ESTIMATING ENERGY AVAILABILITY AND EXAMINING ITS ASSOCIATION WITH BONE MINERAL DENSITY IN MALE CYCLISTS

by

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STATEMENT OF THESIS APPROVAL

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ABSTRACT

Research indicates that male cyclists are at risk for low bone mineral density (BMD), which has largely been attributed to the lack of bone loading afforded by the sport of cycling. There may, however, be other reasons for the low BMD seen in male cyclists including low energy availability resulting from attempts to reduce body weight in order to improve power-to-weight ratio. The purpose of this pilot study was to assess energy availability (EA) and bone health, as well as examine the association between these variables among elite male cyclists (n= 22) as compared to age-matched, nonathletic controls (n=22). EA was determined using 3-day weighed food and activity records designed to capture 3 distinct training days (heavy, moderate and easy). Exercise energy expenditure was calculated using the compendiums for physical activity. Bone health was determined by measuring areal bone mineral density (aBMD) of the lumbar spine and left hip using dual energy x-ray absorptiometry (DXA) and from self-reported stress fracture incidence. Descriptive statistics were calculated and Pearson Chi-square (X^2) analyses were used to examine associations between low EA and aBMD. The results indicated that EA was significantly lower in the cyclists compared to controls (17.7 ± 8.9 kcal-kg^{-1} FFM-d^{-1} vs 33.86 ± 9.8 kcal-kg^{-1} FFM-d^{-1}, $P<0.05$). 91% of the cyclists (n= 20) and 41% (n= 9) of the controls had "low" EA ($\leq$30 kcal-kg^{-1} FFM-d^{-1}) (P= 0.001). None of the cyclists and 4 of the controls met the "optimal" EA value of $\geq$ 45 kcal-kg^{-1} FFM-d^{-1}. Spinal aBMD was lower in cyclists vs. controls (0.950 + 0.12 kg/m^2

and 1.045 + 0.11 kg/m^2, respectively, P= 0.010). Significantly more cyclists (73%, *n*= 16) than controls (32%, *n*= 7) had low spinal aBMD (P< 0.05). Hip aBMD was also lower in the cyclists (0.944 $\pm$ 0.14) compared to controls (0.989 $\pm$ 0.13), and more cyclists (32%, *n*= 7) than controls (9%, *n*= 2) had low hip aBMD, although these differences were not statistically significant. There were no statistical associations between low EA and aBMD at either the spine or hip for either the cyclists or the controls. Despite the lack of a statistical association, the high prevalence of both EA and low BMD in these elite level cyclists warrants further longitudinal investigation and a greater focus on intervention strategies to prevent potential health consequences while maintaining or optimizing cycling performance.

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INTRODUCTION

To be competitive in the sport of road cycling, athletes must maintain physically demanding training and racing schedules. Road cycling races for men can range from single day events to multiday stage events lasting anywhere between 3 days to several weeks (e.g., the Tour de France). The typical training schedule of a professional cyclist encompasses >600 km/week of riding, for an annual training and racing commitment of 25,000 to 35,000km (1)(2). To prepare for these types of road cycling events, athletes will spend several hours a day, often 7 days a week, in the saddle. Such extensive training schedules demand high energy and nutrient intakes.

In training and competition situations, elite level cyclists' need anywhere from 3200-8000 calories per day, and sometimes more, in order to supply sufficient energy to fuel their bodies and effectively recover from training (3). These high calorie levels are required to meet the energy demands, particularly the carbohydrate (CHO) and protein needs of this selective group of athletes. Although general sports nutrition guidelines suggest a daily intake of 7 to 10 g/kg is sufficient for the needs of endurance athletes in training, the prolonged training sessions undertaken by high-level cyclists may necessitate higher CHO intakes of 12 g/kg per day to achieve optimal glycogen restoration. The required mean daily intakes of protein for athletes undertaking a substantial training load is 1.2 to 1.6 g/kg (4).

In the quest to improve performance, cyclists often place an emphasis on obtaining an optimal "power-to-weight" ratio (power: weight), which is measured by the amount of power (watts) one is able to generate per pound or kilogram of body weight (5). A higher power: weight ratio is important to a cyclist, as a light yet strong physique is more efficient at propelling the bike and body up steep mountain grades and for maintaining power in an aerodynamic position in time trail events, as it takes less energy to sustain less body mass during long rides or races. Because of the potential benefits of improving power, cyclists continually strive for the most muscle mass on the lightest body frames. Therefore, they attempt to lose fat mass while maintaining fat free mass (FFM) without losing power on the bike.

A real life example of how an increased power: weight improved cycling performance comes from the story of 7-time Tour de France winner Lance Armstrong, who underwent chemotherapy to combat testicular cancer. The process of chemotherapy caused him to lose 15 pounds, a significant amount of which was fat mass (6). After re-training his body and improving his leg power, he was able to conquer the most treacherous mountain stage, Alpe D'Huez, 3 minutes and 47 seconds faster than his own record time. That historical moment led to a stage win and is often attributed to the increase in his power-to-weight ratio (6). Because of this famous incident and other anecdotal stories, as well as coaching strategies to improve athlete performances, many cyclists attempt to improve their power-to-weight ratios themselves.

There are a number of methods that cyclists use in order to improve their power: weight. The most common is to severely restrict energy intake while continuing high intensity training. This general paradigm can be accomplished in a variety of ways (4).

Cyclists may commence intense 3 to 4 hour morning training in a fasted state in the attempt to stimulate fat oxidation because the body is depleted of carbohydrates (3). Along the same lines, cyclists may train with minimal or even no refueling during their training bout, again forcing the muscles to rely on stored triglyceride (vs. using exogenous CHO). It is recommended that endurance athletes consume about 30–60 g of CHO per hour of training during prolonged training or races >1 hour. By consuming the minimum level of CHO needed, cyclists believe that they can increase the utilization of fat as fuel, and promote loss of body fat (3)(4)(5). Another strategy used by cyclists to lose body fat is to postpone eating after a training session. Athletes are normally advised to consume CHO (1-2 g/kg within 2 hours, then repeat over next 2 hours) along with protein (10-20 g) within 30 minutes postexercise for optimal recovery (25). The concept behind the strategy of not refueling postexercise is to once again force the body to rely on stored triglyceride for fuel. A final noted weight loss method utilized by cyclists to lose weight, particularly body fat is to suppress appetite with diet drugs (5)(8).

The weight loss strategies used by cyclists, while potentially effective in improving the power: weight ratio, can have significant negative consequences on nutritional status, athletic performance and overall health. Exercising in a fasted state compromises the athlete's ability to reach the exercise intensities necessary to induce important training effects and may curtail the training session due to glycogen depletion and subsequent fatigue. Similarly, failure to consume exogenous carbohydrate during exercise will result in more rapid glycogen depletion and earlier onset of fatigue. Also with endurance training, as glycogen stores are depleted less glucose is available for the

brain, which negatively effects cognition and reaction time. The body may break down protein for gluconeogenesis at that point, which could result in an unintended reduction in muscle mass and subsequent power. As some cyclists will restrict calories in liquids, they may avoid drinking sport products, and can become low or depleted in electrolytes and carbohydrates that are essential for performance, especially in endurance training situations (2)(3)(4)(5)(9). Finally, inadequate refueling, especially CHO replenishment, postexercise can impair glycogen synthesis and reduce the effectiveness of recovery, particularly when there is less than 24 hours before the next training session. This can put the body into a catabolic cascade that cannot only impair subsequent performance, but increase the risk of injury (3)(9).

Inadequate energy intake is often associated with inadequate nutrient intake, especially if such a practice is routine over time. Besides CHO, protein, and fat, athletes consuming energy insufficient diets often have inadequate intakes of essential vitamins and minerals including calcium, iron, A, C, D, E, and B vitamins, all of which are essential for optimal performance (9). Therefore, cyclists who actively restrict energy intake may be putting themselves at risk for low EA as well as inadequate micronutrient levels in the body.

Existing evidence suggests that some elite male cyclists engage in disordered eating behaviors in the effort to obtain their desired body weight or body composition (8)(9). A study by Riebl et al. examined eating behaviors among male cyclists (n=61) and found that approximately one third of the athletes admitted to intentionally restricting calories during intense training in the attempt to improve “power to weight” ratios, and 5 of the cyclists openly admitted to practices of disordered eating.

The male cyclists also scored significantly higher than the male control subjects (n=63) on questionnaires assessing eating disorder tendencies, dieting, and food preoccupation. Not surprisingly, the food frequency questionnaires revealed that many of the male cyclists did not consume adequate nutrients to sustain their metabolic needs (7).

The information described above highlights the fact that it is a fairly common practice among road cyclists to reduce energy intake in an attempt improve their power: weight. As indicated in the previous paragraphs, some of these cyclists may develop pathological emphasis on body form and food, leading to disordered eating patterns similar to anorexia and bulimia. Others will cycle through periods of energy restriction as they move through their training periods (8)(11). Regardless of the reason for the energy restriction, the effects on performance and health are the same. Inadequate energy intake can impair the cyclist's ability to sustain the exercise intensities that training and racing demand, as well as negatively impact recovery. In addition, prolonged energy deficiency can increase the risk of injury and illness and may negatively affect skeletal health (3)(4)(10).

The practice of restricting food intake and the subsequent effects of low energy intake has been well-documented in female athletes. The combined components of low energy availability, menstrual dysfunction, and poor bone health are collectively known as the Female Athlete Triad (Triad) (10). There is currently no research documenting a male equivalent of the Triad; however, indirect evidence suggests that male athletes, particularly male cyclists, may be at risk for low energy availability, which could result in compromised bone health.

Energy availability (EA) is defined as the amount of energy available for the metabolic processes of the body after energy is used for exercise, normalized for fat free mass (FFM):

EA = mean energy intake (EI) – mean energy expended in exercise (EEE) normalized for FFM

An individual who fails to consume sufficient calories to meet the cost of energy expended in exercise would have suboptimal energy availability. In female athletes, "low" energy availability is defined as an energy availability of < 30 kcal-kg^{-1}FFM-d^{-1} (10). This value was determined based on research showing that reproductive function is disrupted and markers of bone turnover (i.e., markers of bone formation and bone resorption) are negatively impacted when energy availability drops below 30 kcal-kg^{-1}FFM-d^{-1} (34)(35)(36). Although the concept of energy availability has not been specifically studied in male athletes, it is possible that male athletes who attempt to achieve and/or maintain a low body weight would be in a state of low energy availability, which could negatively affect their bone health, as seen in female studies. This phenomenon warrants further investigation, as the prevalence of low BMD in endurance trained athletes is important to understand in males as much as females in relation to long term consequences of poor bone health.

Bone mineral density (BMD) describes the amount of mineral (primarily calcium and phosphorous) contained within a certain volume of bone and is considered to be a key determinant of bone health. BMD is typically measured via dual-energy X-ray absorptiometry (DXA). BMD assessed by DXA reflects the mineral content per unit area of bone, and therefore is defined as "areal BMD" or aBMD. An athlete's BMD is

influenced by a number of factors, including genetic endowment, diet and exercise behaviors (11)(12). Low BMD has been shown to predispose an athlete to an increased risk of injuries, particularly stress fractures. Generally, strength and power trained athletes have higher BMD than endurance trained athletes due to high mechanical loads and fast rate "loading" muscles providing an osteogenic stimulus (11). However, many road cyclists avoid weight bearing activities considered beneficial for bone health, such as weight lifting and plyometric jump training, in order to not gain more weight than desired for optimal power: weight (13)(14)(15).

A number of studies have demonstrated lower BMD in road cyclists when compared to nonathletic, weight matched controls as well as compared to male athletes participating in other (higher impact or less weight dependent) sports. For example, a study by Warner et al compared the BMD of cross-country mountain bike racers with that of road cyclists who only trained and raced on the road, and sedentary controls. DXA was used to assess areal bone mineral density (aBMD) of the proximal femur, lumbar spine, and total body. Bone free lean body mass was significantly higher among the mountain bikers, and because lean body mass has been shown consistently to be highly correlated with BMD. The results indicated that aBMD, corrected for lean body mass, was significantly higher at all sites in the mountain bikers compared with the road cyclists and controls. The authors concluded that road cycling was no more beneficial to bone health than recreational activity in men of normal bone mass. In addition, the higher aBMD in the mountain cyclists suggested that mountain cycling may provide an osteogenic stimulus that is not inherent to road cycling, perhaps due to its novel and variable application of mechanical loads (16).

In another study, Smathers et al. compared total body, lumbar spine, and proximal femur aBMD in male competitive road cyclists (n = 32) and in age- and body mass-matched controls (n = 30) using DXA. The cycling group had significantly ($P < .05$) lower percent body fat, higher bone-free lean body mass, and lower spine aBMD than the control group, even though the cyclists appeared to consume adequate calories and more calcium in their diets than the controls. Based on DXA-derived t-scores, generated by comparing cyclists' aBMD to a standard reference database, 25% of the cyclists were osteopenic while only 10% of the controls presented with osteopenia. The authors concluded that future studies are needed to clarify the underlying mechanisms for low BMD in cyclists (11).

It should be noted that not all studies have shown lower BMD among male cyclists. Penteado et al. assessed diet, body composition, and aBMD in well-trained cyclists (n=31) and age matched nonathletic controls (n=28). Energy intake was adequate in cyclists, and the cyclists had greater lean body mass and aerobic capacity compared to the controls. In addition, there was no significant difference in aBMD between the cyclists and controls and similar number of cyclists (n=10) and controls (n=9) had low aBMD (15).

The inconsistencies in the existing literature highlight the need for additional research examining the potential contributors to low BMD in male cyclists. As previously indicated, low EA has been shown to suppress markers of bone formation and increase markers of bone resorption in exercising women (35). In addition research has shown that chronic under- nutrition in female athletes can reduce the rate of bone formation (10) and female athletes suffering from disordered eating are at greater risk for

low BMD and stress fractures (10). It is possible, then, that the low BMD frequently seen in male cyclists could be at least partly due to inadequate energy intake to support energy requirements and resulting low energy availability. Thus, the purpose of this study was to assess energy availability and bone health, as well as examine the association between these variables among elite male cyclists as compared to age-matched non-athlete controls. We hypothesize that positive associations between low EA and low BMD will suggest the importance of establishing education and prevention programs aimed at helping elite male cyclists improve their energy and nutrient intakes in order to lessen their risk of low BMD, subsequent skeletal injuries and osteoporosis.

METHODS

Research Design

This descriptive study examined the range of energy availabilities among male cyclists compared to normally active males, and sought to determine the prevalence of low energy availability as defined by existing energy availability categories and correlating those findings with differences in bone mineral density within and between both groups. All participants represented a sample recruited with strict selection criteria.

Participant Selection

Subjects consisted of elite male cyclists and age- matched nonathletic controls (18-45 years of age). For the purposes of this study, an elite level male cyclist (heretofore referred to as "cyclists") was defined as a male individual licensed through USA Cycling as a Category 1, 2, or 3 racer. Elite level cyclists train in road cycling year round, with a minimum of 10 hours per week or 150 miles per week and have been training at these levels for a minimum of 1 year. The nonathletic control group (heretofore referred to as "controls") was defined as sedentary male individuals who fail to meet the minimum level of recommended physical activity (i.e., 150 minutes per week of moderate intensity aerobic exercise or 75 minutes per week of vigorous intensity aerobic exercise), qualifying them as insufficiently active (23). The goal of this pilot study was to recruit 22

elite cyclists and 22 age-matched insufficiently active men. Based on data from similar studies examining aBMD differences between male cyclists and control groups, 22 participants per group was determined to be adequate to detect differences with 80% power and an alpha set at .05 (11)(12).

Individuals in either group that participate in other types of sport or training, including high-impact activities, were excluded from the study. Participants who used hormones such as testosterone or medication that may affect bone mass (anabolic steroids, glucocorticoid, diuretics, bisphosphonates, calcitonin, sodium fluorite, chemotherapeutics, or anticonvulsants within the past 2 years) were also excluded, consistent with previous BMD studies of cyclists (15). Subjects using nutritional supplements were not excluded. Anyone with a history of osteoporosis/osteopenia, hypogonadism, thyroid disease, epilepsy, diabetes, kidney stones, or smoking were excluded, as well as those who did not meet the specific exercise/training requirements listed in the inclusion criteria.

Participant Recruitment

Recruitment of the control subjects was conducted via flyers posted at the University of Utah and around Salt Lake City. Recruitment of cyclists was accomplished via direct contact with local cycling clubs, flyers at local road races, and recruitment emails sent through the Utah Cycling Association.

Assessment of Resting Metabolic Rate

The assessment of resting metabolic rate is required for the calculation of energy expenditure used in the energy availability equation. Resting metabolic rate (i.e., the calories expended at rest) was analyzed via indirect calorimetry using the Korr ReeVue machine (Korr Medical Technologies, Salt Lake City, UT) which uses a mouthpiece and a nose clip and measures oxygen volume (VO_2). Subjects were instructed to abstain from food and beverages, except water, for a minimum of 8 hours and to avoid strenuous activity for at least 12 hours before each visit. Upon coming to the laboratory, subjects rested quietly in a recliner for 30 minutes in a thermally neutral testing room and were provided an explanation of procedures. The Korr machine was auto-calibrated prior to each subject measurement.

Assessment of Energy Availability

Energy availability (EA), defined as the amount of dietary energy remaining for other bodily functions after energy expended in exercise training (10), was measured via 3-day food and exercise records and calculated using the following equation:

EA= mean energy intake (EI) – mean energy expended in exercise (EEE) normalized for FFM

Specifically, energy intake was determined via a food records in which subjects were instructed to measure and record all the food and beverages they consumed for 3 training days. Detailed instructions for accurate measurement of food intake were provided to each subject. Food records were analyzed utilizing Food Processor (version 9.0) diet analysis software. Energy expended in exercise training was also reported by subjects on

the same days that food intake was recorded. Subjects recorded the type, duration, and intensity of exercise performed on each of the 3 days. The control group was told that if they did not exercise to record their food intake alone.

Energy expenditure was calculated from the compendiums of physical activity (18) (19). In healthy, young women, energy balance is hypothesized to occur at an energy availability of > 45 kcal-kg^{-1}FFM-d^{-1} while both reproductive function and bone formation have been shown to be suppressed at energy availability below 30 kcal-kg^{-1}FFM-d^{-1} (10). There are currently no available data documenting energy availability categories in males; thus, for the purposes of this study the categories currently used for female athletes were utilized.

Assessment of Health, Weight, Dietary Patterns and Eating Behaviors

General health, dietary patterns and eating behaviors were assessed using a health, weight, dieting and eating patterns questionnaire modeled after previous research examining the prevalence of the Female Athlete Triad in female endurance athletes and adapted for male athletes (20) (21).

Anthropometric Measures and Assessment of Bone Health

Height in inches and weight in pounds were measured without shoes using a calibrated stadiometer and beam scale, respectively and values derived were subsequently converted into centimeters and kilograms, respectively. Body composition (fat mass and fat free mass) was measured via bioelectrical impedance using a Tanita BC-418 body

composition analyzer machine (Tanita Corporation of America, Inc., Arlington Heights, IL). Areal bone mineral density (aBMD) at the spine and hip were measured via dual energy x-ray absorptiometry (DXA) (Hologic Discovery Ci Bone Densitometer, Hologic Inc., Bedford, MA). The DXA scans were conducted at the offices of the Department of Obstetrics and Gynecology at the Center for Reproductive Medicine at the University of Utah. Quality assurance (QA) tests were performed each morning prior to testing to ensure a coefficient of variation < 5% as per manufacturer specifications. Based on values established in the Female Athlete Triad position stand for prevalence of osteopenia/osteoporosis in athletes, Z-scores $\leq$ -1 was used to define low BMD (10). The Z-score is a comparison of a patient's BMD to the number of standard deviations a patient's BMD differs from the average BMD of their age, sex, and ethnicity (9). Also, factors shown to be associated with risk for low aBMD (e.g., history of osteoporosis, diagnosis of scoliosis, stress fracture prevalence, dairy intake, etc.) were evaluated to assess bone health in the Health History questionnaire and the 3- day food records.

Statistical Methods, Data Analysis and Interpretation

Continuous demographic variables (age, height, weight, fat mass, fat free mass, etc.) were presented as means and standard deviations. Energy availability was examined both as continuous variable and dichotomously based on the categories determined in female athletes (i.e., < or > 30 kcal-kg^{-1}FFM-d^{-1}). CHI square analyses were used to examine the association between energy availability and aBMD. Frequencies and proportions were utilized to describe the prevalence of self-reported dieting, disordered eating behaviors, risk for low aBMD and stress fracture categories (22) (23)(24).

RESULTS

Description of Sample Groups

Of the 46 men sampled (*n*= 24 cyclists and 22 controls), only 2 cyclists did not complete the study due to time constraints. Thus, 44 total men (*n*= 22 cyclists and 22 controls controls) completed the study. Table 1 presents subject characteristics for the sample split by group. There were no significant differences in age between the cyclists and controls (32.1 $\pm$ 9.1 yrs and 31.9 $\pm$ 6.0 yrs, respectively). Average fat free mass was not significantly different between cyclists (63.8 $\pm$ 3.3 kg) and controls (66.0 $\pm$ 10.9 kg). However, body weight, BMI, and body fat percentage were all significantly lower in the cyclists (159.9 $\pm$ 14.2 lbs, 22. $\pm$ 2.53 kg/m^2, and 11.7 $\pm$ 4.2%, respectively) compared to controls (190 $\pm$ 35.6 lbs, 26. $\pm$4.3, 4 kg/m^2 , 19.6 $\pm$ 6.7%, respectively).

Energy Availability

Energy availability (EA), resting metabolic rate (RMR), energy intake (EI), and exercise energy expenditure (ExEE), all averaged from the 3-day diet and activity records for the cyclists and controls are presented in Table 2. There were no significant differences in RMR between the groups (cyclists 2040.9 $\pm$ 301.2 kcal/day and controls 2053.3 $\pm$ 342.4 kcal/day). Both EI and ExEE were significantly higher in the cyclists (3054.1 $\pm$ 820.9 kcals and 2646.8 $\pm$ 497.5 kcals, respectively), compared to controls

(2528.1 $\pm$ 563.9 kcals and 796.3 $\pm$ 211.3 kcals, respectively). Nonetheless, EA was significantly lower in the cyclists compared to controls (17.7 $\pm$ 8.9 kcal-kg^{-1} FFM-d^{-1} and 33.86 $\pm$ 9.8 kcal-kg^{-1} FFM-d^{-1}, respectively). Utilizing the definition of "low" EA previously determined in female athletes (e.g., an energy availability less $\leq$ 30 kcal-kg^{-1} FFM-d^{-1}), it was determined that 91% of the cyclists (n= 20) and 41% (n= 9) controls had low EA (P= 0.001), as shown in Figure 1. None of the cyclists and 4 of the controls met the "optimal" EA value of $\geq$ 45 kcal-kg^{-1} FFM-d^{-1}.

Weight Control Behaviors

Figure 2 presents self-reported weight control behaviors derived from the responses to the health, weight, and diet history questionnaire. Approximately half of the cyclists and controls reported consciously restricted energy intake while 59% and 73% of the cyclists and controls, respectively, indicated purposely restricting the types of foods they ate for weight control. Only 3 cyclists (14%) and 1 control (5%) self-reported they may have an eating disorder. However, 68% of the cyclists and 73% of the controls admitted to engaging in pathogenic weight control behaviors, including the use of diet pills or laxatives, fasting, purging, over-exercising, severely restricting calories, and very low carbohydrate diet. Despite this, 77% of the cyclists and 37% of controls reported being satisfied with their current body weight.

Bone Health

Table 3 and Figure 3 present the bone health data for the cyclists and controls. Spinal areal bone mineral density (aBMD) was significantly lower in the cyclists compared to controls (0.950 + 0.12 kg/m^2 and 1.045 + 0.11 kg/m^2, respectively, P= 0.010) and significantly more cyclists (73%, *n*= 16) than controls (32%, *n*= 7) could be classified as having low , defined as a z-score $\leq$ -1 (P=0.015). Although hip aBMD was also lower in the cyclists (0.944 $\pm$ 0.14) compared to controls (0.989 $\pm$ 0.13), and more cyclists (32%, *n*= 7) than controls (9%, *n*= 2) had low hip aBMD, the differences did not reach significance. The incidence of stress fractures was very low (*n*=1 in both groups) and there was no significant difference in reported incidence of stress fractures between the groups.

Associations Between Energy Availability and Bone Mineral Density

Tables 4, 5, and 6 present the CHI^2 analyses for associations between low EA and low spinal aBMD and low EA and low hip aBMD as a total sample set and within each group, respectively. There were no associations between low EA and aBMD at either the spine or hip for the sample as a whole, the cyclists or the controls. It should be noted, however, that in the CHI^2 analyses of the sample as whole there was one cell with an expected count less than 5 and in group analyses there were two cells with expected counts less than 5; thus, the results should be interpreted with caution.

Table 1

Subject Physical Characteristics

Variable	**Cyclists**[a]	**Controls**[a]	**Significance**
Age (y)	32.1 ± 9.1	31.9 ± 6.0	P = 0.923
Body Weight (lb)	159.9 ± 14.2	190 ± 35.6	P = 0.001[b]
BMI (kg/m^2)	22.3 ± 2.5	26.4 ±4.3	P = 0.000[b]
Body Fat (%)	11.7 ± 4.2	19.6 ± 6.7	P = 0.000[b]
FFM* (kg)	63.8 ± 3.3	66.0 ± 10.9	P = 0.374

Note. *FFM = fat free mass
[a]Values are means ± standard deviation between group; t-test.
[b]Significant difference between groups

Table 2

Resting Metabolic Rate, Energy Intake, Exercise Energy Expenditure and Energy Availability Between Groups

Variable	Cyclists[a]	Controls[a]	Significance
RMR[1] (kcal/24 hrs)	2040.9 ± 301.2	2053.3 ± 342.4	P = 0.900
EI[2] (kcal) *	3054.1 ± 820.9	2528.1 ± 563.9	P = 0.017[b]
ExEE[3] (kcal) *	2646.8 ± 497.5	796.3 ± 211.3	P = 0.000[b]
EA[4] (kcal-kg^{-1} FFM-d^{-1}) *	17.7 ± 8.9	33.86 ± 9.8	P = 0.000[b]

Note. *Represents average over the 3 day recording period
[1]RMR = resting metabolic rate
[2]EI= mean energy intake
[3]ExEE = mean exercise energy expenditure
[4]EA = energy availability
[a]Values are means ± standard deviation.
[b]Significant difference between groups

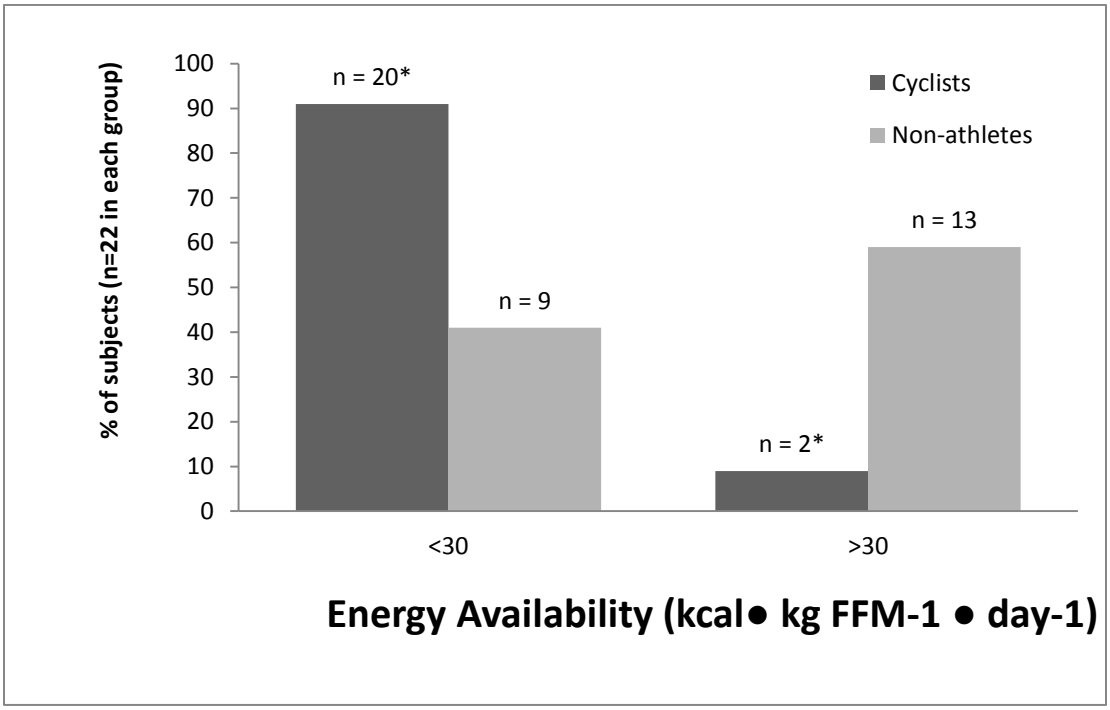

Figure 1. Percentage of cyclists and controlss below or above energy availability level of 30 kcal-kg^{-1}FFM-d^{-1}. * P = 0.001 compared to controls at both energy availability levels (chi-square test).

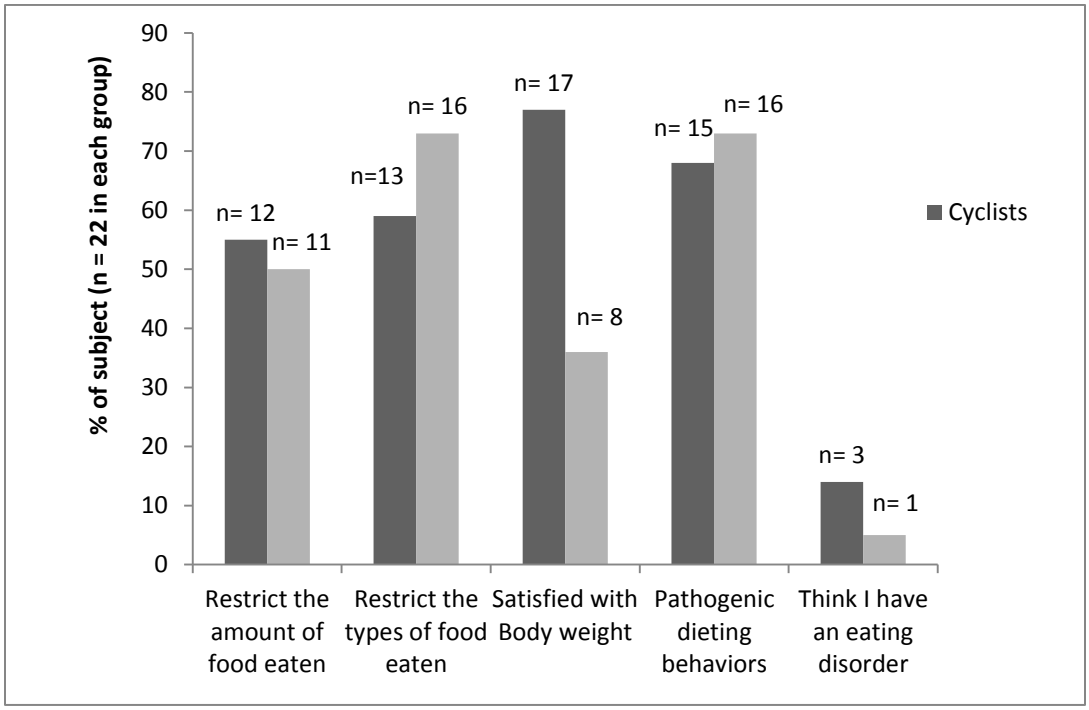

Figure 2. Percentage of subjects reporting weight control behaviors and body satisfaction.

Table 3

Areal Bone Mineral Density in the Spine and Hip for the Cyclists and Controls

Variable	**Cyclists**[a]	**Controlss**[a]	**Significance**
aBMD spine (kg/m^2)	0.950 ± 0.12	1.045 ± 0.11	P = 0.010[b]
aBMD hip (kg/m^2)	0.944 ± 0.14	0.989 ± 0.13	P = 0.272

Note. *aBMD = areal bone mineral density as measured using dual x-ray densitometry (DXA)
[a]Values are means ± standard deviation
[b]Significant difference between groups

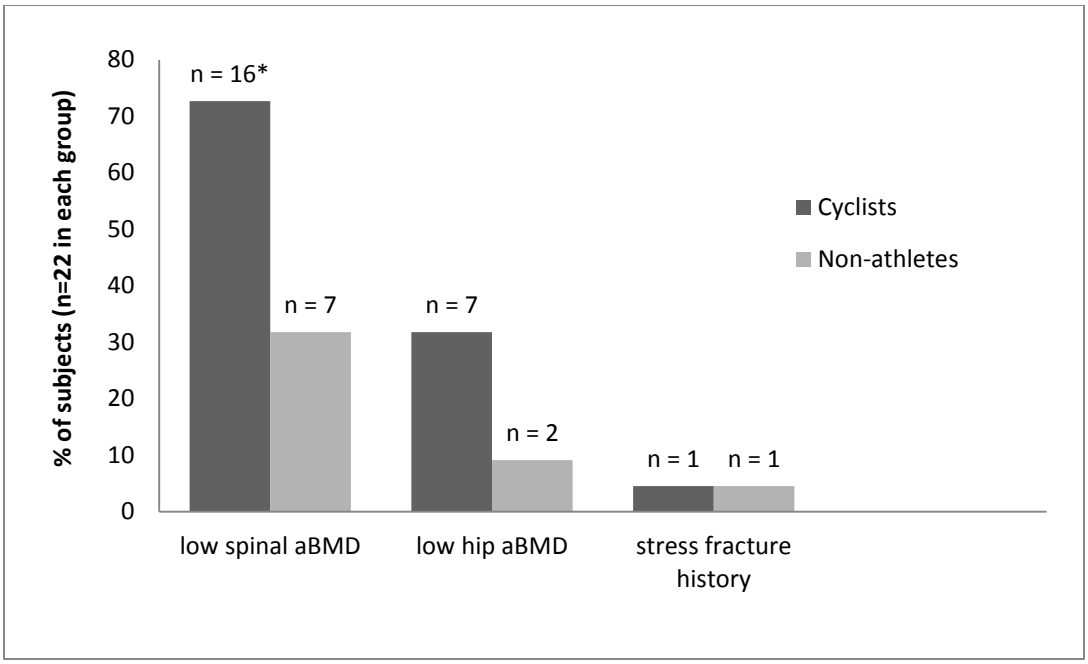

Figure 3. Percentage of cyclists and controlss with low areal bone mineral density (aBMD) in the lumbar spine, low aBMD in the hip, and any incidence of stress fracture during their lifetime. * P = 0.015 compared to controls (chi-square test).

Table 4

Associations Between Low EA, Low Spinal BMD, Low Hip BMD: Total Sample

Variable	EA < 30	EA ≥30	Chi-square	Significance
aBMD spine	18	5	3.272	P=0.112
aBMD hip	6	3	0.003*	P=1.00

Note. *1 cell has expected count < 5

aBMD = areal bone mineral density as measured using dual x-ray densitometry (DXA)

Table 5

Associations Between Low EA, Low Spinal BMD, Low Hip BMD: Cyclists

Variable	EA < 30	EA ≥30	Chi-square	Significance
aBMD spine	14	2	0.825*	P=1.00
aBMD hip	5	2	4.714*	P-0.091

Note. *2 cells have expected count < 5
aBMD = areal bone mineral density as measured using dual x-ray densitometry (DXA)

Table 6

Associations Between Low EA, Low Spinal BMD, Low Hip BMD: Controlss

Variable	EA < 30	EA ≥30	Chi-square	Significance
aBMD spine	4	3	1.119*	P=0.376
aBMD hip	1	1	0.075*	P=1.00

Note. *cells have expected count < 5
aBMD = areal bone mineral density as measured using dual x-ray densitometry (DXA)

DISCUSSION

The aims of this study were to assess energy availability and bone health, as well as to examine the association between these variables among elite male cyclists as compared to age-matched sedentary controls. To our knowledge, this is the first study to examine EA in men in whom there are currently no established criteria for designating low, adequate and optimal EA. For these reasons, we utilized the EA categories that have been established for female athletes as part of the female athlete triad-- low < 30 kcal-kg^{-1}FFM-d^{-1} , adequate 30-44 kcal-kg^{-1}FFM-d^{-1} and optimal $\geq$ 45 kcal-kg^{-1}FFM-d^{-1} – to evaluate the EA of the male cyclists and controls (9).

The results indicated that the mean EA of the cyclists was low (17.7 $\pm$ 8.9 kcal-kg^{-1}FFM-d^{-1}) and all but 2 of the cyclists had EAs below 30 kcal-kg^{-1}FFM-d^{-1}. Moreover, none of the cyclists reached an EA of 45 kcal-kg^{-1}FFM-d^{-1}. The mean EA of the control subjects (33 kcal-kg^{-1}FFM-d^{-1}) was significantly higher, and only 9 of the controls had an EA less than 30 kcal-kg^{-1}FFM-d^{-1} Nonetheless, only four of the controls reached an EA $\geq$ 45 kcal-kg^{-1}FFM-d^{-1}. It should be noted that the EA categories for female athletes were derived from research demonstrating that an EA below 30 kcal-kg^{-1}FFM-d^{-1} suppresses reproductive function and negatively impacts markers of bone turnover. The derivation of these categories raises the question of whether the EA categories established for female athletes are appropriate for male athletes: a question that can only be answered via future research in this area.

Regardless of the EA categories utilized, the data clearly indicates that many of the cyclists in this study were consuming inadequate calories to support their energy needs. In the present study, we found that average EI in the cyclists was 3054.1 $\pm$ 820.9 kcals. Research suggests that elite level cyclists have been shown to need between 3200 and 8000 calories per day in order to supply sufficient energy to fuel their bodies and effectively recover from training (3)(4). A study by Garcia-Roves et al. found that elite road racing requires approximately 5400 kcals/day during training and competition to maintain body weight (28). If we were to estimate average total daily energy requirements for the cyclists in this study it would be approximately 5188 kcal/d[1], which would mean our cyclists were, on average, in an energy deficit of approximately 2134 kcal/day.

These data are not surprising given that analysis of dietary recalls of elite cyclists from previous literature shows that energy balance tends to be negative based on diet recalls (4). For example, Jeukendrup et al. described the challenge of maintaining energy balance during prolonged cycling, attributing the inadequate intake of energy to meet ExEE to practical constraints such as time available for eating and suppression of appetite during and after exhaustive exercise (1). In a review by Louise Burke on endurance athletes notes that many factors could inhibit the implementation of sound nutrition, i.e., poor understanding of the principles of sport nutrition, failure to recognize one's own nutrition requirements, lack of practical nutrition knowledge, busy lifestyle, and inadequate finances for athletes that fund themselves (4). These factors may influence energy availability for some, but there are also numerous articles addressing dietary

[1] Estimated total energy expenditure calculated by RMR x TEF x Activity Factor + ExEE or 2040 kcal/day x 8% x 1.2 + 2647 kcal = 5188 kcal/d

behaviors of elite cyclists, specifically the acts of consciously restricting energy intake for weight control.

The inadequate energy intake and resulting low EAs among the cyclists in this study likely stems from a desire to reduce body weight in order to improve the power-to-weight ratio. Indeed, in the present study half of the cyclists reported consciously restricting energy intake and purposely restricting the types of foods they ate for weight control. The fact that three cyclists self-reported they may have an eating disorder is notable, considering the notion that there may be unreported or unconscious disordered eating in this group due to the private nature of the questions. Also, 68% of the cyclists did admit to engaging in pathogenic weight control behaviors, which indicates that the term "eating disorder" may alter one's likelihood to recognize or admit to define himself as such.

A number of studies have examined the prevalence of weight control behaviors among elite male cyclists. Reibl et al. evaluated 61 male cyclists against 63 noncyclists on self-reported weight control behaviors. They found that cyclist scored significantly higher on the eating attitude test (EAT-26) than the controls, specifically with high scores in the diet restriction, bulimia, and food preoccupation categories. Based on their surveys, 12 of the cyclists were classified with subclinical eating disorders, with 5 of those cyclists self-reporting to have eating disorders (7). Another survey on nutritional practices of male cyclists linked the prevalence of weight restriction behaviors with subjects' perceived vs. actual energy intakes, only 23% actually consuming what they believed they were eating (29). Finally, a study by Ferrand and Brunet found that male cyclists

scored significantly high on surveys addressing eating attitudes, specifically in the categories of dieting, bulimia, and body perfectionism (8).

Among female athletes, disordered eating and low EA have been shown to negatively affect bone health (9). It was originally believed that the effects of disordered eating and low EA on bone were wholly indirect; that is, they were mediated by alterations in reproductive hormones (overtly demonstrated by menstrual dysfunction) (30). However, recent research has shown that both disordered eating and low EA can have direct negative effects on bone independent of changes in reproductive function (10)(37). Thus, it is possible that disordered eating and low EA in male athletes could also lead to changes in bone health as evidenced by low BMD.

In this study, male cyclists had significantly lower spinal aBMD and lower (though not significant) hip aBMD when compared to the control group. Moreover, 72% of the cyclists had Z- scores $\leq$ -1.00, putting them in the ranges of osteopenia and increased fracture risk based on the ACSM criteria (9). These results are consistent with other studies documenting low BMD in elite cyclists (12)(13)(14)(15)(31)(32). For example, Smathers et al. found significantly lower BMD in elite male cyclists compared to untrained controls, with 34% cyclists vs. 13% controls having Z-scores < -1.00 (11). It has also been reported that road cyclists consistently have signficantly lower aBMD than athletes involved in high impact or weight bearing sports. This includes endurance runners, with research showing higher aBMD than endurance cyclists, specifically in the femoral sites (12)(13)(14)(31). Finally, it has been shown that mountain bikers have significantly higher aBMD than road cyclists (16), likely due to the higher and more novel forces on bones from the rocky terrain compared to the pavement.

Currently, it is not known whether the low BMD commonly seen in male cyclists is due to the lack of bone loading (i.e., weight bearing activity) afforded by cycling, the extreme energy expenditures involved in training and competition, or some other confounding factor such as nutritional inadequacies including low EA. The beneficial effects of weight bearing activity on the skeleton have been well documented (32). Bone adapts to biochemical and environmental constraints by increasing bone formation, whereas prolonged weightlessness, as occurs in cycling training, induce bone resorption (31). As previously mentioned, cycling itself provides very little loading on the spine. Moreover, cyclists often avoid engaging in resistance training (which has been shown to improve BMD) (31)(33), for fear of adding extra "bulk" to their frames, thereby upsetting their power-to-weight ratio. And, as previously indicated, research consistently shows that male athletes engaging in weight bearing sports have higher BMD than their male cyclist counterparts (31)(32)(33). Taken together, this would seem to suggest that it is the lack of "bone loading" which is causing the low BMD in male cyclists. Nonetheless, there is also evidence to suggest that the energy deficits produced by the high energy costs of cycling and the resulting nutritional inadequacies may be at least partly responsible for the low BMD common in male cyclists.

Barry et al. examined changes in BMD over 1 year of intense training in elite male cyclists, and found that aBMD decreased significantly in the hip, neck, trochanter, and femur over the course of 1 year. Spinal aBMD also decreased, though not significantly. They also measured dermal calcium (Ca^{++}) losses from sweat and found that higher dermal Ca^{++} losses were associated with lower BMD values within the cyclists. These researchers concluded that excessive dermal losses of Ca^{++} from sweat

during the ExEE of endurance cycling may be a contributing factor to low BMD (14). It should be noted that the researchers did not examine EI or estimate total daily energy expenditure. These findings, though interesting, do not show a correlation between EI (caloric) and changes in BMD.

Based on research in female athletes, we hypothesized that low EA would be linked to low aBMD. However, our data failed to find a significant association between EA and aBMD at either the spine or the hip. One possible explanation for this is the lack of heterogeneity in the EA data. Indeed, with 20 athletes in the low EA category and only 2 in the adequate EA category, it makes valid, statistical determinations of associations nearly impossible. It is likely that a greater range of EAs would be necessary to see a significant association (if one truly exists). Another possible explanation is that the energy value used to designate the category of low EA (i.e., < 30 kcal-kg^{-1} FFM-d^{-1}) may not be appropriate for use in male athletes, given that the category was set based on female athletes. However, if anything a higher (not lower) EA level would seem logical for male athletes, since female athletes are naturally smaller and require fewer calories.

It is important to address the limitations in this study. First, although a power analysis confirmed that the sample size would allow for the detection of statistical significance if it existed, the inadequate range of EAs (particularly among the cyclists), likely rendered statistical analyses pertaining to EA invalid. The estimation and classification of EA in these male subjects is also a limitation. A precise method to determine EA has not yet been identified for men; thus we utilized the method that has been developed for female athletes. This method itself is wrought with potential error

largely stemming from the self-report nature of both energy intake and exercise energy expenditure. There is always a possibility that subjects did not subjects did not provide complete or fully accurate information about their diet and/or activity patterns. The length of the reporting period (i.e., 3 days) may also not have been long enough to capture long-term eating/exercise patterns or seasonal changes in those very same patterns. Next, it is difficult to measure/estimate exercise energy expenditure accurately, as there are numerous factors that influence energy expenditure during endurance exercise (intensity, duration, weather conditions, terrain, genetics, individual metabolism patterns, etc.). Finally, because there are no existing data in men and current research on associations between EA and BMD is focused around the female athlete triad, the present study must base its associations between EA and BMD on the group of cyclists analyzed. So again, a larger sample size as well as a larger control group would strengthen the chances of establishing EA categories for elite male cyclists and provide better opportunity to establish the ranges that affect BMD in this population.

Despite the lack of association between EA and aBMD, in this sample of cyclists, the high prevalence of both low EA and low BMD should not be overlooked. From a health and performance standpoint, it is crucial that elite cyclists consume enough macronutrients (carbohydrates, fat and protein) to fuel their energy output, as well as replenish micronutrients (electrolytes, vitamins, and minerals such as calcium) at rates equal to (or even greater than) which are lost (3)(4)(28). If cyclists do not have enough energy (calories) available to sustain their efforts in training and competition, their performance may decrease or unintentional/unhealthy weight loss may occur beyond any potential benefits of improving the power: weight ratio (4). And whether or not there is a

correlation between low EA and low BMD, the fact that low BMD is consistently seen in cyclists, including those in this study, highlights the importance of practicing behaviors that maintain or even improve bone health, such as resistance training/ weight-bearing exercises and consumption of adequate calories and essential nutrients.

Future implications of this project may lead to the identification of EA categories in elite endurance athletes, specifically male road cyclists. Establishment of high and low ranges of energy availability, especially if correlated with BMD changes, may spearhead future research on the importance of proper nutrition for elite level cycling. A recent article from Fitzgerald et al. found that cyclists are more likely to initiate significant health-related behavioral changes after learning of their bone density results, including calcium supplementation and weight-bearing exercise. They found that men with low BMD had higher motivation to change their diet and eating behaviors in order to improve their learned bone status and decrease the risks associated with poor bone health (33). Findings from this study suggest that early BMD testing in "serious athletes" has important clinical relevance for their potential risk for osteoporosis in the future. Therefore, more positive associations between EA and BMD in elite male cyclists compared to non-athlete controls may establish the need for nutrition education for cyclists and future standardized recommendations for energy intake to optimize performance and decrease long-term health risks.

CONCLUSIONS

Road cycling is a sport that involves extremely high energy expenditures, and therefore requires much greater than average energy intakes. Research has indicated that many cyclists restrict energy intake in an attempt to reduce body weight and improve the power-to-weight ratio which would result in a low EA. Cyclists are also known to have lower BMD than noncyclists. Thus, we hypothesized that low EA would be associated with low BMD in elite cyclists from the greater Salt Lake cycling community. While there was a high prevalence of both low EA and low BMD among the cyclists in our study, we failed to find an association between low EA and low BMD. Nonetheless, the high prevalence of both EA and low BMD in these elite level cyclists warrants further investigation as well as a greater focus on intervention strategies to prevent potential health and performance consequences.

APPENDIX A

HEALTH HISTORY QUESTIONNAIRE

Athlete Health/Nutrition Survey
Please complete all parts of the survey. Responses will remain CONFIDENTIAL

Demographic Information

1. Birthdate (mo/day/yr) _____/_____/_____ 2. Age (yrs) _____

3. Ethnicity: ☐African American ☐Asian ☐Caucasian ☐Hispanic ☐Native American ☐Other

4. Primary sport you participate in: _____ 5. Years of participation: _____

6. Other sports you participate in regularly:_____ 7. Years of participation: __

Medical and Musculoskeletal History

1. Is there a history of osteoporosis in your family? ☐YES ☐NO

2. Have you ever been diagnosed with any of the following? (check all that apply)
☐ osteoporosis ☐ low bone density ☐ scoliosis ☐ any other bone disorder (describe)_____

3. Have you ever been diagnosed by a doctor for a stress fracture from sport participation ☐YES ☐NO
* If you answered ***YES***, how many stress fractures have you had? _____
* If you answered YES, please indicate the *location* and *number* of stress fractures:

Upper back	_____	Lower back	_____
Hip	_____	Pelvis	_____
Upper leg (femur)	_____	Lower leg	_____
Ankle	_____	Foot	_____
Toes	_____	Upper arm	_____
Lower arm	_____	Wrist	_____
Hand	_____	Fingers	_____

4. Have you ever suffered a soft-tissue injury (e.g., muscle, tendon or ligament) as a result of training or competition? ☐YES ☐NO

* If you answered ***YES***, how many soft-tissues injuries have you had? _____ (over lifetime)

* If you answered YES, please indicate the *location* and *number* of soft tissue injuries you have had:

Upper back	_____	Lower back	_____
Hip	_____	Pelvis	_____
Upper leg (femur)	_____	Lower leg	_____
Ankle	_____	Foot	_____
Toes	_____	Upper arm	_____
Lower arm	_____	Wrist	_____
Hand	_____	Fingers	_____

5. Please list medications you are currently taking or have taken in the past 2 years (esp. any that may affect bone mass, i.e. anabolic steroids, glucocorticoid, diuretics, bisphosphonates, calcitonin, sodium fluorite, chemotherapeutics, anticonvulsants, or hormones therapy):

Nutrition History

1. How many meals (i.e., breakfast, lunch, dinner) do you usually eat per day? (check one)

☐ 1 ☐ 2 ☐ 3 ☐4 ☐ 5 ☐ 6 ☐ more than 6

2. How many snacks (i.e., candy bar, sports bar, piece of fruit) do you usually eat per day? (check one)

☐ 1 ☐ 2 ☐ 3 ☐4 ☐ 5 ☐ 6 ☐ more than 6

3. Do you skip meals? ☐ YES, frequently ☐ YES, occasionally ☐ Rarely ☐ Never

4. Are you a vegetarian? ☐ YES ☐ NO

* If you answered ***YES***, please indicate which type: ☐ vegan ☐ lacto/ovo ☐ lacto

5. Do you limit/restrict the ***amount*** of food you eat to control your weight?
☐ YES ☐ NO

6. Do you limit/restrict the ***types*** of food you eat to control your weight?
☐ YES ☐ NO

7. Do you ever feel out of control when eating or feel that you cannot stop eating?
☐ YES ☐ NO

8. Have you ever eaten a large amount of food rapidly (i.e., binged)? ☐ YES ☐ NO
   * If you answered ***YES***, how often have you engaged in this behavior in the past year?
   ☐ < 1x/month ☐ ~ 1x/month ☐ 2-3x/month ☐ ~ 1x/week ☐ > 1x/week ☐ daily

9. Have you ever purged after a binge? ☐ YES ☐ NO
   * If you answered ***YES,*** what type of purging did you engage in?
   (check all that apply)
   ☐ laxatives ☐ vomiting ☐ diuretics ☐ extra exercise ☐ sauna/sweatsuits

10. Do you think your diet is nutritionally adequate? ☐ YES ☐ NO

11. Have other people indicated that your eating habits are unusual or abnormal?
   ☐ YES ☐ NO

12. Do you think you might have an eating disorder? ☐ YES ☐ NO ☐ Maybe

13. Do you take vitamin or mineral supplements?
   ☐ YES, daily ☐ YES, but not every day ☐ NO

15. Please indicate the type(s) of supplement(s) you use (***check all that apply***)
   ☐ multivitamin/mineral ☐ iron ☐ calcium ☐ vitamin C
☐ vitamin E ☐ B-complex vitamins ☐ zinc ☐ herbals ☐ other (describe)

16. Do you use nutritional supplements or sports products?
   ☐ YES, daily ☐ YES, but not every day ☐ NO

17. Please indicate the type(s) of supplement(s) you use (***check all that apply***)
☐ protein powder/drink ☐ sports bar (Powerbar, Cliff bar, Luna bar) ☐ amino acids
☐ glutamine ☐ sports drinks (Gatorade, Powerade) ☐ HMB ☐ chromium
☐ hormones (androstendione, DHEA) ☐ L-arginine ☐ creatine
☐ "fat burners"(ephedrine, MaHuang) ☐ ß alanine ☐ L-carnitine
☐ branch chain amino acids ☐ estrogen blockers ☐ other (please specify) _____

Weight History

1. Height ____/____ 2. Current Weight? 3. Time at current weight?
4. What is your ideal weight? _____ 5. Ever been at your ideal weight?
6. How many times has your weight fluctuated by at least 5 lbs. in the last year?

7. How often are you trying to control your weight ***during*** the season?
☐ never ☐ rarely ☐ sometimes ☐ often ☐ always

8. How often are you trying to control your weight in the "*off season*" or when you reduce your training?
☐ never ☐ rarely ☐ sometimes ☐ often ☐ always

9. When your season is over and you stop or reduce your training do you (check one)
☐ Lose weight ☐ Gain weight ☐ Maintain weight

10. Which of the following are you currently trying to do about your weight?
☐ Lose weight ☐ Gain weight ☐ Maintain weight ☐ I am doing nothing

11. I presently think of myself as being… (check only one)
☐ Very underweight (> 10 lbs.) ☐Slightly underweight (5 – 10 lbs.)
☐ At an "ideal" weight ☐Slightly overweight (< 10 lbs.) ☐Moderately overweight (10 – 20 lbs.) ☐Very overweight (> 20 lbs.

12. How satisfied are you with your current body weight?
☐ very satisfied ☐ somewhat satisfied ☐ neutral
☐ somewhat dissatisfied ☐ very dissatisfied

13. Have you ever been diagnosed with and Eating Disorder ☐ YES ☐ NO
* If yes please indicate the eating disorder diagnosis:
☐ anorexia nervosa ☐ bulima nervosa ☐ eating disorder not otherwise specified

14. Please indicate which of the following methods you have used in your *lifetime* and *within the past year* to control your weight by *checking* the appropriate column:

METHOD	**Lifetime**		**Within past Year**	
	YES	NO	YES	NO
diet pills or "fat burning" supplements				
Fasting				
liquid diet supplements (e.g., Slim Fast)				
very-low-calorie diet (≤ 1000				
using laxatives				
using diuretics				
self-induced vomiting				
high protein/low carbohydrate				
additional exercise beyond regular				
other (please describe)				

APPENDIX B

3-DAY FOOD AND EXERCISE LOG

Instructions for Recording Food and Activity

FOOD INTAKE

1. You will need to record your intake for ***3 days***. Please record ***1 high activity day, 1 moderate activity day and 1 low activity (or rest) day***. The days do not need to be consecutive but they should be "typical" (i.e., typical in terms of your normal eating habits/patterns)

2. Please indicate the date and circle the day of the week that you are recording at the top of the food record.

3. Record each food and beverage you consumed on a separate line.

4. When eating combination foods (e.g., sandwich, lasagna, stew, casserole, etc.) please separate the food/dish into its individual components as much as possible.

5. Record food and beverages in reasonably exact amounts: liquids in cups or fluid ounces; grains, cereals, pasta in cups (please indicate if the measure is dry or cooked); meats, fish, chicken in ounces, fruits & vegetables in cups.

6. Please specify if the food was consumed raw or cooked (and indicate the type of cooking method used). Also indicate if it was prepared from fresh, canned or frozen products.

7. Please indicate how the food was prepared; e.g., fried, baked, grilled, steamed, etc.

8. For fruits, potatoes, chicken etc. please indicate if the skin was removed before consumption

9. Please be sure to indicate if dairy products, (i.e., milk, cheese, yogurt, etc.) was whole, low-fat, non-fat, etc.

10. Be sure to include all the little extras (e.g., sauces, gravies, candy, gum, etc.)

11. Provide any other information you think might be helpful. Remember the more accurate/specific you are with recording the more accurate we can be with the analysis.

ACTIVITY

1. Please record the exercise/training that you do on the days that you are recording your food intake. This would include any and all "training" as well as any significant lifestyle physical activity (e.g., riding your bike to school, walking to the grocery store, dancing at a club)
2. You should include:
    - the type of exercise (e.g., running, cycling, swimming, weight training)
    - the length of time you exercised in minutes (e.g., 30, 45, 55, 60 etc minutes)
    - the distance you covered if appropriate (e.g., 3 miles, 20 miles, 1500 yards)
    - the intensity (e.g., 8 min/ml pace, 18 mph, moderate intensity, etc)

Food/Activity Record

Name: _____**Date**: _____ **Day of Week**: M T W Th F Sa Su

Please record as accurately as possible all food and beverages you consumed for one day. Please give as many details as possible regarding the food/beverage item. Please list all supplements consumed including sports foods/beverages, vitamins, minerals, herbs etc. You may use the back if necessary.

Time	Food/Beverage	Brand or Source	Type of Preparation	Amount
8:00 am	**Example: cinnamon raisin bagel**	**Lenders**	**Toasted**	**1 ea. (3 oz)**
9:00 am	**Example: weight training**	**1 hour**	**moderate intensity**	

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