ENERGY BALANCE AND RUN PERFORMANCE IN ELITE COLLEGIATE MALE AND FEMALE CROSS COUNTRY RUNNERS

A thesis submitted in partial fulfillment of the requirements
For the degree of Master of Science in
Family and Consumer Sciences

by

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May 2014
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ACKNOWLEDGEMENTS

I would like to acknowledge and sincerely thank the investigators on the University of California, Los Angeles and Stanford research teams. Additionally, I would like to thank the study participants who took time to be involved in the project. I would like to express my deepest gratitude to my committee members, Drs. Claudia Fajardo-Lira and Terri Lisagor, and especially to my committee chair, Dr. Michelle Barrack, each of whom have put in a great deal of work in editing and providing critical feedback for this thesis.
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ABSTRACT

ENERGY BALANCE AND RUN PERFORMANCE IN ELITE COLLEGIATE MALE
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Elite collegiate endurance runners undergo strenuous training and racing, which expends high amounts of energy. In the absence of adequate energy replacement, in the form of meals or snacks, athletes may risk fatigue, illness, and injury, which may negatively affect run performance. Research is needed to establish the role of proper fueling in endurance running performance. The primary purpose of this thesis was to evaluate potential relationships between energy balance (EB) and run performance among NCAA Division I male and female collegiate cross country runners. During the Fall 2013 season, baseline questionnaires, evaluating anthropometric, health, and run performance times, were completed by 49 UCLA and Stanford cross-country team volunteer subjects, including 19 females and 30 males. Runners then completed three, unannounced 24-hour dietary recalls and submitted a 7-day exercise log to provide information regarding their energy intake and exercise energy expenditure. Food intake information was entered into the Food Processor SQL Nutrition software (ESHA) to obtain mean daily energy intake (EI). The American College of Sports Medicine Compendium of Physical Activities converted runners’ exercise training to mean daily exercise energy expenditure. Additionally, runners’ total daily energy expenditure (TDEE) and energy balance (EB) were
determined. Run performance data was collected from baseline questionnaires and from the university cross country teams’ Fall 2013 season results web pages. Female subjects’ personal best 6k times were converted into 8k male equivalent times to allow for analysis of the sample as a whole. The chi-square, independent sample t-tests, and Pearson correlation tests, were used to determine any relationship between indicators of energy status and cross-country performance times among the male and female endurance runners. No significant relationship was found between the main independent variable (EB) and our dependent variable (Fall 2013 best performance). Yet, in a supplementary analysis, we found that among male endurance runners, weekly mileage was significantly correlated with Fall 2013 performance times. This study points to a need for further research, with larger samples of male and female athletes, to further establish the relationship between indicators of energy balance and run performance among elite endurance runners.
CHAPTER 1
INTRODUCTION

Elite collegiate cross country runners expend large amounts of energy during run
workouts, strength training sessions, races, and even while physically at rest. In order to
meet high energy demands and fuel their bodies adequately for optimal muscle repair,
glycogen replenishment, and other metabolic processes, elite distance runners must
consume sufficient energy from food. If energy needs are not met, athletes risk a number
of adverse effects including fatigue, decreased mental focus, illness, and injury.
Unbalanced energy status may also lead to run performance losses.

Elite female cross country runners, as competitive endurance athletes, are
particularly susceptible to developing low energy availability and consequent conditions
(Nazem & Ackerman, 2012; ACSM, 2007). For elite female endurance runners, social
and competitive pressures to be thin are coupled with especially high energy expenditures
during training and competitions, increasing the risk of developing an energy deficit—
whether intentional or unintentional. Dietary restriction and disordered eating habits are
common intentional habits resulting in low energy availability. Some causes of
unintentional low energy availability include sudden increased exercise and energy
expenditure, lack of nutritional education or awareness, lack of time and/or resources,
and suppressed appetite (Nazem & Ackerman, 2012).

Among runners with the female athlete triad, irregular hormone levels,
amenorrhea, bone fragility, and nutrient deficiencies associated with low energy
availability are speculated to impact athletic performance. For example, athletes with
low bone mineral density (BMD) are more injury-prone and forced to miss crucial training sessions or even entire competitive seasons. Such athletes would likely face substantial setbacks and perhaps performance losses when compared to other athletes with optimal BMD. Notably, a recent study of high school female athletes found that disordered eating habits (likely associated with low energy availability) more than doubled athletes’ likelihood of suffering a sports-related injury over the course of a season (Thein-Nissenbaum, Rauh, Carr, Loud & McGuine, 2011).

Aside from the indirect effects on females’ athletic performance through amenorrhea and low BMD, low energy availability has a more-direct negative impact on run performance due to coexistent vitamin and mineral deficiencies, which may limit muscular contraction capabilities, endurance, and recovery. Finally, the lack of sufficient macronutrient intake for those with low energy availability may lead to, among other issues, insufficient glycogen replenishment and muscle protein synthesis after training sessions and competitions. Such effects would not be limited to females exhibiting triad characteristics, and would apply to athletes of either gender.

While the aforementioned deleterious effects of low energy availability on athletic performance may be speculated, limited research has been done to specifically explore or quantify the relationship between energy availability and athletic performance in athletes.

**Purpose**

The larger study will examine the effect of a nutrition intervention on energy availability, anthropometric measures, bone mass density, menstrual function (among the females), and the incidence of bone stress injury among male and female cross country
runners from UCLA and Stanford University. The data used for this thesis will be extracted from the baseline data collection of the described study. The primary purpose of this thesis will be to examine the relationship between energy balance (EB) and run performance in male and female collegiate cross country runners. It is hypothesized that male and female collegiate elite cross country runners with neutral and/or positive EB will have faster peak run performance times and more likelihood of achieving lifetime best times during the Fall 2013 season, while those with negative EB will be more likely to have slower times and less likely to attain lifetime personal best times.

**Definitions**

1) Amenorrhea- The “absence of menstrual cycles for more than 90 days” (ACSM, 2007).
   a) Primary Amenorrhea- The “absence of menstruation by age (16) years in girls with secondary sex characteristics” (ACSM, 2007)
   b) Secondary Amenorrhea- Amenorrhea occurring after menarche, generally with “the absence of at least three consecutive menstrual cycles” (ACSM, 2007).

2) Disordered eating- “Various abnormal eating behaviors, including restrictive eating, fasting, frequently skipped meals, diet pills, laxatives, diuretics, enemas, overeating, binge-eating and then purging” (ACSM, 2007).

3) Energy Balance (EB)- Total daily energy intake (EI) minus total daily energy expenditure (TDEE).
   a) Negative Energy Balance- Defined in the current study as energy intake (EI) <95% of total daily energy expenditure (TDEE).
4) Energy Availability (EA)- “Dietary energy intake (EI) minus exercise energy expenditure (EEE), normalized to fat-free mass (FFM),” expressed as kilocalories or kilojoules per kilogram of fat-free mass (ACSM, 2007).
   a) Low Energy Availability- Approximated at <30 kcal/kg lean body mass per day (ACSM, 2007).
5) Energy Expenditure (EE)- Total energy expenditure, defined by summing EEE, NAEE, and REE.
6) Energy Intake (EI)- Total daily amount of energy ingested from food/beverages.
8) Fat Free Mass (FFM)- Total amount of body mass not composed of fat tissue.
9) The Female Athlete Triad- The most current triad definition describes relationships between three interrelated components including low energy availability, functional hypothalamic amenorrhea, and osteoporosis. Each criterion is evaluated along a continuum of levels, ranging in severity from the ideal points of “optimal energy availability,” “eumenorrhea,” and “optimal bone health” to serious disease (ACSM, 2007).
10) Low bone mineral density (BMD)- BMD Z-score < -1.0 and ≥ -2.0.
11) Non-exercise Activity Energy Expenditure (NAEE)- Energy used during non-exercise activities such as metabolizing, driving, etc. This is determined using an activity factor. The activity factor used in the current study was 0.7.
12) Osteoporosis - BMD Z-score less than or equal to 2.0 “and secondary risk factors for fracture (e.g. undernutrition, hypoestrogenism, prior fractures)” (ACSM, 2007).

13) Resting Energy Expenditure (REE) - Energy expended at rest and used to sustain basal metabolic processes, determined using the Harris Benedict Equation.

14) Total Daily Energy Expenditure (TDEE) - Total energy expended in exercise and non-exercise activities, or the sum of EEE and NAEE.

Assumptions

In conducting this study, we will assume the following:

- Our sample of undergraduate male and female runners from University of California - Los Angeles (UCLA) and Stanford University will appropriately represent the NCAA Division 1 male and female cross country runner population.

- Self-reported dietary intake and exercise output information will accurately reflect male and female runners’ energy input and expenditure.

Limitations

We recognize there are limitations to the current study, which include a small sample size, self-reported dietary and exercise data, uncontrolled subject environmental factors, data analysis software limitations, between-subject competition, subject dropout (due to the high physiological demands and likelihood of injury during the cross country season), outside factors affecting performance (such as genetics, sleep, stress, etc.), and human researcher calculation errors. Due to variations in terrain, altitude, and difficulty among cross country courses, some error may be attributable to course inconsistencies between runners’ personal lifetime and in-season best races performances.
CHAPTER 2
REVIEW OF LITERATURE

Introduction of the Collegiate Endurance Runners

Typically, collegiate runners train five to seven days per week, often running multiple times per day. Additionally, many collegiate running teams complete a strength training regimen multiple times per week, and may even perform some sort of endurance cross-training such as biking or swimming. During the collegiate cross country season, which generally lasts about three months during the fall, athletes may have the opportunity to compete in approximately five-to-ten races, depending on health and qualification status.

Endurance running is classified as a “leanness sport” as it favors athletes with efficient body composition and minimal resistance. Thus, some distance runners strive to lose weight hoping to perform better. Considering the extreme energy needs of athletes often training multiple times per day, nearly every day, added pressures to lose weight can be especially dangerous. Some endurance runners, and especially female runners, develop disordered eating habits, which may lead to decreased bone mass and subsequent performance-degrading injury. Notably, a prevalent condition among female endurance athletes, known as the Female Athlete Triad, encompasses the spectrums of low energy availability, reduced bone mineral density, and reproductive health problems (Loucks, 2007).

Nutrition plays a key role in collegiate endurance runners’ performance and exercise recovery (ACSM, 2009). Consequently, athletic trainers, strength and
conditioning specialists, and other professionals in sports nutrition, are frequently employed by collegiate athletic departments. Despite the critical role of nutrition in sports performance and access to knowledgeable athletic trainers and strength and conditioning specialists, the majority of collegiate athletes and coaches are not adequately educated in sports nutrition (Torres-McGehee, Pritchett, Zippel, Minton, Cellamare, & Sibilia, 2012).

**Fueling Recommendations for Optimal Endurance Sport Performance**

In order to perform optimally, endurance runners must take in adequate energy to fuel exercise and to maintain ideal body weight and composition (ACSM, 2009). When runners’ total energy intake (EI) matches total energy expenditure (EE), energy balance is achieved. EI includes energy from all liquid, solid, and supplemental sources, and EE includes energy used through metabolism, digestion, and all forms of activity (ACSM, 2009). In an unbalanced energy state, where EI does not adequately meet EE, runners’ training benefits and performance are compromised (ACSM, 2009). This is attributed to the body’s use of fat and muscle tissue for fuel in energy-deficient states, which leads to reduced muscle mass, bone loss, fatigue, decreased strength, and even suppressed immune and endocrine function (ACSM, 2009).

Energy Intake incorporates consumption of the three macronutrients: carbohydrates, proteins, and fats. Carbohydrates are crucial for sustaining blood glucose levels in exercise athletes, as well as for use as muscle glycogen. Factors contributing to individual athletes’ specific carbohydrate requirements include sport type, total daily
energy needs, gender, and environment (ACSM, 2009). Protein is needed for muscle maintenance and hypertrophy. Fat is a vital source of energy and micronutrients.

Under-consumption of foods and their corresponding macronutrients is directly linked to under-consumption of the micronutrients in those food sources. Because restricting EI involves limiting micronutrient intake, low energy consumption may lead to micronutrient insufficiencies and associate diseases (ACSM, 2009). Endurance runners should take care to meet the recommended dietary allowance (RDA) for all micronutrients by consuming balanced diets with nutrient-dense foods.

Endurance runners should make an effort to take in regular sources of the B vitamins, vitamin C, vitamin D, vitamin E, calcium, iron, zinc, magnesium, and selenium. Supplementation may be beneficial to runners concerned about taking in adequate micronutrients. Specifically, athletes with food allergies, sensitivities, or ethical dietary limitations may limit entire food groups and corresponding micronutrients, and may benefit from supplementation. Yet, for athletes with adequate, nutrient-dense diets, supplementation has not been shown to enhance performance (ACSM, 2009).

Aside from the overall macro- and micro-nutrient quotas which endurance runners must meet, specific nutrient needs must be met before, during, and after workouts and competitions in order to fuel their bodies for optimal performance. Optimal fueling during these times involves the consumption of proper fluid, salt, carbohydrate, and protein sources at proper times and in proper proportions (ACSM, 2009). Appropriate fueling benefits athletes’ hydration, maintenance of blood glucose, and muscle recovery efficiency (ACSM, 2009).
Pre-exercise fuel for endurance runners should include fluid for adequate hydration, a high proportion of carbohydrate to top off blood glucose levels, a moderate proportion of protein, minimal proportions of fat and fiber (ACSM, 2009). Runners should not eat unfamiliar or gastro-intestinally distressing foods prior to exercise. Throughout an exercise bout lasting an hour or more, endurance runners should aim to maintain hydration and blood glucose, with fluids and carbohydrates, as much as possible without causing gastro-intestinal. Post-exercise, runners should aim to replace additional fluids and salts lost to restore optimal hydration. Additionally, after exercise, runners should begin the recovery processes of restoring muscle glycogen and repairing muscle tissue by consuming carbohydrate and some protein. This refueling period should be as close to the commencement of exercise as possible—ideally within 30 minutes post-exercise (ACSM, 2009).

**Common Goals of the Endurance Athlete**

Optimizing body weight and/or composition can be helpful in enhancing endurance sport performance (ACSM, 2009). Optimal body weight and/or composition vary from athlete to athlete, and from sport to sport, based on gender, genes, size, and sport-specific demands. Endurance runners can benefit from reaching an “ideal” weight/composition by improving endurance, speed, strength, and agility. This “ideal” may be determined by recording an athlete’s weight and composition when performing at peak. Yet, athletes should avoid restricting energy too much or too quickly due to the potentially negative effects of extreme fat and muscle loss on performance and overall health (ACSM, 2009). Additionally, it is recommended that athletes aim to make body
weight and/or composition changes during the off-season to avoid detriments to training and performance.

**Endurance Sports and Low Energy Availability**

When energy output is not adequately matched with energy intake, low energy availability, in which minimal energy is available for use by the body, may occur. Disordered eating, dieting or unintentional energy deficiency may lead to low energy availability. Athletes in sports involving components of endurance, aesthetics, and/or weight classes, or with a particular performance-related body size and/or composition goal are particularly susceptible to energy deficiency (Loucks, 2004). Whether due to intentional or unintentional under-fueling, low energy availability is an especially prevalent issue for endurance athletes with high energy output over training sessions, competitions, and even during recovery from exercise.

Some athletes habitually and purposely under-eat, and may develop clinical eating disorders (Loucks, 2007). Endurance athletes, including marathon runners, often have low energy availability due to purposely decreasing energy intake, through dieting or various types of disordered eating habits, to attain a desired body size and/or composition for performance benefits (Loucks, 2007).

Disordered eating is common even among high school-aged athletes (Thein-Nissenbaum, Rauh, Carr, Loud, & McGuine, 2011). Without adequate attention and treatment, high school athletes may carry unhealthy, highly energy-restrictive, eating patterns into their college athletic careers.
Female athletes are more likely to under-eat, and thus face low energy availability, than men due to reasons beyond sports performance (Loucks, 2007). Female collegiate athletes and non-athletes alike exhibit symptoms of disordered-eating (Reinking & Alexander, 2005). In fact, among lean individuals, women are nearly nine times as likely as men to be pursuing weight-loss (Loucks, 2007). This discrepancy is attributed to the increased tendency of females to perceive their bodies as overweight (Loucks, 2007). Furthermore, female athletes participating in sports emphasizing leanness have been shown to be at greater disordered eating risk than their non-lean sport female athlete counterparts (Reinking & Alexander, 2005).

Another cause of low energy availability among endurance athletes is inadvertent undercompensating for exercise energy expenditure (Loucks, 2007). Some athletes simply do not nourish their bodies properly due to the lack of hunger signal response to the energy losses during training (Loucks, 2007). Endurance athletes should not rely on hunger signals alone as indicators of energy needs, but should “eat by discipline beyond their appetites” (Loucks, 2007).

Energy deficiency negatively impacts athletic performance and overall health (Loucks, 2004). Limiting energy intake may cause decreased resting metabolic rate (ACSM, 2009), decreased bone formation and increased bone resorption (Ihle & Loucks, 2004), and increased musculoskeletal injury risk (Gerlach, Burton, Dorn, Leddy, & Horvath, 2008).

In junior elite female swimmers, energy deficient statuses were strongly correlated with poorer 400-meter swim performances (Vanheest, Rodgers, Mahoney, &
De Souza, 2013). This correlation was linked to the energy conservation state—a decrease in metabolic hormones—caused by energy restriction and low energy availability (Vanheest, Rodgers, Mahoney, & De Souza, 2013).

Endurance runners hoping to maintain bone health for optimal performance should avoid energy deficiency. Energy restriction causes decreased bone formation and increased bone resorption (Ihle & Loucks, 2004). The combination of bone loss and lessened bone growth pose a severe threat to the bone development of young women. In active premenopausal women with adequate energy status, normal bone formation and resorption function have been observed (De Souza, West, Jamal, Hawker, Gundberg, & Williams, 2008). Contrastingly, active women with energy deficiency and corresponding estrogen deficiency experienced decreased bone formation and increased bone resorption—and consequent bone loss (De Souza, West, Jamal, Hawker, Gundberg, & Williams, 2008).

In otherwise healthy athletes, whether recreational or elite, low dietary calcium intake—a potential side effect of under-eating—has not been shown to increase stress fracture risk independently (Bennell, Matheson, Meeuwisse, & Brukner, 1999). However, disordered eating behavior has been linked to heightened stress fracture risk in athletes (Bennell, Matheson, Meeuwisse, & Brukner, 1999). Bone injuries and subsequent lapses in training would likely have negative effects on endurance runners’ performance. While endurance runners with energy availability risk reproductive and skeletal health consequences, genes and age may alter the degree of health impairment (Loucks, 2007).
Low energy intake and/or availability have been linked—though not significantly—with overuse injury (Gerlach, Burton, Dorn, Leddy, & Horvath, 2008). Among female high school athletes, disordered eating—a common cause of low energy availability—has been highly correlated to musculoskeletal injury occurrence. Throughout a 2006-2007 high school sports season, sports-related injury incidence was twice as high for female athletes with a self-reported eating disorder (Thein-Nissenbaum, Rauh, Carr, Loud, & McGuine, 2011). Moreover, menstrual irregularity—a common symptom of low energy availability—has also been linked to increased severe musculoskeletal injury prevalence among high school female athletes (Thein-Nissenbaum, Rauh, Carr, Loud, K.J., & McGuine, 2012). This increased severe injury risk may lead to increased time away from training, and subsequent performance loss.

The Female Athlete Triad in Endurance Sports

Whether resultant of intentional or unintentional under-compensatory eating, female athletes have an increased predisposition towards low energy availability, reproductive health complications, and decreased bone mineral density (Loucks, 2007). The combination of these three health conditions is commonly exhibited in Female Athlete Triad cases (ACSM, 2007). The American College of Sports Medicine (ACSM) first recognized and identified the Female Athlete Triad in 1992 (Nazem & Ackerman, 2012) as a syndrome involving three interrelated components: disordered eating, amenorrhea, and osteoporosis. The original definition has evolved to reflect advances in scientific observations. For example, “low energy availability” rather than “disordered eating” is now used in classification of the triad to include athletes with insufficient
energy intake unrelated to disordered eating behaviors. The current definition also includes “functional hypothalamic amenorrhea” in order to distinguish athletes with amenorrhea specifically due to inadequate energy intake rather than other clinical disorder causes, such as Polycystic Ovarian Syndrome.

Just as female endurance runners are particularly at risk for low energy availability in general, the competitive pressure, emphasis on leanness, and high volume training associated with distance running nudge these athletes into a high-risk category for developing triad symptoms (Beals & Manore, 2002). According to a study cited in a Female Athlete Triad position stand by the IOC Medical Commission Working Group Women in Sport, up to 65% of female collegiate long distance runners at a selected university were amenorrheic (Dusek, 2001).

Young female endurance athletes with amenorrhea have exhibited less desirable lipid profiles, suggesting a possible link between the triad and increased atherosclerosis risk (Rickenlund, Eriksson, Schenck-Gustafsson, & Hirschberg, 2005). A positive correlation between the triad and atherosclerosis would further exacerbate the proposed disadvantages for female athletic performance, placing increased stress on the athletes’ cardiovascular systems during exercise, and protruding the flow of oxygen and nutrients to and from major muscles. Nevertheless, increased androgen hormone levels in female athletes with low energy availability and amenorrhea may actually lead to enhanced athletic performance (Rickenlund, Carlstrom, Ekblom, Brismar, Von Schoultz & Hirschberg, 2003).
CHAPTER 3

METHODOLOGY

Study Design

This observational study was designed to assess relationships between energy availability (EA) and run performance of Pacific-12 Conference male and female cross country runners from the University of California at Los Angeles (UCLA) and Stanford University. At the beginning of the Fall 2013 cross country season, we recruited subject volunteers from the entire pool of male and female cross country team members at each university. We obtained written informed consent prior to each athlete’s participation in the study. The collaborative project was approved by the UCLA and Stanford University institutional review boards.

After obtaining consent, participants completed a baseline questionnaire and had their height and weight measured. Following the initial questionnaire, throughout the competitive cross country season, students were contacted by researchers and asked to recall all foods and beverages consumed during the previous 24-hour day. This information, along with data obtained from an additional ex-post-facto phone recall of a one-week exercise log, was used to determine subjects’ average daily energy intake (EI) and exercise energy expenditure (EEE). Subject names, questionnaire data, and collected energy intake, expenditure, and run performance data, were kept confidential with the researchers, and all data was stored on a password-protected desktop computer.

Sampling Technique

Female UCLA and Stanford cross country runners were recruited for participation
in this voluntary study during a brief team meeting where researchers discussed the study
aims and procedures. Following the meeting, researchers distributed consent forms to
athletes wishing to volunteer. After reviewing the forms and providing consent, subjects
were provided with the baseline questionnaire. Males and females completed their
questionnaires in separate and private rooms. In each room, a study investigator was
available to answer any questions from the athletes. After the completion of the
questionnaires, subjects were reminded that they would be contacted via phone in the
subsequent weeks by the researchers for dietary and exercise data collection purposes.

**Questionnaire and Anthropometric Assessments**

The questionnaire (Appendix A) was used to obtain information regarding
subjects’ basic health information. The questionnaire inquired about runners’ cross-
country and track and field run times, prior sports participation, fracture history, eating
attitudes and behaviors, menstrual function, and medication use. Additionally, the
questionnaires asked subjects to list and explain any personal or family health
complications, which may have related to the athlete’s health and/or athletic
performance. This information was used in our analysis of study limitations and
alternative interpretations of results.

Anthropometric data, such as current body weight and height were calculated
during the athlete’s pre-participation physical exam. These data were also used to
calculate body mass index. Team health professionals were present to evaluate these
statuses for the athletes on both teams. Standardized measuring scales were used when
conducting the assessments.
Phone Interview Protocol

To obtain average EI data, graduate student researchers, trained in the multiple pass method of interview (Appendix B) (United States Department of Agriculture, Agricultural Research Service, 2013) conducted three unannounced phone calls with each subject over a two-week period during the 2013 Pacific-12 Conference cross country season. Participants were encouraged to maintain their normal eating habits throughout the study, and to report any atypical consumption behaviors. In order to obtain an accurate record, recalls were conducted for two weekdays and one weekend day. During each 15-20 minute phone call, the student-athlete subjects were instructed to recall all specific types and amounts of foods, beverages, and supplements consumed throughout the previous day. During the final food recall, subjects were also asked to list and briefly describe all purposeful exercise completed within the past week. This exercise information was used to determine subjects’ average total daily energy expenditure (TDEE).

Nutrition Analysis and Energy Balance Calculations

The 24-hour food recall data were analyzed with the ESHA Food Processor SQL software (ESHA Research, 2010). After the completion of the three recalls for each participant, all EI data was entered into the program to determine participants’ mean daily caloric intake (three-day average). One-week exercise recall data were analyzed for total daily EEE. Athletes’ EEE was determined using the exercise logs and metabolic equivalent (MET) levels from the ACSM Compendium of Physical Activities. Mean daily EEE was calculated by dividing the total weekly EEE by seven. We calculated
TDEE by summing the athletes’ resting metabolic rate (calculated using the Harris-Benedict Equation), energy expended from non-exercise activities (calculated by multiplying RMR by 0.5), and daily EEE. Energy balance (EB) was determined by subtracting TDEE from EI. A negative EB was defined as EI<95% of TDEE.

**Performance Indicators**

Run performance was evaluated using athletes’ lifetime personal best cross country times as reported in the baseline questionnaires at the start of the Fall 2013 cross country season. In addition to previous personal best times, male and female athletes’ Fall 2013 best performance times were collected from the universities’ cross country team website race result pages. Female previous and Fall 2013 best 6k times were compared to determine whether best times were attained during the Fall 2013 cross country season. Correspondingly, male previous and Fall 2013 best 8k times were compared to determine whether a best time was achieved.

All female personal best 6k performance times were converted into male 8k performance time equivalents using the Mercier Scoring Tables gender conversion calculator (Athletics Canada, 1999) followed by the HillRunner.com time conversion calculator (HillRunner.com, 1999). The male 8k performance time conversion was used as an equivalence factor to evaluate potential relationships between energy measures (EI, EEE, TDEE, and EB) and run performance times for both genders simultaneously. All male and female adjusted times were converted from time format into decimal format.

**Statistical Analysis**

In order to sufficiently characterize our sample, we computed average
anthropometric measures, including height, weight, and body mass index (BMI) for the male and female runners. For female runners, we also calculated the average age of menarche and number of menstrual cycles reported in the past calendar year. All anthropometric and menstrual function data was obtained from the initial questionnaires.

Additionally, we characterized our male and female samples’ run performance and training by determining the average personal best mile times, average fall 2013 personal best times (adjusted to male 8k), average weekly mileages, and percentage of athletes who obtained a lifetime personal best time during the fall 2013 cross country season. This data were collected from the initial questionnaires as well as the university cross country teams’ online results pages.

Male and female runners’ average energy values, including EI, EEE, TDEE, and EB, as well as the percentages of those with negative EB, were calculated separately. Combined male and female EB and percentage with negative EB were also computed.

Lastly, all energy and run performance data were analyzed for possible correlation using the Statistical Package for Social Sciences (SPSS) software. Two one-tailed, independent T-tests were used to detect potential relationships between the continuous dependent variable, Fall 2013 performance time (adjusted to mens’ 8k time), and the independent variables, EB (categorized as “negative” or “normal”), and weight loss status (categorized as “currently trying to lose weight” or “not currently trying to lose weight”). A Pearson Correlation analysis was used to determine any relationships between Fall 2013 adjusted run times and energy/training continuous variables including EI, EEE,

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1 All mean and standard deviation data were computed using Microsoft Office Excel 2010 software.
TDEE, EB and weekly mileage. Categorical variables, EB (either “negative” or “neutral/positive”) and Fall 2013 personal best achievement status (either “achieved personal best time in Fall 2013” or “did not achieve personal best time in Fall 2013”), were assessed for possible relationship using a Chi-square analysis. All relationships were considered significant and p<0.05.
CHAPTER 4

RESULTS

Descriptive Characteristics

Table 1 summarizes general characteristics of our sample, including participants’ mean chronological age, anthropometric values, and menstruation data (among females). On average, the runners’ BMI fell in the normal range (between 18.5-24.9 kg/m$^2$), however, two out of 49 men and women in the sample (4.1%) met criteria for underweight status (BMI < 18.5 kg/m$^2$). The mean age at menarche among the female runners fell in the normal range ≤15y. However, six of the 19 female athletes (31.2%) met criteria for late age at menarche (age at menarche ≥15y).

<table>
<thead>
<tr>
<th></th>
<th>Male, n=30</th>
<th>Female, n=19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>177.6 ± 6.9</td>
<td>169.6 ± 5.0</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>68.6 ± 5.7</td>
<td>57.2 ± 3.5</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>21.7 ± 1.8</td>
<td>19.9 ± 1.4</td>
</tr>
<tr>
<td>Age at Menarche (y)</td>
<td>14.3 ± 1.8</td>
<td></td>
</tr>
<tr>
<td>Menses in the Past Year (n)</td>
<td>7.5 ± 3.5</td>
<td></td>
</tr>
</tbody>
</table>

Among the female runners, four of the 19 (21.1%) reported currently taking oral contraceptives. Additionally, five of the 19 (26.3%) met criteria for amenorrhea, having reported less than six menstrual cycles in the past year.
Performance and Training Characteristics

Table 2 displays the male and female runners’ Fall 2013 training and performance figures, including lifetime personal best times in the mile, in-season best times in the 6k (for females) and 8k (for males), weekly training mileage, as well as Fall 2013 personal best achievement category (achieved personal best in-season or not). Notably, average reported weekly mileage for males was 16.1% higher than females’ average weekly mileage. Data regarding Fall 2013 personal best achievement could not be obtained for freshman runners. Thus, a total of 22 out of the 49 athletes (44.9%), were not evaluated for Fall 2013 personal best achievement status.

<table>
<thead>
<tr>
<th></th>
<th>Male, n=30</th>
<th>Female, n=19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mile Time (min)</td>
<td>4.1 ± 0.1</td>
<td>4.8 ± 0.2</td>
</tr>
<tr>
<td>Fall 2013 Personal Best, 8K (min)</td>
<td>24.9 ± 0.9</td>
<td></td>
</tr>
<tr>
<td>Fall 2013 Personal Best, 6K (min)</td>
<td></td>
<td>21.4 ± 1.5</td>
</tr>
<tr>
<td>Current Weekly Mileage (mi)</td>
<td>62.9 ± 17.5</td>
<td>54.2 ± 9.1</td>
</tr>
<tr>
<td>% Attained Personal Best in Fall 2013</td>
<td>57.14%</td>
<td>83.33%</td>
</tr>
</tbody>
</table>

Energy Intake, Energy Expenditure, and Energy Balance

For male runners, both average energy intake (EI) and average exercise energy expenditure (EEE) were higher than for female runners (Table 3). Specifically, average male EI was approximately 35.5% higher than average female EI, and average male EEE
was about 39.1% higher than average female EEE. Similarly, male runners’ average total daily energy expenditure (TDEE) was 25.2% higher than the average TDEE for females.

There was no significant difference between the percentages of males (37.93%) and females (50%) with negative EB.

Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Male, n=30</th>
<th>Female, n=19</th>
<th>Total, n=49</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI (kcal/day)</td>
<td>3621.2 ± 696.6</td>
<td>2671.7 ± 597.2</td>
<td></td>
</tr>
<tr>
<td>EEE (kcal/day)</td>
<td>903.1 ± 320.0</td>
<td>649.1 ± 177.5</td>
<td></td>
</tr>
<tr>
<td>TDEE (kcal/day)</td>
<td>3502.6 ± 339.7</td>
<td>2797.3 ± 175.2</td>
<td></td>
</tr>
<tr>
<td>EB (kcal/day)</td>
<td>118.7 ± 767.6</td>
<td>-121.3 ± 566.8</td>
<td>33.4 ± 712.1</td>
</tr>
<tr>
<td>% with Negative EB</td>
<td>37.93%</td>
<td>50%</td>
<td>42.22%</td>
</tr>
</tbody>
</table>

Mean±SD
SD, standard deviation; kcal, kilocalories; EI, energy intake; EEE, exercise energy expenditure; TDEE, total daily energy expenditure; EB, energy balance

Relationships between Energy Status and Performance

A one-tailed, independent t-test, used to evaluate differences in our sample of male and female runners’ best run times during the Fall 2013 cross-country season (adjusted to male 8k times) between those with a normal or negative EB yielded a p-value of 0.34. Because this value was not less than our alpha level of 0.05, we determined that there was no significant relationship between EB and the runners’ Fall 2013 performance times. An additional one-tailed, independent T-test was used to detect a possible relationship between reported weight loss status (whether the athlete was currently trying to lose weight or not- as a substitute measure of energy status) and
athletes’ Fall 2013 season best performance times (adjusted male 8k run times). The p-value of 0.39, also greater than the alpha level of 0.05, indicated that no significant relationship existed between these two variables.

Table 4.

*Pearson Correlation Analysis between Indicators of Energy Status and Performance Times among Male (n=23) and Female (n=17) Cross Country Runners*

<table>
<thead>
<tr>
<th>Fall 2013 Times, Adjusted to Mens' 8k Time</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
<td>r</td>
</tr>
<tr>
<td>EB</td>
<td>0.2</td>
<td>0.49</td>
<td>-0.1</td>
</tr>
<tr>
<td>EI</td>
<td>0.31</td>
<td>0.27</td>
<td>-0.16</td>
</tr>
<tr>
<td>EEE</td>
<td>0.06</td>
<td>0.81</td>
<td>-0.36</td>
</tr>
<tr>
<td>TDEE</td>
<td>0.4</td>
<td>0.14</td>
<td>-0.09</td>
</tr>
<tr>
<td>Mileage</td>
<td>-0.01</td>
<td>0.98</td>
<td>-0.45</td>
</tr>
</tbody>
</table>

EB, energy balance; EI, energy intake; Kcal, kilocalories; EEE, exercise energy expenditure; TDEE, total daily energy expenditure; *p<.05

Table 4 displays the findings of a Pearson Correlation analysis, used to determine a potential relationship between indicators of energy status and Fall 2013 run performance times. No significant relationship was found between EB statuses (normal or negative EB) and Fall 2013 times (adjusted to male 8k time) \((r = 0.04, p\text{-value} = 0.81)\). Additionally, no significant relationship existed between EI values and Fall 2013 times \((r = 0.15, p\text{-value} = 0.39)\). Yet, separate gender correlation tests revealed that among the males, mileage was significantly related to Fall 2013 best performance time \((p = 0.04, r = -0.45)\). Thus, as males’ weekly mileage increased, Fall 2013 best performance times were faster.
Additionally, a chi-square test was conducted to evaluate whether a relationship existed between EB and Fall 2013 personal best attainment status. The test showed that 53.8% of male and female runners with negative EB improved their personal best times during the Fall 2013 cross country season, while 46.2% did not. Additionally, 47.4% of runners with normal EB improved their best times during the season, while 52.6% did not improve. These values reflected no significant relationship (p = 0.72) between EB and Fall 2013 personal best achievement statuses.
CHAPTER 5
DISCUSSION

The purpose of this study was to determine whether a relationship existed between energy balance (EB) and Fall 2013 running performance among male and female NCAA Division 1 cross-country athletes. We hypothesized that those with normal EB would have faster performance times (lower values) than those with negative EB—or that more runners with a normal compared to a negative EB would report an improvement in their performance during the Fall 2013 season. However, our t-test and chi-square tests indicated that there was no significant association between the EB status and Fall 2013 improvement status, and we were not able to reject the null hypothesis—that no relationship existed between EB and run performance.

Implications

While we did not decipher a clear relationship between energy balance and run performance in the current study, we were able to unveil a relationship between weekly mileage and run performance among male collegiate endurance runners. This information may be useful in determining ideal weekly mileages for elite male endurance runners. Previous research findings have varied regarding the association between training volume and run performance among male endurance runners. A 2007 field study conducted with 15 male ultra-runners found no significant association between weekly training hours and distance run in a 24-hour race, suggesting that training volume has no major effect on 24-hour race performance (Knechtle, Wirth, Knechtle, Zimmermann, & Kohler, 2009). Yet, in a 2010 analysis of 66 male ultra-runners, weekly run volume was
significantly linked to 100-km run race time, signifying a potential association between higher training volume and faster 100-km performance among male ultra-runners (Knechtle, Wirth, Knechtle, & Rosemann, 2010). In order to clarify the effects of various training volumes on endurance run performance, further research is needed.

**Limitations**

Our sample of collegiate endurance runners was limited in size, and included significantly more males than females—with a total of 19 females (38.8%) and 30 males (61.2%). Thus, these outcomes may not represent the overall collegiate endurance athlete population, and may more-adequately characterize male collegiate athletes than their female counterparts. While results did not vary significantly for our study when genders were analyzed independently, this study could be reproduced using a larger, more gender-balanced, sample to determine specific energy-performance relationships for female and/or male endurance athletes. An additional advantage in this potential study would be that run performance distances would not need to be converted between genders, and run performance times could be evaluated at one distance across a single gender, leaving less room for error in inter-gender and inter-distance conversion calculations.

**Suggestions for Future Research**

Among the male endurance runners in our current study, increased weekly mileage was shown to be associated with faster Fall 2013 best performance times. Further research could be done to better-establish this relationship among male vs. female elite endurance runners. Such research could help to determine potential weekly mileage categories which may translate to projected performance trends. This may help elite
athletes optimize performance with ideal weekly training mileage while avoiding excess miles and overtraining.

Further studies could be conducted beyond this observational, ex post facto study which could introduce more experimental approaches. For example, male and female cross country athletes’ EA could be manipulated with controlled dietary intake and training protocol. The athletes could undergo standardized run testing procedures at regular intervals pre-, during-, and post-season so that effects of various controlled EAs (independent variable) on run performance (dependent variable) could be determined. This would enhance the quality of our study, as athletes would serve as their own control and would have multiple data points over time rather than at one point.

An additional observational study could be conducted in which the relationship between male and female collegiate endurance runners’ body weight, body composition, and race times are assessed over multiple continuous racing seasons. Researchers could evaluate potential associations between the variables to determine any effects of body weight/composition changes on run performance times, or vice versa. Findings could add to the body of knowledge regarding optimal body weights and/or compositions for endurance runners.

Low EA status may negatively affect athletic performance, as athletes with low EA are unlikely to be meeting micronutrient and macronutrient needs for optimal health, energy replenishment, and muscle recovery. While previous research has related increased androgen hormone levels to enhanced athletic performance among female athletes with low energy availability and amenorrhea (Rickenlund, Carlstrom, Ekblom,
Brismar, Von Schoultz & Hirschberg, 2003), further research could be done to re-evaluate this relationship. Female endurance athletes’ EA and menstrual function could be monitored over multiple athletic seasons to evaluate potential relationships between EA, menstrual function, and run performance. Such a study could aid in developing educational and/or counseling programs for female collegiate endurance runners and other female endurance athletes to learn and practice fueling for optimal performance with the assistance of qualified health professionals.

Conclusions

Male and female collegiate endurance runners have elevated energy and nutrient demands during intense training and competition seasons. These demands must be adequately met in the diet in order for athletes to maintain adequate immune function, bone health, and to recover optimally from workouts via muscle repair and glycogen replenishment. Proper fueling with quality foods, at the proper times, in the proper proportions may play an important role in optimal health maintenance and performance maximization. Further study is needed to explore this potential role.
REFERENCES


ESHA Research. (2010). The Food Processor SQL (version 10.6.3) [computer software]. Oregon: Salem


APPENDIX A

*Questionnaire*

Optimizing Health in Distance Runners: Intake Questionnaire (45 Questions Total)

Please enter your study ID: Date:

Sports Participation History

1. Indicate any sports other than running that you previously participated in on a regular basis. Please select ALL that apply. Indicate age you started participating in the sport, number of months, and average hours per week of participation:

   Sport: If YES, age started sport; If YES, # of months; If YES, average hours/wk
   Gymnastics □ YES □ NO ______ ______ ______
   Dance □ YES □ NO ______ ______ ______
   Volleyball □ YES □ NO ______ ______ ______
   Baseball/Softball □ YES □ NO ______ ______ ______
   Soccer □ YES □ NO ______ ______ ______
   Basketball □ YES □ NO ______ ______ ______
   Ice Hockey □ YES □ NO ______ ______ ______
   Football □ YES □ NO ______ ______ ______
   Tennis/Racquet Sports □ YES □ NO ______ ______ ______
   Water Polo □ YES □ NO ______ ______ ______
   Swimming □ YES □ NO ______ ______ ______
   Martial Arts □ YES □ NO ______ ______ ______
   Speed Skating □ YES □ NO ______ ______ ______
   Cycling □ YES □ NO ______ ______ ______
   Hurdling/Jumping Track Events □ YES □ NO ______ ______ ______
   Field Hockey □ YES □ NO ______ ______ ______
   Other (specify) ___________________________ ______ ______ ______

2. Indicate other forms of activity that you previously participated in on a regular basis. Please select ALL that apply. Indicate age you started participating in the activity, number of months, and average hours per week of participation:

   Activity: If YES, age started; If YES, # of months; If YES, average hours/wk
   Plyometrics □ YES □ NO ______ ______ ______
   Weightlifting, lower body □ YES □ NO ______ ______ ______
   Core strengthening/abdominal exercise □ YES □ NO ______ ______ ______
   Calf strengthening exercises □ YES □ NO ______ ______ ______

3. At what age did you start competing in running races? ____________

4. List your best time for the 1-mile or 1600 meter race (enter minute:seconds) ____________
5. List your best time in cross-country for the 5000-meter (females) or 8000-meter distance (males). (minute:seconds) ____________

6. What is your primary track event(s). Please select ALL that apply, placing a #1 by your primary event if more than one applies.

☐ 800 meters  
☐ 1500 meters  
☐ steeplechase  
☐ 5,000 meters  
☐ 10,000 meters  
☐ Other (specify)

7. How many miles per week did you average this past summer (June to August 2013)? miles/week

8. How many miles per week do you currently average? miles/week

9. Have you ever been diagnosed with a stress reaction or stress fracture by a doctor?

☐ YES ☐ NO

If YES, how many times?

☐ 1  
☐ 2  
☐ 3  
☐ >3

If YES, what bone(s) were injured and how were you diagnosed?

☐ Tibia Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Fibula Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Metatarsal(s) Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Femoral neck Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Femoral shaft Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Sacrum Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Pelvis Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Navicular bone of foot Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Sesamoid bone of foot Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other  
☐ Other (list site of injury) ____________ Circle if diagnosed by: ☐ X-ray ☐ MRI ☐ bone scan ☐ CT scan ☐ other

10. Please indicate any other forms of injury you have had in the past:

☐ Achilles tendonitis  
☐ Shin splints

34
Runner’s knee/patellofemoral pain
IT Band syndrome
Knee injury/ACL tear
Plantar fasciitis
Sprained ankle
Other tendon/bone/joint injury (please specify) ________________________

Menstrual History (male athletes – please skip to question 21)

11. Have you ever had a menstrual period?
☐ YES ☐ NO

If YES, when did you get your first menstrual period (month/year)?
How old were you (age in years)?

12. Please indicate the number of menstrual cycles you have had each year from 9th grade to the current year. Mark “NA” for the year if you had not yet begun your menstrual cycle.

<table>
<thead>
<tr>
<th>Year</th>
<th>9th grade</th>
<th>10th grade</th>
<th>11th grade</th>
<th>12th grade</th>
<th>College - 1st year</th>
<th>College - 2nd year</th>
<th>College - 3rd year</th>
<th>College - 4th year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NA</td>
<td>0</td>
<td>1-3</td>
<td>4-9</td>
<td>10-12</td>
<td>&gt;12</td>
<td>0</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1-3</td>
<td>4-9</td>
<td>10-12</td>
<td>&gt;12</td>
<td>0</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1-3</td>
<td>4-9</td>
<td>10-12</td>
<td>&gt;12</td>
<td>0</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1-3</td>
<td>4-9</td>
<td>10-12</td>
<td>&gt;12</td>
<td>0</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1-3</td>
<td>4-9</td>
<td>10-12</td>
<td>&gt;12</td>
<td>0</td>
<td>1-3</td>
</tr>
</tbody>
</table>

13. Over the past 12 months, how many menstrual periods did you have? _______________

14. Are your menstrual periods (Check one)

☐ Regular (every 21-35 days apart)
☐ Shorter than 21 days apart
☐ Longer than 35 days apart

15. During the cross-country/track season or when you are training harder do your periods (Check one only)

☐ Stop
☐ Become farther apart and/or are shorter or lighter
☐ Come closer together and/or are heavier
☐ My periods don’t change during the cross-country season or when training harder

16. Have you missed 3 or more consecutive months of your menstrual period? Answer yes or no to missing 3 or more consecutive periods from 9th grade to the current year. If YES, for each year, indicate the number of menstrual cycles missed.
Year If YES, number of consecutive menstrual cycles missed (check one)

35
17. Are you currently taking birth control pills or hormones?
   YES ☐ NO ☐

18. Have you taken birth control pills or hormones in the past year?
   YES ☐ NO ☐

   If YES, how many months did you take birth control pills or hormones in the past year?

19. Have you taken birth control pills or hormones prior to the past year?
   YES ☐ NO ☐

   If YES, how many months did you take birth control pills or hormones prior to the past year?

20. Has a doctor ever prescribed you birth control pills or hormones to regulate your menstrual periods?
   YES ☐ NO ☐

   If YES, indicate reason(s) why (select all that apply):

   ☐ they were prescribed because my period was too infrequent (i.e. diagnosed with amenorrhea)
   ☐ they were prescribed because my period was too frequent or heavy
   ☐ they were prescribed due to strong menstrual pains or cramps
   ☐ they were prescribed to improve my bone health
   ☐ other (please describe):

Eating Behaviors

21. Do you take calcium supplements or have you consistently over the past 12 months?
   YES ☐ NO ☐

   If YES, how much do you take?

   ☐ Less than 500mg a day
   ☐ 500 to 1,000 mg a day
   ☐ 1,000 to 1,500 mg a day
   ☐ More than 1,500 mg a day

22. Do you take vitamin D supplements or have you consistently over the past 12 months?
   YES ☐ NO ☐
If YES, how much do you take?

☐ Less than 500 IU a day
☐ 500-1000 IU a day
☐ Between 1,000-2,000 IU a day
☐ >2,000 IU a day

23. Do you follow a vegetarian diet (meaning that you never eat fish, chicken, or meat, but you do eat eggs and dairy)?

☐ YES ☐ NO

24. The following questions relate to the PAST FOUR WEEKS ONLY (28 days). Please read each question carefully and select the appropriate number. Please answer all of the questions.

On how many days out of the past 28 days …

No 1-5 6-12 13-15 16-22 23-27 every days days days days days day

Have you been consciously trying to restrict the amount of food you eat to influence your shape or weight?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Have you gone for long periods of time (8 hours or more) without eating anything in order to influence your shape or weight?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Have you attempted to avoid eating any foods that you like in order to influence your shape or weight?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Have you attempted to follow definite rules regarding you eating in order to influence your shape or weight; for example, a calorie limit, a set amount of food, or, rules about what or when you should eat?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Have you had a definite desire for your stomach to feel empty?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

25. Have there been times when you have eaten what most people would regard as an unusually large amount of food?

☐ No ☐ Yes

How many such episodes have you had over the past four weeks? ________________________

During how many of these episodes of overeating did you have a sense of having lost control? ________________________

26. Have you had other episodes of eating in which you have had a sense of having lost control, but have not eaten an unusually large amount of food?

☐ No ☐ Yes

How many such episodes have you had over the past four weeks? ________________________
27. Over the past four weeks, have you made yourself sick (vomit) as a means of controlling your shape or weight, or to counteract the effects of eating?  
☐ No ☐ Yes  
On how many days of the last 28 have you done this? ________________________

28. Over the past four weeks, have you taken laxatives as a means of controlling your shape or weight or to counteract the effects of eating?  
☐ No ☐ Yes  
On how many days of the last 28 have you done this? ________________________

29. Over the past four weeks, have you taken diet pills or diuretics (water) tablets as a means of controlling your shape or weight or to counteract the effects of eating?  
☐ No ☐ Yes  
On how many days of the last 28 have you done this? ________________________

30. Over the past four weeks, have you vigorously exercised as a means of controlling your weight, altering your shape or your amount of fat, or burning off calories?  
☐ No ☐ Yes  
On how many days of the last 28 have you done this? ________________________

31. Have the past four weeks been typical of the past year?  
☐ No ☐ Yes  
If NO, how has the past year differed from the past four weeks (please write below)

32. Are you currently trying to LOSE weight? (check one)  
☐ YES ☐ NO

33. Are you currently trying to GAIN weight? (check one)  
☐ YES ☐ NO

34. How do you currently consider yourself? (check one)  
☐ Very underweight (>10 lbs.) ☐ Slightly underweight (5-10 lbs.) ☐ At an ideal weight  
☐ Slightly overweight (<10 lbs.) ☐ Moderately overweight (10-20lbs) ☐ Very overweight (> 20lbs)

35. Are you trying to change your body weight or body composition to improve your performance? ☐ YES ☐ NO

36. Have you ever been diagnosed with an eating disorder? ☐ YES ☐ NO  
If YES, were you diagnosed with.....? (check all that apply)  
☐ Anorexia Nervosa  
☐ Bulimia Nervosa  
☐ Eating Disorder Not Otherwise Specified  
☐ Disordered Eating
If YES to any of the above, were you ever hospitalized for this diagnosis?  □ YES □ NO

General Health Questions

37. Have you ever broken a bone from a fall (ie. wrist, forearm, other)? □ YES □ NO

If YES, please list what bone(s) you broke?

□ Wrist
□ Forearm
□ Leg (tibia or fibula)
□ Other (please list) ____________________

38. Have you ever been diagnosed with low bone mineral density, osteopenia or osteoporosis by getting a bone density test (DXA)? □ YES □ NO

39. Do you have a family history (grandparent, parent, sibling) of osteopenia or osteoporosis? □ YES □ NO

If YES, did your family member ever break a bone or have a stress fracture? □ YES □ NO

40. On AVERAGE, how many hours of sleep do you get per day (i.e., a 24-hour period) on:

   Weekdays (Sunday through Thursday): _________ average sleep hours per day
   Weekends (Friday & Saturday): ________________ average sleep hours per day

41. In the past 30 days, how many days did you feel that you did not get enough rest or sleep? - ________ days.

42. Please indicate your sex:
□ Female □ Male

43. What is your age (in years)?

44. With which ethnic group do you most identify (check one)?

□ White/Caucasian □ Latino □ African American □ Asian/Pacific Islander □ Other (specify): ____________

45. Please let us know if any questions were confusing or if you have additional comments or feedback on the survey.

THIS IS THE END OF THE QUESTIONNAIRE. THANK YOU FOR YOUR PARTICIPATION
APPENDIX B

*Multiple Pass Approach*

<table>
<thead>
<tr>
<th>Step</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick List</td>
<td>Collect a list of foods and beverages consumed the previous day</td>
</tr>
<tr>
<td>Forgotten Foods</td>
<td>Probe for foods forgotten during the Quick List</td>
</tr>
<tr>
<td>Time &amp; Occasion</td>
<td>Collect time and eating occasion for each food</td>
</tr>
<tr>
<td>Detail Cycle</td>
<td>For each food, collect detailed description, amount, and additions. Review 24-hour day</td>
</tr>
<tr>
<td>Final Probe</td>
<td>Final probe for anything else consumed</td>
</tr>
</tbody>
</table>