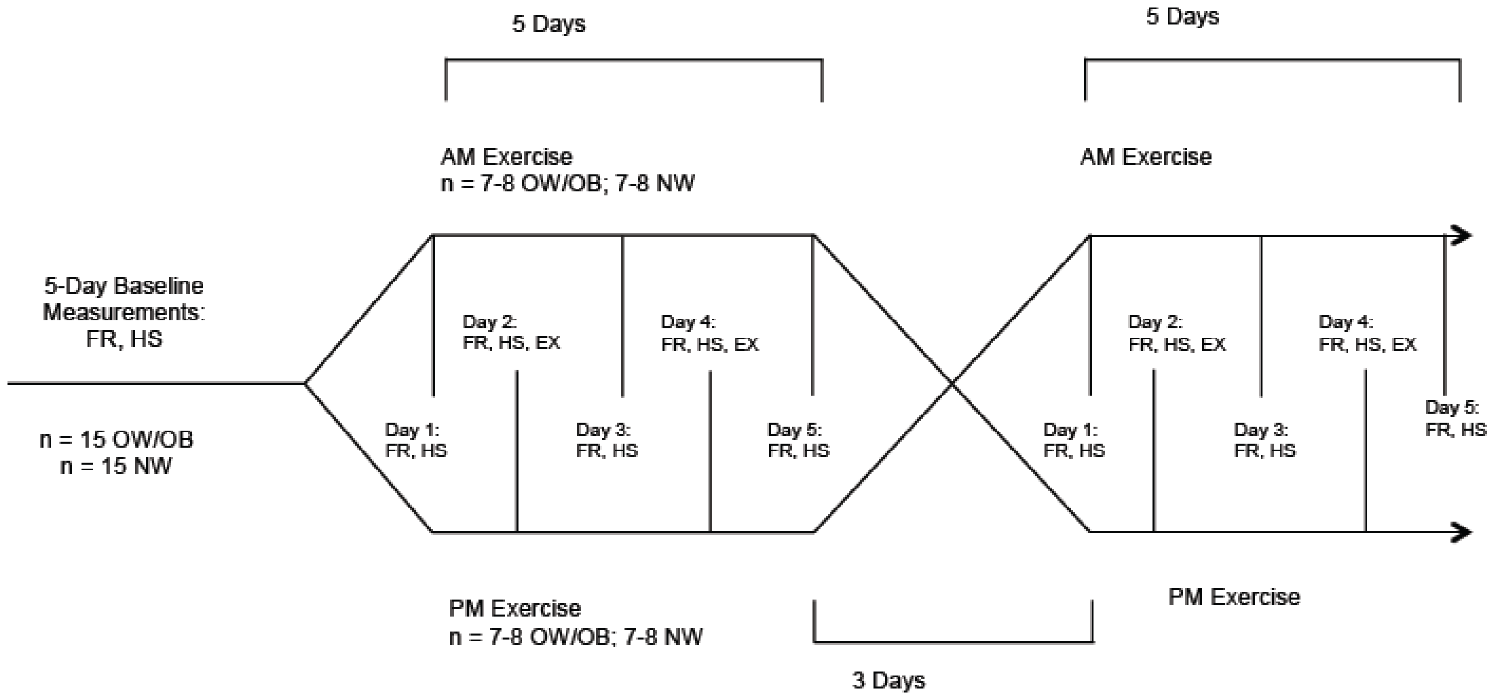
All subjects will record their level of self-perceived hunger during each week of the study for those 5 days that food intake is recorded. Baseline hunger will be measured when subjects wake up and then 30 minutes after their first meal, and 30 minutes before sleep every day during the first week of baseline diet recording. On weeks with exercise intervention, hunger will be recorded when subjects wake up, 15 minutes after the 150-200 kcal snack, then 15 and 30 minutes after their exercise session. On non-exercise days during the exercise intervention weeks, hunger will be measured when subjects wake up, 30 minutes after their first meal and 30 minutes before sleep. Hunger levels will be assessed using a 100 mm visual analogue hunger scale (51).

Statistics

All data will be log transformed to reduce the effects of non-uniformity and then analyzed using IBM Statistical Packages for the Social Sciences software (SPSS 21 for Macintosh). Paired sample t-tests will be conducted to analyze the effects of the time of exercise (morning vs. evening) on daily caloric intake (day 1, day 2, etc.), hunger ratings, and average daily caloric intake. Caloric intake and hunger data that will be obtained during the exercise weeks (morning and evening) will be aggregated and compared to the non-exercise week, to determine the general effects of exercise. Significance will be set at $p < 0.05$ and all data will be displayed as means ± SE.

Figure 2.1: Experimental Design

Randomly counterbalanced, cross over design: OW/OB, overweight/obese; NW, normal weight; FR, food record, HS, hunger scale, EX, exercise



CHAPTER THREE

MANUSCRIPT

Exercise and Time of Day: Influence on Hunger and Caloric Intake Among Overweight/Obese Adults

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ABSTRACT

The purpose of this study was to determine whether or not the time of day at which exercise was performed, morning compared to evening, influences acute daily caloric intake and hunger in overweight/obese sedentary adults. 8 overweight/obese (Age: 40 ± 4 yrs, Height: 170 ± 4 cm, Weight: 85.7 ± 6.4 kg, BMI: 29 ± 2 kg/m^2) sedentary adults completed 3 trials: control, morning, evening in a randomly counterbalanced cross over design. Caloric intake was assessed over three 4-day periods with subjects consuming ad libitum diets. Hunger was measured 15 minutes before exercise and 15 and 30 minutes following exercise. Exercise was performed on stationary bicycle ergometers at moderate intensity (40-60% of HHR) for 40 minutes. Average daily caloric intake was not different between morning and evening exercise ($p = 0.99$). However, average daily caloric intake during the exercise trials was greater than the control week ($p = 0.018$). Both morning and evening exercise sessions increased hunger but there was no differential between the two ($p = 0.42$). These data demonstrate that exercise performed at different times of the day, i.e. in the morning or evening, does not affect average daily caloric intake or hunger in overweight/obese sedentary adults, though more research needs to be conducted with a larger sample size.

INTRODUCTION

Between 2011 and 2012, 68.5% of the United States population was overweight (defined as body mass index (BMI) of 25.0 to 29.9 kg/m^2) and of that percentage 34.9% were classified as obese (obese defined as BMI of ≥ 30) (41). Obesity is accompanied by many health implications including but not limited to an increased risk of developing type 2 diabetes, hypertension, dyslipidemia, arthritis, asthma, coronary heart disease and some cancers (35). It has also been linked to lower health-related quality of life, particularly in physical function but also in mental health (14). The health implications also translate to an increased economic burden (56). Since obesity has become such a public health crisis effective treatments like physical activity, exercise, and diet modifications have been emphasized in both research and practice to help alleviate the impact of this disease.

Weight loss occurs when energy expenditure exceeds energy intake, and a sustained period of negative energy balance is required for weight loss. Various factors influence the energy balance equation, with exercise and diet emerging as the two primary factors. There are many ways to achieve an energy deficit through both exercise and diet. Regardless of the nuances (intensity, duration, frequency) of a specific exercise program or of a diet program, weight loss should result if energy intake does not exceed energy output (18, 19, 20, 44, 45, 49). Short-term weight loss interventions that combined both diet and exercise have shown to improve overall body composition more than either one alone (6, 16, 20, 22), with some contention (9, 24, 55). When it comes to weight maintenance, the combination of both diet and exercise seems to be the best way to maintain weight loss (6, 34). Although research suggests that exercise and diet should be combined, the acute relationship between exercise and caloric intake is still unknown. To develop the most efficient weight loss program factors which influence caloric intake need to be taken into account.

Overweight/obese adults tend to increase energy intake following exercise (10 minutes to 4 hours following exercise), (13, 15, 28, 48, 52) although this finding is not universal (13, 28, 29, 53). The tendency for overweight/obese adults to increase energy intake post-exercise may be precipitated by changes in hunger. There is evidence in short-term studies (2 days to 12 weeks) that overweight/obese adults experience a greater hunger response following exercise, which may lead to compensatory eating (13, 15, 28, 29, 48). Satiety (perceived fullness) is another factor that has a reported impact on caloric intake. Satiety levels decrease throughout the day, which may precipitate greater food intake at night thus increasing total daily caloric intake (7). The changes in hunger following exercise coupled with reduced satiety throughout the day may have an effect on caloric intake following exercise performed at different times of the day. Nothing is known about how the time of day when the exercise is performed may influence dietary intake in overweight/obese adults. Time of day that exercise is performed has been examined in the normal weight population and no difference in energy intake after exercise in the morning versus evening exercise sessions was observed (31, 39).

Because exercise elicits a greater hunger response in overweight/obese adults (13, 15, 28, 29, 48) and satiety levels decrease throughout the day (7), it is logical to speculate that overweight/obese adults who perform evening exercise may experience a marked increase in energy intake, thereby making it more difficult to lose weight (16, 29, 53). However, this hypothesis has not been examined. Therefore, the primary aim of this project is to determine whether the time of day at which exercise is performed will have an acute effect on hunger and daily energy intake in overweight/obese adults.

METHODS

Subjects

Twenty male and female sedentary adults were recruited to participate in the study: normal weight (n=3) and overweight/class 1 obese (n=17). Nine subjects withdrew from the study prior to completion due to sickness, schedule changes and reoccurrence of a previous injury. Therefore, complete data was gathered on 3 normal weight and 8 overweight/obese subjects. Because of the small number of subjects, no statistical analyses were applied to the results obtained from the normal weight group, although data are displayed in the results. All subjects were sedentary (performing physical activity/exercise < 3 times per week for 30 minutes or more in the last 3 months). Exclusion criteria were: diagnosed cardiovascular, pulmonary or metabolic disease, signs and symptoms of cardiovascular, pulmonary, or metabolic disease, presence of any contraindication to exercise, use of medications affecting weight loss, pregnancy or planning to become pregnant, and breastfeeding. Prior to any testing, subjects completed a consent form detailing study procedures, risks and benefits of participation, and confidentiality standards. All procedures were approved by the James Madison University Institutional Review Board.

Experimental design

After subjects reported to the laboratory for basic anthropometric measurements (height and weight), subjects completed 5 days of food records and visual analog hunger scales. Once the initial week was completed, a 2-week exercise intervention was conducted in a randomly counterbalanced, cross over fashion (Figure 3.1). All subjects exercised for two days one week during the morning and two days one week in the evening another week. Each exercise session was separated by one day, and the evening and morning phases were separated by at least 3 days. During each phase subjects recorded both energy intake throughout the day and hunger before and after each exercise session.

Exercise Intervention and Assessment

Basic anthropometric measurements were obtained prior to the intervention. Specifically, body weight and height were measured in light clothing and without shoes in the evening. Weight was measured to the nearest tenth of a kilogram (kg) on a calibrated scale (Seca, United Kingdom). Height was measured with a stadiometer to the nearest 0.1 centimeter (cm) (Chorder, Taichung, Taiwan). BMI was calculated as weight in kilograms divided by height in meters squared. Resting heart rate was recorded during this session using heart rate monitors (Polar Kempele, Finland). The resting heart rate was determined by the average heart rate over a 5-minute period. Subjects then received a brief orientation to the facility and bicycle ergometers (Schwinn Evolution/Spinner, Chicago, Illinois US) that were used during the exercise intervention.

Morning exercise (ME) was performed between 6:00 and 8:00 am and evening exercise (EE) was performed between 5:00 and 7:00 pm on stationary bicycle ergometers. Subjects were encouraged to exercise at moderate intensity defined as 40-60% of heart rate reserve (Calculated: Target Heart Rate = (fractional intensity)(HR_{MAX} –

HR_{REST}) + HR_{REST}, Fractional intensity being 0.4 and 0.6) (2) for 40 minutes, which included a 5 minute warm up period and then a 5 minute cool down. Warm up and cool down were completed on the stationary bicycle ergometers. During the warm up subjects were instructed to get comfortable with the bike and to slowly increase heart rate. For the cool down subjects were instructed to slowly decrease intensity of exercise, which was done with a steady decrease in heart rate. During each exercise session, subjects, along with investigators, utilized heart rate data to adjust workload to ensure proper intensity. The primary investigator and/or research assistants recorded heart rates at 5-minute intervals during all exercise sessions. All subjects were also asked to rate their perceived exertion once during the exercise session (at 20 minutes in) and following the completion of exercise, using the 0-10 RPE scale (4).

Dietary and Hunger Assessment

All foods were self selected and prepared by the subjects and no dietary supplements were provided throughout the duration of the study. Subjects were instructed to maintain normal eating habits during the study.

All subjects were required to keep a five-day food record each week of the study (total = 15 daily food records). A Registered Dietitian trained subjects on how to fill out food records. A food record was completed for 5 days prior to the exercise intervention and was used as the baseline dietary measurement. During the exercise intervention, five-day food records were recorded beginning the day prior to exercise and ending the day following the second exercise session of the week for both weeks involving exercise.

All subjects were instructed to eat a 150 to 200 calorie snack 30 minutes prior to each exercise session. A handout was provided to all subjects for examples of 150-200 kcal snack options. Only water consumption was permitted during the exercise sessions. To ensure continuity, because morning exercise were conducted after an overnight fast, subjects were instructed to fast 2 hours prior to the evening pre-exercise snack. Subjects were asked to abstain from food during the initial 30 minutes following each exercise session. Subjects were asked to eat meals and snacks at the exact same time each day throughout the study, matching the times recorded on the baseline food record.

Diet records were reviewed using a nutrition database (University of Minnesota, Nutrition Data System for Research) to analyze total calorie and macronutrient intake. Analyzed diet records were randomly selected and reanalyzed by a second investigator to ensure quality of diet records.

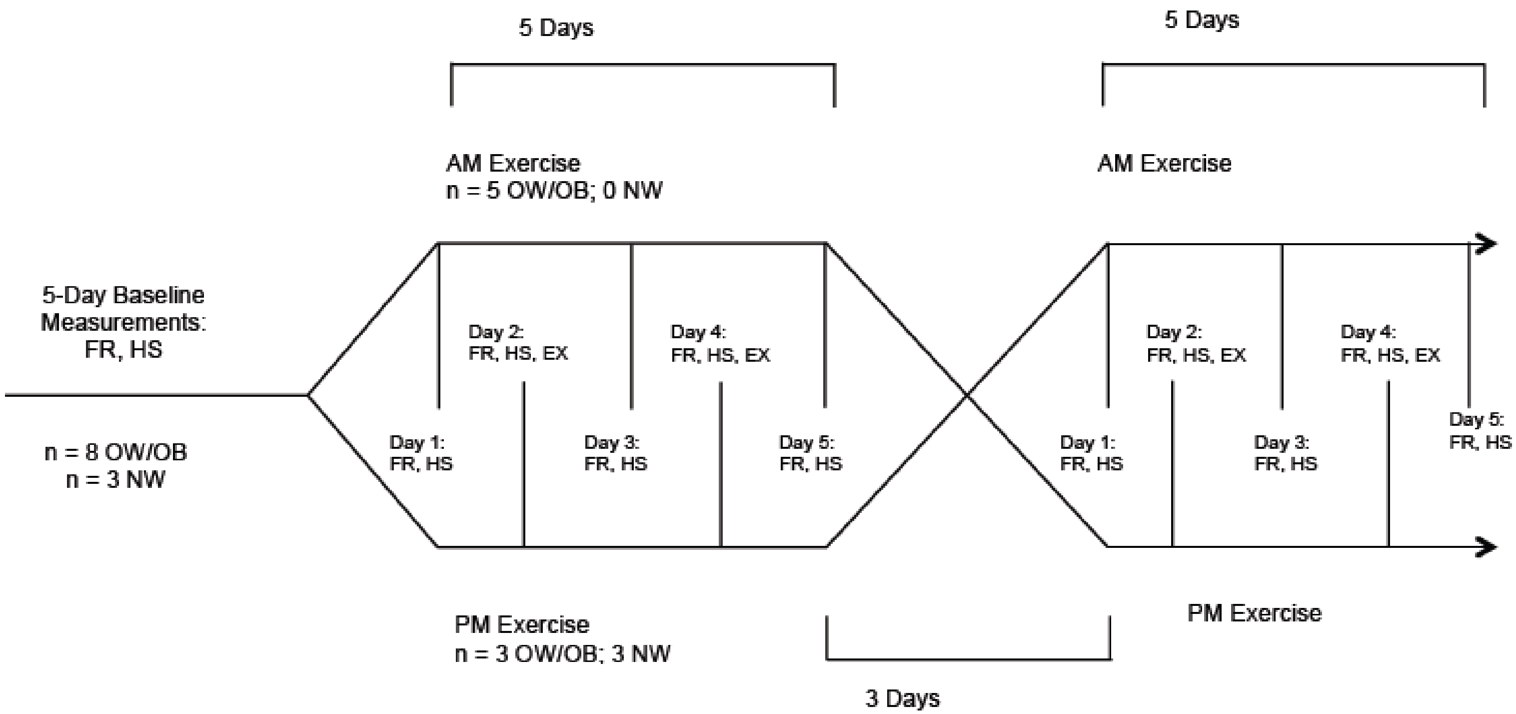
All subjects recorded their level of self-perceived hunger during each week of the study for the 5 days that food intake was recorded. Baseline hunger was measured when subjects woke up and then 30 minutes after their first meal, and 30 minutes before sleep every day during first week of baseline diet recording. On weeks with exercise intervention, hunger was recorded when subjects woke up, 15 minutes after the 150-200 kcal snack, then 15 and 30 minutes after exercise session and 30 minutes before sleep. On non-exercise days during the exercise intervention weeks, hunger was measured when subjects woke up, 30 minutes after their first meal and 30 minutes before sleep. Hunger levels were assessed using a 100 mm visual analogue hunger scale (51).

Statistics

All data was log transformed to reduce the effects of non-uniformity and then analyzed using IBM Statistical Packages for the Social Sciences software (SPSS 21 for Macintosh). Food records and hunger scales were reported for 5 days of each trail, 4 of which were used in the analysis. Paired sample t-tests were used to analyze the effects of the time of exercise (morning vs. evening) on daily caloric intake (day 1, day 2, etc.), hunger ratings, and average daily caloric intake. Further, caloric intake and hunger data obtained during the exercise weeks (morning and evening) were aggregated and compared to the non-exercise week, to determine the general effects of exercise. Significance was set at $p < 0.05$ and all data is displayed as means ± SE.

Figure 3.1: Experimental Design

Randomly counterbalanced, cross over design: OW/OB, overweight/obese; NW, normal weight; FR, food record, HS, hunger scale, EX, exercise



RESULTS

Heart Rate and RPE:

Among overweight/obese, average heart rate was 136 ± 2 and 135 ± 2 bpm (55-58% of heart rate reserve) during the morning and evening exercise sessions, respectively, with no difference between the two. The average heart rate, among normal weight, was 130 ± 6 and 133 ± 5 (56-57 % of heart rate reserve) during the morning and evening exercise sessions, respectively with no difference observed. There was also no difference in RPE between morning and evening exercise sessions.

Caloric and Macronutrient Intake:

Average daily caloric intake was similar between AM and PM exercise ($p = 0.99$) (Table 3.3, Figure 3.2). Likewise, no differences were observed between AM and PM when daily comparisons were made (Day 1, $p = 0.633$, Day 2, $p = 0.708$, Day 3 $p = 0.530$, Day 4, $p = 0.609$). However, average daily caloric intake during the exercise weeks was greater than the control week ($p = 0.018$) (Table 3.4).

Hunger Scales:

Tables 3.5 and 3.6 show the hunger scales before and after each exercise session. Both AM and PM exercise sessions increased hunger. There was no difference in hunger before or after exercise in regards to the time of day that exercise was performed (Table 3.5 and 3.6).

Table 3.1: Subject Characteristics

	Normal Weight: (n=3)	Overweight/Obese (n=8)
Age (years)	36 ± 9	40 ± 4
Height (m)	1.63 ± 0.02	1.71 ± 0.04
Weight (kg)	57.4 ± 2.5	85.7 ± 6.4
BMI (kg/m^2)	22 ± 1	29 ± 2

All data are reported as mean ± SE.

Table 3.2: Normal Weight (n=3): Average Daily Caloric and Macronutrients Intake

	Control	Morning	Evening
Calories (kcal)	1396 ± 201	1368 ± 171	1418 ± 78
Fat (g)	65 ± 10	57 ± 12	53 ± 6
Carbohydrate (g)	170 ± 41	173 ± 22	166 ± 13
Protein (g)	63 ± 12	51 ± 4	63 ± 9

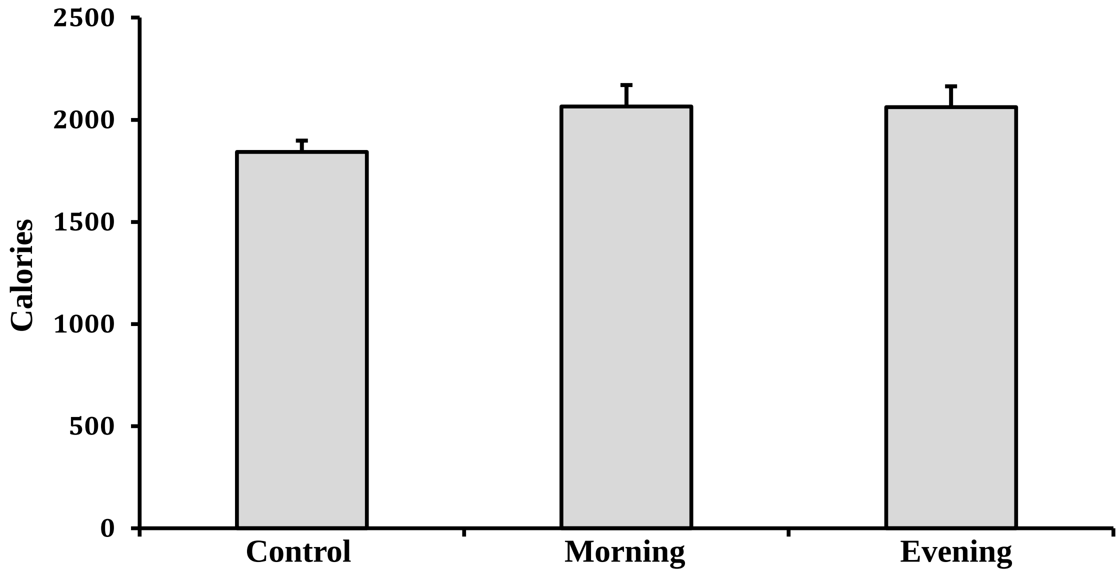
All data are reported as mean ± SE.

Table 3.3: Overweight/Obese (n=8): Average Daily Caloric and Macronutrient Intake

	Control	Morning	Evening
Calories (kcal)	1842 ± 56	2065 ± 105	2062 ± 102
Fat (g)	74 ± 5	75 ± 5	83 ± 6
Carbohydrate (g)	222 ± 13	260 ± 16	230 ± 16
Protein (g)	74 ± 7	84 ± 6	82 ± 5

All data are reported as mean ± SE

Figure 3.2: Overweight/Obese (n=8): Average Caloric Intake over 4-day Period: Control, Morning and Evening



All data are reported as mean ± SE.

Table 3.4: Overweight/Obese (n=8): Average Caloric Intake over 4-day Period: Control Compared to Average of Both Exercise Trials

	Control	Combined Exercise
Calories (kcal)	1842 ± 56	2063 ± 67*
Fat (g)	74 ± 5	80 ± 5
Carbohydrate (g)	222 ± 13	245 ± 12
Protein (g)	74 ± 7	83 ± 4

All data are reported as mean ± SE
***** $p < .05$ compared to control

Table 3.5: Normal Weight (n=3) Hunger Scales Before and After Exercise Sessions

Morning Day 1			Evening Day 1			Morning Day 2			Evening Day 2		
E-15	E+15	E+30	E-15	E+15	E +30	E-15	E+15	E+30	E-15	E+15	E+30
13 ± 6	24 ± 13	32 ± 16	10 ± 6	17 ± 12	31 ± 17	18 ± 10	14 ± 8	20 ± 14	16 ± 9	30 ± 11	38 ± 18

E-15 = data obtained 15 minutes prior to exercise; E+15 = data obtained 15 minutes following exercise; E+30 = data obtained 30 minutes following exercise. All data are reported as mean ± SE

Table 3.6: Overweight/Obese (n=8): Hunger Scales Before and After Exercises Sessions

Morning Day 1			Evening Day 1			Morning Day 2			Evening Day 2		
E-15	E+15	E+30	E-15	E+15	E +30	E-15	E+15	E+30	E-15	E+15	E+30
5 ± 2	13 ± 3	25 ± 7*	8 ± 2	23 ± 5	21 ± 3*	7 ± 3	17 ± 5	25 ± 7*	11 ± 2	23 ± 7	26 ± 6*

E-15 = data obtained 15 minutes prior to exercise; E+15 = data obtained 15 minutes following exercise; E+30 = data obtained 30 minutes following exercise. All data are reported as mean ± SE
*$p < .05$ compared to 15 minutes before exercise.

DISCUSSION

The primary aim of this study was to determine whether or not the time of day at which exercise was performed, morning compared to evening, influences acute daily caloric intake in overweight/obese sedentary adults. The impact of morning versus evening exercise on ratings of perceived hunger was also examined. We hypothesized that evening exercise would increase average daily caloric intake but that there would be no difference in hunger between morning and evening exercise. In contrast to our primary hypothesis, there was no difference in average caloric intake when comparing morning and evening exercise. However, the results did support the hypothesis that hunger would not be different when comparing morning and evening exercise. These data demonstrate that exercise performed at different times of the day, i.e. in the morning or evening, does not affect average daily caloric intake or hunger.

While there is a dearth of relevant literature to aid the interpretation of our data, the chief finding that exercise timing does not influence caloric intake among overweight/obese adults is consistent with previous work in normal weight adults. Maraki et al. found no difference in caloric intake over a 24-hour period following a one-hour exercise session in the morning compared to the evening in healthy sedentary females (31). Likewise, others reported similar dietary habits for 26 hours following 45 minutes of exercise performed by healthy, active males (39). The unique aspect of the present investigation is the inclusion of overweight/obese sedentary adults. As detailed above, because overweight/obese adults tend to increase caloric intake with acute exercise (consistent with the current data) and satiety declines throughout the day, we suspected that this specific population would be influenced by the timing of exercise (7, 13, 15, 28, 48, 52). Although the subjects did increase their caloric intake with exercise, this was apparently not exacerbated by any difference in satiety that may have been present. One potential reason the evening was no different than the morning is the greater number of waking hours following exercise in the morning thus providing the subjects with greater opportunity for food intake. Due to longer time period following exercise subjects could have been affected more by environment i.e. peer pressures, visual stimuli including advertisements and restaurants signs (13) along with the potential for rewarding with food (5, 36). Though subjects were instructed to consume a snack before morning exercise, the amount of calories may have been less than their typical breakfast this could have led to greater compensation of more calorically dense foods throughout the day (47) thus leading to different overall eating habits throughout the morning and evening exercise interventions.

Though there was no difference between morning and evening exercise, exercise itself increased average caloric intake compared to the control week. In this study subjects consumed an average of 200 more calories each day following exercise. We estimate the cost of exercise as 180-240 calories per session (2), thus subjects were not overcompensating on the day of exercise but did overcompensate over the course of 4 days; they consumed an additional 320 to 480 calories over the 4 day period, compared to the non-exercise week. The findings agree with several studies, including both short term (less than one week) and longer term (over 12 weeks) studies (13, 28, 48). Schneider et al. reported an increase in caloric intake following only three minutes of exercise when subjects reported a negative mood associated with exercise (48). Two studies conducted over a 12-week period reported that when subjects were classified as compensators/responders based on weight loss, caloric intake was increased with exercise leading to less weight loss, whereas if classified as noncompensators/nonresponders there was no increase in caloric intake thus leading to greater weight loss (13, 28). This is in contrast to studies involving overweight/obese adults, which reported no change or a decrease in acute energy intake following exercise (10, 15, 29, 60). One study found that after increasing sedentary adult's activity by 125%, there was a decrease in relative caloric intake of about 300 to 400 calories (60). Two of the studies showing no difference in energy intake, only measured one meal following exercise and both meals were presented to subject within 30 minutes of completing exercise. This short duration following exercise may be one reason for differences in intake between previous studies and the present one since the present one included multiple days of caloric intake measurement.

The secondary aim of the present study was to determine if hunger was influenced by the time of day that exercise was performed. Though hunger increased following exercise at both times, there was no difference between the morning and evening exercise. This is consistent with some (28, 31, 54), but not all studies (10, 17, 43). Since hunger is a subjective measure, each study establishes it own parameters for hunger measurement. In the studies that agreed with the present findings, hunger scales were recorded following exercise (from 15 minutes to 120 minutes after) though exercise duration and form were varied (28, 31, 54). The studies that observed no change in hunger with exercise assessed hunger throughout the day both before and after exercise (10, 17, 43). Since hunger was measured throughout the day and not just after exercise the effects of exercise on hunger may have been not as noticeable versus the present study where hunger was measured 30 minutes following exercise.

The increase in hunger following exercise in this present study may account for the increase in average daily caloric intake. It is also possible that the increase in energy intake resulted from negative emotions associated with exercise. Indeed, data has demonstrated that when exercise is perceived as negative this can lead to an increase in caloric intake (48, 52). Also the conjectural perception that exercise makes a person hungrier thus leading a person to consume more could affect intake, though this was not measured in the present study. Along with the actual performance of exercise, preliminary evidence suggests that simply reading about exercise can increase acute caloric intake in overweight/obese adults (1, 58). Due to the fact that multiple stimuli affect both hunger and caloric intake this study added an element to the understanding of the relationship between exercise, hunger and caloric intake and how it is not affected by the time of day. This finding suggests that overweight/obese individuals need to be reminded to be diligent about their caloric intake following exercise to avoid compensatory eating. Awareness of all stimuli needs to be taken into account when performing exercise in the hopes of losing or maintaining weight.

This investigation has some notable limitations that weaken the conclusions. The primary limitations include the small sample size and acute nature of the intervention. Also since there was no hunger scale record following the final meal (and it was recorded after first meal), there could be a lack of understanding of hunger throughout the day. The small sample size limits our ability to confidently generalize these findings to the population. However, the virtually identical caloric intake across morning and evening strengthen the conclusion that time of day has negligible impact on caloric intake, although individual variations in this response were evident, making future large scale studies worthwhile. Also a longer intervention period should help to understand if the findings of the present study would be validated. For instance, the precise effect of emotions, the effects of different exercise, i.e. aerobic versus strength, and adherence to exercise programs need to be better understood. Future studies should also take into account: level of hormones before, during and following exercise to better understand hunger. Strengths of our design include a crossover approach. Due to this, each subject was their own control, which limits the discrepancy of comparing recorded foods (33). Also the subjects completed two days of exercise each week, whereas both of the previous studies on the effect of time of day only had exercise once in the morning and once in the evening. Another difference is that food records were collected over a 4-day period, including day of exercise and day following exercise. Maraki et al. only collected diet records on the day of exercise (31). O'Donghue et al. tracked food intake the day of exercise along with only breakfast the day following exercise (all food was provided to the subjects) (39). The more complete food records and frequency of exercise gives the potential for better representation in the present study.

In conclusion, the results though inconsistent with the proposed hypothesis found that over an acute period of time, there was no difference in average caloric intake following morning or evening exercise. Since over 60% of the US population is overweight/obese, individuals and practitioners are always looking for and prescribing different diets and exercise to develop a negative energy balance, in hopes for individuals to lose and maintain weight (41). Researchers are also trying to develop the best diet and exercise plan to elicit the most efficient weight loss. This present study clarifies that exercise can be performed at any time of the day without negative effects on caloric intake, but shows that overweight/obese need to be cognizant of potential compensatory eating. The lack of effect of time of day puts one less constraint on a person who is trying to develop a personal exercise regimen in hopes to lose weight.

Appendix I

Email sent out to potential subjects

SPRING into a Healthy Lifestyle

With a Free Diet and Exercise Consult with a Registered Dietitian to Develop a Healthy Lifestyle Plan, all you have to do is participate in a JMU short-term research study where you will exercise for 4 days over a 2 week period and keep track of your eating habits.

To be eligible for the study you must:

- Not participate in exercise (defined as not participating in any exercise program: exercising more than 3 times per week for 30 minutes or more in the last 3 months)
- Be between the age of 25 to 55 years
- Have no diagnosed cardiovascular, pulmonary or metabolic disease
- Not be currently pregnant, planning on becoming pregnant or breastfeeding

For more information please contact Molly Weber, at weber2mc@jmu.edu. Data collection will be completed Spring 2014

Appendix II

Spring into a Healthy Lifestyle...

With a Free Diet and Exercise Consult with a Registered Dietitian to Develop a Healthy Lifestyle Plan

All you have to do is participate in a JMU short-term research study where you will exercise for 4 days over a 2 week period and keep track of your eating habits

To be eligible for the study you must:

- Not participate in exercise (defined as not participating in any exercise program: exercising more than 3 times per week for 30 minutes or more in the last 3 months)
- Be between the age of 25 to 55 years
- Have no diagnosed cardiovascular, pulmonary or metabolic disease
- Not be currently pregnant, planning on becoming pregnant or breastfeeding

For information please contact Molly Weber, at weber2mc@jmu.edu. Data collection will be completed March and April 2014

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Appendix III

Consent to Participate in Research

Identification of Investigators & Purpose of Study

You are being asked to participate in a research study conducted by Molly Weber and Nick Luden, Ph.D. from James Madison University. The purpose of this study is to look at the effects of the time at the relationship between RPE and appetite and if it changes at different times of the day. This study will contribute to the researcher's completion of her master thesis.

Research Procedures

Should you decide to participate in this research study, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. This study consists of an exercise intervention, which will be conducted in the cycle room of Godwin Hall, located at James Madison University. You will be required to complete a health history form and a physical activity readiness questionnaire (PAR-Q) that will be reviewed by the researcher before your participation in this study. Once these forms are filled out you will be asked to report to the lab for preliminary data collection where your height, weight, and resting heart rate will be measured and you will be given instructions on how to operate a stationary bike. During the initial week you will be asked to fill out a 5 day food record and 5 day hunger scales. Once the preliminary data collection session is completed you will be asked to exercise on 4 separate days over a two-week period of time, 2 days between the times of 6:00 and 8:00 am, and 2 days between 5:00 and 7:00 pm each exercise session lasting 40 minutes (5 minute warm up, 30 minute workout, 5 minute cool down).

During the study you will be required to complete the following (total of ~9 hrs):

- Preliminary data collection (~ 60 minutes)
- All exercise sessions (4 total x ~40 minutes = 2 hrs. and 40 minutes)
- Food records (15 total x 20 minutes = 5 hrs)
- Hunger Scale (15 total x 5 min = 1 hour and 15 minutes)

Risks

The investigator does not perceive more than minimal risks from your involvement in this study (that is, no risks beyond the risks associated with everyday life).

- Muscular discomfort from exercise sessions

Benefits

- Height, weight, heart rate reserve information during preliminary data collection
- Information on dietary analysis upon result

Summary of Subjects Responsibilities:

- Provide accurate health history questionnaire and PAR-Q forms
- Inform the researchers of any discomfort before, during and after any exercise session
- Be on time to measurements and exercise sessions
- Follow all instructions

- Record food consumed as instructed and turn in on time
- Record Hunger as instructed and turn in on time

Confidentiality

The results of this research will be presented as a master's thesis. The results of this project will be coded in such a way that the respondent's identity will not be attached to the final form of this study. The researcher retains the right to use and publish non-identifiable data. While individual responses are confidential, aggregate data will be presented representing averages or generalizations about the responses as a whole. All data will be stored in a secure location accessible only to the researcher. Upon completion of the study, all information that matches up individual respondents with their answers will be destroyed or returned to the subjects.

Participation & Withdrawal

Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind.

Questions about the Study

If you have questions or concerns during the time of your participation in this study, or after its completion or you would like to receive a copy of the final aggregate results of this study, please contact:

Molly Weber
Kinesiology
James Madison University
weber2mc@jmu.edu

Nick Luden
Kinesiology
James Madison University
(540) 568-4069
ludennd@jmu.edu

Questions about Your Rights as a Research Subject

Dr. David Cockley
Chair, Institutional Review Board
James Madison University
(540) 568-2834
cocklede@jmu.edu

Giving of Consent

I have read this consent form and I understand what is being requested of me as a participant in this study. I freely consent to participate. I have been given satisfactory answers to my questions. The investigator provided me with a copy of this form. I certify that I am at least 18 years of age.

____
Name of Participant (Printed)

______________________________________ ______________
Name of Participant (Signed) Date

______________________________________ ______________
Name of Researcher (Signed) Date

Appendix IV

Health History Questionnaire

Instuctions: Accuratey fill out form, all information provided will be kept confidental

Demographic Information

Legal Name: ________________________________ Nick name: ______________________

Phone Number: ______________________________ What time is best to contact you:__________

Email Address: ______________________________
Gender (please circle): Male Female
Race: ______________________________________
Date of birth: _______________________________
Month/Day/Year

Medical History

Date of last medical exam: ____________________

Circle operations you have had: Back Heart Kidney Eye Joint Lung Other ____________________

Circle any of the following that you have been diagnosed or treated by a physician or other health care provider:

Alcoholism	Diabetes	Kidney problems
Anemia (sickle call)	Emphysema	Mental Illness
Anemia (other)	Epilepsy	Neck Strain
Asthma	Eye Problems	Obesity
Back Strain	Gout	Phlebitis
Bleeding trait	Hearing Loss	Rheumatoid arthritis
Bronchitis, chronic	Heart problem	Stroke
Cancer	High blood pressure	Thyroid problem
Cirrhosis, liver	Hypoglycemia	Ulcer
Concussion	Hyperlipidemia	Other _______
Congenital Defect	Infectious mononucleosis	

List any medications or supplements you are currently taking:

Name	Dose	How often	Why

____
____
____
____
____
____
____

Any of these health symptoms that occur frequently is the basis for medical attention. Circle the number indicating how often you have each of the following:
5 = Very often 4 = Fairly often 3 = Sometimes 2 = Infrequently 1 = Practically never

Cough up blood:	1	2	3	4	5
Abdominal Pain:	1	2	3	4	5
Low Back pain:	1	2	3	4	5
Leg pain:	1	2	3	4	5
Arm or Shoulder Pain:	1	2	3	4	5
Chest Pain:	1	2	3	4	5
Swollen Joints:	1	2	3	4	5
Feel faint:	1	2	3	4	5
Dizziness:	1	2	3	4	5
Breathless with slight of exertion:	1	2	3	4	5

Health Related Behavior
Do you smoke? (Please circle) Yes No
If yes please circle type and number smoked per day
Cigarettes: 40 or more 20-39 10-19 1-9
Cigars or pipe only: 5 or more or any inhaled Less than 5 none inhaled

Do you exercise regularly? (Please circle) Yes No

Please circle the number of times per week that you spend 20 or minutes doing moderate to strenuous exercise
1 2 3 4 5 6 7 days per week

Weight History

Current Weight ________________ Height _________________

Have you experienced a recent change in weight? If yes, please explain:

What is your highest adult weight? __________________ Age _____________
Lowest adult weight (after age 21)? __________________ Age _____________

Adapted from: Howley and Franks. 2007. *Health Fitness Instructor's Handbook.* Health Status Questionnaire. Champaign: Human Kinetics

Appendix V

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	**7. Do you know of <u>any other reason</u> why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to <u>all</u> PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

<u>Informed Use of the PAR-Q</u>: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ______________________________

SIGNATURE ______________________________ DATE ______________________________

SIGNATURE OF PARENT ______________________________ WITNESS ______________________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

continued on other side...

Appendix VI

Baseline Measurements:

Subject Number: ___________
Date: _____________________
Age: _____________________

Height: ___________________

Weight: ___________________

BMI: ______________________

Heart rate:

1 Minute: _________________

2 Minute: _________________

3 Minute: _________________

4 Minute: _________________

5 Minute: _________________

Average: _________________

Heart rate max: ___________

Target Heart Rate Zone: _______________________

Appendix VII

5-Day Food Record, Week 1

Subject number _______________
Date: ________________________

Day 1:
Record the food at time of consumption, please be as detailed as possible

Time	Food Item	Serving Size	Prepared How?

Appendix VIII

TIPS for filling out food record:

- Please fill out the form right after each meal. If you decide to wait until the end of the day to fill out all of your meals, there is a chance that you will forget something.
- Please be as detailed as possible and ask yourself these questions when filling out the record:
    - Did I record the time that I ate the meal?
    - Do I know the brand? If yes, please record it
    - Did I use any condiments or sauces with the meal?
    - Did I have a beverage with the meal?
    - Did I record the serving size? (If you are unsure, use the food amount booklet in your subject informational packet)
    - How was my food prepared? (Baked, fried, broiled, steamed, with sauce etc.)
    - If the food was bought from a restaurant or fast food, please write down the name of the restaurant in the "prepared how" column.
- Please limit your record to one food item per line
- Please make sure to record beverages (including water) throughout the day

It is important to not change your eating habits, please consumed meals, as you normally would

Appendix IX

WEEK 1, Hunger Scales

Subject Number:________________

Date: __________________________

Day 1:

- **At time of waking: Time:_________________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

- **30 minutes after first meal: Time:________________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

- **30 minutes before bed: Time:_____________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

Appendix X

WEEK 2, Hunger Scale

Subject Number:________________

Date: _________________________

Day 2: Exercise

- **At time of waking: Time: ________________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

- **15 minutes after 150-200 calorie snack: Time:________________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

- **15 minutes after exercise: Time:________________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

- **30 minutes after exercise: Time:________________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

- **30 minutes before bed: Time:_____________**

How hungry do you feel? (Please mark on the line how hungry you feel at this time)

Not at all hungry ____ As hungry as I have ever felt

Appendix XI

Exercise Record Sheet

Day 1: ____________

Subject Number: _____________________

Date: _______________________________

Target Heart Rate: ____________________

HR, 5 minutes: _______________________

HR, 10 minutes: ______________________

HR, 15 minutes: ______________________

HR, 20 minutes: ______________________ RPE: _____________

HR, 25 minutes: ______________________

HR, 30 minutes: ______________________

HR, 35 minutes: ______________________

HR, 40 minutes: ______________________ RPE: _____________

Average HR: _____________

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