Nutrition-Related Factors Impacting the Bone Health of Female Sports and Performance Collegiate Athletes

Elizabeth Doll

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NUTRITION-RELATED FACTORS IMPACTING THE
BONE HEALTH OF FEMALE SPORTS AND
PERFORMANCE COLLEGIATE
ATHLETES

by

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A Thesis Presented in Partial Fulfillment
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ABSTRACT

Low bone mineral density is commonly found in female athletes and has been related to the energy adequacy and nutrient density of the athlete’s diet. Insufficient dietary energy intake and/or excessive energy expenditure can lead to low energy availability in female athletes, which has been shown to disrupt endocrine, metabolic, and physiological functions. Psychological distress in competitive athletes may affect dietary choices and patterns. To meet their personal or performance standards/goals, an athlete may go to extremes to achieve those standards/goals, including altering their dietary intake.

This study aimed to evaluate the nutrition-related factors affecting the bone health of collegiate female sports and performance athletes. Specifically, this study explored the associations between diet quality, bone health, low energy availability symptoms, and mental health risks. It was a cross-sectional study that obtained data from female athletes attending NCAA Division I programs in the state of Louisiana, with a subset group of female athletes attending Louisiana Tech University providing additional physical data (BMD measurements & InBody 770). The online questionnaire obtained data to examine diet quality (REAP-S), mental health as measured by the APSQ and BTPS-SF, low energy availability symptoms (LEAF), and bone fracture history. The participant sample included Louisiana Tech University female athletes ($n = 44$) and non-Louisiana Tech athletes ($n = 52$), for a total of 96 participants.
Approximately half (54.2%) were White and non-Hispanic and 31.3% were classified as freshmen. The majority (69%) of the female athletes were less than 10 years of age when they began participating in their chosen collegiate sport. Of the 17.1% of the athletes who reported vaping, 73.7% vaped occasionally; two (2.1%) participants stated that they smoked. From the APSQ, 43.5% of the female athletes experienced “very high distress” during their season, while 30.6% of the female athlete tested experienced “high distress”. Correlations from the total sample are: the subscales of the BTPS-SF significantly correlated $r (79) = .551, p < .281$ with each other, and the 3 subscales of the APSQ positively correlated with the total score of the APSQ, the correlation between the LEAF and the BTPS-SF subscale, Rigid Perfectionism, was significant and positive, $r (81) = .305, p < .006$, the LEAF questionnaire negatively correlated with the total score of the APSQ and the subscale, Self-Regulation, $r (81) = .443, p < .001$, the subscale of the APSQ, Self-Regulation, had a positive correlation with the subscale of the BTPS-SF, Rigid Perfectionism, $r (82) = .270, p < .014$, we found that both subscales correlated with the LEAF, and the total score of the APSQ and its subscales Self-Regulation and Performance has a significant positive correlation with the BTPS-SF subscale, Self-Critical Perfectionism, $r (81) = .397, p < .001$. The Louisiana Tech University female athletes had the physical measurements. Correlations were run for the sample with physical measurements and the following was found: The correlation between the APSQ and LEAF was significant and positive, $r (42) = .245, p < .028$, the category of the BTPS-SF, “rigid perfection,” was significant and positive to the SI, T, and Z scores, $r (42) = .424, p < .005$, Rigid perfectionism also had a significant positive correlation with the LEAF, $r (42) = .305, p < 0.06$, and there was a positive correlation between the total
score of the APSQ and the “self-critical” category of the BTPS-SF, $r (42) = .397, p < .01$. An independent samples t-test was run to compare the diet quality and distress levels in those athletes with a bone fracture history to those without within the subset of Louisiana Tech female athletes ($N = 42$). There was a difference between the fracture ($M = 28.79, SD = 8.06$) and non-fracture ($M = 22.71, SD = 8.48$) group for the APSQ, the athletes with a history of no fractures ($M = 31.61, SD = 4.13$) had a higher diet quality ($M = 28.43, SD = 3.98$) compared to the female athletes with a history of fractures and female athletes with a history of bone fractures ($M = 4.18, SD = .59$) had a higher average of rigid perfection ($M = 3.57, SD = .96$) than those with no history of bone fractures.

In summary, we found that mental health status risk was related to diet quality, low energy availability, and bone injury health frequency amongst female collegiate athletes. The more likely a female athlete is to strive to be perfect and is a harsh critic of herself, the higher the distress level of that individual. Nutritional professionals and athletic departments working with female athletes on their campus should consider all aspects of the athlete when treating them, such as mental health, diet quality, symptoms of low energy availability, and history of bone fractures.
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CHAPTER 1

INTRODUCTION

Low bone mineral density is commonly found in female athletes (Lambrinoudaki et al., 2010). The primary pathophysiologic mechanism that leads to low bone mineral density (BMD) in female athletes is low energy availability and the resultant amenorrhea (absence of menstruation) (Ihalainen et al., 2021). Additionally, the nutrient density of the athlete’s diet plays an important role in bone health. When there is low dietary calcium and vitamin D intake, an individual may experience secondary hyperparathyroidism as an increased level of the parathyroid hormone (PTH) triggers bone reabsorption leading to low bone mass (Lambrinoudaki et al., 2010). Low bone mineral density (BMD) risk increases when an athlete expends a large amount of physical energy and does not meet their energy requirements.

Insufficient dietary energy intake and/or excessive energy expenditure can lead to low energy availability in female athletes, which has been shown to disrupt endocrine, metabolic, and physiological functions. Female athletes that do not meet energy-expended needs are at risk for menstrual dysfunction. Studies have shown a higher prevalence of menstrual irregularity (MI) in the female athletic population than in the general population of women (Ihalainen et al., 2021). Regular and early menstruation is crucial for the maintenance and synthesis of bone in adolescent female athletes (Ihalainen et al., 2021). The mineralization of bone depends heavily on the availability of estrogen.
Estrogen stimulates osteoblasts while inhibiting osteoclast function. Without ample/adequate estrogen, bone demineralization occurs, causing the BMD to decline (Ihalainen et al., 2021). Menstrual irregularity may stem from physical and psychological stress from training and competition, energy deficiency, low body mass, low body fat percentages, and low energy availability is also a contributing factor.

Psychological distress in competitive athletes may affect dietary choices and patterns. Distress is “emotional, social, spiritual, or physical pain or suffering that may cause a person to feel sad, afraid, depressed, anxious or lonely” (NIH, 2020, pg 1). To meet their personal or performance standards/goals, an athlete may go to extremes to achieve those standards/goals, including altering their dietary intake. A perfectionistic athlete may adjust their diet to achieve weight loss or gain to enhance performance. Perfectionism has been associated with low energy availability (LEA) and eating disorders, such as bulimia and anorexia (Smith et al., 2016).

**Research Purpose**

This study aimed to evaluate the nutrition-related factors affecting the bone health of collegiate female sports and performance athletes. This study explored the associations between diet quality, bone health, low energy availability symptoms, and mental health risks.

**Justification**

There is limited literature on nutrition-related factors impacting the bone health of female collegiate athletes. In collegiate sports, resources are limited for screening and treatment for eating disorders, low energy availability, and bone and mental health risks.
in colleges that are less funded. Equal opportunities in college sports under Title IX suggest that a college institution must provide male and female athletes with equal access and opportunity. The findings from this research will add to the body of literature by expanding the knowledge on the relationships of factors impacting the nutrition status and bone health of female collegiate athletes.
CHAPTER 2

LITERATURE REVIEW

Low bone mineral density can lead to an increase in bone fractures and if an individual continues to lose bone mass it can lead to osteoporosis. Osteoporosis is characterized by diminishing bone mass, leading to an increased risk of fractures, decreased bone strength, and low bone mineral density (BMD) (Nguyen et al., 2014). BMD results from a balance between bone reabsorption and bone formation. An imbalance of BMD occurs when the rate of bone resorption is greater than bone formation. Common risk factors for osteoporosis include being a perimenopausal woman, aging, smoking, long-term use of steroids, low body mass index (BMI), or an insufficient intake of nutrients. While osteoporosis may occur in any individual, women are at greater risk when compared to men. The National Health and Nutrition Examination Survey, from 2017 – 2018, recorded that osteoporosis was prevalent in 12.6% of adults aged 50 and over and was significantly higher among women (19.6%) compared to men (4.4%) (Egan et al., 2008). Additionally, female athletes have been reported to be among those women who are in an at-risk group for low bone mineral density and osteoporosis (Egan et al., 2008).
Impact of Mental Health on Dietary Intake

In recent years, the mental health among collegiate athletes has drawn the attention of the sports medicine community. Studies have indicated that competitive athletes are at a higher risk for mental illness than their non-athlete peers (Smith et al., 1994; Christensen et al., 2021). Athletes can be at risk for depression, suicide, anxiety, substance use, eating disorders, and gambling. An athlete’s psychological state may be influenced by distress factors related to athletic performance, performance in the classroom, and athletic injuries. A study reviewed five cases of female and male collegiate athletes who committed suicide to determine whether there were common factors among them. The team of researchers found that the athletes had experienced the following shared factors: 1) considerable success before the injury, 2) serious injury requiring surgery, 3) long rehabilitation with restriction from play, 4) inability to return to the prior level of play and 5) being replaced in their position by a teammate (Smith et al., 1994). Athletes may experience any of these factors throughout their sports season, which can influence their mental health. Athletes are often described as having high expectations for themselves, and some are perfectionists (Christensen et al., 2021). Perfectionists have personality characteristics that include compulsively pursuing exceedingly high standards for oneself.

Psychological Strain in Athletes

Psychological strain can be characterized as a continuum of emotional exhaustion due to stressful experiences (Christensen et al., 2021). The athlete experiences many mental challenges throughout their sport. For example, an athlete may experience low self-confidence or a lack of trust in their athletic ability. These athletes tend to
overanalyze their performance or question their ability. Athletes may have a fear of failure and social approval. “A fear of failure is characterized by high expectations, a strong desire to succeed, anxiety or tension, worrying too much about results or outcomes, social approval issue or worrying too much about what others think, and performing with a serious, controlled mindset” (Edger, 2012, pg. 1). A sport's stress and strain on an athlete may affect dietary choices and patterns in part related to the pressure on female athletes to maintain low body weight and a lean and aesthetic appearance (Barrack et al., 2014). A study was done on 774 international-level Chinese athletes, men and women, to investigate the direct and indirect effects of psychological strain on suicidal ideation (Sun, 2020). The participants took a 56-item questionnaire that covered psychological strain, hopelessness, and suicidal ideation. Suicidal ideation was measured using one item: “Have you ever thought of killing yourself?” The study found that 18% (140 participants) of the athletes had suicidal ideation. They also found that psychological strain was associated with suicidal ideation in the athletes. Hopelessness was correlated with psychological strain and suicidal ideation. Hopelessness may occur when an athlete feels that there is no way to deal with conflicting situations, such as failure, injury, or even a bad game (Sun, 2020).

The Athlete Psychological Strain Questionnaire (APSQ) was developed to measure the psychological strain an athlete may experience during their season (Rice, 2019). The questionnaire asks about one’s coping mechanisms, impulse control, frustration tolerance, team interactions, and worries related to athletic performance. The questionnaire is a series of 10 items asking for responses on a 5-point scale, with answers ranging from 1 = “None of the time” to 5 = “All of the time.” A higher score reflects
higher distress; a score of 16 to 21 means moderate distress, 22 to 29 indicates high distress and 30 plus indicates very high distress. The APSQ was validated in an elite group of male and female athletes in Australia (Rice et al., 2020). The researchers described the APSQ as “excellent” for correctly identifying athletes experiencing high psychological distress and demonstrated high sensitivity and specificity.

**Perfectionism in Athletes**

Perfectionism is characterized as striving for perfection, harsh evaluation of oneself and others, and high personal standards (Feher et al., 2020). It has been linked to mental health symptoms such as anxiety, depression, and eating disorders. To meet their standards/goals, an athlete may go to extremes to achieve those standards/goals, including altering their dietary intake. A Perfectionistic athlete is characterized by high levels of motivation, an intense desire to succeed, and a strong work ethic (Edger, 2012). A perfectionistic athlete may adjust their diet to achieve weight loss or gain and enhance performance. Perfectionism has been associated with low energy availability and eating disorders, such as bulimia and anorexia (Smith et al., 2016). One common approach to measuring perfectionism is utilizing Hewitt and Flett’s (2016) Multidimensional questionnaire, that is a measurement of three perfectionism dimensions. Self-oriented, social, and other-oriented perfectionism are the three dimensions tested for by the tool. Hewitt and Flett (2016) observed that parents of a perfectionistic child reserved positive feedback for occasions that exceeded their expectations. The child strove towards excessively high-performance standards to attain the approval of their parents. Athletes often experience this, not only with their parents but with their coaches. Similar to Hewitt and Flett’s Multidimensional questionnaire, the Big Three Perfectionism Scale was
developed by Smith et al. (2016). The Big Three Perfectionism Scale (BTPS) was originally a 45-item self-report measure of perfectionism with three subscales. The three subscales are rigid, self-critical, and narcissistic perfectionism. Researchers have also developed and validated the 16-item short-form version (BTPS-SF) of the BTPS, which replicates the same structure regarding rigid, self-critical, and narcissistic perfectionism (Feher et al., 2020). The validation of the BTPS-SF was conducted using Canadian University students. The short form displayed a high internal consistency with the reduction of items from 46 to 16 without a loss of reliability.

**Bone Mineral Density in Female Athletes**

Decreased bone mineral density is common in female athletes (Cooke et al., 2010). The main pathophysiologic mechanisms leading to low bone mineral density in female athletes are low energy dietary intake and resultant amenorrhea (absence of menstruation). Additionally, one’s nutrient intake also plays an important role in bone synthesis. When there is low calcium and vitamin D consumption, there is an increase in parathyroid hormone production that can lead to secondary hyperparathyroidism. An increased level of the parathyroid hormone (PTH) triggers bone reabsorption resulting in low bone mass (Lambrinoudaki et al., 2010). An elite athlete typically expends a large amount of energy, and when those energy needs are not met, their risk is heightened for developing amenorrhea and lower BDM. Nichols (2006) found that 21.8% of female high school American athletes had low bone mineral density (BMD). To decrease the risk of low BMD, athletes should consume a diet adequate in energy, vitamin D, and calcium.

**Relative Energy Deficiency in Sports (RED-S)**

The Female Athlete Triad was once the term to use when describing a root cause of performance-depleting symptoms in athletes who were under-nourished. Due to recent
advances in research, researchers have discovered a more comprehensive term to describe the symptoms of being undernourished, Relative Energy Deficiency in Sports (RED-S). Relative Energy Deficiency in Sports, also known as RED-S, refers to "impaired physiological functioning caused by a relative energy deficiency and includes, but is not limited to, impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health" (Mountjoy et al., 2018, p. 316). The primary focus of RED-S is low energy availability. LEA is directly related to the complications that develop when an athlete does not fuel their bodies properly for their sport, whether that is intentionally or unintentionally. Energy availability is the difference in an athlete's energy intake (diet) and the energy expended in exercise divided by an athlete's fat-free mass (FFM) in kilograms. An athlete is at risk for low energy availability if they unintentionally or intentionally consume fewer calories than they expend during exercise or their sport. When the body does not have adequate energy available, the body will experience disruptions in numerous hormonal, metabolic, and functional processes.

**Low Energy Availability**

Energy availability is defined as the difference between energy intake and energy expenditure. Energy Availability can be calculated using the following equation (E.A. = (Energy Intake – Energy Expenditure) / kg Fat - Free Mass of individual). Optimal health and performance have been associated with an intake of 45 kcal/ kg FFM, 45 kcal/kg to 30 kcal/kg FFM is considered maintenance, and < 30 kcal/kg FFM is considered inadequate energy availability (Mountjoy et al., 2018). Low energy availability can develop when there is an increase in exercise, reduced dietary intake, or a combination of both (Areta et al., 2020). Energy availability in females can be screened using the Low
Energy Availability in Females Questionnaire (LEAF-Q) (Burns & Sim, 2021). The LEAF-Q has a 90% specificity and 78% sensitivity. “The 25-item LEAF-Q questionnaire identifies athletes at risk for low energy availability by utilizing subsets of gastrointestinal symptoms, injury frequency, and menstrual dysfunction” (Burns & Sim, 2021). Each item can be worth between 0 to 4 points. The score is then added and a score of greater than or equal to 8 indicates that an individual is at risk for the female athlete triad (Refer to Appendix A). It is important to screen because low energy availability strongly correlates with poor bone health and an increased risk for fractures. This results in a “negative energy balance and hormonal adaptative alterations: low growth hormone (G.H.) and insulin-like growth factor-1 (IGF-1), low free T3 and high cortisol levels, which suppress bone synthesis” (Lambrinoudaki et al., 2010). LEA can be found not only in females but also in males. Clinicians and researchers created a validated questionnaire that could be used as a screening tool for LEA in males (LEAM). A total of 405 male elite to sub-elite athletes were recruited between the ages of 18 – 50 years of age. The questionnaire is 42 items covering dizziness, GI function, injury and illness, well-being, recovery, sleep, and sex drive.

**Diet Quality Measurement**

Young adults in college have unhealthy eating habits (Choi, 2020). College athletes are especially at risk for unhealthy eating habits due to high demands from their sport, busy schedules, and insufficient knowledge relating to nutrition specific to their sport (Kurka et al., 2014). The Rapid Eating and Activity Assessment for Patients (REAP-S-S) was initially developed to evaluate dietary eating behaviors by assessing the consumption frequency of fruits, vegetables, calcium-rich foods, saturated fat, sugar-rich
foods and beverages, and whole grain intake. The validity of the REAP-S-S was tested on NCAA (National Collegiate Athletic Association) Division-I athletes using pattern identification. The dietary pattern scores were examined in males and females between each sport type (Kurka et al., 2014). This test confirmed the validity of the REAP-S in NCAA female and male athletes while finding that in both the female and male athletes, the aesthetic sports (for example, gymnastics) had a higher diet quality score than the non-aesthetic sports (for example, baseball/softball). The REAP-S has 13 questions with a possible score ranging from 13 to 39, with a higher score indicating a higher diet quality (Refer to Appendix A).

**Menstrual Dysfunction in Female Athletes**

Normal and early menstruation is crucial for maintaining bone health in adolescent female athletes. Whereas late/delayed and disturbed menstruation has been associated with low BMD in female athletes. According to Lambrinoudake & Papadimitriou (2010), adolescent girls achieve 40% of their peak bone mass (PBM) during puberty, while 90% of the peak bone mineral content is gained by the age of 17. The mineralization of bone depends heavily on the appearance of estrogen. Estrogen stimulates osteoblast while inhibiting osteoclast function. Without estrogen, the athlete's bone will go through demineralization, causing the BMD to gradually decline. Studies have shown a higher prevalence of menstrual irregularity in the athletic population than in the general population of women. Menstrual irregularity can be caused by several factors: physical and psychological distress from training and competition, Caloric deficiency, low body mass, and low body fat percentages. Menstrual irregularity can be categorized as primary amenorrhea, secondary amenorrhea, or oligomenorrhea (Carr et
Primary amenorrhea is defined as the absence of menarche by age 15 or greater, secondary amenorrhea is the absence of three or more consecutive periods in a row by someone who experienced having a period, and oligomenorrhea is known as having infrequent menstrual periods, fewer than six to eight per year. Menstrual irregularity is associated with decreased bone mineral density. Women who are elite athletes that exercise excessively are at risk for "athletic amenorrhea." Athletic amenorrhea can be caused by low levels of body fat and the effects of exercise-related hormones on the menstrual cycle (Ihalainen et al., 2021). The female body cannot menstruate properly below 13% body fat; the essential percentage of body fat for women is between 10 to 13 percent (Ihalainen et al., 2021). Because disrupted menstruation can lead to low body mass, if an athlete is not treated, she may be at risk for an increased risk of fractures, broken bones, and increased aging of bone.

Body Composition Measurement

Body composition can be measured in numerous ways, including bioelectrical impedance analysis (BIA). In BIA, an electrical current is sent through the body, allowing it to accurately measure an individual’s body fat, water mass, skeletal muscle mass, and lean mass by measuring tissue resistance to the current. BIA can be used to estimate bone mineral content and can be used to look at body fat percentages to determine if low energy availability is present in an individual. The InBody 770 uses BIA and has been proven to be a safe, portable, quick, short-duration, low-cost, and reliable alternative to dual-energy X-ray absorptiometry (DEXA) for providing body composition reports (Castagna et al., 2020). A recent study compared the InBody to the DEXA for reliability and validity and they were comparable (Castagna et al., 2020). Studies have
shown that BIA underestimates fat mass and overestimates fat-free mass (Brewer et al., 2021). A recent study was done to “assess whether the regular increase in water consumption has any significant effects on measurements of body composition using BIA” (Ugras, 2020, pg. 1). Eighty males and sixty females voluntarily participated in the study. To ensure that food intake and exercise did not influence the results of the BIA, subjects were asked to have no food or liquid intake for at least 12 hours prior to the test. Each subject was tested using BIA before the beginning of the study. The study consisted of 4 stages, (1) all subjects had 500 mL of water, and a second measurement was taken, (2) each subject had an additional 500 mL totaling 1000 mL and was then measured for the third time, (3) a third 500 mL was given to each participant equaling 1500 mL total, and a fourth measurement was given, (4) and finally another 500 mL was given totaling 2000 mL, and the final measurement was taken. All measurements were performed 15 minutes after water intake. The BIA measurement compared body weight, fat mass, body fat percentage, fat-free mass, and total body water. High hydration levels have been reported to cause an increase in body fat percentages. The study found that the fat mass in both males and females increased after each stage of water consumption. They compared that results to another study that found an increase in fat mass using BIA due to increased extracellular water, which could be a result in plasma sodium concentration after water intakes (Ugras, 2020).

**Bone Health in Adult Females**

Bone mineral density peaks in early adulthood and begins to decline after menopause in women. The notable factors affecting bone health in women are diet, poor nutrition, eating disorders, and inadequate calcium intake. According to Sarafraz (2021),
osteoporosis among women has increased from 14% in 2008 to 19.6% in 2018. According to the CDC, researchers reported that low BMD was prevalent in 43% of adults aged 50 years and older and was higher in women (51%) than men (33%). Individuals should eat a diet high in calcium and vitamin D to decrease the risk of low BMD and osteoporosis.

**Nutrients for Bone Health**

**Vitamin D**

Bone comprises connective tissues supported by various minerals such as calcium and vitamin D. Calcium is a mineral your body needs to maintain strong bones. The human body cannot absorb calcium without the help of Vitamin D. Vitamin D is a fat-soluble vitamin found in limited food sources and is produced by the body using ultraviolet rays from the sunlight, triggering vitamin D production. Vitamin D can be found in small doses in fatty fish, eggs, fortified foods, and fruits such as oranges. Although it can be found in food sources, the vitamin D recommended intake value is rarely met through diet alone due to inadequate vitamin D content in food sources (NIH, 2022). The recommended daily amount of vitamin D for individuals between the ages of 1 to 70 years is 600 international units (I.U.) (Lewis et al., 2013). Vitamin D promotes calcium absorption in the gut and helps maintain adequate serum calcium concentration to enable normal bone mineralization. A Vitamin D deficiency is often characterized as a serum total 25-hydroxyvitamin-D concentration of less than 50 mmol/l (Backx et al., 2016). A deficiency can occur when limited sun exposure, inadequate nutrient intake, or absorption is disrupted. A study with females ranging from 12 – 17 years old in an elite gymnastics program at the Australian Institute of Sports revealed that 83% of female
athletes had a diet that was vitamin D insufficient, and 34% of the female athletes were vitamin D deficient because of playing an indoor sport (Lambrinoudaki et al., 2010). Individuals with a vitamin D deficiency may experience adverse effects such as fatigue, not sleeping well, bone aches, hair loss, muscle weakness, and loss of appetite. Female athletes may also experience muscle weakness, decreased physical performance, inflammation, impaired immune function, and increased incidence of injury due to weak bones.

**Indoor versus Outdoor Athletes**

Inadequate vitamin D status is common in female athletes and can impact their bone health. A deficiency in vitamin D can be managed and prevented by proper nutrition, oral supplements, and sun exposure. Recent studies have suggested that indoor athletes, compared to outdoor athletes, have lower vitamin D status. Not only does the training environment affect vitamin D status but the season the athletes train during. A recent study studied indoor and outdoor female collegiate athletes in Japan. Blood was collected from the athletes one day out of each month to analyze serum 25-OH-Vitamin D levels. The study found that vitamin D status was the lowest in the month of March and highest in September for both indoor and outdoor athletes. The vitamin D status in all the outdoor athletes was above the cut-off for insufficiency throughout the whole year, whereas the indoor athletes were insufficient in the month of March and December (Maruyama-Nagao et al., 2016).

**Calcium**

The importance of adequate calcium intake for bone health has been well documented. Adequate calcium intake has been shown to maintain skeletal bone mass.
The Recommended Daily Allowance (RDA) for calcium intake is 1300 mg for adolescents and 1000 mg for women aged 18 to 50. Dietary sources of calcium include fortified dairy products (milk, yogurt, cheese), green leafy vegetables, and fish (such as sardines and salmon). Vitamin D status, intestinal transit time, mucosal mass, and stage of life are physiologic factors that affect calcium absorption in the body. Malabsorption of calcium can cause a negative calcium balance in the body, secondary hyperparathyroidism, increased bone loss, and osteoporosis. Aside from the actual calcium content of the food item, potential calcium sources vary in bioavailability. The calcium absorption is similar in dairy products, at approximately 30%. Whereas the calcium absorption of spinach is approximately 5%. For example, a serving of milk has 300 mg of calcium, but 32% of milk is absorbable, leaving only 96.3 mg of calcium to absorb by the body. According to Lambrinoudaki (2010), 72% of female athletes reported a daily calcium intake below 1300 mg (RDA for their age). Calcium intake can be measured using a food frequency questionnaire focusing specifically on vitamin D and calcium food sources.

**Bone Density Measurements**

Overall, bone health can be affected by nutrition, lifestyle, physical activity, and genetics. Bone mineral density (BMD) is measured to discover an individual’s bone age/health and can be measured using (DEXA) or ultrasound. Although a DEXA scan is the gold standard for measuring BMD, it is expensive. Ultrasound technology offers an affordable and quick means to accurately assess fracture risk and initial osteoporosis screening tool. The Achilles EXP measures the stiffness index, Broadband Ultrasound Attenuation (BUA), Speed of Sound (SOS), % age-matched, and % young adult. The
Stiffness Index is the basic measurement of bone density, using the SOS and BUA. The stiffness index value is then compared to a selected reference population to generate a T- and Z Score. A T-Score -1 to 2.5 indicates osteopenia, and below -2.5 indicates osteoporosis (Refer to Appendix A). The T-Score represents the individual’s stiffness index above or below a reference “Young Adult” (20 - 35 years old) means. The Z-Score represents the individual’s stiffness index above or below the expected Age-Sex matched value. The precision, sensitivity, and specificity of the Achilles EXPII were compared with a central dual-energy X-ray absorptiometry (cDEXA) on groups of women between the ages of 25-35 years of age and 45 years of age or older (cDEXA) (Grabe et al., 2014). In this study, the Achilles EXPII had a sensitivity of 92% and provided a low number of false negative results for osteoporosis (Grabe et al., 2014). The Achilles EXPII, an updated model, can help identify athletes at risk for low bone mineral density (BMD) and osteoporosis. If the athletes at risk are correctly identified, interventions can be initiated to reduce any further bone deterioration.

Other Factors

Smoking and Vaping Effect on Bone Health

Evidence has shown that tobacco smoke has numerous deleterious effects on the human body. Smoking can result in chronic diseases, such as coronary heart disease and lung disease. Smoking has now been identified as a risk factor for osteoporosis and has been shown to cause an imbalance in bone growth, causing an individual to have a low bone mineral density (BMD) (Al-Bashaireh et al., 2018). Similar to smoking cigarettes, vaping or the use of an electronic cigarette (e-cigarette) has harmful effects on the body. According to Fiani (2020), metallic compounds and chemical toxins have been linked
with systemic inflammation and negatively effects osteoblast cells, increasing the risk for low BMD and osteoporosis. There are direct and indirect effects of smoking tobacco and vaping.

**Direct Effects of Smoking**

Tobacco smoking directly decreases osteogenesis (formation of bone) and angiogenesis (formation of new blood vessels). When there is a decrease in osteogenesis, there is an increase in osteoclast and bone resorption, along with a decrease in osteoblast and bone formation, ultimately decreasing bone mass (Al-Bashaireh et al., 2018).

**Indirect Effects of Smoking**

Five indirect mechanisms of smoking tobacco affect bone health in an individual who smokes (Al-Bashaireh et al., 2018). Nicotine suppresses appetite, which influences an individual to have a poor diet and energy intake. Smoking reduces the body's ability to absorb vitamin D and calcium in the bone. The third effect is the alteration of the adrenal hormones, particularly an increase in cortisol levels. Cortisol may negatively affect bone density by altering bone turnover. Nicotine alters the production and metabolism of estrogen. Individuals who smoke have been found to have high levels of free radicals and a significantly lower number of antioxidants (Al-Bashaireh et al., 2018).

**Research Purpose and Hypotheses**

This study aims to evaluate the nutrition-related factors affecting the bone health of collegiate female sports and performance athletes. This study will explore the associations between diet quality, bone health, low energy availability symptoms, and mental health risks. The study hypotheses are:
(1) $H_0$: There will be no relationship between mental health risk and diet quality, low energy availability symptoms, and BMD in female collegiate athletes.

(2) $H_0$: There will be no relationship between diet quality and BMD, and bone injury in female collegiate athletes.

(3) $H_0$: There will be no relationship between bone injury and mental health risk in female collegiate athletes.

(4) $H_0$: There will be no relationship between low energy availability symptoms and diet quality, body fat percentage, and bone mineral density in female collegiate athletes.
CHAPTER 3

METHODS

Research Design

This is a descriptive cross-sectional study that obtained survey data from a group of female athletes that attended a division one collegiate program in the state of Louisiana, with a subset group of female athletes attending Louisiana Tech University representing the physical data (BMD measurements & InBody 770) while also completing the survey data. This study examined the relationships among diet quality, mental health risks, low energy availability symptoms, and bone health in collegiate female athletes. The survey data was collected using an online survey that was self-reported and confidential; physical measurements from the subset group of athletes at Louisiana Tech University were obtained in the Nutrition and Dietetics Research Measurement Laboratory.

Study Population and Sampling Design

All the female athletes participating in NCAA Division I athletic programs in the state of Louisiana were invited to participate in the study. Invitations were electronically sent to the Division I programs in the state of Louisiana, including Louisiana Tech University, Louisiana State University, McNeese State, Grambling State University, the University of Louisiana at Lafayette, the University of Louisiana at Monroe, University
Nicholls State University, Northwestern State University, Southeastern Louisiana University, Southern University, and Tulane University. Coaches from each sport from the list of Louisiana universities received an email regarding the approved study. The email of each coach was collected from the staff directory of their university’s website, and they were asked to share the email and link to the questionnaire with the female athletes they coach.

All female athletes representing the 10 university athletic teams attending Louisiana Tech University were invited to be a sample group to represent the physical data in this study. The athletes were recruited via flyers and emails for network sampling. Flyers were posted in team areas, distributed at team practices, and via email. The 10 teams from Louisiana Tech University included basketball, bowling, cheerleading, cross-country, dance team, soccer, softball, tennis, track and field, and volleyball. No data was collected until IRB approval was received (IRB #1438,22-110). Once the participants that were willing to take part in the study arrived at the Nutrition and Dietetics Research Measurement lab, they were provided with a link to the survey. The link to the survey brought the participants to the consent for the study; once the participants gave consent, they were then routed to the questionnaire. The female athletes from Louisiana Tech University completed the questionnaire portion of the study and then underwent a heel bone ultrasound densitometer test to measure bone health and an InBody scan to determine body composition.
Setting

The physical data were collected in the Nutrition and Dietetics Research and Measurement Lab at Louisiana Tech University. Louisiana Tech University is located in North Louisiana. Louisiana Tech serves approximately 11,000 students. It has 10 women varsity sports competing in NCAA Division I- Conference USA.

Procedures

Questionnaire

This proposed cross-sectional study included an online, self-reported, confidential questionnaire that provided descriptive data from a larger group of female collegiate athletes across the state of Louisiana and collected non-invasive physical measurements from a subset of female collegiate athletes at Louisiana Tech University. This study examined diet quality (REAP-S), mental health as measured by the APSQ and BTPS-SF, low energy availability symptoms (LEAF), and bone fracture history. Physical data included body composition results from the InBody 770 and heel bone densitometry. Each Louisiana Tech female athlete that participated in the physical measurement component received a unique study identification number from the researchers that allowed the researchers to match physical data collection components with the survey data while keeping the data de-identified.

Off-Campus Participants

Female athletes attending other Division I schools in the state of Louisiana were recruited using network sampling. Initial contacts included personal contacts of the researchers and current Louisiana Tech female athletes. An email was also sent directly to coaches requesting participation in the study. These athletes received an email
disclosing the study details and containing a link to the study consent and questionnaire (Appendix C). It was estimated to take approximately 15 minutes to complete the questionnaire.

**On-Campus Participants**

Using network sampling and personal connections within the campus athletic department of Louisiana Tech University, female athletes were recruited to participate in physical measurements study. They were the only individuals that used the InBody Scale 770 and the GE Achilles EXPII for physical measurements (Stiffness Index (SI), T and Z Score) and completed the questionnaire. The heel bone mineral density was measured according to the recommended standard procedures of the GE Achilles EXPII. Participants were asked to place their non-dominant bare foot on the machine for approximately 2-3 minutes while the machine used a non-invasive ultrasound method to measure the bone density. No contraindications were noted for the use of the machine.

Body composition was measured using the InBody 770. Participants were asked if they were pregnant or had a pacemaker; those who self-identified as such were not measured. Participants were asked to step up on the machine and place their bare feet on the electrodes shoulder-width apart. The participant’s unique ID was put into the machine and body composition measurements were collected. The results of the InBody 770 included fat-free mass, body fat mass, weight, skeletal muscle mass, body mass index, percent body fat, and basal metabolic rate. The test takes approximately five minutes. Prior to getting tested, participants were asked to stay hydrated throughout the day and were asked to use the restroom before getting scanned. The results of both the physical data tests were matched using participant I.D. numbers with the I.D. numbers from the
questionnaire. Participants received their results at the time of the physical measurements. The results of the study were explained to the participants by a graduate student or professor on staff during the testing. The results of the Inbody 770 also served as an incentive for the female athletes to participate in the study. The data collected will be used separately from this thesis project.
CHAPTER 4

RESULTS

Characteristics of the Total Sample

Questionnaire responses were obtained from 92 female athletes. Among the total sample of female athletes (n = 92), approximately half (54.2%) were White and non-Hispanic and 31.3% were classified as freshmen. The majority (69%) of the female athletes were less than 10 years of age when they began participating in their collegiate sport. Of the 17.1% of the athletes who reported engaging in vaping, 73.7% vaped occasionally. A total of 2 (2.1%) participants stated that they smoke. Forty-four participants (47%) also completed this study’s physical measurements (InBody 770 and heel bone densitometer) along with the questionnaire making this subgroup available for additional analysis. The study participants represented 9 sports at a potential 12 Division 1 universities in the state of Louisiana, with the greatest number (47%) representing soccer. Among the total sample of participants (n = 96), no more than 7 participants did not complete some questions. Table 1 summarizes the characteristics of the study participants. Table 2 briefly shows the number of participants that take a vitamin or mineral and take calcium and vitamin D supplements regularly. We found that 43% of the total sample take a vitamin or mineral and only 8% take a calcium supplement, while 16% take a Vitamin D supplement regularly.
Table 1

**Characteristics of Sample Population**

<table>
<thead>
<tr>
<th>Baseline characteristics</th>
<th>Total Sample</th>
<th>Sample with Physical Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>96 (100)</td>
<td>44 (100)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>52 (54.2)</td>
<td>25 (56.8)</td>
</tr>
<tr>
<td>White, Hispanic</td>
<td>12 (12.5)</td>
<td>5 (11.4)</td>
</tr>
<tr>
<td>African American</td>
<td>16 (16.7)</td>
<td>7 (15.9)</td>
</tr>
<tr>
<td>Black Hispanic</td>
<td>1 (1.0)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td>Asian</td>
<td>2 (2.1)</td>
<td>2 (4.5)</td>
</tr>
<tr>
<td>Middle Eastern</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Biracial</td>
<td>6 (6.3)</td>
<td>3 (6.8)</td>
</tr>
<tr>
<td>Multiracial</td>
<td>1 (1.0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Missing</td>
<td>6 (6.3)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td><strong>Student Class</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>30 (31.3)</td>
<td>11 (25.0)</td>
</tr>
<tr>
<td>Sophomore</td>
<td>18 (18.8)</td>
<td>8 (18.2)</td>
</tr>
<tr>
<td>Junior</td>
<td>17 (17.7)</td>
<td>10 (22.7)</td>
</tr>
<tr>
<td>Senior</td>
<td>24 (25.0)</td>
<td>13 (29.5)</td>
</tr>
<tr>
<td>Graduate</td>
<td>3 (3.1)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td>Missing</td>
<td>4 (4.2)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td><strong>Sport</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basketball</td>
<td>2 (2.1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Bowling</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Cheerleading</td>
<td>3 (3.1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Cross-Country</td>
<td>1 (1.0)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td>Dance Team</td>
<td>7 (7.3)</td>
<td>4 (9.1)</td>
</tr>
<tr>
<td>Soccer</td>
<td>47 (49.0)</td>
<td>20 (45.5)</td>
</tr>
<tr>
<td>Tennis</td>
<td>2 (2.1)</td>
<td>2 (4.5)</td>
</tr>
<tr>
<td>Track &amp; Field</td>
<td>8 (8.3)</td>
<td>4 (9.1)</td>
</tr>
<tr>
<td>Volleyball</td>
<td>4 (4.2)</td>
<td>4 (9.1)</td>
</tr>
<tr>
<td>Other</td>
<td>17 (17.7)</td>
<td>8 (18.2)</td>
</tr>
<tr>
<td>Missing</td>
<td>5 (5.2)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td><strong>Smoke</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2 (2.1)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td>No</td>
<td>87 (90.6)</td>
<td>41 (93.2)</td>
</tr>
<tr>
<td>Missing</td>
<td>7 (7.3)</td>
<td>2 (4.6)</td>
</tr>
<tr>
<td><strong>Vape</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>17 (17.1)</td>
<td>10 (22.7)</td>
</tr>
<tr>
<td>No</td>
<td>73 (76.0)</td>
<td>33 (75.0)</td>
</tr>
<tr>
<td>Missing</td>
<td>6 (6.3)</td>
<td>1 (2.3)</td>
</tr>
<tr>
<td><strong>Start of Sport</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10 years old</td>
<td>69 (71.9)</td>
<td>33 (75.0)</td>
</tr>
<tr>
<td>10-14 years old</td>
<td>13 (13.5)</td>
<td>7 (15.9)</td>
</tr>
<tr>
<td>&gt;14 years old</td>
<td>8 (8.3)</td>
<td>3 (6.8)</td>
</tr>
<tr>
<td>Missing</td>
<td>6 (6.3)</td>
<td>1 (2.3)</td>
</tr>
</tbody>
</table>

*Note: Total group mean age 19; Physical Measurement mean age 20*
Table 2

Positive Responses to Vitamin and Mineral Questions

<table>
<thead>
<tr>
<th>Questions</th>
<th>n</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you take vitamins or minerals?</td>
<td>42</td>
<td>43.8</td>
</tr>
<tr>
<td>Do you take a calcium supplement regularly?</td>
<td>8</td>
<td>8.3</td>
</tr>
<tr>
<td>Do you take a Vitamin D supplement regularly?</td>
<td>16</td>
<td>13.7</td>
</tr>
</tbody>
</table>

The Athlete Psychological Strain Questionnaire

The APSQ measures the amount of distress an athlete experiences in the previous season of their sport. Scores of this measurement can be categorized as the following: 0-15 – not in distress 16-21 - moderate distress, 22-29 - higher distress, and ≥30 - very high distress. There were 85 participants that took this questionnaire, with 11 missing.

According to the self-reported scores (n=85), a significant percentage (43.5%) of the female athletes experienced “very high distress” during their season, while 30.6% of the female athlete tested experienced “high distress”. Table 3 summarizes the percentage of athletes that experienced a normal, moderate, high, or very high distress level during their season. The group with “high” and “very high” distress is primarily made up of Freshmen (26%) and Seniors (22%) and is mainly made up of soccer players (41%). There was no significant difference in the scores of the LEAF between the players who had a “high” or “very high” distress to those with moderate to normal distress.
Table 3

The Athlete Physiological Strain Questionnaire (n=85)

<table>
<thead>
<tr>
<th>Classification</th>
<th>n</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>5</td>
<td>5.9</td>
</tr>
<tr>
<td>Moderate Distress</td>
<td>17</td>
<td>20.0</td>
</tr>
<tr>
<td>High Distress</td>
<td>26</td>
<td>30.6</td>
</tr>
<tr>
<td>Very High Distress</td>
<td>37</td>
<td>43.5</td>
</tr>
</tbody>
</table>

Bone Fracture Correlation with Mental Health and Diet Quality

This independent samples t-test was a comparison between those with and without a history of bone fractures in the sample of Louisiana Tech female athletes (N = 42), to determine if there was a difference between diet quality and mental health. Scores for the APSQ were significantly higher in the fracture group (\(M = 28.79, SD = 8.06\)) than the non-fracture group (\(M = 22.71, SD = 8.48\)). Similarly, diet quality was significantly higher in the athletes with a history of no fractures (\(M = 31.61, SD = 4.13\)) compared to the female athletes with a history of fractures (\(M = 28.43, SD = 3.98\)). Scores for rigid perfection were higher in the female athletes with a history of bone fractures (\(M = 4.18, SD = .59\)) than those with no history of bone fractures (\(M = 3.57, SD = .96\)). Table 4 summarizes the results of the independent samples t-test.

Among the larger sample of Louisiana athletes (\(N = 78\)), we discovered that there was only one significant difference between those with and without a history of bone fractures. Similarly, to the Louisiana Tech athletes, the scores for the APSQ were the only significantly higher in the fracture group (\(M = 30.67, SD = 7.16\)) than the non-fracture group (\(M = 25.90, SD = 8.79\)). Unlike the Louisiana Tech athletes, this was the only significant finding for this group of athletes.
Table 4

Sample with Physical Measurements Bone Fracture vs. No Bone Fracture

<table>
<thead>
<tr>
<th>Variable</th>
<th>Bone Fracture</th>
<th>No Bone Fracture</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>Cohen d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$M$ (SD)</td>
<td>$n$</td>
<td>$M$ (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APSQ $^a$</td>
<td>14</td>
<td>28.79 (8.06)</td>
<td>28</td>
<td>22.71 (8.48)</td>
<td>2.22</td>
<td>40</td>
</tr>
<tr>
<td>REAP $^b$</td>
<td>14</td>
<td>28.43 (3.98)</td>
<td>28</td>
<td>31.61 (4.13)</td>
<td>-2.38</td>
<td>40</td>
</tr>
<tr>
<td>Rigid Perfectionism $^c$</td>
<td>14</td>
<td>4.18 (.59)</td>
<td>28</td>
<td>3.57 (.96)</td>
<td>2.17</td>
<td>40</td>
</tr>
<tr>
<td>Self-Critical Perfectionism $^c$</td>
<td>13</td>
<td>3.56 (.84)</td>
<td>28</td>
<td>3.56 (.84)</td>
<td>1.82</td>
<td>39</td>
</tr>
<tr>
<td>Narcissistic Perfectionism $^c$</td>
<td>14</td>
<td>1.82 (.68)</td>
<td>28</td>
<td>1.64 (.52)</td>
<td>.94</td>
<td>40</td>
</tr>
</tbody>
</table>

Notes:

$^a$ Athlete Psychological Strain Questionnaire
$^b$ Rapid Eating Assessment for Patients
$^c$ Subscales for the Big Three Perfectionism Scale – Short Form
Louisiana Tech Athletes vs Other Female Athletes in Louisiana

An independent samples t-test was performed to compare the distress, diet quality, Rigid Perfectionism, and risk for low energy availability between two groups: Louisiana Tech female athletes and other female athletes in the state of Louisiana (Table 5). The sample found three significant differences between the two groups; distress (APSQ), diet quality (REAP), and risk for low energy availability (LEAF). The other female athletes in the state of Louisiana ($M = 30.98$, $SD = 7.10$) had higher distress than the Louisiana Tech Athletes ($M = 24.65$, $SD = 8.65$). The other female athletes in the state of Louisiana ($M = 27.06$, $SD = 5.09$) also had a lower diet quality score (REAP) than the Louisiana Tech female athletes ($M = 30.37$, $SD = 4.41$). The third significant finding of the sample found was the other female athletes in the state of Louisiana ($M = 11.10$, $SD = 4.07$) had a higher risk for low energy availability than the female athletes at Louisiana Tech ($M = 8.42$, $SD = 4.59$).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Louisiana Tech Athletes</th>
<th>Other Athletes in Louisiana</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>Cohen d</th>
</tr>
</thead>
<tbody>
<tr>
<td>APSQ&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43</td>
<td>24.65 (8.65)</td>
<td>42</td>
<td>30.98 (7.10)</td>
<td>3.68***</td>
<td>83</td>
</tr>
<tr>
<td>REAP&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43</td>
<td>30.37 (4.41)</td>
<td>36</td>
<td>27.06 (5.09)</td>
<td>-3.11**</td>
<td>77</td>
</tr>
<tr>
<td>Rigid Perfectionism&lt;sup&gt;c&lt;/sup&gt;</td>
<td>43</td>
<td>3.71 (.98)</td>
<td>39</td>
<td>3.73 (.82)</td>
<td>.107</td>
<td>80</td>
</tr>
<tr>
<td>LEAF&lt;sup&gt;d&lt;/sup&gt;</td>
<td>43</td>
<td>8.42 (4.59)</td>
<td>38</td>
<td>11.10 (4.07)</td>
<td>2.77**</td>
<td>79</td>
</tr>
</tbody>
</table>

Notes: **p < .01  
***p < .001  
<sup>a</sup> Athlete Psychological Strain Questionnaire  
<sup>b</sup> Rapid Eating Assessment for Patients  
<sup>c</sup> Subscales for the Big Three Perfectionism Scale – Short Form  
<sup>d</sup> Low Energy Availability in Females Questionnaire
Correlations

Correlations on Total Sample

Bivariate correlations were computed for the entire group (N= 92). Variables included risk of low energy availability (LEAF), diet quality (REAP-S), perfectionism (BTPS; subscales: rigid perfection, self-critical, narcissistic), and athlete strain (APSQ; subscales: self-regulation, performance, coping). Categories for the variables are as follows; LEAF: a total score greater than or equal to 8 is to be considered at risk for low energy availability; REAP-S: has a possible score of 13 to 39, with a higher score indicating a higher diet quality; BTPS-SF: The higher the average score, the more the athlete shows the tendency for the three subscales; Bone Health: The Stiffness Index for ages around 20 years old should be 100 or above, anything less suggests an increased risk for fractures. A T and Z Score of -1 to -2.49 indicates osteopenia, and below -2.5 indicates osteoporosis. Table 6. shows the results of the 16 correlations that were statistically significant. The subscales of the BTPS-SF significantly correlated \( r(79) = .551, p < .281 \) with each other, and the 3 subscales of the APSQ positively correlated with the total score of the APSQ, suggesting that when the average score of the three subscales increase the total score of the APSQ score goes up. The correlation between the LEAF and the BTPS-SF subscale, Rigid Perfectionism, was significant and positive, \( r(81) = .305, p < .006 \) indicating that female athletes that demand flawless performance of themselves tend to have low energy availability. The LEAF questionnaire negatively correlates with the total score of the APSQ and the subscale, Self-Regulation, \( r(81) = .443, p < .001 \). Self-Regulation assesses a combination of low motivation and interpersonal difficulties. Female athletes reporting low motivation and interpersonal
difficulties had low energy availability scores. The subscale of the APSQ, Self-Regulation, had a positive correlation with the subscale of the BTPS-SF, Rigid Perfectionism, $r(82) = .270, p < .014$. We found that both subscales correlated with the LEAF, suggesting that low scores of both are related to low energy availability. Both subscales have the personality trait of someone who has interpersonal difficulties within oneself. The total score of the APSQ and its subscales, Self-Regulation and Performance, has a significant positive correlation with the BTPS-SF subscale, Self-Critical Perfectionism, $r(81) = .397, p < .001$. Self-Critical Perfectionism is harsh self-evaluation, fear of failure, and concerns over making mistakes. Self-Regulation, Performance, and Self-Critical Perfectionism are measuring related concepts.
<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
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<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>1. REAP&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>2. BTPS Rigid Perfectionism&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>4. BTPS Narcissistic Perfectionism&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>.279*</td>
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<td>5. APSQ&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-.083</td>
<td>.199</td>
<td>.397**</td>
<td>.124</td>
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<tr>
<td>6. Self-Regulation, APSQ&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.020</td>
<td>.270*</td>
<td>.443**</td>
<td>.192</td>
<td>.865**</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7. Performance, APSQ&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-.109</td>
<td>.148</td>
<td>.304**</td>
<td>.015</td>
<td>.869**</td>
<td>.559**</td>
<td></td>
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</tr>
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<td>8. Coping, APSQ&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>-.077</td>
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<td>.496**</td>
<td>.299**</td>
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<td>9. LEAF&lt;sup&gt;e&lt;/sup&gt;</td>
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<td>.245*</td>
<td>.281*</td>
<td>.209</td>
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</table>

**Notes:**

* p < .05
** p < .01

<sup>a</sup> Rapid Eating Assessment for Patients
<sup>b</sup> Subscales for the Big Three Perfectionism Scale – Short Form
<sup>c</sup> Athlete Psychological Strain Questionnaire
<sup>d</sup> APSQ Subscales
<sup>e</sup> Low Energy Availability in Females Questionnaire
On-Campus Participants with BMD and InBody 770 Measurements Correlations

There were approximately 135 female athletes at Louisiana Tech University, that potentially could have participated in the physical measurements. There were 44 female athletes who participated in the on-campus BMD measurements, meaning there was more than a 30% acceptance rate from Louisiana Tech University female athletes. Bivariate correlations were calculated for the subset of participants with physical measurements including 12 variables: bone mineral density health, risk of low energy availability, diet quality, perfectionism (rigid perfection, self-critical, narcissistic), and athlete strain (self-regulation, performance, coping) on 44 female athletes. The correlations are represented in Table 7. The correlation between the APSQ and LEAF was significant and positive, \( r(42) = .245, p < .028 \). The category of the BTPS-SF, “rigid perfection,” was significant and positive to the SI, T, and Z scores, \( r(42) = .424, p < .005 \). Rigid perfectionism also had a significant positive correlation with the LEAF, \( r(42) = .305, p < 0.06 \). There was a positive correlation between the total score of the APSQ and the “self-critical” category of the BTPS-SF, \( r(42) = .397, p < 0.01 \).
### Table 7

**Sample with BMD Measurements Correlation Table (n=44)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>8</th>
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<th>10</th>
<th>11</th>
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<tbody>
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<td>1. Stiffness Index (^a)</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td>2. T-Score (^a)</td>
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<td>1.000**</td>
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<td></td>
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<tr>
<td>3. Z-Score (^a)</td>
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<td>1.000**</td>
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</tr>
<tr>
<td>4. LEAF (^b)</td>
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<td>.156</td>
<td>.157</td>
<td>.155</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. REAP (^c)</td>
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<td>.236</td>
<td>.233</td>
<td>-.102</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6. BTPS Rigid Perfectionism (^d)</td>
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<td>.424**</td>
<td>.425**</td>
<td>.436**</td>
<td>.305**</td>
<td>.123</td>
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</tr>
<tr>
<td>7. BTPS Self-Critical Perfectionism (^d)</td>
<td></td>
<td>.351*</td>
<td>.352*</td>
<td>.359*</td>
<td>.115</td>
<td>.003</td>
<td>.551**</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>8. BTPS Narcissistic Perfectionism (^d)</td>
<td></td>
<td>.163</td>
<td>.166</td>
<td>.172</td>
<td>.114</td>
<td>.169</td>
<td>.427**</td>
<td>.279*</td>
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<td>9. APSQ (^e)</td>
<td></td>
<td>.094</td>
<td>.097</td>
<td>.101</td>
<td>.245*</td>
<td>-.083</td>
<td>.199</td>
<td>.397**</td>
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<td>10. Self-Regulation, APSQ (^f)</td>
<td></td>
<td>.173</td>
<td>.175</td>
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<td>.281</td>
<td>.020</td>
<td>.270*</td>
<td>.443*</td>
<td>.192</td>
<td>.865**</td>
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</tr>
<tr>
<td>11. Performance, APSQ (^f)</td>
<td></td>
<td>.056</td>
<td>.059</td>
<td>.060</td>
<td>.209</td>
<td>-.109</td>
<td>.148</td>
<td>.304**</td>
<td>.015</td>
<td>.869**</td>
<td>.559**</td>
</tr>
<tr>
<td>12. Coping, APSQ (^f)</td>
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<td>-.135</td>
<td>-.133</td>
<td>-.037</td>
<td>-.185</td>
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<td>&lt;.001</td>
<td>.299**</td>
<td>.276*</td>
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</table>

**Notes:**

\(^{a}\) *p < .05  
\(^{**}\) *p < .01  
\(^{a}\) is measured using the Heel Bone Densitometer.  
\(^{b}\) Low Energy Availability in Females Questionnaire  
\(^{c}\) Rapid Eating Assessment for Patients  
\(^{d}\) Subscales for the Big Three Perfectionism Scale – Short Form  
\(^{e}\) Athlete Psychological Strain Questionnaire  
\(^{f}\) APSQ Subscales
Importance of Diet

Likert scale items asked the participants to rate how important diet was to their mental health, performance, and overall health (1 being not important, 10 being very important). We found that Importance for Overall Health had the highest average score ($M = 8.71, SD = 1.59$), second was Importance for Performance ($M = 8.48, SD = 1.56$), and last was Importance for Mental Health ($M = 7.51, SD = 1.97$) (Table 8). Correlations were run between the Importance for Mental Health, Importance for performance, and Importance for overall health the scores from the LEAF, REAP-S, and APSQ (See Table 9). We found that the LEAF was significant and negatively correlated with the feeling diet was important for performance.

Table 8

*Importance of Diet for Mental Health, Performance, and Overall Health*

<table>
<thead>
<tr>
<th>Question</th>
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<th>$M$ (SD)</th>
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<tr>
<td>Importance for Mental Health</td>
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<td>7.51 (1.97)</td>
</tr>
<tr>
<td>Importance for Performance</td>
<td>79</td>
<td>8.48 (1.56)</td>
</tr>
<tr>
<td>Importance for Overall Health</td>
<td>79</td>
<td>8.71 (1.59)</td>
</tr>
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</table>
Table 9

*Importance of Diet Correlations Table (n = 79)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>1. Importance for Mental Health</td>
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<td></td>
<td></td>
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<tr>
<td>2. Importance for Performance</td>
<td>.329**</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Importance for Overall Health</td>
<td>.443**</td>
<td>.394**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. LEAF&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.086</td>
<td>-.230*</td>
<td>.035</td>
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</tr>
<tr>
<td>5. REAP-S&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.333</td>
<td>.116</td>
<td>.081</td>
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<tr>
<td>6. APSQ&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-.067</td>
<td>-.074</td>
<td>-.108</td>
<td>.245*</td>
<td>-.083</td>
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</table>

Notes:
* *p < .05
** *p < .01
<sup>a</sup> Low Energy Availability in Females Questionnaire
<sup>b</sup> Rapid Eating Assessment for Patients
<sup>c</sup> Athlete Psychological Strain Questionnaire
CHAPTER 5

DISCUSSION

This study aimed to evaluate the nutrition-related factors that influence the bone health of collegiate female sports and performance athletes. The influencing variables included diet quality, low energy availability, bone injury history, and mental distress. Correlations indicated associations between the variables. We found that no variable significantly correlated with diet quality (REAP-S). However, an independent samples t-test that compared diet quality and distress between those with and without a history of bone fractures found that the group of athletes with a history of bone fractures had a lower REAP-S (diet quality) than the group of athletes without a history of bone fractures. Similar to our study, a prospective study that focused on dietary diversity and the risk of fractures in adults found that higher dietary diversity contributed to a lower risk of bone fractures (Zhang, J et al., 2020). We ran a test to determine how important diet was to the female athlete’s mental health, performance, and overall health/well-being. We found that all three mean scores were above a score of 7, indicating that diet is relatively important to their mental health, performance, and overall health.

Low energy availability, as measured by the LEAF, was significantly correlated with three variables: the APSQ total score, the Rigid Perfectionism, and Self-Regulation subscales. The LEAF was significantly, and positively correlated with Rigid Perfectionism. Rigid Perfectionism measures an individual’s need for their performance
to be impeccable and only feels worthwhile when perfect. The correlation of these two variables may suggest that an athlete that has the Rigid Perfectionism trait may go to more extreme lengths to improve their performance, intentionally or unintentionally lowering their energy availability. This is consistent with a previous study by Smith (2019), which also found that perfectionism has been associated with low energy availability. Female athletes who had higher average total scores of the APSQ had higher scores of the LEAF, suggesting that female athletes with greater distress are at a greater risk for low energy availability. The third variable that the LEAF positively correlated with was Self-Regulation, a sub-scale of the APSQ. Self-Regulation assesses a combination of low motivation and interpersonal difficulties. The female athletes who were at a greater risk of low energy availability tended to overthink certain situations, have low motivation, become irritable easily, and find it difficult to be around their teammates.

The bone mineral density and fracture risk (stiffness index) were measured in the Louisiana Tech University female athlete participants. We found that these athletes had an overall healthy bone mineral density range (T and Z score) and were not at risk for fractures (SI) related to BMD, as there were only 2% of the participants had measures indicating risk for fractures and low bone mineral density. It is important to remember, however, that these measures are screening measurements, and more sophisticated measures, such as would be obtained by DEXA scans, could reveal more subtle changes in BMD in this young adult group. The BMD measurements (SI, T, and Z score) were positively and significantly correlated with two subscales of the BTPS-SF: Rigid Perfectionism and Self-Critical Perfection. As previously mentioned, Rigid Perfectionism
is an individual need for perfect performance and the Self-Critical subscale reflects high personal striving as well as harsh self-evaluation and fear of failure. Individuals in this group who strived for perfection also had a healthy bone mineral density. The history of bone fractures was self-reported on the questionnaire. Comparing with and without a history of bone fractures in the sample of Louisiana Tech female athletes indicated there was a difference between diet quality and mental distress. We found that those with a history of bone fractures had lower diet quality and higher distress levels. It is difficult to ascertain whether low diet quality was a result of distress following fractures as this would disrupt athletic performance and goals or did low diet quality influenced distress negatively. Future research should focus efforts on determining these relationships more completely.

We compared diet quality, distress, Rigid Perfectionism, and risk for low energy between Louisiana Tech female athletes and other female athletes in the state of Louisiana. We found that the female athletes outside of Louisiana Tech University had a lower diet quality, higher distress level, and greater risk for low energy availability than the athletes at Louisiana Tech. These results were unexpected and possible influencing factors may be: coaches’ individual training styles, the team environment and teammates, the resources available to the athletes on individual campuses, and the family and social support experienced by the individual athlete.

It was postulated that a high level of distress might influence alteration in dietary intake in order to improve athletic performance. To measure the distress level of our athletes, we used the Athlete Psychological Strain Questionnaire (APSQ). We found that a significant number of female athletes attending a division one program reported
experiencing “very high distress” (43.5 %) and “high distress” (30.6%). In the demographics sample, we found that 30% of our sample population had an academic classification of “freshmen”. Freshmen come into a new environment, start making stressful decisions on their own, must manage their own time schedule, and begin to perform at a higher level than they are not used to. This could suggest that the freshmen influenced the higher distress levels in our population. Self-Regulation and Performance were the two subscales of the APSQ that had the highest averages. As stated above Self-Regulation assess a combination of low motivation and interpersonal difficulties, while Performance measures the distress experienced during training and the distress associated with the desire for athletic success. The APSQ was not the only tool used to measure mental health symptoms, we also used the BTPS-SF to measure perfectionism. The BTPS-SF had three subscales: Rigid Perfectionism, Self-Critical Perfectionism, and Narcissistic Perfectionism. These three subscales correlated not only with themselves but with the subscales of the APSQ, suggesting that female athletes that are harsh critics of themselves and strive to be perfect in their athletic success, tend to be under a higher distress level.

The NCAA conducted a national survey of Division I, II, and III athletes. between the dates of November 17 to December 13, 2020. The survey collected data from 9,800 student-athletes on mental exhaustion, anxiety, and depression. The study found that “38% of those in women’s sports reported feeling mentally exhausted constantly or almost every day” (Johnson, 2022). And only 47% of the women’s sports agreed or strongly agreed that their mental health was a priority to their athletic department. Mental health continues to be a huge concern amongst collegiate athletes and has recently been
brought to the attention of the NCAA following the tragic self-inflicted deaths of five college athletes, Sarah Shulze, Katie Meyer, Jayden Hill, Robert Martin, and Lauren Bernett. This study suggests that athletes should be provided necessary resources throughout their sports’ seasons.

Athletic departments in college sports need to begin to take the mental health of their athletes seriously and develop strategies to lessen the strain their athletes experience. The NCAA provides four practices that a school should take into consideration when promoting mental health in their athletes: 1) schools are encouraged to provide a licensed individual who is qualified to provide mental health services, 2) encourage athletic departments to work with the sports medicine and campus mental health service to develop emergency and non-emergency action plans in for when a college athlete faces mental health challenges, 3) schools are encouraged to develop and apply mental health screening tools, prior to an athlete’s initial participation in college athletics (Tools for anxiety and depression), and 4) athletic departments are encouraged to educate their athletes, coaches, and faculty to help promote a healthy environment (NCAA, 2023). Diet quality could play a role in improving mental health status.

Nutrition education by a Sports Dietitian needs to start as early as high school to promote a healthy eating lifestyle in teens prior to their participation in collegiate sports. The promotion of healthy eating behaviors should continue to be promoted to athletes in college by a Dietitian provided by the University. The education should include how to properly nourish the body to prevent low energy availability, grocery store use, time management, and timing of meals/snacks to sporting events. Prior to an athlete's
participation in collegiate sports, the athletic department should screen the athlete for diet quality, low energy availability, and risk for disordered eating.

We partially rejected the hypothesis that stated there would be no relationship between mental health risk and diet quality, low energy availability symptoms, and BMD in female collegiate athletes. We found that diet quality did not correlate with mental health risks, low energy availability symptoms, and BMD. However, we found a correlation between the LEAF Rigid Perfectionism, the total score of the APSQ, and Self-Regulation, a subscale of the APSQ. We found that two subscales from the BTPS-SF, Rigid and Self-Critical Perfectionism, correlated with BMD indicators in the group of female athletes. We partially rejected the second null hypothesis stated that there would be no relationship between diet quality and BMD, and bone injury in female collegiate athletes. We found that diet quality did not correlate with any BMD indicators. However, we found that female athletes with a history of bone fractures had a lower diet quality than those with a history of no bone fracture. This hypothesis was partially rejected. We fully rejected the third null hypothesis which stated that there would be no relationship between bone injury and mental health risk in female collegiate athletes. We found that athletes who had a history of bone fractures had a higher level of stress than compared to those with no history of bone fractures. We accepted the fourth null hypothesis which stated that there will be no relationship between low energy availability symptoms and diet quality, body fat percentage, and bone mineral density in female collegiate athletes. We found no correlations between these variables.
Study Limitations

Limitations of the study should be considered when interpreting the findings of this study. The questionnaire was self-reported and lengthy, which may have caused the athletes to rush through the survey or be biased toward questions, resulting in inaccurate scores. Due to the limited participant sample size, some of the data analyses such as the bone mineral density measurements (SI, T & Z Score) did not result in significant outcomes. The GE Achilles EXPII bone densitometer compares the participants to “young adults”, which may have skewed the results of the bone measure to favor a higher bone mineral density.

Conclusion

In summary, we found that mental health status risk was related to diet quality, low energy availability, and bone injury health frequency amongst female collegiate athletes. The more likely a female athlete is to strive to be perfect and is a harsh critic of herself, the higher the distress level of that individual. The higher distress levels then cause the athlete to have a lower diet quality and be at a higher risk for low energy availability. Athletic department staff that work with female athletes on their campus should consider all aspects of the athlete when treating them, such as mental health, diet quality, symptoms of low energy availability, and history of bone fractures. Future research should consider adding a detailed nutrient and calorie intake to use in the calculation for energy availability. Energy availability is calculated by subtracting energy expenditure from energy intake and dividing it by the athlete’s fat-free mass. Using a diet quality tool did not allow this calculation in this study. This calculation would provide another method of identifying low energy availability. A benefit to future research would
be the availability of BMD measures such as that provided by a DEXA scan. This may reveal subtle changes in BMD in this young adult group. Additionally, a detailed nutrient intake analysis would allow for exploring relationships among nutrient intake, perfectionism, and bone mineral density.
REFERENCES


APPENDIX A

OPERATIONAL DEFINITIONS
Operational Definitions

**Female collegiate athlete:** The female collegiate athlete in this study is classified as a sport and performance female athlete who participates in their sport at a Division one college in Louisiana.

**Low energy availability:** Will be measured using the Low Energy Availability in Females Questionnaire (LEAF-Q). A total score greater than or equal to 8 is to be considered at risk for low energy availability.

**Diet Quality:** Will be measured using the Rapid Eating Assessment for Participants (REAP) questionnaire. The REAP has a possible score range from 13 to 39, with a higher score indicating a higher diet quality.

**Mental Health Risks:** Will be measured using the Athlete Psychological Strain Questionnaire (APSQ) and the Big Three Perfectionism Scale – Short Form (BTPS-SF). The APSQ score indicates 16+ - moderate distress, 22+ - higher distress, and 30+ - very high distress. The Big Three Perfectionism Scale has three subscales: Rigid Perfectionism, Self-Critical Perfectionism, and Narcissistic Perfectionism. The higher the average score for each subscale the more likely they are to have that trait of perfectionism.

**Bone Health:** Will be measured using the GE Achilles EXPII. The Stiffness Index for ages around 20 years old should be around 100, anything less suggests an increased risk for fractures. A T-Score -1 to -2.49 indicates osteopenia, and below -2.5 indicates osteoporosis.

**BTPS-SF:** is measured with the average score between each of the three subscales. The higher the average score, the more the athlete shows the tendency for the three subscales.
APPENDIX B

RESEARCH MATRIX
<table>
<thead>
<tr>
<th>Purpose Statement</th>
<th>Hypotheses</th>
<th>Study Design</th>
<th>Variables (Measurement tools)</th>
<th>Type of Data</th>
<th>Statistical Test (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The purpose of this study is to evaluate the nutrition-related factors affecting the bone health of collegiate female sports and performance athletes.</td>
<td>$H_0$: There will be no relationship among mental health risk and diet quality, low energy availability symptoms, and BMD in female collegiate athletes.</td>
<td>Purposive &amp; network sampling</td>
<td><strong>Demographics</strong>&lt;br&gt;<strong>Diet Quality</strong>&lt;br&gt;- REAP&lt;br&gt;<strong>Low energy symptoms</strong>&lt;br&gt;- LEAF&lt;br&gt;- BF %</td>
<td>Descriptive</td>
<td>Central Tendency&lt;br&gt;Correlations&lt;br&gt;Regression</td>
</tr>
<tr>
<td></td>
<td>$H_1$: There will be no relationship among diet quality, BMD, and Bone injury in female collegiate athletes.</td>
<td>Louisiana Tech female athletes for physical data.</td>
<td><strong>Mental Health risk</strong>&lt;br&gt;- ASPQ&lt;br&gt;- BTPS-SF</td>
<td>Continuous</td>
<td>Correlations&lt;br&gt;Regression&lt;br&gt;T-tests</td>
</tr>
<tr>
<td></td>
<td>$H_2$: There will be no relationship between bone injury and mental health risk in female collegiate athletes.</td>
<td>Recruit via email for other LA universities for survey data.</td>
<td><strong>Bone Health</strong>&lt;br&gt;BMD (heel densitometer)&lt;br&gt;- Stiffness index/fracture risk&lt;br&gt;- Age-matched Z-Score</td>
<td>Continuous Score&lt;br&gt;Categorical (2)</td>
<td>Correlations&lt;br&gt;Regression&lt;br&gt;Chi-Square</td>
</tr>
<tr>
<td></td>
<td>$H_3$: There will be no relationship among low energy availability symptoms and diet quality, Body composition, and BMD, in female collegiate athletes.</td>
<td>Louisiana Tech: Target 100&lt;br&gt;Other LA universities: Target &gt;150 participants</td>
<td></td>
<td></td>
<td>Correlations&lt;br&gt;Regression</td>
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<tr>
<td></td>
<td></td>
<td>Statistical significance set @ $p &lt; .05$</td>
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</tr>
</tbody>
</table>
APPENDIX C

QUESTIONNAIRE
Q1 What is your sex?

- Female (1)
- Male (2)
- Transgender (3)

Q2 What is your age in years?

Q3 What is your student academic classification?

- Freshman (1) ... Graduate Student (5)

Q4 Which athletic or performance sport do you participate in?

- Basketball (1) ... Other (10)

Q5 On average, how many minutes of your physical activity occurs outdoors each day?

Q6 What is your height in feet and inches OR centimeters?

- Feet (4) ________________________________
- Inches (5) ________________________________
- Centimeters (6) ________________________________

Q7 What is your weight in pounds OR kilograms?

- Pounds (4) ________________________________
- Kilos (5) ________________________________
Q8 What is your race/ethnicity?

- White, non-Hispanic (1)
- White, Hispanic origin (2)
- African American or Black (3)
- Black, Hispanic origin (4)
- Native American or Alaskan Native (5)
- Pacific Islander or Hawaiian (6)
- Asian, Pacific Islander (7)
- Asian Indian (8)
- Middle Eastern (9)
- Biracial, Please list: (10) ________________________________________________
- Multiracial, Please list: (11) ________________________________________________

Q9 Do you ever smoke cigarettes?

- Yes (1)
- No (2)

Skip To: Q11 If Do you ever smoke cigarettes? = No

Q10 How often do you smoke?

- Daily (2)
- Few times a week (3)
- Occasionally (4)
Q11 Do you ever engage in vaping?
   ○ Yes (1)
   ○ No (2)

Q12 How often do you vape?
   ○ Daily (1)
   ○ Few times a week (2)
   ○ Occasionally (3)

Q13 When did you begin playing/participating in your sport?
   ○ < 10 years old (1)
   ○ 10 - 14 years old (2)
   ○ > 14 years old (3)
**Q14** These questions concern how you felt through the latest completed season of your sport. Please mark the answer that best represents how you felt.

<table>
<thead>
<tr>
<th>None of the Time (1)</th>
<th>A little of the time (3)</th>
<th>Some of the time (4)</th>
<th>Most of the time (5)</th>
<th>All of the time (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It was difficult to be around teammates (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. I found it difficult to do what I needed to do (2)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. I was less motivated (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>4. I was irritable, angry or aggressive (4)</td>
<td>○</td>
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<tr>
<td>5. I could not stop worrying about injury or my performance (5)</td>
<td>○</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>6. I found training more stressful (6)</td>
<td>○</td>
<td>○</td>
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<tr>
<td>7. I found it hard to cope with selection pressures (7)</td>
<td>○</td>
<td>○</td>
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<tr>
<td>8. I worried about life after sport (8)</td>
<td>○</td>
<td>○</td>
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<tr>
<td>9. I needed alcohol or other substances to relax (9)</td>
<td>○</td>
<td>○</td>
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<tr>
<td>10. I took unusual risk off-field (10)</td>
<td>○</td>
<td>○</td>
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</tr>
</tbody>
</table>

15 Please answer each statement below by bubbling in the circle that best reflects your degree of agreement or disagreement with the following statements. There are five possible responses to each statement, ranging from “Disagree Strongly to Agree Strongly”.
<table>
<thead>
<tr>
<th>Statement</th>
<th>Disagree Strongly (1)</th>
<th>Somewhat Disagree (2)</th>
<th>Neutral (3)</th>
<th>Somewhat Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have a strong need to be perfect (1)</td>
<td></td>
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<tr>
<td>It is important to me to be perfect in everything I attempt (2)</td>
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<tr>
<td>Striving to be as perfect as possible makes me feel worthwhile (4)</td>
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<tr>
<td>My opinion of myself is tied to being perfect (5)</td>
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<td>The idea of making a mistake frightens me (6)</td>
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<tr>
<td>When I notice that I have made a mistake, I feel ashamed (7)</td>
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<tr>
<td>I have doubts about everything I do (8)</td>
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<tr>
<td>I judge myself harshly when I don’t do something perfectly (9)</td>
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<tr>
<td>I feel disappointed with myself, when I don’t do something perfectly (10)</td>
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<tr>
<td>People are disappointed in me whenever I don’t do something perfectly (11)</td>
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<tr>
<td>I expect those close to me to be perfect (12)</td>
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<tr>
<td>I am highly critical of other people’s imperfections (13)</td>
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<tr>
<td>I feel dissatisfied with other people, even when I know they are trying their best (14)</td>
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<tr>
<td>It bothers me when people don’t notice how perfect I am (15)</td>
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<tr>
<td>Statement</td>
<td>Disagree Strongly (1)</td>
<td>Somewhat Disagree (2)</td>
<td>Neutral (3)</td>
<td>Somewhat Agree (4)</td>
<td>Strongly Agree (5)</td>
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<tr>
<td>I deserve to always have things go my way (16)</td>
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<tr>
<td>I know that I am perfect (17)</td>
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</tbody>
</table>

End of Block: Big 3 Perfectionism Scale

Start of Block: LEAF

Q16 Have you had absences from your training, or participation in competitions during the last year due to injuries?

- No, not at all (1)
- Yes, once or twice (2)
- Yes, three or four times (3)
- Yes, five times or more (4)

Skip To: Q18 If Have you had absences from your training, or participation in competitions during the last year due to injuries have you had in the last year?

Q17 If yes, for how many days absence from training or participation in competition due to injuries have you had in the last year?

- 1-7 days (1)
- 8-14 days (2)
- 15-21 days (3)
- 22 days or more (4)
Q18 Do feel gaseous or bloated in the abdomen, also when you do not have your period?

- Yes, several times a day (1)
- Yes, several times a week (2)
- Yes, once or twice a week or more seldom (3)
- Rarely or never (4)

Q19 Do you get cramps or stomach aches which cannot be related to your menstruation?

- Yes, several times a day (1)
- Yes, several times a week (2)
- Yes, once or twice a week or more seldom (3)
- Rarely or never (4)

Q20 How often do you have bowel movements on average?

- Several times a day (2)
- Once a day (3)
- Every second day (4)
- Twice a week (5)
- Once a week or more rarely (6)

Q21 How would you describe your normal stool?

- Normal (soft) (1)
- Diarrhea like (watery) (2)
- Hard and dry (3)
Q22 Do you use oral contraceptives?

- Yes (1)
- No (2)

Skip To: Q24 If Do you use oral contraceptives? = No

Q23 If yes, why do you use oral contraceptives?

- Contraception (1)
- Reduction of menstruation pains (2)
- Reduction of bleeding (3)
- To regulate the menstrual cycle in relation to performance etc... (4)
- Otherwise menstruation stops (5)
- Other (6) _________________________________________

Q24 How old were you when you had your first period?

- 11 years or younger (1)
- 12-14 years (2)
- 15 years or older (3)
- I don’t remember (4)
- I have never menstruated (if you have answered “I have never menstruated” there are no further questions to answer) (5)

Skip To: End of Block If How old were you when you had your first period? = I have never menstruated (if you have answered “I have never menstruated” there are no further questions to answer)
Q25 Did your first menstruation come naturally (by itself)

- Yes (1)
- No (2)
- I don’t remember (3)

Skip To: Q48 If Did your first menstruation come naturally (by itself) = Yes

Q26 If no, what kind of treatment was used to start your menstrual cycle?

- Hormonal Treatment (1)
- Reduced amount of exercise (2)
- Weight Gain (3)
- Other (4) __________________________________________________________

Q48 Do you have normal menstruation?

- Yes (1)
- No (2)

Skip To: Q33 If Do you have normal menstruation? = No

Q28 When was your last period?

- 0-4 weeks ago (1)
- 1-2 months (2)
- 3-4 months ago (3)
- 5 months ago or more (4)
Q29 Are your periods regular? (Every 28th to 34th day)
   - Yes, most of the time (1)
   - No, mostly not (2)

Q30 For how many days do you normally bleed?
   - 1-2 days (1)
   - 3-4 days (2)
   - 5-6 days (3)
   - 7-8 days (4)
   - 9 days or more (5)

Q31 Have you ever had problems with heavy menstrual bleeding?
   - Yes (1)
   - No (2)

Q53 How many periods have you had during the last year?
   - 12 or more (1)
   - 9-11 (2)
   - 6-8 (3)
   - 3-5 (4)
   - 0-2 (5)
Q33 If no or “I don’t remember”, when did you have your last period?

- 2-3 months ago (1)
- 4-5 months (2)
- 6 months ago or more (3)
- I’m pregnant and there do not menstruate (4)

Q34 Have your periods ever stopped for 3 consecutive months or longer (besides pregnancy)?

- No, never (1)
- Yes, it has happened before (2)
- Yes, that’s the situation now (3)

Q35 Do you experience changes in your menstrual period when you increase exercise intensity, frequency, or duration?

- Yes (1)
- No (2)

Skip To: End of Block If Do you experience changes in your menstrual period when you increase exercise intensity, frequency... = No

Q36 If yes, how? (Check one or more options)

- I bleed less (1)
- I bleed fewer days (2)
- My menstruation stops (3)
- I bleed more (4)
- I bleed more days (5)
Start of Block: Dietary Assessment

Q37 Do you take any vitamin or mineral supplement?

- Yes (1)
- No (2)

Skip To: Q44  If Do you take any vitamin or mineral supplement? = No

Q38 Do you take a calcium supplement regularly?

- Yes (1)
- No (2)

Skip To: Q41  If Do you take a calcium supplement regularly? = No

Q39 Is the calcium part of a multivitamin and mineral or is it a supplement alone?

- Multivitamin and mineral (1)
- Alone (2)

Q40 How many days per week do you take calcium?

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- 6 (6)
- 7 (7)
- Less than weekly, describe (8)
Q41 Do you take a vitamin D supplement regularly?

- Yes (1)
- No (2)

Skip To: Q44 If Do you take a vitamin D supplement regularly? = No

Q42 Is the calcium part of a multivitamin and mineral or is it a supplement alone?

- Multivitamin and mineral (1)
- Alone (2)

Q43 How many days per week do you take this supplement?

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (5)
- 5 (6)
- 6 (7)
- 7 (8)
- Less than weekly, describe (9)
Q44 In the past week, on how many days did you eat this food item? (place the slider on how many days).

<table>
<thead>
<tr>
<th>Food Item</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>Cows Milk</td>
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<td>Almond Milk</td>
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<td>Oat Milk</td>
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<td>Soy Milk</td>
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<td>Yogurt</td>
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<td>Cheese</td>
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<td>Buttermilk</td>
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<td>Salmon</td>
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<td>Spinach</td>
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<td>Kale</td>
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<td>Broccoli</td>
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<td>Orange Juice</td>
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<td>Tofu</td>
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</table>

End of Block: Dietary Assessment

Start of Block: REAP
<table>
<thead>
<tr>
<th>Q45 In an average week, how often do you:</th>
<th>Usually/Often (1)</th>
<th>Sometimes (2)</th>
<th>Rarely/Never (3)</th>
<th>Does not apply to me (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skip Breakfast? (1)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Eat 4 of more meals from sit-down or take out restaurants? (2)</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>Eat less than 2 servings of whole grain products or high fiber starches a day? Serving = 1 slice of 100% whole grain bread; 1 cup whole grain cereal like shredded wheat, Wheaties, grape nuts, high fiber cereals, oatmeal, 3-4 whole grain crackers, 1/2 cup brown rice or whole wheat pasta, boiled or baked potatoes, yuca, yams or plantain. (3)</td>
<td>☐</td>
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<tr>
<td>Eat less than 2 servings of fruits a day? Serving = 1/2 cup or 1 med. fruit or 3/4 cup 100% fruit juice. (4)</td>
<td>☐</td>
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<tr>
<td>Eat less than 2 servings of vegetables a day? Serving = 1/2 cup vegetables, or cup leafy raw vegetables. (5)</td>
<td>☐</td>
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</tr>
<tr>
<td>Eat or drink less than 2 servings of milk, yogurt, or cheese a day? Serving = 1 cup milk or yogurt; 1 1/2 - 2 ounces cheese. (6)</td>
<td>☐</td>
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<tr>
<td>Eat more than 8 ounces (see seizes below) of meat, chicken, turkey or fish per day? Note: 3 ounces of meat or chicken is the size of a deck of cards or ONE of the following: 1 regular hamburger, 1 chicken breast or leg (thigh and drumstick), or 1 pork chop. (7)</td>
<td>☐</td>
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<tr>
<td>Use of regular processed meats (like bologna, salami, corned beef, hotdogs, sausage or bacon) instead of low fat processed meats (like roast beef, turkey, lean ham; low-fat cold cuts/hotdogs)? (8)</td>
<td>☐</td>
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<tr>
<td>Eat fried foods such as fried chicken, fried fish, French fries, fried plantains, tostones, or fried yuca? (9)</td>
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</tbody>
</table>
Q45 In an average week, how often do you:

<table>
<thead>
<tr>
<th></th>
<th>Usually/Often (1)</th>
<th>Sometimes (2)</th>
<th>Rarely/Never (3)</th>
<th>Does not apply to me (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eat regular potato chips, nacho chips,</td>
<td>○</td>
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<td>corn chips, crackers, regular popcorn,</td>
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<td>nuts instead of pretzels, low-fat chips</td>
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<tr>
<td>or low-fat crackers, air-popped popcorn?</td>
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<td>(10)</td>
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<tr>
<td>Add butter, margarine or oil to bread,</td>
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<td>potatoes, rice or vegetable at the table. (11)</td>
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<tr>
<td>Eat sweets like cake, cookies, pastries,</td>
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<tr>
<td>donuts, muffins, chocolate, and candies</td>
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<td>more than 2 times per day.</td>
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<td>(12)</td>
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<tr>
<td>Drink 16 ounces or more of non-diet</td>
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<td>soda, fruit drink/punch or Kool-Aid a</td>
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<td>day? Note: 1 can of soda = 12 ounces.</td>
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<td>(13)</td>
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</table>

End of Block: REAP

Start of Block: Bone Health History

Q46 Have you ever broken or fractured a bone while playing/participating during the course of the season of your sport?

- ○ Yes (1)
- ○ No (2)
- ○ Unsure (3)

Skip To: End of Block If Have you ever broken or fractured a bone while playing/participating during the course of the season... = No
Q47 How many times have you broken or fractured a bone while playing/performing your sport?

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 or more (5)

Q48 List the bone or bones you have fractured or broken while playing your sport.

________________________________________________

End of Block: Bone Health History

Start of Block: Diet and Health Perspective

Q49 On a scale of 1 to 10 (1 being not important and 10 being the most important). Rate how important diet is to you for your mental health, performance, and overall/long term health.

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<tbody>
<tr>
<td>Mental health ()</td>
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<td>Performance ()</td>
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<td>Overall/long term health ()</td>
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</table>
APPENDIX D

COMMUNICATION
FEMALE ATHLETES NEEDED

WHAT WILL BE DONE?
Survey
InBody 770 (Body Comp)
Heel Bone Densimeter
(Fracture Risk)

WHERE:
CTH 148

WHEN:
Monday: 8-12  
3-5  
Tuesday: 8-12  
5-7  
Thursday: 8-1 
Friday: 9-12 
Sunday: 1-3

Approved HUC #: 1438,22-110
APPENDIX E

HUMAN USE APPROVAL LETTER
Office of Research and Partnerships

MEMORANDUM

TO: Dr. Simone Camel and Elizabeth Doll (student researcher)
FROM: Dr. Walter Buboltz, Professor/Elva L. Smith Endowed Professor
        buboltz@latech.edu
SUBJECT: Human Use Committee - Review DECISION
DATE: August 26, 2022

In order to facilitate your project, an EXPEDITED REVIEW has been completed for your proposed study:

HUC No.: 1438, 22-110
TITLE: Nutrition-related factors impacting the bone health of female sports and performance collegiate athletes

HUC DECISION: EXEMPT FROM FULL REVIEW

According to the Code of Federal Regulations Title 45 Part 46, your research protocol is determined to be exempt from full review under the following exemption category(s):
It has been determined that your study meets the requirements for exemption 45 CFR §46.104(d) (2) (i):

(2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:

(i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects;

Additional Comments from HUC IRB Reviewer: Data are deidentified and participants are provided a unique identification number. The survey is administered through Qualtrics. Data are maintained on a password-protected device that is available only to researchers. Heel bone mineral density is measured non-invasively using ultrasound InBody 770 and GE Achilles EXPII. Participants place a bare foot on the machine for 2-3 minutes. Participants who are pregnant or have a pacemaker will not be measured. Participants may withdraw from the study at any time with no penalty.

Thank you for submitting your Human Use Proposal to Louisiana Tech’s Institutional Review Board.

P.O. Box 8597 | Ruston, LA 71272-0859 | O: 318.257.2871
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