AN EXAMINATION OF THE RELATIONSHIP BETWEEN DISORDERED EATING STATUS AND NUTRIENT INTAKE AMONG NCAA CROSS-COUNTRY RUNNERS

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

by

Elisabeth J. Daniels

August 2014
The thesis of Elisabeth Daniels is approved by:

_______________________________________                         ____________________
Erik Froyen, Ph.D.                                                                 Date

______________________________________                           ____________________
Yoko Mimura, Ph.D.                                                    Date

______________________________________                           ____________________
Michelle Barrack-Gardner, Ph.D., R.D., Chair                         Date

California State University, Northridge
DEDICATION

I dedicate this work to my family, especially Francisco. Thank you all for your constant encouragement, and support. Francisco, thank you for your patience and for putting up with me during this process.
ACKNOWLEDGMENTS

I would like to thank everyone that made this thesis possible. Thank you to my family and friends, who endured this process with me. Thank you to the primary researchers from UCLA and Stanford University, for allowing me to be part of this exciting study. Thank you to the athletes that participated, for their endurance and commitment to the study. Thank you to my supervisors at MEND for being flexible with my ever-changing schedule, especially during recall season. Thank you to my committee – Dr. Eric Froyen, thank you for your kindness and sincere interest in my work. Dr. Yoko Mimura, thank you for your honest feedback and your discerning eye. You always keep me on track. Lastly, I would like to express my sincerest and deepest gratitude to my committee chair, Dr. Michelle Barrack-Gardner. Thank you for your support, wisdom, and guidance. Your enthusiasm and constant encouragement always made me feel like I was capable, even when I thought I wasn’t. Your intelligence, patience, and unflagging kindness are inspirational. I feel incredibly honored to have had you as my advisor.
# TABLE OF CONTENTS

Signature Page ii  
Dedication iii  
Acknowledgment iv  
List of Tables vi  
Abstract vii  

## CHAPTER I – INTRODUCTION
- Statement of the Problem 2  
- Definitions 3  
- Assumptions 4  
- Limitations 5  

## CHAPTER II – REVIEW OF LITERATURE 6
- Overview of Eating Disorders 6  
- Diagnostic Criteria for Eating Disorders 6  
- Prevalence of Eating Disorders in Athletes 7  
- Impact of Eating Disorders on Nutrient Status 11  

## CHAPTER III – METHODOLOGY 14
- Procedure 14  
- Measurement 14  
- Statistical Analysis 16  

## CHAPTER IV – RESULTS 18
- Sample 18  
- Prevalence of Disordered Eating 19  
- Nutrient Status 20  
- Multivariate Analyses 25  

## CHAPTER V – DISCUSSION 27
- Summary of Findings 27  
- Discussion 27  
- Implications and Conclusion 34  

REFERENCES 36  
APPENDIX 42
LISTS OF TABLES

Table 1 - Demographic, anthropometrics, energy, and training characteristics among the runners
Table 2 - Daily energy and macronutrient intakes based on mean 24-hour food recall data among the runners
Table 3 - Daily micronutrient intakes in female runners based on mean 24-hour food recall data and percentage of RDA consumed
Table 4 - Daily micronutrient intakes in male runners based on mean 24-hour food recall data and percentage of RDA consumed
Table 5 - Prevalence of disordered eating and pathogenic weight control behaviors (PWCB) in runners
Table 6 - Multiple regression model of variables contributing to the prediction of negative energy balance among the male and female runners

Figures 1a-1d – Energy variables among male and female runners with and without disordered eating
ABSTRACT

AN EXAMINATION OF THE RELATIONSHIP BETWEEN DISORDERED EATING STATUS AND NUTRIENT INTAKE AMONG NCAA CROSS-COUNTRY RUNNERS

by

Elisabeth Daniels

Master of Science in

Family Consumer Sciences

The purpose of this study was to examine the prevalence of disordered eating and the relationships between disordered eating and nutrient status among male and female NCAA cross-country runners (n=49). At the beginning of the Fall 2014 cross-country season, runners completed a baseline questionnaire, which assessed sports participation history and training volume, injury history, menstrual history, eating behaviors, and general health history. Runners also completed in three, unannounced, phone-based 24-hour dietary recalls, which were used to analyze nutrition status, and an evaluation of their exercise training, which was used to determine mean daily exercise energy expenditure. Using independent t tests, results showed that 36.7% of female runners and 40% of male runners were classified with disordered eating (DE). Among those with DE, 50% of female runners met the criteria for dietary restraint and 41.7% of male runners reported excessive exercise. Male and female runners with DE also admitted to having disordered weight perceptions (83.3% and 75%, respectively). Female runners with DE
had significantly lower intakes of energy (2318.7±284.2 vs. 2875.3±604.5, p=0.05), protein in g/day and g/kg (96.9±18.3 vs. 125.7±23.5, p=0.02; 2.3±0.5 vs. 1.6±0.4, p=0.01), and carbohydrates in g/day (5.2±1.3 vs. 7.2±0.8, p=0.04) compared to female runners with no DE. Male runners with DE had significantly higher calcium intake than male runners with no DE (2111.2±682.6 vs. 1480.3±562.9, p = 0.01). The findings in this study underscore the need for standardized nutrition intervention and education programs in university athletics departments as well as the need for gender specific assessment criteria for disordered eating.
CHAPTER 1
INTRODUCTION

Collegiate cross-country running is an endurance sport that involves high-volume training to prepare for seasonal competitions. Running is classified as a leanness sport, as athletes often perceive low body fat or body weight as ideal for enhanced performance. The emphasis on leanness can, therefore, put intense pressure on runners to maintain a lean physique, which leads to an increased risk for developing disordered eating behaviors (DE), and pathologic weight control behaviors (PWCB) such as laxative and/or diuretic use, excessive exercising, self-induced vomiting, disordered weight perception, and dietary restraint. (Sundgot-Borgen, 1993; Picard, 1999; Byrne & McLean, 2002; Sundgot-Borgen & Torstveit, 2004).

The increased prevalence of DE, and PWCB in female athletes compared to non-athletes has been consistently reported over the past 20 years (Sundgot-Borgen, 1993; Byrne & McLean, 2002; Greenleaf, Petrie, Carter, & Reel, 2009). However, the dietary behaviors of male and female collegiate athletes, including cross-country runners, have yet to be fully characterized. What’s more, the prevalence of disordered eating in male runners has not been well documented, and limited research exists on the relationship between DE, PWCB, and nutrient status.

Runners require sufficient energy from carbohydrates (CHO), protein (PRO) and fat to meet the demands of their sport. One study used doubly labeled water, the gold standard method for measuring total energy expenditure (TEE), and determined that female runners require approximately 2800 calories per day to compensate for TEE (Schulz, Alger, Harper, Wilmore, & Ravussin, 1991). Another study indicated that male
athletes (not runners specifically) require 3,600 calories or more daily to compensate for TEE (Hinton, Sanford, Davidson, Yakushko, & Beck, 2004). A more recent study conducted on adolescent runners showed that at least 3100 calories daily are required to compensate for TEE (Barrack, Nichols, Rauh, & Van Loan, 2014).

Runners need to consume specific macronutrient compositions for glycogen storage and positive nitrogen balance (Academy of Nutrition & Dietetics, 2009). Previous studies have recommended runners consume 6-10g/kg from carbohydrates, 1.2-1.4g/kg from protein, and 20-35% of total energy intake from fat (Beals & Manore, 1998; AND, 2009). Research has also indicated that athletes are at risk for deficiency in key micronutrients required for energy production and bone formation, such as calcium and vitamin D (Beals & Manore, 1998).

**Statement of the Problem**

If left untreated, disordered eating behaviors and pathologic weight control behaviors may lead to clinical eating disorders, which can have detrimental health consequences on runners, including stress fractures, hormonal imbalances, menstrual dysfunction (i.e. The Female Athlete Triad), and chronic health conditions that manifest in later life (Zanker & Swaine, 1998; Nattiv, 2000; Bennell, Matheson, Meeuwise, & Brukner, 1999; Ihle & Loucks, 2004; Daneshvar et al; 2012; Moran et al., 2012; Duckham et al, 2013).

**Purpose**

The purpose of this study is to 1) examine the prevalence of disordered eating behaviors in male and female runners and 2) to examine the relationship between disordered eating and nutrient status in male and female NCAA cross-country runners.
Definitions

1. College/Student-Athlete: A student-athlete is a student whose enrollment was solicited by a member of the athletics staff or other representative of athletics interests with a view toward the student’s ultimate participation in the intercollegiate athletics program. Any other student becomes a student-athlete only when the student reports for an intercollegiate squad that is under the jurisdiction of the athletics department, as specified in Constitution 3.2.4.5. A student is not deemed a student-athlete solely on the basis of prior high school athletics participation (2012-13 NCAA Division I Manual).

2. Cross-Country Running: Races, for both teams and individuals, [that] are run on either grass or woodland courses and might also include stretches of gravel paths, road and hills. Races usually take place in the winter months, outside the usual track and field season (IAAF, 2013).

3. Eating Disorders: Debilitating psychiatric illnesses characterized by a persistent disturbance of eating habits or weight control behaviors that result in significantly impaired physical health and psychosocial functioning (Krause’s Food and the Nutrition Care Process, 2012).

4. Endurance Sport: A sports activity in which key muscles are exercised at submaximal intensity for prolonged periods of time (Medical-dictionary.thefreedictionary.com)

5. Energy Availability: The amount of energy that is not expended on exercise and therefore is available for performing the basal metabolic processes involved in organ function and the non-exercise activities of daily living. This relationship is represented in the following equation: Energy Availability = (Energy Intake −

6. Energy Balance: The physiological state of equilibrium between energy intake and energy output where energy intake is defined as the sum of energy from all foods and beverages consumed and energy output is defined as energy expended through basic physiologic and metabolic processes as well as energy expended during physical activity (Gropper, Smith, & Goff, 2009).

7. Female Athlete Triad: The interconnection between low energy availability, hypothalamic dysmenorrhea, and low bone mineral density experienced by female athletes with low energy intake (Nattiv et al., 2007).

8. Leanness Sport: Sport in which leanness or a specific weight are important for performance, including running, swimming, rhythmic gymnastics, dancing, wrestling and taekwondo (Sundgot-Borgen, 1993; Vardar, Vardar, & Kurt, 2005).

9. Macronutrients: Complex molecules such as carbohydrates, proteins, and lipids that provide energy required for metabolic and physiologic processes.

10. Micronutrients: Nutrients required in minute quantities that regulate metabolic and physiologic functions. They include vitamins, minerals, and phytonutrients.

11. Stress fracture: A complete or partial fracture (breakage) of bone resulting from its inability to withstand stress applied in a rhythmic, repeated sub threshold manner (Bennell, Matheson, Meeuwisse, Brukner, 1999).

Assumptions

Results of this study are based on the assumptions that:

1. The participants are cross-country athletes attending the University of California, Los Angeles or Stanford University.
2. Participants understood the purpose of the study as explained by the primary researchers and distributed consent forms.

3. Participants understood all forms, questionnaires, and tasks that they were given to complete.

4. Participants answered all questions truthfully.

5. The parameters of the study set forth by the primary researcher were sufficient for answering the research questions.

6. Data were documented and analyzed accurately.

7. Results were analyzed and interpreted accurately.

**Limitations**

Limitations to this study include:

1. Study Design: A cross sectional study can only determine a relationship between two variables. It cannot determine causality.

2. Attrition: Participants may drop out of the study.

3. Sample and Generalizability: The sample may not be sufficient for generalizability to other cross-country collegiate athletes.

4. Limited Data: The data collected from the participants may not be sufficient and may negatively impact the results.

5. Dishonesty: The participants may not have provided the honest and accurate information to the researchers, either knowingly or unwittingly.
CHAPTER II
REVIEW OF LITERATURE

Overview of Eating Disorders

Eating disorders (ED) are severe, life-threatening pathologic conditions that affect 20 million women and 10 million men in the United States (National Eating Disorders Association [NEDA], n.d.). This number does not reflect those that avoid treatment, suggesting that the number of people with ED may be higher. The Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) classifies anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED), and Other Specified Feeding and Eating Disorder (OSFED) as clinically diagnosable and treatable ED (DSM-V; American Psychiatric Association [APA]; 2013).

Diagnostic Criteria for Eating Disorders

A majority of the previous studies that examined the prevalence of ED in athletes used diagnostic criteria from the revised DSM-IV-TR (APA, 2000). However, the recently published DSM-V includes many notable revisions to the diagnostic criteria for ED, including replacing Eating Disorders Not Otherwise Specified (EDNOS) with Other Specified Feeding and Eating Disorder (OSFED), and defining binge eating disorder (BED) as a distinct condition. OSFED now encompasses conditions such as atypical anorexia (anorexic pathologies occurring in normal weight individuals), BN with less frequent behaviors, BED with infrequent occurrences of bingeing, purging disorder, and night eating syndrome (NEDA, n.d.). Criteria for AN and BN have changed as well. The term “refusal” has been removed from the weight management section and secondary menorrhea has also been removed as a diagnostic symptom (DSM-V, 2013). BN
diagnostic criteria have changed from exhibiting bingeing and compensatory behaviors twice a week to only once a week (DSM-V, 2013). While it is important to be cognizant of the changes incorporated into the DSM-V, diagnostic criteria from the DSM-IV will be used in this study for continuity.

In addition to ED diagnoses, there are sub-categories used to classify disordered eating behaviors, including partial-syndrome ED and subclinical ED. Partial-syndrome ED (PS-ED) was first recognized in adolescent females thirty years ago. Since then, population-based studies have shown that the prevalence of PS-ED is consistently greater than full ED, particularly in adolescents (Patton et al., 2008). PS-ED is defined as meeting criterion A plus at least one other symptom from criterion B, C, or D for AN or BN (Lewinsohn, Seeley, Moerk, & Streigel-Moore, 2002; Patton et al., 2008). Subclinical ED (Sub-ED) appears to have criteria similar to PS-ED, with one study using a similar definition used by Patton et al. for classifying participants with Sub-ED (Beals & Manore, 1998). Other studies defines Sub-ED as an EDNOS, with Sub-ED behaviors including dietary restraint (Barrack & Van Loan, 2011) or anorexia athletica, which refers to athletes that use dietary restraint and excessive exercise to maintain low weight status (Sundgot-Borgen & Torstveit, 2004).

**Prevalence of Eating Disorders in Athletes**

Multiple studies over the past twenty years have attempted to determine the prevalence of ED in athletes. While many of these studies are methodologically sound, most fail to explore energy intake (EI) and energy balance (EB) as supplemental quantitative measurements. These measurements are helpful for measuring the degree of dietary restraint and food avoidance in athletes with ED. For instance, Sundgot-Borgen
used the Eating Disorder Inventory (EDI) as a screening tool, and then personal
interviews and clinical examinations to determine the prevalence of ED in Norwegian
elite female athletes compared to controls (1993). She found that athletes in the
Endurance group had lower prevalence of ED compared Aesthetic and Weight-dependent
group athletes (34%, 27%, 20% respectively), but that cross-country athletes had the
highest prevalence rates among the Endurance group \((p < 0.05)\) (Sundgot-Borgen, 1993).
This indicated a greater need to focus attention on runners and the causative factors
involved with ED development. While this study was well designed, it did not look at EI
or EB, nor did it address differences in prevalence rates between genders amongst
runners.

To address the limitations found in the first study, Byrne and McLean conducted a
large-scale controlled study examining the prevalence of ED in Australian, elite, male
and female athletes compared to male and female non-athletes (2002). The study was
conducted in two phases. Phase One utilized the Composite International Diagnostic
Interview (CIDI) to identify athletes that met the criteria for ED (Note: a trained clinical
psychologist conducted the interview). Phase Two consisted of self-reported measures
using the BULIT-R, and subscales of the EDI, including Drive for Thinness, Body
Dissatisfaction, and Bulimia (Byrne & McLean, 2002). Results showed a continuum
effect with female athletes and thin-build athletes (of both genders) participating in
leanness sports having that highest prevalence of ED (15% in thin-build females, 2% in
normal build females, 1% in control females, and 5% of thin-build male athletes). While
the authors of this study compensated for the previous oversight of gender differences,
they failed to look at EI and EB to assess and measure dietary restraint, the most common
symptom of ED. ED status was only determined by clinical interview and self-reporting methods. What’s more, this study grouped runners into one category (“thin-build athletes”). This generalized grouping system does not take into consideration how sport-specific demands factor in ED development.

Two years after Byrne & McLean explored gender differences in the prevalence of ED in athletes, Sundgot-Borgen published a similar study addressing the prevalence of ED in male and female Norwegian elite athletes compared to controls (Sundgot-Borgen & Torstveit, 2004). Using the same methodology as in the previous Sundgot-Borgen study, the authors found that athletes in general had greater prevalence of ED (13.5%) compared to controls (4.6%). Amongst male athletes, those in anti-gravitational sports had the highest prevalence (22%), followed by endurance sports (9%). Amongst female athletes, those in aesthetic sports had the highest prevalence (42%), followed endurance (24%). These findings echoed those of Byrne and McLean (with the exception of addressing thin-build athletes) in that athletes, specifically leanness and weight dependent sport athletes, have greater prevalence of ED compared to controls. However once again, EI and EB were not examined.

In 2008 the same researchers conducted two separate studies examining the prevalence of ED and disordered eating behaviors (DE) in male and female collegiate athletes (Petrie, Greenleaf, Carter, & Reel, 2008; Greenleaf, Petrie, Carter & Reel, 2008). In both studies, they examined athletes from three different NCAA Division I colleges using the Questionnaire for Eating Disorder Diagnosis (QEDD) and Bulimia Test-Revised (BULIT-R). In the study on male athletes they found that 20% reported symptoms of DE (none reported ED) and in the study on female athletes, they found that
2% reported having an ED, and 25.5% reported symptoms of DE (Petrie et al., 2008; Greenleaf et al., 2008). While these studies did use samples from multiple colleges, which enhanced generalizability, they only used self-reporting measures to assess ED and DE and again did not use any quantitative measurements to assess EI and EB in either the male or female athletes.

This last study looked at eating attitudes and behaviors as well as prevalence of ED in female collegiate athletes from one NCAA Division II university (Lim & Smiley, 2008). They compared 60 athletes from various sport disciplines to 65 controls and found no significant difference in attitudes, behaviors, or prevalence between groups. While this finding contradicts those from earlier studies, this study was heavily flawed. First, the authors only used self-reported data (the Eating Attitudes Test [EAT-26]) to find their results. Plus the questionnaire was given during class sessions shortly before final examinations week, which may account for the small sample. Another reason for the small sample was the use of one university for recruiting participants. Second, authors recruited athletes from a Division II school, which is less competitive (and thus not as comparable) to Division I schools or national sport teams. Third and lastly, the authors did not employ any supplementary measures for determining EI or EB in athletes.

In addition to lacking data on EI and EB, many of these studies used under-representative samples of runners. Likewise, runners were often grouped with other “endurance” sport athletes. Sundgot-Borgen used the total population of Norwegian female athletes in her 1993 study (n=522), and identified 15 of the 80 Endurance group athletes with ED as runners (Sundgot-Borgen, 1993). Byrne and McLean recruited 263 male and female athletes from national and state sport teams, yet identified only eight
male and five female athletes as runners (2002). In the back-to-back studies conducted by Petrie et al. and Greenleaf et al., only five of the 203 male athletes and only two of the 204 female athletes in their respective studies were cross-country runners (Petrie et al., 2008; Greenleaf et al., 2008).

In short, these studies provided important information about the eating behaviors of athletes, which has lead to a greater understanding of the relationship between diet, health, and performance. They also underscore the need for multiple measurement methods in addition to self-reporting, as well as the need for more in depth analyses of the diet behaviors and health consequences of individual sport groups, like runners.

**Impact of Eating Disorder on Nutrient Status**

Studies on the nutrient status in athletes with ED are scant. Much of the research conducted on nutrient intake in athletes was observational and conducted on athletes in general. One early observational study looked at the dietary intake of 35 female athletes (11 runners) and found that runners consumed less than the recommended levels of protein, and carbohydrates during training and competition periods (Hassapidou & Manstrantoni, 2001). However, under-reporting was a major limitation of this study and the authors were not concerned with ED status in the athletes.

Another study examined the nutrient intakes in 185 male and 165 female collegiate athletes (Hinton et al., 2004). Runners represented 11% of the male athletes and 12% of the female athletes. The authors found that both male and female athletes had low energy and carbohydrate intake, and that male athletes consumed higher than recommended levels of saturated fat, typically because they dined out more frequently (Hinton et al., 2004). Along with low energy intake, male and female athletes had higher
than recommended intakes of vitamin A and C, as well as calcium, but lower intakes of iron. In regard to vitamin D, it is important to note that at the time, the adequate intake (AI) of vitamin D was 5 micrograms (mcg), which is lower than the current RDA (15 mcg). This would indicate then that vitamin D intake was low among the athletes.

A more recent study looked at the relationship between dietary intake and stress fractures in male combat recruits, which have similar characteristics to athletes in terms of duration and intensity of training (Moran et al., 2012). The authors analyzed anthropometrics (height, weight, body fat percentage, and BMI), dietary intake (Food Frequency Questionnaire [FFQ]), and blood calcium and iron levels in 72 recruits. Measurements were taken at baseline, four months, and then at six months. Incidence of stress fracture was monitored throughout. Their findings showed that the recruits diagnosed with stress fractures during the course of the study (n=12) had lower intake of carbohydrates, calcium and vitamin D compared to those without (Moran et al., 2012).

While this study does not reflect the nutrient status and intake or male runners, or athletes, it does provide a more comprehensive understanding of the health consequences of poor nutrient status, which can be useful when working with athletes. It also demonstrates how using dietary assessment methods can be useful for determining EI and EB.

This last study addressing nutrient status in athletes used a combination of dietary assessment methods in addition to anthropometrics (height, weight, body composition) to determine whether female collegiate athletes were following the sport nutrition standards for dietary intake (Shriver, Betts, & Wollenberg, 2013). The authors examined the diet behaviors of 52 female athletes from one Division I university using a three-day food
journal, one 24-hour diet recall interview, and a nutrition questionnaire. They found that female athletes had low energy and carbohydrate intakes compared to the recommended guidelines (Shriver et al., 2013). Through the nutrition questionnaire they also found that 33% of female athletes wanted to lose weight and 29% struggled with weight maintenance. Again, while the findings of this study did not pertain to collegiate runners per se, they did show that female athletes typically have lower EI than recommended and still suffer from weigh preoccupation, which warrants further examination into the relationship between ED, DE, and nutrient intake.

While the studies on male athletes provide insight into the problems males have with consuming sufficient nutrients, they do not demonstrate any relationship between intake and ED or DE status, particularly in male runners. Overall, these studies reflect the need for a more comprehensive approach to assessing both the prevalence of ED and the relationship between ED and intake. This approach should incorporate questionnaires with diagnostic criteria for ED, as well as anthropometric data and dietary analysis.
CHAPTER 3

METHODOLOGY

This research is a cross-sectional study designed to determine the prevalence of eating disorders in male and female NCAA cross-country runners and also to examine the relationship between eating disorders and nutrient status in male and female athletes. The study was approved by the University of California, Los Angeles (UCLA) Institutional Review Board. Written informed consent was obtained from each athlete prior to participation.

Procedure

Data Collection

Female and male athletes from Stanford University and UCLA cross-country and track and field teams were eligible to participate. At the beginning of the Fall 2013 Cross-Country season, a meeting was held with the male and female teams to explain the goals of and criteria for the study. Participation was voluntary. A self-administered baseline questionnaire called Optimizing Health in Distance Runners (OHDR) was used to obtain information about variables of interest, including demographics, sports participation history and training volume, injury history, menstrual history, eating behaviors, and general health history.

Measurement

Nutrient Status

Following completion of the questionnaire, a nutrition assessment was conducted on the participants to evaluate their nutrient status. Three unannounced 24-hour phone-based recalls were performed over a three-week period during fall and spring quarters. A
three-day analysis using 24-hour food recalls was previously shown to be sufficient for assessing usual intake (Yunsheng et al., 2009). To obtain a representative record food intake was evaluated on two weekdays and one weekend day. During the 24-hour recalls, participants were prompted to describe and provide the time of intake and amount of all food, drink, and supplement items consumed over a 24-hour period. Nutrition interviewers used the three-step, multiple pass method of interview for the recalls. At the end of the final recall (day 3), exercise expenditure was measure by recording all purposeful exercise runners participated in during the past seven days. The American College of Sports Medicine Compendium of Physical Activities was used to estimate the number of calories (kcal) expended for each activity and duration (Ainsworth et al., 2011).

Data collected from the 24-hour recalls were analyzed using the ESHA Food Processor Nutrient Analysis Program (Salem, OR). The interviewers conducting the recalls were nutrition graduate students from CSUN trained in the 24-hour recall protocol. To aid in the process of estimating portion size, participants were given handouts containing images of serving sizes for various food products (i.e. liquids, cheese, meat, cereal/snacks, vegetables, etc.).

During the study participants were encouraged to continue their normal eating patterns and note whether their diet was typical. If intake was not typical they were asked to notify the researchers (e.g. illness, dining out more than usual, traveling). Data obtained from the nutrition assessment included participants’ mean daily calorie, macronutrient, and micronutrient intake. Mean daily intake values were calculated by averaging total intake for the three days food intake was assessed.
The energy balance (EB) equation (EB=energy intake (EI) – total energy expenditure (TEE)) was used to assess energy status. Total energy expenditure was calculated by summing the basal metabolic rate (using the Harris-Benedict equation), exercise energy expenditure, and then adding an activity factor of 1.5 to account for non-exercise activity thermogenesis). A negative energy balance was pre-defined as an energy intake ≤90% of total daily energy expenditure.

Disordered Eating

Disordered eating status was assessed using the Eating Behaviors section on the OHDR. This section contained from the dietary restraint subscale and questions regarding PWCBs, including excessive exercise, self-induced vomiting, laxative or diuretic use, from the Eating Disorder Examination questionnaire 6.0 (EDE-Q6). Runners were characterized with DE if they met one or more of the following criteria: a score of three or more on the EDE-Q6 dietary restraint subscale, reporting one or more PWCBs during the past 28 days, or reporting an abnormal body perception (i.e. perceiving one’s self as overweight when actually normal or underweight).

Nutrient Status

All macronutrients were assessed for energy status. Specific micronutrients assessed were vitamins A and C, iron, calcium, and vitamin D. Special consideration was given to calcium and vitamin D, as both are markers of bone health, which is important for runners.

Statistical Analysis

Independent t tests were used to evaluate differences in energy, macronutrient, and micronutrient intake among groups according to DE status among male and female
runners. A multivariate analysis was conducted using a multiple logistic regression to identify variables (BMI, dietary restraint, age, and gender) contributing to the prediction of negative energy balance. An alpha level of 0.05 was used to determine statistical significance. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) (Version 20.0, SPSS Inc., Chicago, IL).
CHAPTER 4

RESULTS

Sample

Demographic, anthropometric, energy, and training characteristics among the male and female runners are outlined in Table 1. The sample included 49 cross-country athletes from both UCLA and Stanford University. Females represented 39% (n = 19) and males represented 61% (n = 30) of the participants. Mean participant’s age was 20.2. Of the participants, 61% identified as White/Caucasian (n = 30), 2% identified as Latino (n = 1), 8% identified as other (n = 4), and 29% (n = 14) did not identify their race or ethnicity. Of the female athletes, 26% (n = 5) met the criteria for secondary amenorrhea (absence of menses ≥ 6 months), and 21% (n = 4) were taking oral contraceptives at the time of the study.

Table 1

Demographic, anthropometrics and training characteristics among the runners (n=49)

<table>
<thead>
<tr>
<th></th>
<th>Females</th>
<th></th>
<th>Males</th>
<th></th>
<th>Total ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DE (n=6) No DE</td>
<td></td>
<td>DE (n=12) No DE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(n=13)</td>
<td>p</td>
<td>(n=18)</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Age (yrs.)</td>
<td>19.6±0.4 19.9±1.4</td>
<td>0.51</td>
<td>20.0±1.4 20.5±1.4</td>
<td>0.38</td>
<td>20.1±1.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>167.6±5.8 170.6±4.7</td>
<td>0.23</td>
<td>178.0±6.8 177.4±7.3</td>
<td>0.81</td>
<td>174.5±7.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.9±4.1  56.0±2.7</td>
<td>0.02*</td>
<td>68.2±5.9  68.8±5.9</td>
<td>0.79</td>
<td>64.2±7.5</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.3±1.2  19.3±1.0</td>
<td>0.001*</td>
<td>21.3±1.4  21.8±2.0</td>
<td>0.60</td>
<td>21.0±1.9</td>
</tr>
<tr>
<td>Mileage (mi/d)</td>
<td>52.0±16.7 52.3±10.3</td>
<td>0.96</td>
<td>66.8±17.4 59.9±18.1</td>
<td>0.32</td>
<td>58.7±16.6</td>
</tr>
</tbody>
</table>
Mean Age at Menarche

<table>
<thead>
<tr>
<th></th>
<th>14.0±1.0</th>
<th>14.5±0.4</th>
<th>0.63</th>
<th>-</th>
<th>-</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menarche</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.3±1.2</td>
</tr>
<tr>
<td>Cycles/yr.</td>
<td>7.8±0.8</td>
<td>7.3±1.2</td>
<td>0.83</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.5±3.6</td>
</tr>
</tbody>
</table>

Note. Independent $t$-test used. DE = disordered eating behaviors. Yrs. = years. Cm = centimeters. Kg = kilograms. BMI = body mass index measured in kilograms (kg) of body weight over height in meters squared (m$^2$). Mi/d = miles per day. Cycles/yr. = Number of menstrual cycles per year, measured only in female runners. SD = Standard deviation. * $p < 0.05$

Prevalence of Disordered Eating

Disordered eating (DE) classification was based on results of the Eating Behaviors portion of the OHDR questionnaire. Athletes were classified either with disordered eating behaviors ($n = 18$, 36.7%) or no disordered eating behaviors ($n = 31$, 63.3%). Disordered eating behaviors were further categorized into three subgroups – dietary restraint, disordered weight perception (perception as overweight despite normal weight status), and pathogenic weight control behaviors (self-induced vomiting, laxative and diuretic use, excessive exercise). The prevalence of DE compared to no DE among the runners is outlined in Table 2. None of the athletes reported having a past or current diagnosis of clinical eating disorders.

Table 2

Prevalence of disordered eating and pathogenic weight control behaviors (PWCB) in runners ($n=49$)

<table>
<thead>
<tr>
<th></th>
<th>PWCB</th>
<th>No DE</th>
<th>DE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>[n (%)]</td>
<td>[n (%)]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>31</td>
<td>18</td>
</tr>
</tbody>
</table>

* $p < 0.05$
Males  

<table>
<thead>
<tr>
<th></th>
<th>DE (n=12)</th>
<th>No DE (n=18)</th>
<th>P</th>
<th>DE (n=12)</th>
<th>No DE (n=18)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>3752.6±503.7</td>
<td>3523.7±802.0</td>
<td>0.39</td>
<td>3752.6±503.7</td>
<td>3523.7±802.0</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Nutrient Status

Energy

Energy intake (in kcal/d and kcal/kg) and energy balance was significantly lower in female runners with DE compared to those without (Table 3). There were no significant differences in TEE and EEE between groups. Among the male runners, there were no significant differences in energy intake, energy balance, TEE, or EEE between groups (Table 3). Figure 1 illustrates the differences in EI, EB, average mileage and TEE between groups and genders.

Table 3

Daily energy and macronutrient intakes based on mean 24 hour food recall data among the runners (n=49)
<table>
<thead>
<tr>
<th></th>
<th>kcal/d</th>
<th>kcal/kg</th>
<th>kcal/kg</th>
<th>kcal/kg</th>
<th>kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>38.9±6.2</td>
<td>51.4±11.0</td>
<td>0.02*</td>
<td>55.4±8.5</td>
<td>51.5±12.3</td>
</tr>
<tr>
<td>EB (kcal/d)</td>
<td>-559.0±256.8</td>
<td>119.4±543.8</td>
<td>0.01*</td>
<td>119.9±606.5</td>
<td>41.9±933.1</td>
</tr>
<tr>
<td>TEE (kcal/d)</td>
<td>2877.6±78.6</td>
<td>2756.0±45.9</td>
<td>0.17</td>
<td>3632.7±98.0</td>
<td>3481.7±103.5</td>
</tr>
<tr>
<td>EEE (kcal/d)</td>
<td>708.4±98.3</td>
<td>621.8±42.3</td>
<td>0.35</td>
<td>995.3±77.2</td>
<td>841.6±83.1</td>
</tr>
<tr>
<td>PRO (g)</td>
<td>96.9±18.3</td>
<td>125.7±23.5</td>
<td>0.02*</td>
<td>154.0±33.7</td>
<td>149.0±39.2</td>
</tr>
<tr>
<td>PRO (g/kg)</td>
<td>1.6±0.4</td>
<td>2.3±0.5</td>
<td>0.01*</td>
<td>2.3±0.5</td>
<td>2.2±0.6</td>
</tr>
<tr>
<td>CHO (g)</td>
<td>311.9±70.2</td>
<td>399.9±102.5</td>
<td>0.08</td>
<td>511.7±85.6</td>
<td>458.7±133.3</td>
</tr>
<tr>
<td>CHO (g/kg)</td>
<td>5.2±1.3</td>
<td>7.2±1.8</td>
<td>0.04*</td>
<td>7.6±1.4</td>
<td>6.7±2.1</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>81.9±14.8</td>
<td>93.7±25.1</td>
<td>0.31</td>
<td>124.3±13.9</td>
<td>126.7±32.9</td>
</tr>
<tr>
<td>Fat (g/kg)</td>
<td>1.4±0.2</td>
<td>1.7±0.5</td>
<td>0.14</td>
<td>1.8±0.3</td>
<td>1.9±0.5</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>34.5±12.3</td>
<td>40.1±10.4</td>
<td>0.32</td>
<td>37.5±5.0</td>
<td>34.9±3.3</td>
</tr>
</tbody>
</table>

Note. Independent t-test used. DE = disordered eating behaviors. Kcal/d = kilocalories per day. Kcal/kg = kilocalories per kilogram of body weight. EB = energy balance measured in kilocalories per day. TEE = total energy expenditure measured in kilocalories per day. EEE = exercise energy expenditure measured in kilocalories per day. PRO = protein. CHO = carbohydrates. G = grams. G/kg = grams per kilogram of body weight. SD = Standard deviation.

* p < 0.05
Macronutrient Intake

Macronutrient (CHO, PRO, and fat) intake, reported in Table 3, was expressed as total grams per day (g/day), and as grams per kilogram of body weight (g/kg). Independent $t$ tests were used to determine significance between disordered eating and macronutrient intake. Females classified with DE reported a significantly lower intake of protein (g/day and g/kg) and intake of carbohydrates (g/kg) than female runners without DE (Table 3). Macronutrient intake was not significantly associated with DE in male runners.
Micronutrient Intake

Runners’ micronutrient intake is outlined in Table 4 (females) and Table 5 (males), including intakes of vitamin A (IU), vitamin C (mg), vitamin D (IU), calcium (mg), and iron (mg). Independent *t* tests were used to evaluate the association between
DE and micronutrient intake. Female runners without DE reported significantly lower vitamin A intake than female runners with DE. Male runners with DE reported significantly higher calcium intake than male runners without DE (Table 5).

Table 4

Daily micronutrient intakes in female runners (n=19) based on mean 24 hour food recall data and percentage of RDA consumed

<table>
<thead>
<tr>
<th></th>
<th>DE (n=6)</th>
<th>No DE (n=13)</th>
<th>Total ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake (Mean ± SD)</td>
<td>Consuming &lt; RDA</td>
<td>_intake (Mean ± SD)</td>
<td>Consuming &lt; RDA</td>
</tr>
<tr>
<td>Vitamin A (IU/d)</td>
<td>26699.3±14044.3</td>
<td>1 (16.7)</td>
<td>11867.7±13107.2</td>
</tr>
<tr>
<td>Vitamin C (mg/d)</td>
<td>227.2±52.6</td>
<td>0 (0)</td>
<td>183.7±85.7</td>
</tr>
<tr>
<td>Vitamin D (IU/d)</td>
<td>1014.8±2092.4</td>
<td>5 (83.3)</td>
<td>267.6±252.9</td>
</tr>
<tr>
<td>Calcium (mg/d)</td>
<td>1381.2±670.5</td>
<td>3 (50)</td>
<td>1832.2±1077.1</td>
</tr>
<tr>
<td>Iron (mg/d)</td>
<td>24.0±11.8</td>
<td>4 (33.3)</td>
<td>30.7±11.8</td>
</tr>
</tbody>
</table>

Note. Independent t test used. DE = disordered eating behaviors. RDA = Recommended Dietary Allowances. SD = standard deviation. IU/d = international units per day. Mg/d = milligrams per day. *p < 0.05

Table 5

Daily micronutrient intakes in male runners (n=30) based on mean 24 hour food recall data and percentage of RDA consumed
<table>
<thead>
<tr>
<th></th>
<th>DE (n=12)</th>
<th>No DE (n=18)</th>
<th>Total ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intake (Mean ± SD)</td>
<td>Consuming &lt; RDA [n (%)]</td>
<td>Intake (Mean ± SD)</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>8966.8±9230.3</td>
<td>6 (50)</td>
<td>9876.3±8800.3</td>
</tr>
<tr>
<td>(IU/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin C</td>
<td>243.9±84.7</td>
<td>0(0)</td>
<td>183.1±121.7</td>
</tr>
<tr>
<td>(mg/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin D</td>
<td>354.4±233.9</td>
<td>9 (75)</td>
<td>387.1±471.8</td>
</tr>
<tr>
<td>(IU/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>2111.2±682.6</td>
<td>0 (0)</td>
<td>1480.3±562.9</td>
</tr>
<tr>
<td>(mg/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>24.0±11.8</td>
<td>4 (33.3)</td>
<td>30.7±11.8</td>
</tr>
<tr>
<td>(mg/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Independent t test used. DE = disordered eating behaviors. RDA = Recommended Dietary Allowances. SD = standard deviation. IU/d = international units per day. Mg/d = milligrams per day

* *p < 0.05

**Multivariate Analyses**

A multivariate analysis evaluated potential predictors of negative energy balance. According to the analysis, classification with elevated dietary restraint (p=0.07) and body mass index (p=0.06) trended toward significance as positive predictors (Table 6). The model also adjusted for age, and gender, however these factors did not reach statistical significance (Table 6). The odds of exhibiting negative energy balance were 3.3 higher for female runners than for male runners, 2.5 times higher with self-reporting dietary restraint, and 1.5 for each additional BMI unit.
Table 6

Multivariate logistic regression model of variables contributing to the prediction of negative energy balance among the male and female runners

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>1.1</td>
<td>(0.7, 1.9)</td>
<td>0.64</td>
</tr>
<tr>
<td>Body mass index (kg/m2)</td>
<td>1.5</td>
<td>(1.0, 2.4)</td>
<td>0.06</td>
</tr>
<tr>
<td>Gender¹</td>
<td>3.3</td>
<td>(0.6, 19.3)</td>
<td>0.31</td>
</tr>
<tr>
<td>Dietary restraint</td>
<td>2.5</td>
<td>(0.9, 6.5)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*Note.* CI = Confidence interval.
¹Males were coded as the reference group.
*P*-value <0.05
CHAPTER 5
DISCUSSION

Summary of Findings

The purpose of this study was to determine the prevalence of disordered eating (DE), and to identify the relationship between DE and nutrient status among male and female cross-country athletes from UCLA and Stanford University. Results showed that 31.7% of female runners and 40% of male runners were characterized with DE. Of the female runners, 50% reported using dietary restraint as a PWCB and 83.3% reported disordered weight perception. Of the males, 41.7% reported using excessive exercise as a PWCB and 75% reported disordered weight perception.

Discussion

Prevalence of Disordered Eating

There were no reports of current or previous eating disorders among the runners. However, the results did find that approximately one-third (36.7%) of runners reported engaging in DE, characterized by dietary restraint, pathogenic weight control behaviors (PWCB) like self-induced vomiting, laxative or diuretic use, and excessive exercise, and/or disordered weight perception. Binge eating was not included as a PWCB in this study because past research has indicated that athletes may not be able to distinguish between bingeing and consuming sufficient calories to maintain energy balance (Sundgot-Borgen & Torstveit, 2004).

Female Cross-Country Runners

Results of the current study showed that 31.6% of female runners engaged in DE, with 50% of those females with DE reporting dietary restraint (Table 5). The prevalence
of DE among female runners is relatively high when compared to athletes of all sports; however these findings are comparable to past research findings and may be explained by the fact that athletes participating in leanness sports feel increased pressure to maintain their physique (Sundgot-Borgen, 1993; Byrnes & McLean, 2002; Sundgot-Borgen & Torstveit, 2004; Greenleaf et al., 2008). Byrne and McLean (2002) conducted the first large-scale study exploring the prevalence of eating disorders (ED) as well as influential factors in developing ED in male and female athletes compared to non-athletes. They found that athletes participating in leanness sports, like cross-country running, had a higher prevalence of ED. They also found that leanness-sport athletes with a thin build felt increased pressure to maintain their physique compared to normal build athletes in the same type of sport (Byrne & McLean, 2002). Sundgot-Borgen and Torstveit (2004) later confirmed this finding. In addition, women are subject to societal pressure to conform to Western standards of beauty, which includes maintaining a thin physique (Cafri, Yamamiya, Brannick & Thompson, 2005; Greenleaf et al., 2008).

**Male Cross-Country Runners**

While previous research has also shown that female athletes are at greater risk for DE, especially when compared to male athletes (Sundgot-Borgen, 1993; Byrne & McLean, 2002; Sundgot-Borgen & Torstveit, 2004; Greenleaf, Petrie, Carter, & Reel, 2009), results of this study showed that female runners (31.6% prevalence) were not necessarily at higher risk of DE when compared to the male runners (40% prevalence). The prevalence among men was slightly higher, though not significant. One reason for this could be that there were almost twice as many male runners as female runners in this study (30 and 19, respectively). An earlier study exploring the prevalence of eating
disorders in athletes found that only 9% of endurance male athletes met the criteria for clinical and subclinical ED (Sundgot-Borgen & Torstveit, 2004). One reason for this discrepancy may be that this previous study was conducted on a larger scale and they did not use disordered weight perception as a classification criteria. Findings from the current study are notable and warrant further study of the unique and specific characteristics of DE in male runners.

Of the male runners with DE, 41.7% reported engaging in excessive exercise as a method for weight control. Previous studies have shown that excessive exercise is typically used as a method of weight control compared in male athletes with a high prevalence of DE behaviors, (Chatterton & Petrie, 2013; DiGioacchino, Wethington, & Sargent, 2002; Lewinsohn et al., 2002; Sundgot-Borgen & Torstveit, 2004), therefore this finding is consistent with prior reports.

The most intriguing finding among the male runners pertained to disordered weight perception. A majority of male runners with DE (75%) reported distorted weight perception (being slightly or moderately overweight), yet none of them reported engaging in dietary restraint and only 41.7% of the DE male group reported engaging in PWCB (excessive exercise). This finding suggests that male runners have distorted perceptions about weight, but are not engaging in typical compensatory behaviors. This finding in male runners is novel. Previous research hints at potential explanatory factors behind this occurrence. Byrne & McLean suggested a threshold effect (with regard to sociocultural pressure on athletes) that impacts thin build athletes (2002). They also suggest protective and aggravating external factors that may impact ED development (Byrne & McLean, 2002). It is possible then that the male runners with ED in this study, while perceiving
their bodies as overweight, may not have reached the sociocultural threshold or that they may have a greater number of protective factors like high self-esteem. Another study exploring body image among male athletes found that pride in their physical performance outweighed body dissatisfaction (Galli & Reel, 2009).

**Demographic Characteristics**

There were no differences in demographic or training status among male athletes with DE compared to those with normal eating attitudes and behaviors. Also, among women, there were no differences in age, height, weekly running mileage, or menstrual variables according to DE status. However, results showed that female runners with DE had significantly higher weight and BMI than those without (Table 1). Female runners in the DE group also reported significantly lower energy intake and negative energy balance compared to the no DE group (Tables 1 and 2, Figure 1b). This finding is consistent with other reports (Cobb et al., 2003; Beiseigel & Nickols-Richardson, 2004; Barrack, Rauh, Barkai, & Nichols, 2008).

Results showed that 83.3% of female runners with DE reported perceived themselves as overweight or needing to lose weight despite being within healthy weight limits. This finding may correspond with the significantly higher BMI and weight as well as the significantly lower energy intake and energy balance reported in the female DE group. In previous studies conducted on the prevalence of ED in female athletes, drive for thinness was one of the primary factors in developing PWCB (Beals & Manore, 1994; Byrne & McLean, 2002; Lewinsohn et al., 2002). The female runners with DE in this study may have been driven by internal and external pressure to weigh the same as their low-weight teammates. External pressures may include coaches, parents, perceived
competitive edge, or socio-cultural factors (Hinton et al, 2004). In fact, Biesecker & Martz showed that male and female athletes responded with more anxiety, fear, and PWCB from being exposed to negative coaching styles (as cited in Baum, 2006).

**Nutrient Status**

**Energy Status**

Female runners with DE also reported significantly lower energy intake and negative energy balance compared to those without DE (Tables 1 and 2, Figure 1b). The cause of negative energy balance in female runners with DE appears to be primarily from low energy intake, as mileage and EEE were similar between both female groups (Figures 1a-1d). Negative energy balance in athletes can lead to severe complications in physiologic functions, including suppressed basal metabolic rate, decreased protein turnover, impaired physical performance, and increased risk of injury (Carbone, McClung, & Pasiakos, 2012).

Sufficient energy intake is essential to maintain positive energy balance. As female runners are at high risk for eating disorders, they are also at high risk for negative energy balance. Using, doubly labeled water, the gold-standard method of assessing energy expenditure, Schulz et al. determined that competitive female runners require approximately 2800 kcal/day to compensate for energy expenditure (Schulz et al., 1991). However, results from this study showed that energy intake was lower than the value recommended and lower than their TEE (Schulz et al., 1991). Hinton et al determined that female collegiate athletes required 2200 kcal per day and male collegiate athletes may require 3600 kcal or more, but typically consume much lower values (Hinton et al., 2004).
Female cross-country athletes with negative energy balance are also at increased risk for developing the Female Athlete Triad. Clinical manifestations of the Triad include functional hypothalamic amenorrhea (or dysmenorrhea) and low bone mass. The process of the Triad begins with low energy availability, which leads to disrupted levels of growth, gonadal, and metabolic hormones, and disrupted bone metabolism. The disruption of bone metabolism leads to increased risk of stress fracture and osteoporosis. Low energy intake may be inadvertent and related to poor dietary habits or it may intentional and symptomatic of disordered eating or a clinical eating disorder. Increasing energy intake to meet the needs of the athlete generally leads to reversal of symptoms (Nattiv et al., 2007).

**Macronutrient Intake**

Results of this study showed that female runners in the DE group had significantly lower protein (PRO) intake than those in the no DE group, both in grams and grams per kilogram of body weight. They also had significantly lower carbohydrate (CHO) intake in g/kg (Table 3). Runners are recommended to consume 6-10g/kg of CHO and 1.2-1.4g/kg of PRO daily (AND, 2009). PRO intake of up to 1.7 g/kg has also been suggested for maintaining nitrogen balance (Barrack & Van Loan, 2011). Both the DE and no DE female runner groups were within the recommended guidelines for PRO, but females in the DE group were below the guidelines for CHO (g/kg).

Sufficient CHO intake in female runners is essential for glycogen repletion and energy metabolism (Barrack & Van Loan, 2011). Low carbohydrate intake combined with low energy availability has also been linked to hormonal dysfunction, which reduces bone formation in female athletes (Nattiv, 2000; Ihle & Loucks, 2004). The significantly
lower intake of PRO and CHO in female runners with DE can be attributed to the significantly lower energy intake (Table 2, Figure 1a) and prevalence of dietary restraint (50%) found among this group.

**Micronutrient Intake**

Results showed that there was no significant difference in mean intakes of the examined micronutrients between groups and genders, with the exception of two micronutrients. Intake of calcium in male runners with no DE was significantly lower compared to male runners with DE (Table 5). However, mean calcium intake among this group (1480 mg/day) was within 90% of the Recommended Daily Allowance (RDA) of 1500 mg/day, which is considered sufficient. Vitamin D intake was lower than the RDA in both groups of male runners. Vitamin A was significantly lower among the female runners with No DE (Table 4), yet intake of vitamin A in both groups of female runners was significantly higher than the RDA (2300 IU/day). Despite the lack of significant differences between groups of female runners, results showed that 50% of the female runners with DE had low calcium intake and over 80% of female runners in both groups had low vitamin D intake.

Adequate calcium and vitamin D intake is important for bone mineralization. In runners, it is especially important for preventing health disorders like stress fractures. Stress fractures are a common and debilitating problem in male and female competitive runners. They occur when bone breaks due to inability to handle the stress of repetitive, physical activity. Previous studies have suggested a correlation between energy deficit, micronutrient deficiencies, and increased risk of stress fracture (Nattiv, 2000; Benenll, Matheson, Meeuwise, & Brukner, 1999; Moran et al., 2012; Duckham et al, 2013). Low
intake of micronutrients like calcium and vitamin D has been associated with calcium depletion in bone, which also leads to increased bone resorption and fractures (Moran et al, 2012; Daneshvar et al; 2012). Zanker and Swaine previously found a correlation between poor energy balance, low body mass, low estrogen status and increased bone turnover, indicating that poor energy intake causes hormonal imbalance at the level of the hypothalamus, thus increasing the rate of bone turnover (1998). The increase in bone turnover leads to a negative balance between bone growth and bone breakdown. When bone breakdown exceeds bone growth, bone becomes porous and susceptible to fracture.

Overall, micronutrient status was similar between groups and sufficient with regard to vitamins A and C and iron. One explanation for these findings is that runners with DE, while restricting macronutrient intake, were still eating similarly nutrient-dense foods as the runners with No DE. Beals and Manore found a similar result in a study that explored the macro- and micronutrient intakes of female athletes with Sub-ED (1998). Another explanation may be that many of the athletes were using vitamin and mineral supplements.

Implications and Conclusion

The findings in this study provide a current summary of the health status of runners. A correlation between DE status and insufficient nutrient intake, specifically carbohydrate and protein consumption, was established. A significant relationship between DE status and low energy intake was also established, which indicates that male and female runners are still vulnerable to pathologic eating and weight behaviors despite advances in knowledge about eating disorders in athletes as well as advances in nutritional knowledge over the past 20 years. What’s more, results from this study
underscore the need for gender specific assessment of eating disorder status in athletes and in the general populations, as many of the assessment tools designed to screen for ED were developed based on ED symptoms exhibited by women. Male runners (and non athletes), while feeling pressure to conform to a certain body image, may not react to these pressures in the same way as female runners and non-athletes. In addition to gender specific screening tools for ED, nutrition education and interventions should be a standard part of athletic training and must be a collaborative, consistent effort between coaches, doctors, and dietitians.

The findings in this study also provide a platform from which further research can be conducted. Future research exploring the prevalence of DE and/or ED and the relationship between DE status and nutrient intake should also look at physiological markers of energy restraint and micronutrient status, including bone mineral density and serum micronutrient levels. Plus, future researchers may want to consider using multiple diet history methods, like the FFQ in combination with 24-hour food recall interviews along with enhanced screening questionnaires. These methods can provide a more complete and accurate picture of the impact of DE status on runners’ health, which can then lead to more robust and effective treatment options.
REFERENCES


Shriver, L. H., Betts, N. M., & Wollenberg, G. (2013). Dietary intakes and eating habits of college athletes: Are female college athletes following the current sports


APPENDIX

24-HOUR RECALL METHOD

ADMINISTERING THE 24-HOUR RECALLS

Summary

When calling the runners, you will go over all of the foods they have eaten in the previous 24 hours. For example, if you are calling on a Tuesday, you will ask about all of the foods they ate on the previous Monday. You will need to get their food intake on 2 weekdays and 1 weekend day, however you won't necessarily call on 2 weekdays and 1 weekend day, since, for example, you would call on a Monday to get food intake from Sunday. Weekdays are Monday-Friday and weekend days are Saturday and Sunday. Make sure to identify the food item description, portion size, and time that the food was consumed. On the last recall you will also ask them information about their purposeful exercise during the past week.

Script for the beginning of each 24-hour recall:

“Hello, may I please speak with _________________. Hello ________________, my name is ______________________ and I am with the UCLA/Stanford Cross-Country research study. I am going to ask you about all of the food and beverages you had yesterday, during the past 24 hours. Do you have approximately 10 to 15 minutes for this phone call? Do you currently have access to a computer? If so can you open the link from the CDC website?

http://www.cdc.gov/nchs/nhanes/measuring_guides_dri/measuringguides02.htm”
Script for the end of each 24-hour recall:

“Thank you for your time. I will be calling you _______ (# of 24-hour recalls remaining) more times between today and __________ (end date of the 24-hour recall period). On the last phone call I will also ask you about all of the structured exercise you have participated in during the past week. Prior to the call, it may be helpful to write down the time and type of structured exercise you participate in each day.”

Questions to ask on the first 24-hour recall:

Do you have any food allergies or food intolerances?

Do you avoid or restrict certain types of foods for religious, cultural, or other personal reasons?

Are you a vegetarian or vegan? If so, what animal foods do you avoid (i.e. beef or other similar mead, chicken, fish, eggs, dairy)- circle all those that apply

Do you follow any other special diet?

What dietary supplements do you currently take (on at least 3 days per week)?

1. If dietary behaviors have changed in any way since the fall (Y/N)

2. If YES, how their diet has changed

3. If YES, were the changes related to the recommendations provided by the RD/nutritionist during their one-on-one meeting(s)?

Purpose and Overview of the 24-hour Recall

To obtain an accurate & complete listing of all food/drink client consumed within last 24 hrs (i.e. What food/drink was consumed? How much was consumed? Time it was
consumed? How was it prepared? How was it served? Specifics of food (low fat, 1%, whole))

**Strengths:** if unannounced, may better reflect true intake; administered by a trained student/professional, short-term reflection of food intake

**Weaknesses:** may not represent typical intake over a long-term period

**Important Points Regarding Administration of the 24-hour Recall**

**3 STEP METHOD**

**Step 1: Quick List**

Get a list of all foods eaten without determining amounts, go back and get amounts in step 2

The client should tell you everything eaten or drunk, including snacks, coffee breaks, alcoholic beverages, even carbonated water (at home or away from home)

**Step 2: Detailed Description**

Get more complete info on foods already reported “Do you remember anything else you ate or drank with this food?”; “What else did you have at this meal?”, “Was this (bread, vegetable) eaten plain or did you put something on it?”

Ask if they took dietary supplements in a pill, capsule, powder, or other form

- **Food Probe Questions** (to be used during Step 2)
  - Type of food (i.e. what type of milk?)
  - Form purchased (fresh/frozen/canned/dry?)
  - Method of prep (boiled/baked/fried/breaded?)
Step 3: Review (at the end of interview)

Review the 24-hour list, ask if there’s anything else that he/she may have forgotten before or that you missed?

Determine if this intake is typical of most days.

Overview

Begin by asking open-ended questions

Save closed ended questions for later

Avoid leading questions (“You don’t drink whole milk, do you?”)

Avoid labeling meals, breakfast/lunch/dinner

Parts eaten (whole item/half?)

Ingredients (if mixed dish, what ingredients used and amts?)

Addition to foods: was anything added to food during prep or at table? Was dressing added? Cream or sugar?

Estimating Portion Size (see Measuring Guides for the 24-hour Recall Interview)

http://www.cdc.gov/nchs/nhanes/measuring_guides_dri/measuringguides02.htm