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Does endurance training alter energy balance?

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DOES ENDURANCE TRAINING ALTER ENERGY BALANCE?

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ABSTRACT

An examination of the effects of a structured activity program on resting metabolic rate (RMR), physical activity, and dietary behavior is essential in gaining a better understanding of potential strategies that may be used in future exercise training programs. **PURPOSE**: To explore whether endurance training alters energy balance via changes in resting metabolic rate (RMR), daily energy expenditure (EE) and energy intake (EI). M**ETHODS**: Twenty-four subjects (17 females, 7 males; 21 $\pm$ 0.3 years old) were assigned to one of two groups: 1) endurance (E; n = 12), or 2) active control (AC; n = 12). The E group completed 15 weeks of marathon training and the AC group maintained their usual exercise routine. Primary outcomes were measured pre- and post-training and included: anthropometric indices, RMR, EI, EE, and time to complete 1.5 miles (in minutes). Dietary intake and energy expenditure were also measured mid-training. **RESULTS**: Differences present among the groups at baseline included: the E group had significantly higher estimated VO2max values (as measured by the time to complete 1.5 miles) and higher energy expenditure rates (measured via accelerometer data) than the AC group. Analyses revealed that both the E and AC groups significantly increased daily energy expenditure from baseline measures ($p = 0.005$) and decreased time to complete 1.5 miles ($p = 0.022$). During training, the E group significantly increased energy expenditure during the tenth week of training ($p = 0.009$). No significant changes or group differences were observed in body weight, resting metabolic rate, or energy intake. **CONCLUSION**: The results of the study suggest individuals following an intensive, marathon training program may experience an increase in EE without a concomitant increase in EI. They may also fail to see improvements in body weight or RMR. Additionally, the parallel changes in EE and EI, and the increase in VO2max observed in the AC, when compared with the E group, may indicate that an uncontrollable factor may have been involved.

CHAPTER 1 – INTRODUCTION

The incidence of overweight and obese adults is rising at a rapid rate in the United States costing on average 147 billion dollars per year in health care costs (1). Recent data indicate an estimated 33% of the adults are overweight, 34% are obese and 6% are extremely obese (2). Lack of daily physical activity and exercise coupled with poor dietary habits, including excess caloric intake have been directly related to the development of this epidemic (3,4). An important factor in weight maintenance and weight loss is energy balance, or the state in which energy going into the body matches the energy being used to maintain the body and complete physical activities (5). In order to maintain weight or prevent weight gain, an individual should create a neutral energy balance. Neutral energy balance occurs when the calories consumed equal the calories expended. Thus, positive energy balance is associated with weight gain, and negative energy balance is associated with weight loss (5,6). An individual can achieve a negative energy balance by creating a calorie deficit through reduced caloric intake or increased physical activity and exercise (5,6).

Maintenance of energy homeostasis implies a long-term regulation of energy balance (5). When physical activity levels are increased, energy intake should increase proportionally to maintain energy balance at an increased level of energy turnover (7); however this particular energy state depends on the goal of the activity program. If weight loss is expected, then there needs to be a calorie deficit; though if weight maintenance is the goal, then calories consumed should equal calories expended each week (6). While there is no consistent definition in the literature for "overcompensation", it will be interpreted as the consumption of excess calories than those expended (8) for the remainder of this document. Overcompensation can lead to a positive energy balance if the calories are consumed but not expended through exercise. It is possible that individuals tend to overcompensate by increasing energy intake (EI) when

following in an intensive endurance training program thus creating a positive energy balance that could result in weight gain or attenuate weight loss. Westerterp, et al. examined the effects of long-term physical activity on energy balance and body composition in 16 males and 16 females, aged 28-41 years, and body mass index 19.4-26.4 kg/m^2. The subjects prepared to run a half-marathon after 44 weeks of training. Body composition was measured via hydrodensitomery and isotope dilution, and EI with 7-day diet records. Energy expenditure was measured overnight in a respiration chamber and in a number of subjects over 2-week intervals with doubly labeled water. The study concluded that body composition changes were more pronounced in men and that women are more likely than men to compensate for the increased energy expenditure (EE) induced by exercise with an increased EI, resulting in a smaller effect of body mass and fat mass compared with men (9). Overcompensation may also be linked to psychological factors. For instance, an individual who chronically exercises may feel as though they are entitled to eat higher calorie foods as a reward for exercise (10). Another contributing factor to a positive energy balance is compliance to the exercise-training program. Byrne et al. (11) showed that most individuals complete less than the prescribed amount of exercise for a given training program. Additionally, Wallace et al. (12) also found that on average, only 50% of an exercise prescription is completed. These data were derived when investigating exercise adherence to a 12-month training program comparing single individuals with those whom enrolled with a spouse, and resulted in single individuals being less compliant to the exercise training (12). Therefore, adherence has the potential to greatly affect outcomes related to body composition and body weight. This may be especially true for those participating in marathon-training program. In these programs, the mileage increases week but also includes a period of reduced mileage (reduced mileage weeks, “rest weeks” or taper) to allow for the body to recover prior to

the marathon event. As training progresses, individuals increase their mileage each week, which increases required energy intake. If an individual runs fewer miles than recommended for that particular week due to either fatigue or injury, she or he may still increase their energy intake, which could result in weight gain or prevention of weight loss, if weight loss is the target goal.

CHAPTER 2 – REVIEW OF LITERATURE

Physical Activity and Exercise

Physical activity and exercise are two terms that describe different concepts, though they are often used interchangeably. Physical activity is defined as any bodily movement, produced by skeletal muscles, that results in energy expenditure (13). Activities that constitute physical activity are typically categorized into occupational, sports, household and other activities (13). Physical activity can vary among individuals and for a given individual over time (13). A decrease in physical activity, or increased time spent engaging in sedentary behaviors, independent of physical exercise, is correlated with the progression of type 2 diabetes, cardiovascular disease, and metabolic syndrome (14,15). Furthermore, prolonged inactivity, or sedentary behavior, is correlated with impaired glucose metabolism, obesity, high blood pressure (14), decreased HDL concentrations, and reductions in lipoprotein lipase activity (15). To promote a healthier and more active lifestyle, in addition to structured exercise programs, it is recommended that individuals supplement daily lifestyle activities with non-exercise physical activities, such as taking the stairs rather than an elevator (15).

Physical exercise is a subset of physical activity; however it is defined as activity that is planned, structured and repetitive and has a final or an intermediate objective to improve or maintain physical fitness (13). Exercise has clearly been shown to benefit health and improve cardiometabolic risk factors (15,16); however, it is reported that adults in the United States spend approximately 70% of their waking hours sitting, 30% in light activities, and little to no time in exercise (16). While physical exercise among individuals has shown a steady decline, it has been noted that physical activity has also declined throughout recent years thereby further promoting a decline in energy expenditure among individuals (14,17). According to the ACSM Guidelines, individuals should participate in moderately intense cardiovascular exercise for thirty minutes a

day, for five days a week, or do vigorous cardiovascular exercise for twenty minutes a day for three days a week, and resistance training twice a week (18) and it is evident that these guidelines are not being met by the vast majority of the US population (16,17).

Non-exercise Activity Thermogenesis

The exact role of non-exercise activity thermogenesis (NEAT) in human energy balance is difficult to determine as it is variable both within and between subjects. NEAT is defined as physical activity separate from voluntary exercise and intended for activities of daily living (19). Spontaneous physical activity (SPA) is another subset of activity, separate from NEAT and is more reflective of energy expended due to fidgeting and postural changes (20). SPA can contribute to as little as 8% percent of total daily energy expenditure in very sedentary individuals, and as high as 15% in very active individuals (21). It is also reported that individuals with low NEAT and SPA levels are more likely to develop obesity than those with higher levels of NEAT and SPA (5). Technology has made sedentary lifestyles quite feasible with the invention of cars, elevators and electric dishwashers for domestic purposes and televisions, iPhones, and computers for entertainment purposes (15,17,22). By promoting individuals to increase daily NEAT as an addition to structured exercise, individuals will have a higher likelihood of losing weight, as well as maintaining weight loss.

There are now commercially available tools to measure NEAT in free-living conditions, such as accelerometers and pedometers, in a non-invasive nature and with relative ease (22). While accelerometers are a justifiable means for measuring movement, movement intensity is not accounted for through accelerometry. The use of accelerometry in interventions provides a more objective measurement of activity than self-reported exercise logs. Furthermore, with self-reported logs, individuals have the tendency to experience a change in physical activity levels as

a result of increased attention to physical activity behaviors (22). Pedometers are typically used to monitor steps taken throughout a period of time, and are most relevant to ambulatory activity, and as with accelerometers, do not provide an accurate measure of intensity (22,23). Additionally, it is important to note that both accelerometers and pedometers need to be removed before water-based activities, such as swimming, and if worn on the hip, activities such as cycling and weight lifting cannot be measured (23).

Physical Exercise and Non-exercise Activity Thermogenesis

Physical exercise also has the potential to play a role in NEAT levels in individuals. It is reported that when individuals follow a structured, endurance-training program for a long period of time, they may start to experience exercise-induced feelings of fatigue (10). This could potentially lead to a decrease in NEAT (i.e., an increase in sedentary behavior) and is thought to be an automatic mechanism that promotes compensatory responses to energy expenditure prompts (10). These compensatory responses may play a role in the lack of success in weight loss programs targeted to exercise, especially when diet and non-exercise activity are not taken into account. This knowledge in combination with the potential outcomes of weight loss trials suggests that further attempts should be made to determine the role of structured exercise on NEAT levels.

Researchers have examined the role of exercise-induced fatigue, especially of vigorous intensity, on decreased performance (24). Exercise-induced fatigue and feelings of overtraining may contribute to decreases in NEAT as well. For instance, an individual who rises early in the morning to run may retire for bed earlier than usual resulting in fewer potential bouts of activity throughout the evening (10). Data from Colley et al. (22) showed how exercise played a role in non-exercise activity using a walking intervention. Individuals had higher levels of NEAT before

and after intervention; though during intervention, NEAT was higher on non-walking, or non-exercise days when compared to walking, or exercise days. Participants were given feedback regarding their energy expenditure each week but were instructed to maintain normal dietary habits and to complete 3-day food logs during various phases of the study.

Researchers agree that it is possible for a decrease in NEAT to lead to a plateau in weight loss. For example, Thompson et al. aimed to determine the effects of a 24-week program, either diet only or diet combined with exercise, on select components of energy expenditure, basal metabolic rate and bone mineral density in postmenopausal women. Many of the women in this study experienced a plateau in weight loss after 12 weeks of exercise training. It was reported that activity levels remained constant in the prescribed exercise program and compliance was high for strength training with subjects attending more than 90% of all sessions. Thus, it was hypothesized that the plateau could have been attributed to a lack of compliance with the dietary program or that the women overcompensated for the increased energy expenditure by increasing the time spent engaged in sedentary behaviors, or more recently known as decreased NEAT (25). It is important to note that this study did not measure NEAT using accelerometers before and after training, so their conclusion is merely speculation at this point in time.

Physical Exercise and Resting Metabolic Rate

To date, previous studies examining the effects of endurance training on resting metabolic rate (RMR) have been inconsistent. Some studies suggested that endurance training can lead to an increase in RMR (26,27) while others found that RMR was unaltered (28,29,30), or saw a slight decline in RMR (31) after extended training periods. For example, Tagliaferro, et al. found that RMR and thermic effect of food was unaltered, but showed a wide range of variation in 10 healthy women after participating in a 10-week progressive jogging program (28).

These results were similar to those found by Bingham, et al. when examining six individuals (three male, three female) after a nine week training program in which diet remained constant. Results from this study showed at the end of the study, the subjects were able to run for one hour per day for five days a week, but still showed no change in RMR (29). Another study showed a decrease in RMR after six pairs of male monozygotic twins completed a 22-day ergocycle program that induced a deficit in energy balance (31). Furthermore, a majority of the research on RMR and physical exercise was conducted over twenty years ago and did not examine exercise loads that correspond to a progressive, endurance training regimen such as a marathon training program.

It is well established that RMR measures taken less than 24 to 48 hours after an exercise bout may result in the detection of transient, exercise-induced increases in RMR. For example, the HERITAGE Family Study (32) concluded that a 20-week endurance exercise training program had no effect on RMR in men and women aged 17-63 despite slight changes in body composition and a significant increase in $VO_{2max.}$ RMR measurements were taken 24 and 72 hours after the last exercise bout to test for transitory increases in RMR. Results showed that there were still elevations in RMR at the 24-hour time point, but these changes were not evident 72 hours after the last exercise bout. Broeder et al. (33) found that RMR was increased during the 14 hours after the last exercise bout after 12 weeks of high-intensity aerobic training, but returned to pre-training levels within 48 hours. The measurement of RMR may also be affected by the mode and intensity of the exercise (34), and the length of abstention from exercise (35). As a result, it appears that RMR measures obtained after 48-72 hours after an intense exercise bout should be unaltered. Evidence also suggests that ideally RMR measurements for

premenopausal women are taken during the same cycle of their menstrual cycle, as it suggested that RMR is significantly increased during the luteal phases versus the follicular phase (36).

The metabolic adaptations that occur during modest caloric restriction, as evidenced by metabolic adaptation of RMR and reduced EE through physical activity may result in weight loss retention (20). In one study, the effects of calorie restriction on RMR and SPA were examined over a 6-month period. Non-obese subjects were randomly assigned to either a control group or one of three groups with different caloric restriction strategies: calorie restriction, calorie restriction plus structured exercise, and low-calorie diet (20). SPA for this particular study was measured via a respiratory chamber equipped with radar motion detectors to represent the percent of time the subject was active in the chamber. A possible limitation to measuring SPA via respiratory chambers is the confined nature of the chambers, which may prevent free-living conditions (5). This study was one of the first to measure activity in both a respiratory chamber and during free-living conditions using a doubly labeled water method for predicting total energy expenditure. Results indicated that RMR decreased beyond values from expected changes in body weight and composition as a result of the energy deficits for all groups except the control. Physical activity levels (PAL) significantly decreased with calorie restriction (CR) only; however there was no decrease in SPA. The lack of change in SPA in response to exercise in this study could have been due to the exercise dose, as the main focus was on the effects of CR rather than structured exercise. For the present study described within this document, the primary aim was to examine the effects of structured exercise on physical activity, non-exercise activity and energy balance, and will not include a calorie restrictive portion.

Physical Exercise, Resting Metabolic Rate, and Energy Balance

It is important to note that RMR may not be affected when exercise training is the primary intervention aimed at inducing a negative energy balance, resulting in weight loss. For instance, Broeder et al. (33) found that RMR was not significantly changed after 12 weeks of either high-intensity endurance or heavy resistance training; however a slight decline in energy intake per training day and a decline in fat-free weight were observed in the endurance group. Therefore, it was suggested that exercise training can assist in the maintenance of RMR during extended periods of calorie restriction by either preserving or increasing fat-free weight. Thus the absence of change in RMR in the presence of weight loss may represent a beneficial effect of training in comparison to the documented effect of diet-induced weight loss on RMR (29).

Energy balance and energy flux may also affect RMR (35,37). Bullough, et al. examined the effects of energy flux on RMR in trained male athletes. They measured RMR after three days of high-intensity exercise while eating adequate energy and after three days when energy intake was reduced, or resembled a non-exercise day. Results showed that RMR was significantly higher during high energy flux than during negative energy flux (35). These findings are in agreement with the notion that RMR can be elevated during a state of energy balance when energy flux is increased, which means that increased daily energy expenditure is matched by an increase in daily energy intake (37). However as previously stated, these transient increases in RMR are likely attributed to acute exercise bouts and only marginally related to chronic adaptations to exercise training (32). Furthermore, it is suggested that the effect of exercise on daily energy turnover decreases over time thus resulting in an increased efficiency of exercise as a result of training (32). This could potentially result in initial weight loss at the start of training,

but as an individual becomes more efficient at performing the same exercise, such as running, it may lead to fewer metabolic changes in RMR.

Summary and Specific Aims

Though the effects of aerobic exercise on RMR have been previously examined, a study examining the effects of endurance training on a higher magnitude, such as marathon training, has yet to be completed. Moreover, the results from previous studies have been inconsistent (26,28,31). The identification of factors associated with weight loss maintenance and weight regain, such as compensatory behaviors to exercise, have been brought to attention through recent literature (10). Further examination of the effects of structured exercise on daily energy expenditure and energy intake can help bridge the gap between weight loss and weight regain that frequently occurs with weight loss trials (38). Accordingly, the specific aims of this study are to determine whether a structured endurance training program would: alter resting metabolic rate, change daily energy expenditure and energy intake, and change daily physical activity. It is hypothesized that endurance training will not alter resting metabolic rate, and there will be a positive relationship between endurance training and both caloric expenditure and caloric intake, as well as an inverse relationship between endurance training and daily physical activity.

In conclusion, an examination of the effects of a structured activity program on RMR, physical activity, and dietary behavior is essential in gaining a better understanding of potential strategies that may be implemented in future exercise training and weight loss programs.

CHAPTER 3 – METHODS

Study Subjects

Twenty-four undergraduate students were recruited to participate in this experiment (17 females, 7 males; 21 $\pm$ 0.3 years old). Subjects were assigned to one of two groups: 1) endurance training (E; n = 12; 7 females, 5 males), or 2) active control (AC; n = 12; 10 females, 2 males). Subjects in the E group were from different majors and were recruited to participate as part of a class entitled The Physiology of Endurance Training (KIN 4526) at Louisiana State University. The subjects in the AC group were recruited from various other Kinesiology courses. Enrollment into the E group required the capability of running three miles, three times a week prior to the start of the study. Enrollment into the AC group required participation in a consistent workout plan with at least 3 days of inactivity per week for at least one year prior to the start of the study. All subjects were in overall good health, and female subjects were not pregnant.

Study Design

All subjects signed an informed consent and completed a physical activity questionnaire prior to initiation of testing. Subjects in the E group were required to complete a medical history form and receive permission to participate from a State licensed M.D. or D.O. prior to the beginning of class. The E group completed a 15-week training regimen that included 3 runs each week with one supervised long run and cross-training on the weekend days (Table 1). The duration of the aerobic workouts varied depending upon each individual's running pace as the runs were distance-based. All training was documented weekly and monitored to ensure adherence and progress. Subjects were instructed to report any adverse events that interrupted training. The AC group was instructed to maintain their normal daily diet and activities. Several measurements were taken before and after the training intervention (W2 and W14). Post

measurements were taken during the last week of the taper period and before the E subjects competed in a marathon event. A complete study outline can be viewed in Figure 1.

Table 1. Endurance training plan for the E group.

Marathon Training Plan (Distances in Miles)								
Week	**Mon**	**Tues**	**Wed**	**Thur**	**Fri**	**Sat**	**Sun**	**Total (miles/wk)**
1	Rest	3	3	3	Rest	6	cross	15
2	Rest	3	4	3	Rest	7	cross	17
3	Rest	3	4	3	Rest	8	cross	18
4	Rest	3	4	3	Rest	7	cross	17
5	Rest	3	5	3	Rest	10	cross	21
6	Rest	3	6	3	Rest	12	cross	24
7	Rest	3	5	4	Rest	11	cross	23
8	Rest	4	7	4	Rest	14	cross	29
9	Rest	4	8	5	Rest	16	cross	33
10	Rest	4	9	5	Rest	18	cross	36
11	Rest	5	8	5	Rest	15	cross	33
12	Rest	5	8	5	Rest	20	cross	38
13	Rest	5	10	5	Rest	12	cross	32
14	Rest	5	6	5	Rest	8	cross	24
15	Rest	3	4	2	Rest	RACE		

Rest, running or other intense aerobic exercise should not be performed. *Cross*, cross-training (swimming, cycling, etc.) should be performed for aerobic exercise rather than running.

W2	**W10**	**W14**
WHR BMI RMR 1.5 mile run 3-Day Diet Recalls (W2) 7-Day Accelerometers (W2)	← E (15-wk Marathon Training Plan)→ ← AC → 3-Day Diet Recalls (W10) 7-Day Accelerometers (W10)	WHR BMI RMR 1.5 mile run 3-Day Diet Recalls (W14) 7-Day Accelerometers (W14)

Figure 1. Study outline. Endurance (E) n = 12; Active control (AC) n = 12.
Abbreviations: W2 – Week 2; W10 – Week 10; W14 – Week 14; WHR – waist-to-hip ratio; BMI – body mass index; RMR – resting metabolic rate

Anthropometry

Height and weight were recorded during W2 and W14 in order to calculate body mass index (BMI). Height was assessed using a stadiometer while weight was read from a balance scale. Waist and hip circumferences were measured using a Gulick tension tape to calculate the waist-to-hip ratio (WHR).

Resting Metabolic Rate

Resting metabolic rates (RMR, kcal/day) were assessed via analysis of oxygen consumption using a metabolic cart (Moxus Metabolic Systems, Pittsburgh, PA) at W2 and W14. All subjects reported to the lab having been fasting for 12 hours, euhydrated, and having refrained from exercise, caffeine, or alcohol for at least 24 hours. RMR measurements for all subjects were obtained at least 48 hours after the last strenuous exercise bout. The procedure continued until 10 minutes of steady state data was collected, defined as ± 5% of the respiratory exchange ratio (39). RMR was calculated via the modified Weir equation (40). Due to the critical timing of data collection, different phases of the menstrual cycle for female participants were a limitation. The menstrual phase of all female participants was noted and an effort was made to take subsequent measurements during the same phase to limit potential variations in post-measurements.

Cardiorespiratory Fitness Testing

All subjects completed a timed 1.5 mile run prior to the intervention period and during the taper period of training (W2 and W14, respectively) to determine aerobic capacity. The tests were conducted outdoors on a flat, paved area near the college campus. Subjects were instructed to cover 1.5 miles in the fastest possible time (walking was allowed, but the objective was to finish in the shortest amount of time). The elapsed time was called out (in minutes) as the subject

crossed the finish line. The completion times were inserted into the VO_{2max} prediction equation (483/time of completion + 3.5) for each individual subject to predict VO_{2max} (41).

Accelerometry

Accelerometers (Actigraph; CSA Inc., Shalimar, FL) were worn for seven consecutive days on three separate occasions (W2, W10, W14) to obtain an accurate assessment of energy expenditure (EE) for each subject. Only those subjects with a minimum of three days of accelerometer wear-time were included in the study. According to Marr and Heady, approximately seven days of measurement is likely to provide a representative assessment for a three or four month period. The seven-day measurements can be repeated during that length of time to obtain a better understanding of variables, such as season (21,42) or training status.

Dietary Assessment

Participants completed 3-day diet recalls (Appendix C) while wearing the accelerometers (W2, W10, and W14) to obtain an assessment of energy intake (EI) for each subject. The participants were informed on how to properly complete a diet recall, and were provided with examples. Diet recalls were analyzed using standard computer-assisted nutritional analysis software (ESHA Food Processor SQL, version 10.10; ESHA, Salem, OR). Diet recall data were compared to the accelerometer data and RMR measurements to determine if caloric intake exceeded expenditure.

Sickness and Injury Reports

All subjects in the E group were asked to report any injury or sickness that limited their activities of daily living on a weekly basis. This data was collected along with the weekly training documentation and monitored on a continuous basis throughout training.

Statistical Analysis

Data were analyzed using Statistical Packages for Social Sciences software (SPSS for Windows version 19.0). Descriptive statistics including means, standard deviations and standard error were obtained for the following outcome all variables (age, height, weight, estimated VO_{2max}, dietary intake (calories/day), RMR, accelerometer measures, and final race time). The following measures were analyzed using a series of 2 (group) x 2 (time) analyses of variance (ANOVA): estimated VO_{2max}, body mass index, waist-to-hip ratio, RMR. The following measures were analyzed using a series of 2 (group) x 3 (time) analyses of variance (ANOVA): accelerometer measures and dietary intake (calories/day). Significance was set at $P < 0.05$; however, actual P values are reported for each variable.

CHAPTER 4 – RESULTS

Anthropometric Data

Anthropometric data for the two groups (E and AC) are reported in Table 2. There were no significant changes from W2 to W14 for any variables measured: height, weight, BMI, WHR, and RMR.

Table 2. Anthropometric Data.

	W2		W14	
	E (*n*=12)	AC (*n*=12)	E (*n*=12)	AC (*n*=12)
Ht (cm)	169.03 ± 2.84	168.68 ± 2.00	169.03 ± 2.84	168.68 ± 2.00
Wt (kg)	65.87 ± 2.39	64.68 ± 2.99	65.93 ± 2.17	65.85 ± 3.06
BMI	23.04 ± 0.57	22.70 ± 0.97	23.01 ± 0.44	23.08 ± 0.96
WHR	0.78 ± 0.01	0.76 ± 0.02	0.77 ± 0.01	0.76 ± 0.02
RMR (kcal)	1503.99 ± 77.77	1327.97 ± 81.04	1505.13 ± 91.44	1411.91 ± 93.07
Race Time (hr)			4.34 ± 0.16	

Anthropometric data for Endurance (E) and Active Control (AC) Groups for Week 2 (W2) and Week 14 (W14) are represented as mean (SE). No significant differences between the groups ($p > 0.05$).

Comparisons of data for males and females, regardless of group assignment, are reported in Table 3. Males had higher pre- and post-testing measures for height and WHR ($p = 0.02$). Also, the anthropometric data in Table 4 show a detailed comparison of gender outcomes between the two groups for the variables measured. None of the changes observed from pre to post were significant. Furthermore, a percent change was calculated for all major variables listed (Table 5). The largest percent change was observed in RMR for the AC group.

Table 3. Comparison of W2 and W14 variables by gender.

	Week 2		**Week 14**	
	Females (n = 17)	Males (*n*=7)	Females (*n*=17)	Males (*n*=7)
Ht (cm)	165.14 ± 1.55 *	177.60 ± 2.27	165.14 ± 1.55 *	177.60 ± 2.27
Weight (kg)	61.53 ± 1.85	74.71 ± 2.10	62.16 ± 1.83	75.13 ± 1.95
BMI	22.62 ± 0.76	23.69 ± 0.53	22.79 ± 0.70	23.79 ± 0.61
WHR	0.75 ± 0.01 *	0.80 ± 0.01	0.75 ± 0.01 *	0.81 ± 0.01
RMR (kcal)	1283.18 ± 46.89	1676.81 ± 102.67	1333.93 ± 46.07	1753.20 ± 146.15

Females had significantly lower heights and WHR when compared to males at W2 and W14.
* denotes significant change ($p < 0.05$)

Table 4. Comparison of W2 and W14 variables by gender and group.

	W2	W14	W2	W14	W2	W14	W2	W14
	E Females (*n* = 7)	E Females (*n* = 7)	E Males (*n* = 5)	E Males (*n* = 5)	AC Females (*n* = 10)	AC Females (*n* = 10)	AC Males (*n* = 2)	AC Males (*n* = 2)
Ht (cm)	162.81 ± 2.34	162.81 ± 2.34	177.72 ± 3.03	177.72 ± 3.03	166.95 ± 1.88	166.95 ± 1.88	177.30 ± 4.00	177.30 ± 4.00
Wt (kg)	59.71 ± 1.18	60.06 ± 0.89	74.50 ± 1.70	74.14 ± 0.76	62.5 ± 2.96	63.50 ± 1.13	75.23 ± 7.95	77.61 ± 8.07
BMI	22.61 ± 0.88	22.67 ± 0.59	23.64 ± 0.61	23.48 ± 0.69	22.48 ± 1.13	22.78 ± 1.11	23.80 ± 1.50	24.56 ± 1.45
WHR	0.76 ± 0.02	0.74 ± 0.01	0.80 ± 0.02	0.81 ± 0.01	0.75 ± 0.02	0.75 ± 0.02	0.81 ± 0.01	0.80 ± 0.00
RMR (kcal)	1393.6 ± 94.8	1360.7 ± 54.9	1658.5 ± 104.0	1707.3 ± 177.0	1249.1 ± 55.1	1320.7 ± 67.6	1722.6 ± 332.0	1868.0 ± 341.7

No significant differences detected between groups when divided by gender ($p > 0.05$).
Abbreviations: W2 – Week 2; W10 – Week 10; W14 – Week 14; BMI – body mass index; WHR – waist-to-hip ratio; RMR – resting metabolic rate

Table 5. Percent change.

	W2	W14
	E (n=12)	AC (n=12)
Age	0.00	0.00
Ht (cm)	0.00	0.21
Weight	0.09	0.12
BMI	0.13	0.30
WHR	1.28	1.30
RMR	0.08	6.19

Data are represented as percentage changes from W2 to W14 for all major variables for E and AC Groups.

Resting Metabolic Rate

No significant effect for time was observed for RMR (p = 0.360), nor were there group differences in RMR (p = 0.248), as shown in Figure 2. Neither the E group (1503.99 ± 77.77 kcal/d vs. 1505.13 ± 91.44 kcal/d) nor the AC group (1327.97± 81.04 kcal/d vs. 1411.91 ± 93.07 kcal/d) had a significant change from W2 to W14.

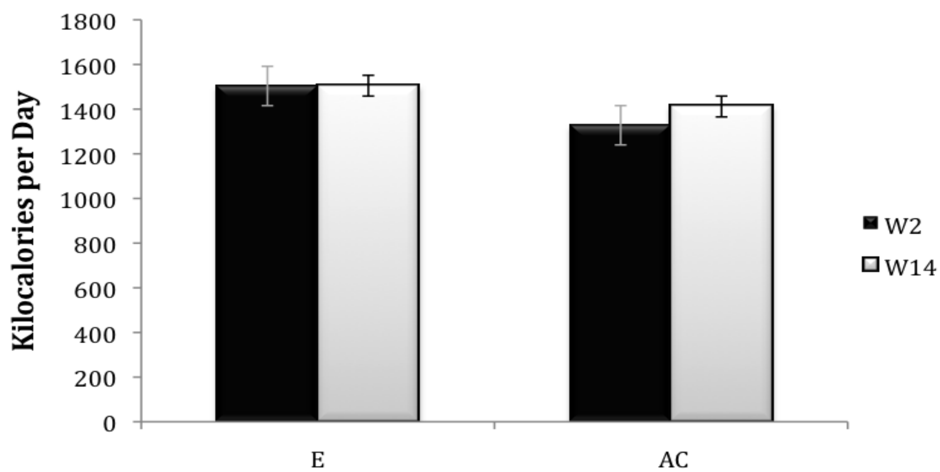

Figure 2. Resting Metabolic Rate. Data represent resting metabolic rate (RMR; kilocalories per day) expressed as mean (SE) for Endurance (E) and Active Control (AC) Groups at Week 2 (W2) and Week 14 (W14). No significance was observed over time for RMR in subjects (p > 0.05).

Performance Measurements

Changes in 1.5 mile run time across the 15 weeks of marathon training were compared by use of 2 x 2 ANOVA. While the E group subjects had faster times than the AC group at both time points, both groups decreased from baseline to W14 (E = 10:39 $\pm$ 0:20 vs 10:19 $\pm$ 0:22; AC = 14:48 $\pm$ 0:42 vs 13:50 $\pm$ 0:35). Additionally, estimated VO_{2max} values were predicted from run times and both groups significantly increased VO_{2max} from baseline ($p = 0.022$). Figure 3 shows estimated VO_{2max} values for the E and AC groups at W2 and W14. The group by time interaction effect was not significant, indicating that the slope of the change did not differ significantly between the two groups ($p = 0.677$). When comparing overall gender differences, males had higher VO_{2max} values than females at W2 and W14, although both genders increased estimated VO_{2max} values at W14 ($p = 0.002$)

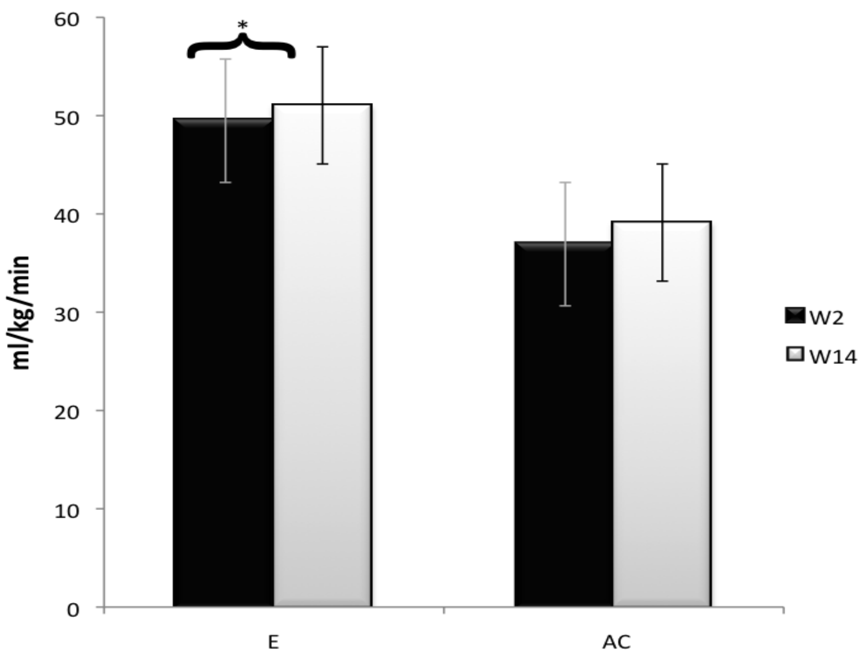

Figure 3. Estimated VO_{2max} . Data represent estimated maximal cardiorespiratory fitness (VO_{2max} ml/kg/min) expressed as mean (SE) for Endurance (E) and Active Control (AC) Groups at Week 2 (W2) and Week 14 (W14). The changes did not differ significantly between the two groups ($p > 0.05$). Both groups increased significantly from baseline to W14 ($p < 0.05$). * Indicates that the E group subjects have significantly higher ($p < 0.05$) VO_{2max} values than the AC group at W2 and W14.

Energy Expenditure

When compared, a statistically significant change in EE throughout the testing period was observed between the E and AC groups ($p = 0.005$). The differences in EE between the two groups over the fifteen weeks are illustrated in Figure 4. Both groups showed a significant decrease in EE at W14 when compared to W2 and W10 ($p = 0.000$). Only the E group significantly increased EE during W10 ($p = 0.009$). Furthermore, the E group had higher daily EE than the AC group at all testing points (E group, W2 = 534.70 $\pm$ 51.69, W10 = 630.49 $\pm$ 52.20, W14 = 263.55 $\pm$ 19.64; AC group, W2 = 350.99 $\pm$ 61.82, W10 = 344.78 $\pm$ 69.37, W14 = 201.60 $\pm$ 38.50 (measured in kilocalories)).

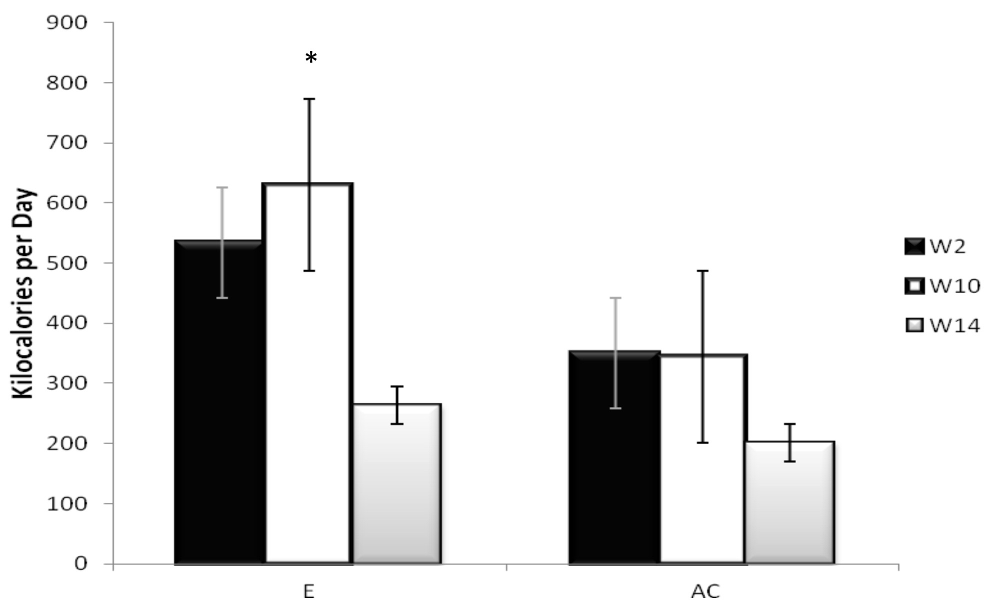

Figure 4. Energy Expenditure. Data represent energy expenditure (EE; kilocalories per day) expressed as mean (SE) for Endurance (E) and Active Control (AC) Groups at Week 2 (W2), Week 10 (W10), and Week 14 (W14). The E group reported higher EE rates than the AC group at W10. Both groups showed a significant decrease in EE at W14 when compared to W2 and W10 ($p < 0.05$). Only the E group significantly increased EE during W10 ($p < 0.05$).

Energy Intake

The main effect for time was not significant, indicating that EI did not vary significantly across time points. The time by group interaction was also non-significant indicating that the pattern of EI across time did not differ between the groups. Figure 5 illustrates the difference in EI between the two groups over the fifteen weeks. The E group had higher daily EI than the AC group at all testing points (E group, W2 = 2821.64 $\pm$ 268.05, W10 = 2450.84 $\pm$ 277.44, W14 = 2592.28 $\pm$ 272.83; AC group, W2 = 1882.46 $\pm$ 219.54, W10 = 2001.28 $\pm$ 183.65, W14 = 1952.76 $\pm$ 270.35 (measured in kilocalories)).

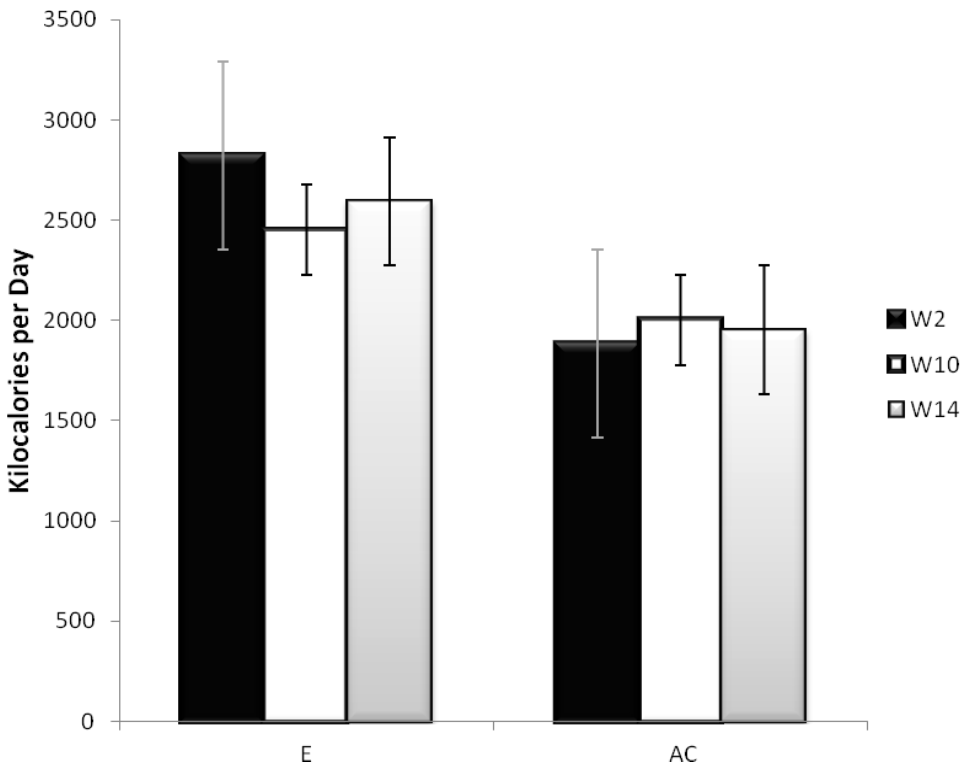

Figure 5. Energy Intake. Data represent energy intake (EI; kilocalories per day) expressed as mean (SE) for Endurance (E) and Active Control (AC) Groups at Week 2 (W2), Week 10 (W10), and Week 14 (W14). No significant changes in EI were observed for the E and AC groups from W2 and W14 ($p > 0.05$). No significant changes between the two groups over time ($p < 0.05$).

CHAPTER 5 – DISCUSSION

A number of participants in the E group lost body weight, but it is likely that they experienced a loss in fat-free mass (FFM) as well resulting in a decline or no change in resting metabolic rate (RMR) (33). The effects of both endurance and resistance training on RMR have been examined throughout the years; although, the effects of resistance training have been more consistent in showing improvements in RMR (27,29,33). Resistance training is suggested to increase RMR by increasing FFM, and it is well known that RMR is largely determined by FFM (33,43). Fat-free mass is considered to be a gold standard when predicting energy expenditure (44), thus it is common for investigators to adjust RMR per unit FFM to compare individuals of different body size or to estimate RMR from body composition (45) Our study did not incorporate resistance training into the program, nor did we collect body composition data to assess for fat-free mass, so it can only be speculated that the subjects in the E group lost body weight, and presumably both fat-free and fat mass, which could explain the decline or lack of change in RMR observed in some of the E subjects.

However, some studies have shown that fat mass also has the ability to significantly alter RMR. One study in particular, assessed the influence of fat mass and fat distribution on RMR in 164 women and 98 men aged 60 to 85 years with a BMI of 18.3 to 36.5 kg/m^2. (46). Results from this study showed that abdominal fat mass has a higher RMR than fat mass located in the gluteal-femoral region, independent of body composition. Nicklas et al. (47) showed that RMR adjusted for fat-free mass did not correlate with WHR or visceral fat mass in 29 obese women aged 52 to 72. There was; however, a positive correlation between waist circumference and RMR when adjusted for fat-free mass. Conversely, results from a literature review that included 31 data sets comprising a total of 1,111 subjects, reported body fat mass contribution was negligible when looking at RMR (43). Hallgren et al. suggest that adipose tissue may account for

~4% of 24-hour EE (48); these data combined suggest that the obviousness of RMR may be improved when fat mass is considered in addition to FFM. We were not able to examine the effects of fat-free mass nor fat mass in our subjects due to a lack of measure for body composition, aside from weight and WHR. Weight and WHR measures were taken pre- and post-training on the days the subjects came to the lab for RMR, however, no correlations between WHR and RMR were observed at W2: $r(21) = 0.277$, $p = 0.201$ nor W14: $r(21) = 0.304$, $p = 0.159$.

Though the results from previous studies examining the effects of endurance training on RMR have been mostly inconsistent, most are in agreement that transient increases in RMR are likely attributed to acute exercise bouts and only marginally related to chronic adaptations to exercise training (20,32). Furthermore, there seems to be a consensus that RMR is likely to be elevated during a state of energy balance when energy flux is high (32,37). Thus, the observation that RMR did not decline in the E group is important to consider, particularly during W10, when significant increases in EE were matched with decreases in EI (33,37). From these data, it is possible to assume that subjects in the E group experienced declines in their RMR at W10 during this point of low energy flux but RMR returned to pre-training levels during the taper period as a result of a restoration of energy balance, resulting in what appeared to be no effect of exercise on RMR. However, this can only be speculated as RMR was not assessed during W10, but instead only EE and EI measures were collected. To help control for the observed transient increases observed in RMR with acute exercise, all measurements were taken at least 48 hours after a bout of physical activity for all subjects and during the taper period for the E group in which training volume decreased. During the few weeks leading up to the marathon event, EE was not

significantly different from the AC group; in fact expenditure was very similar between the two groups at W14.

When comparing post-training differences in cardiorespiratory fitness between the two groups, pre-training fitness levels of the study participants should also be taken into consideration. The E group was instructed to run at least 3 days per week for a minimum of one month prior to initiation of marathon training in order to acclimate themselves to training, which could have resulted in increased cardiorespiratory fitness when compared to the AC group. It is well established that the degree of improvement in VO_{2max} with training is inversely related to pretrainingVO_{2max} (49). The magnitude of training response in young adults is also related to their level of physical activity prior to entering the study, the training stimulus applied (intensity, frequency, and duration of sessions), and duration of the program (50). Therefore, the E group may have been limited from gaining further improvements due to their pre-training fitness levels as compared to those in the AC group. Furthermore, cardiorespiratory fitness gains that occurred within the AC group, in spite of being instructed to maintain their current physical activity levels could have been due, in part, to the Hawthorne effect (51), which is very difficult to control for in studies. For instance, the AC group was informed that there would be a baseline and follow-up test for the timed 1.5 mile run which may have may resulted in training for improvement because they knew they were being tested.

When comparing gender differences between the two groups, the females in this study had lower VO_{2max} values than the males, which is consistent with previous research (52-53,54). The lower VO_{2max} values seen in females, when compared to males, are suggested to be a result of a lower hemogloblin levels and higher sex specific fat values (52-53). There is also direct anatomical evidence to show the differences observed between males and females in terms of

aerobic fitness. For instance, Mead (54) assessed the association between airway size and lung size and determined that women have airways that are approximately 17% smaller in diameter than are the airways men.

While energy expenditure declined from pre to post for both the E and AC groups, the decline was more pronounced at the end of training for the E group. This could have been due to the training load of the marathon training. Given that the E group was tested during the taper period, the training volume was significantly decreased thus leading to lower energy expenditures. Another possible explanation is that baseline measures were taken at the beginning of the semester for all participants, and the post measurements were obtained during the week of final exams for most participants. Throughout the stress of final exams (55), the participants were likely spending more time indoors studying as opposed to being active.

Another observed trend worth noting is the differences in caloric intake observed between the two groups. While none of the changes were significant, energy intake slightly decreased as the training load increased for the E group, which occurred during the tenth week of training. The energy intake slightly increased for the AC subjects during this time period, though there were no changes in expenditure from W2 and W10 for the AC group. From a training standpoint, it is possible that subjects in the E group may have been experiencing symptoms of overtraining syndrome around the W10 data collection time point. The term 'overtraining syndrome' is often used to describe athletes suffering from prolonged fatigue and underperformance. Athletes labeled as overtrained may complain of irritability, loss of appetite, and heavy and painful muscles (56).

This concept of overtraining syndrome may help to explain the decrease in EI observed in the E group during W10, in which EE was significantly increased. For instance, a recent study

examined the prevalence of nonfunctional overreaching/overtraining (NFOR/OT) in 376 young English athletes from 19 different sports and found that 29% of the athletes self-reported being NFOR/OT at least once in their sporting career, with the incidence of females being significantly higher than males. Of all the NFOR/OT symptoms reported, "often lose appetite/periods of hard training" made the list for the top seven most frequently reported symptoms. Another important finding from this study is that training load is not always the main factor for the development of NFOR/OT, and that it can occur at high rates even in athletes who are not exposed to high training loads (57). When considering the training load for our present study, it is likely that subjects in the E group felt symptoms of overtraining.

From a behavioral standpoint, W10 of testing occurred during the same time as midterm exams for the students, which is often a stressful time period for college students (55), and could have led to behavioral changes in respect to eating. The influence of exercise on individuals' responses to stressful events has previously been documented (58), as well as the effects of stress on eating behaviors. When stressed, some individuals increase their food consumption (59) and others decrease consumption (60). It is also suggested that individuals also alter the types of foods they consume when stressed, in particular increase consumption of highly caloric sweet and fatty snack foods (61). These findings may helps to explain the variations observed in EI between subjects.

To help alleviate the anticipated feelings of fatigue, overreaching, and loss of appetite within the E subjects, a taper period was incorporated into the 15-week program. The training plan included 3 runs each week with one supervised long run and cross training on the weekend days. The runs progressed in distance each week and time varied depending upon each individual's running pace, and incorporated a taper period three weeks prior to the marathon

event. During the taper period, the subjects reduced training volume, but intensity and frequency remained unchanged. According to a meta-analysis of six databases, the optimal strategy to optimize performance is a tapering period of two weeks, where the training volume is decreased by 41% - 60% without any modification of either training intensity or frequency (62). It also been shown that athletic performance is improved or maintained with a 60% - 90% reduction in weekly training volume during a 6 to 21 day taper period, primarily due to an enhanced ability to exert muscular power (63). These data aid in confirmation that the three week taper period (reduced volume though intensity and frequency remained unchanged) from our study was sufficient in reducing the negative consequences accrued with daily training while allowing the participants to maintain performance.

There are many variations in the meaning for the taper period of training. Previously taper was referred to as “an incremental reduction in training volume for 7-21 days before a championship race” (64,65), and “specialized exercise training technique which has been designed to reverse training-induced fatigue without a loss of training adaptations” (64,66). More recently in the literature, the taper has been redefined as “a progressive nonlinear reduction of training load during a variable period of time, in an attempt to reduce physiological and psychological stress of daily training and optimize sports performance” (64,67). The primary goal of the taper is to reduce the negative impact of daily training, such as accumulated fatigue, rather than to achieve further positive consequences of training, such as fitness gains (64). It has been deduced from previous data (64,68) that performance gains during the tapering periods are mainly related to the marked reductions in negative influences of training. This suggests that an athlete should achieve most or all expected physiological adaptations through daily training prior

to the start of the taper period, thus making improved performance adaptations apparent as soon as the accumulated fatigue fades (64,68).

Our current study includes several limitations worth mentioning. First, subjects were mostly female (n = 17) with few males (n = 7), resulting in uneven distribution of treatment between the two groups. For instance, the AC group (M = 2, F = 10) has very few males by comparison to the E group (M = 5, F = 7). Noncompliance was the greatest limiting factor within the study, resulting in the exclusion total of 22 subjects, including six males. Eight males were recruited into the AC group, but two of them withdrew themselves from the study and four were excluded from the analyses due to missing data. Twenty females were recruited into the AC group, but 3 withdrew themselves from the study and 7 were excluded due to non-compliance, (i.e. relapse in cessation of smoking, failure to complete diet recall, etc.), leaving a total of 12 subjects in the AC group (M = 2, F = 10). Of the participants in the E group, a total of six were excluded in the final data analyses for various reasons, but all subjects completed the marathon with the exception of one female whom withdrew herself from the class. Two females and one male participant were dropped from E group due to non-compliance, leaving a total of 12 subjects in the E group (M = 5, F = 7). Data were skewed for one male and one female in the E group thus voiding their data from analyses.

While accelerometers can be useful tools to capture EE in individuals, it has been suggested that accelerometer devices may underestimate EE of certain activities, such as resistance exercise, or overestimate activities such as sprinting (69). A recent study revealed that the RT3 triaxial accelerometer underestimated EE by as much as 30% - 60% when compared with measurements based on indirect calorimetry while performing resistance exercise (69). Furthermore, prior studies have confirmed that triaxial accelerometers are valid for measuring

overall daily energy expenditure (particularly exercises like walking and jogging) (69-71); however it is possible that the accelerometers used in this study did not detect physical activity during resistance training workouts (69). It is also possible that the accelerometers underestimated EE from certain activities of daily living, particularly those activities requiring isolated upper body movement (69).

Another shortcoming in our data collection is the reliance on self-reported 24-hour diet recalls to assess energy. Underreporting of food intake is a commonly documented problem within the literature (72-74). Edwards et al. (72) observed consistent underreporting of EI in female intercollegieate distance runners. The data of this current study are also suggestive of underestimation of EI considering that body weight was not significantly altered within the E group, despite the reported EI being much lower than EE. Different factors may play a role in the ability and willingness to report various foods, such as age, body weight, concern about diet and body weight, and social desirability (74).

CHAPTER 6 – CONCLUSION

Improvements in cardiorespiratory fitness are also likely to occur over the course of fifteen weeks of marathon training; however, the pre-training fitness levels of individuals should be taken into consideration when assessing the magnitude of change after training. Additionally, the changes in EE and EI, and the increase in VO2max observed in the AC, when compared with the E group, may indicate that an uncontrollable factor may have been involved.

In summary, endurance training may not lead to overcompensation in young, healthy, and active adults. Furthermore, endurance training led to increases in EE and aerobic fitness, but no significant changes in body weight, energy intake or resting metabolic rate were observed after the 15-week training period.

Future Directions

Future research should continue to focus on better methods of assessing energy expenditure in free-living conditions. Accelerometers are useful and non-invasive; however, for this particular study in college-aged individuals, compliance was very low in regards to the subjects wearing the accelerometers for the required time period. The subjects were given the accelerometers to wear nonstop for seven consecutive days. The goal was to capture at least four days of wear-time data for an accurate representation of physical activity patterns. Due to the number of noncompliant subjects, it was reduced to a minimum of three days.

Furthermore, due to the commonly documented problem of underreporting of food intake, relying on self-reported data for energy intake can distort the interpretation of results from studies. Recently in the literature, camera-enabled cell phones have been to shown to provide an opportunity to strengthen dietary recalls through automated imaging (75). This can

also help to reduce the burden of strict record-keeping of on the participant, thus improving retention rates of studies.

To better determine the effects of marathon training on body composition, future studies may include dual-energy X-ray absorptiometry (DXA) as a means of measuring total body composition and fat content. It would also be interesting to see the correlation between negative energy balance combined with high training load and bone mineral density, as weight loss induced by calorie restriction has been associated with reduction in bone mineral density (76).

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APPENDIX 1

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

Physical Activity Readiness Questionnaire

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 and 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 any other reason 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 all 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.

Informed Use of the PAR-Q: 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
or GUARDIAN (for participants under the age of majority) ______________________ WITNESS ________________________

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.

 Supported by: Health Canada Santé Canada

continued on other side...

24-Hour Diet Recall

Subject Number __________ **Date _______________**

Day of the Week ___________________

Time	Food	Quantity	Brand Name	Preparation

APPENDIX 2

LSU IRB Approval

ACTION ON PROTOCOL APPROVAL REQUEST

Institutional Review Board
Dr. Robert Mathews, Chair
131 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.6792
irb@lsu.edu | lsu.edu/irb

TO: Laura Stewart
Kinesiology

FROM: Robert C. Mathews
Chair, Institutional Review Board

DATE: March 7, 2012
RE: **IRB#** 3219
TITLE: Endurance Training and Energy Balance

New Protocol/Modification/Continuation: Modification

Brief Modification Description: Addition of the Function Movement Screen

Review type: Full ___ Expedited X **Review date:** 3/8/2012

Risk Factor: Minimal _______ Uncertain X Greater Than Minimal_______

Approved________ **Disapproved** ___________

Approval Date: 3/8/2012 **Approval Expiration Date:** 11/3/2012

Re-review frequency: (annual unless otherwise stated)

Number of subjects approved: 80

Protocol Matches Scope of Work in Grant proposal: (if applicable) N.A.

By: Robert C. Mathews, Chairman Robt C Mathews

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. SPECIAL NOTE:

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

1. Study Title: Endurance Training And Energy Balance Study

2. Performance Site: **Louisiana State University**
   Baton Rouge, LA 70803

3. Investigators: The following investigators are available for questions about this study, M-F, 8:00 a.m.-4:30 p.m.

   Principal Investigator: Laura K. Stewart, Ph.D. 225.578.3549

   Co-investigator: Brittany Inlow, B.S. 225.505.6315

   Birgitta Baker, Ph.D. 225.578.9232

4. Purpose of the Study:

   The purpose of this research project is to examine the effect of a 15 week intensive marathon training program on energy balance in young adults.

5. Subject Inclusion:

   Participants in both the control and training groups must be at least 18 years of age, currently enrolled as students at LSU and not pregnant. Students in the training group must have medical clearance following a complete comprehensive physical from a State licensed M.D. or D.O. The cleared student must provide documentation of permission by returning a signed "Physician Approval Form" after the physical and before participating in the study. All participants (both groups) must complete a health history and a physical activity readiness questionnaire (PAR-Q) before participating.

   Number of subjects= 80 (Endurance Training Group (n=40) and Active Control Group (n=40))

6. Study Procedures: This project will be 15 weeks in duration. All members of the active control will participate in the measures below and continue their normal activity and dietary patterns. Members of the endurance training group will complete a 15 week marathon training program. All measures below will be taken from all subjects at the time points specified below.

   Descriptive Measures

   These measures will be taken during Week 1 and Week 14 and will include height, weight, blood pressure and heart rate. At this time, you will also fill out a health history and physical activity questionnaire. Hip and waist circumference will be measured using a Gullick tension tape.

1.5 Mile Run/Walk

These measures will be taken during Week 1 and Week 14 and include an assessment of your physical fitness will be estimated by having you perform a 1.5 mile run/walk test. This test will require you to run 1.5 miles at a maximal effort.

Indirect Calorimetry

Resting metabolic rate (RMR) will be measured for 30 minutes. The RMR testing portion of the study will take place during Week 2, Week 10, and Week 14. You will be instructed to report to the lab in the kinesiology building having been fasting for 12 hours, euhydrated, and having refrained from exercise (for 48 hours), caffeine, or alcohol for at least 24 hours.

Accelerometer and Pedometer Measures

Assessments of your energy expenditure will be estimated by having you wear an accelerometer and pedometer for seven consecutive days during Week 2, Week 10, and Week 14 of the training period. You will be instructed on how to properly apply and wear the accelerometer prior to initiation of this procedure.

Dietary Assessment

Also, throughout the 15 week training period (Week 2, Week 10 and Week 14), you will complete diet recall logs. You will receive instructions for completing a seven-day diet record to estimate habitual energy and macronutrient intakes.

Functional Movement Screen™

You will perform the Functional Movement Screen (FMS) ™ at weeks four and 14. The FMS™ is a seven-part screening tool used to determine inefficient and asymmetrical movement patterns. The FMS™ is used to determine susceptibility to injury over the course of an athletic season or training period. This measure will take approximately 30 minutes. You will perform and be evaluated on the following movement patterns:

1. Overhead Squat- subjects will hold a PVC dowel horizontally overhead and perform a squat. Squat technique will be evaluated.

2. Hurdle Step- subjects will hold a PVC dowel horizontally across the back of the shoulders and step over a plastic band that is placed just below the kneecap. Hip movement and balance will be evaluated bilaterally.

3. In-line Lunge- subjects will hold a PVC dowel vertically behind their back and perform a lunge. Lunge technique will be evaluated bilaterally.

4. Shoulder Mobility- subjects will reach one arm behind their head and one arm behind their low back. Distance between hands will be evaluated bilaterally.

5. Active Straight Leg Raise- subjects will lie on their back and actively raise one leg as high as possible. Range of motion will be evaluated bilaterally.

6. Trunk Stability Push-up- subjects will lie on their stomach and perform a push-up. Technique will be evaluated.

7. Rotary Stability- subjects will assume a quadruped position (on hands and knees) and raise the same or opposite arm and leg. Balance will be evaluated.

7. Benefits:

While no guarantee of benefits can be made, you will be given training instruction and assessment of your balance and strength at no cost to you. You may also learn more about your physical capacity for endurance and should significantly improve your aerobic fitness. Subjects will be provided a comparison of his/her pre-training and post-training results at the end of the semester.

8. Risks/Discomforts:

Exercise Training & Testing: As with any exercise program, there is a chance that you will experience muscle soreness, fatigue, or even injuries such as sprains or strains. There is also a remote risk of a heart attack or stroke and in very rare cases, death. Precautions to minimize this risk have been taken by requiring medical clearance to participate as well as completion of a health history questionnaire. Your cooperation in obtaining approval from your physician as well as providing honest answers in completing the health history form will decrease this risk.

Accelerometers and Pedometers: There is a slight chance of skin irritation and discomfort from wearing these devices, but if present, the discomfort should be minimal.

In addition to the risks listed above, you may experience a previously unknown risk or side effect.

9. Injury/Illness: In the unlikely event of injury or medical illness resulting from the above procedures, contact **Laura Stewart, Ph.D., 225-578-3549**. You will be referred for treatment, but the expense of medical treatment will be your responsibility. No compensation is available in case of study-related illness or injury.

11. Right to Refuse: You may choose not to participate or to withdraw from the study at any time without penalty or loss of any benefit to which you might otherwise be entitled.

12. Privacy: Your identity will remain confidential unless disclosure is required by law. In other words, data will be kept confidential unless release is legally compelled. All data collected will be handled only by the investigators and kept in a secure location. Results of the study may be published using group means only and names or identifying information will not be included in the publication.

13. Financial Information: There is no cost to you, nor is there any compensation for participating in the study.

14. Signatures: The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have any questions about subjects' rights or other concerns, I can contact Robert C. Matthews, Institutional Review Board at (225) 578-8692. I agree to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

______________________ ______________

Participant's Signature Date

The study subject has indicated that s/he is unable to read. I certify that I have read this consent form to the subject and explained that by completing the signature line above, the subject has agreed to participate.

______________________ ______________

Reader's Signature Date

Study Approved By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Approval Expires: 11/3/2012

VITA

Brittany was born in November of 1985 in Baton Rouge, Louisiana. She graduated with honors from high school in 2004 and attended Louisiana State University, majoring in nutritional sciences. During this time, she worked as a student worker at Pennington Biomedical Research Center under Dr. Jennifer Rood in the Clinical Chemistry Core, where she gained experience in working in a laboratory.

Upon earning her degree in the spring of 2008, she applied for a full-time position as an analyst in the Imaging Department at Pennington Biomedical Research Center. During her time in the Imaging Department, she has gained knowledge in the analysis of MR spectroscopic and visceral fat data, as well as performing various procedures within the department, such as optical spectroscopy, peripheral arterial tonometry, and dual-energy X-ray absorptiometry. She also serves as the Quality Improvement officer for the department and has recently begun assuming Clinic Coordinator position as well.

In spring of 2010, she decided to take a few classes within the Kinesiology Department as a nonmatriculating student. During this time, she enrolled in the class entitled The Physiology of Endurance Training, and found a passion for research, sports performance, and distance running.

She decided to further her education and applied to the Kinesiology Department at Louisiana State University, under the mentorship of Dr. Laura Stewart in spring of 2012. With the help of Dr. Stewart, Brittany began her thesis project in the spring of 2012. She will defend her thesis in the summer of 2012 in order to be awarded a Master of Science in Kinesiology.

Brittany's immediate future plans are to fulfill her obligations at Pennington Biomedical Research Center. She then plans to explore her options for furthering her education to the doctoral level. As of now, she is most interested in the areas of Public Health and Health Promotion.