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UTILIZING THE LEAF-QUESTIONNAIRE TO DETERMINE THE RISK OF LOW ENERGY AVAILABILITY IN COLLEGE FEMALE WRESTLERS

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BY

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ABSTRACT

“UTILIZING THE LEAF-QUESTIONNAIRE TO DETERMINE THE RISK OF LOW ENERGY AVAILABILITY IN COLLEGE FEMALE WRESTLERS”

By

Rafaela Rafajlovska

The challenge of maintaining a specific weight class alongside rigorous practices and competitions, within the college lifestyle of female wrestlers, can potentially induce unhealthy eating habits and overtraining. This can ultimately lead to Low Energy Availability (LEA). **Purpose:** The primary purpose of this study was to examine the number of National Collegiate Athletic Association Division II female college wrestlers at risk for LEA during in-season training. The secondary purpose was to explore additional characteristics that may be related to the “at risk” group. **Methods:** To examine the risk of LEA in Division II female wrestlers, an online survey utilizing the Low Energy Availability in Females Questionnaire (LEAF-Q) was administered. In addition to the LEAF-Q, supplementary questions were asked to help describe characteristics of the sample and to assess factors that may have also contributed to those at risk for LEA. **Results:** Twenty nine percent (n=20) of the total participants met the criteria for LEAF-Q and therefore were placed in the “at risk” group. The “at risk” group reported that 90% (n=18) had ≥ 3 years of wrestling experience, and 85% (n=17) were currently exercising outside the assigned practice and workouts. Additionally, 65% (n=13) indicated that they always concern themselves with overeating. **Conclusion**: LEAF-Q identified 29% (n=20) of the Division II female wrestlers at risk for LEA. The supplementary questions revealed that the “at risk” group exhibited excessive exercising alongside concerns regarding overeating.

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This thesis follows the format prescribed by the American Psychological Association (APA), Manual of Style, 7th edition.

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CHAPTER 1: INTRODUCTION

In sports and athletics, female athletes have made outstanding progress in reaching greatness and pushing the limits of physical performance. Unfortunately, there is a hidden barrier that often goes unnoticed: low energy availability (Logue et al., 2020). Low energy availability (LEA) is defined as a state in which the body lacks energy to cover all physiological processes necessary to sustain optimum health consistently. For female athletes hoping to succeed in their particular sports, being aware of LEA becomes crucial. The pressure for lean, aesthetic appearance, and performance perfectionism among athletes, places them at significant risk for adverse health problems. Female athletes who persistently consume fewer calories than their body requires might experience various severe effects from chronic LEA. Chronic LEA is the main cause of Relative Energy Deficiency in Sports (RED-s), and it occurs when there's an imbalance between energy intake and energy expenditure over an extended period. These effects of chronic LEA include but are not limited to reduced bone mineral density followed by an increased risk of stress fractures, hormonal imbalances followed by menstrual dysfunction, poor immunological function, muscle loss, and decreased strength resulting in decreased performance and impeded recovery, weariness, and diminished cognitive function (Gibbs et al., 2013; Logue et al., 2020; Melin et al., 2019; Mountjoy et al., 2023). LEA is reported in female athletes of all levels and ages but is frequently seen in weight-sensitive sports (endurance and aesthetic sports) (Jesus et al., 2021), and weight-class sports (Dadgostar et al., 2009; Redman & Loucks, 2005). However, based on our literature review, studies done on weight-class female athletes were very limited (Dadgostar et al., 2009; Gillbanks et al., 2022; Thomas et al., 2021).

Female wrestling is a fast-growing, fairly new NCAA collegiate sport. The pressure to stay inside a certain weight class while juggling demanding practices and competitions on top of a college lifestyle, may lead to unhealthy eating patterns and overtraining. Over time, these habits might result in LEA which can greatly impact female wrestlers' well-being and effectiveness. The student investigator identified only one study that reported on LEA in female wrestlers (Dadgostar et al., 2009), and three studies that reported on LEA and male wrestlers (Daneshvar et al., 2013; Sams & Geiselman, 2021, Zaekov et al., 2019), but to the best of our knowledge, no studies have been done on collegiate female wrestlers. Therefore, the primary purpose of this study was to examine the number of NCAA Division II female college wrestlers at risk for LEA during in-season training. The secondary purpose was to explore additional characteristics that may be related to the "at risk" group.

In order to examine the risk of LEA in Division II female wrestlers, an online survey utilizing the Low Energy Availability in Females Questionnaire (LEAF-Q) (Melin et al., 2014) was administered. The LEAF questionnaire includes questions on injuries, gastrointestinal health, and reproductive health. It was created as a screening tool to enable female athletes to self-report FAT (Melin et al., 2014; Witkoś et al., 2023). In addition to the LEAF-Q, supplementary questions were asked to help describe characteristics of the sample and to assess factors that may have also contributed to those at risk for LEA. It was anticipated that 20% of the athletes would be at risk for LEA. The results of this study were intended to elucidate whether further assessment of LEA with stronger methodology was required in this population.

CHAPTER 2: LITERATURE REVIEW

Introduction

Sufficient energy levels play a key role in the health and physical performance of the athlete. Low energy availability (LEA) occurs due to reduced energy intake (EI), increased energy expenditure (EE), or a combination of both (DeSouza et al., 2022). The Female Athlete Triad (FAT) and the Relative Energy Deficiency in Sports (RED-s) syndrome conceptualize the effects of prolonged LEA (DeSouza et al., 2022; Gibbs et al., 2013; Jagim et al., 2022). The FAT is a medical condition that includes three components: 1) LEA, 2) menstrual dysfunction, and 3) low bone mineral density. It describes how insufficient nutrition and prolonged physical activity create LEA that impacts the menstrual cycle through the dysfunction of hormones, such as cortisol, leptin, estrogen, progesterone, among others. The disruption of normal hormone secretion may lead to damaged bone health. The FAT model was the first to identify the detrimental health effects of LEA in active females (Charlton et al., 2022). Later, the International Olympic Committee extended the RED-s model, which is described as a medical condition of impaired physiological function, including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health derived from long term exposure of insufficient energy, or problematic LEA, in both males and females (Mountjoy et al., 2023). The enlarged model of RED-S was established to highlight that LEA is a problem for both male and female athletes that may adversely affect a wider number of bodily systems, and cause performance implications (Charlton et al., 2022, Kuikman & Burke, 2023; Jagim et al., 2022).

Assessment of LEA

One method to determine LEA in athletes attempts to measure energy availability (EA). Energy availability in athletes is determined by assessing EI minus exercise energy expenditure (EEE) relative to fat-free mass (FFM) (Jonvik et al., 2022; Jurov et al., 2021). Currently there is not a gold standard method to determine EI, however, the most common method used in research is a 24-hour to 7-day surveillance of food recording. On the other hand, monitoring EEE has been done mostly via heart rate monitors during vigorous or moderate intensity activities. In the low intensity activity, an accelerometer might be a better option (Jurov et al., 2021). There are other techniques to measure total EE, and some argue more accurate, such as direct calorimetry (metabolic chamber) or the indirect, Doubly Labeled Water technique (Pinheiro Volp et al., 2011). The drawbacks of these techniques include their high cost, the requirement for professionals, time-intensive nature, plus the assessment of large groups is financially impractical. Another method to estimate EEE is through recording exercise and activity logs and estimating the energy cost of these with metabolic equivalents (METs) for each activity. By converting the amount of time spent in physical activity to energy equivalents, this makes it possible to estimate EEE, however, it has its own limitations. Physical activity estimates are only as accurate as the data they contain, therefore a key determining element is how well a person can recall the amount and intensity of the physical activity they have done (Hills et al., 2014).

Another key element to assessing EA more accurately includes FFM estimate. Dual energy X-ray absorptiometry (DEXA) is considered a high-quality method as it yields low precision errors with trained personnel. However, when it comes to a larger population sample, it might be time consuming and costly. Another way to determine FFM is through bioelectrical impedance which might be more appropriate for an assessment of a larger population sample, but the downside of this method is the reliance on proper hydration of the participants (Jurov et al., 2021).

To help establish if a large group of athletes is at risk for LEA before employing these time and money costly methods, a survey may be a helpful method to use first. If a population is discovered to be at risk of LEA through survey outcomes, both dietary EI and EEE at a variety of timepoints throughout an athlete's season need to be measured using gold-standard evidence-based methods to determine true prevalence of LEA.

In order to screen for the risk of FAT in female athletes, Anna Melin and her colleagues (2014) developed the Low Energy Availability in Females Questionnaire (LEAF-Q). The LEAF-Q consists of three subgroups of questions examining gastrointestinal symptoms, injury frequency, and menstrual function and use of contraceptives. It was found that the LEAF-Q was able to accurately identify female athletes who were at risk for LEA. The study included 84 female athletes recruited from endurance sports and professional dancing (endurance and aesthetic athletes). All athletes completed the LEAF-Q and two different subgroups of the population were used to determine reliability, internal consistency, and validity. Reliability and internal consistency were assessed in a subgroup of 37 athletes by performing a test-retest. The test was validated through a verification of the self-reported symptoms by clinically assessing for LEA. The results showed that the LEAF-Q had a total validity of 73%, sensitivity of 77% and a specificity of 80% for identifying individuals at risk for FAT.

The LEAF-Q is a useful tool for identifying individuals who may be at risk for LEA. By using this questionnaire, healthcare providers can help address LEA and its negative health outcomes in females and perhaps prevent symptoms from developing into deleterious effects on body tissues and/or performance outcomes. The LEAF-Q may also be used by coaches, trainers, and other professionals to quickly identify at risk individuals for LEA and further, facilitate swift interventions and referrals to appropriate health professionals.

Implementation of LEAF-Q in College Female Wrestlers

Low energy availability can harm one's capacity to compete in sports, especially those that depend on strength and power that demand quick energy stored in one's body such as glucose and glycogen (Witkoś et al., 2022). In athletes with LEA, these stores are depleted. For female collegiate wrestlers, physical strength and power are crucial aspects of this sport, and any deterioration in these aspects could limit their ability to perform at the highest levels. Coaches and athletes may come up with more effective training and dietary plans if they are aware of the link between EA and performance in this demographic. Many female college wrestlers might not understand the dangers of having LEA or how to properly nourish their bodies for peak performance. The need for good nutrition and energy balance may be stressed via teaching and raised awareness through research on this topic. Using the LEAF-Q to assess the risk in female college wrestlers would be ideal for a number of reasons. It is a quick determinant of risk of LEA in a large group, it is cost-effective, and it enables the evaluation of distinct subgroups within the LEAF-Q, offering a sophisticated comprehension of several markers of poor EA within a subgroup (GI, MD, and injuries). Assessing these areas might be out of great importance to this population due to the nature of the sport.

It is imperative to immediately tackle the risk of LEA since, if uncontrolled, it can result in chronic health consequences described in RED-s and FAT. Therefore, protecting the health and physical abilities of female wrestlers requires early identification of those at risk of LEA. Detecting athletes in a large sample who may be at risk for LEA and determining whether additional studies may be necessary to diagnose LEA may be more efficient by using tools like the LEAF-Q.

Consequences of LEA

Menstrual dysfunction

Low energy availability creates a reallocation of energy away from compartments that are not absolutely necessary, including reproduction, growth, and development, prioritizing the most crucial survival compartments, such as movement, cellular maintenance, and thermoregulation (De Souza et al., 2019). A series of metabolic and energetic adaptations, including the reduction of resting energy consumption, occur when available energy is redirected away from growth and reproduction in order to save fuel (De Souza et al., 2019). Energy availability of <30 kcal/kg/ FFM per day over more than five days has been shown to negatively impact the endocrine system (Jagim et al., 2022). For example, the hormone leptin, known to regulate reproductive functions through stimulation of the Gonadotropin releasing hormone (GnRH), is directly proportional to a person's stored fat energy (Charlton et al., 2022). It has been shown that athletes with LEA and lower fat mass have lower leptin levels (Charlton et al., 2022; Melin et al., 2019). Lower levels of leptin also suppress the pulsatile activity of the GnRH that in turn causes low secretion of Luteinizing Hormone (LH) and Follicle-Stimulating Hormone (FSH). These hormones act on the ovaries and the production of sex steroid hormones such as estrogen and progesterone. The suppression of estrogen and progesterone over time may lead to MD (Charlton et al., 2022; Gibbs et al., 2014; Jagim et al., 2022).

Menstrual dysfunction refers to a wide range of irregularities in the menstrual cycle. The persistent lack of menses (3 menstrual cycles or fewer within a 12-month timeframe) is referred to as amenorrhea, and a length of a menstrual cycle greater than 35 days, or four to nine menstrual cycles in one year, refers to oligomenorrhea (Gibbs et al., 2013, Rauh et al., 2010). Disordered and inconsistent LH release suppresses ovarian follicular growth, ovulation, and luteal function, resulting in consistently low levels of estrogen and progesterone, diminishing endometrial proliferation leading to an absence of menses (De Souza et al., 2017, Redman & Loucks, 2005). When the body is persistently experiencing LEA due to inadequate EI or excessive exercising, causing dysfunction of the hormones associated with menstrual cycle, functional hypothalamic amenorrhea might occur. Functional hypothalamic amenorrhea (FHA) is a type of chronic anovulation that is frequently linked to stress, weight loss, extreme exercise, or a combination of these factors. The word "functional" suggests that ovulatory ovarian function will be restored by the correction or amelioration of the behavioral aspects that cause it. FHA is not caused by any identifiable organic causes, and it can be classified as primary: no menarche beyond age 15, or secondary: absence of three or more consecutive menstrual cycles (Gordon et al., 2017). Therefore, athletic amenorrhea is an FHA that is observed in female athletes who display LEA (Elliott-Sale et al., 2018). Reproductive health may be restored by improving EA through increasing EI or expending less energy with or without consistent menses (Williams et al., 2017).

Previous studies on exercising women have shown that excessive exercise in combination with caloric restriction can lead to MD. A study done by Day and colleagues (2015) on college female runners (n=25, age=19.5 ± 1.8) indicated that 92% (n=23) of the participants had subclinical LEA with a <45 kcals/kg of FFM/day, while 52% (n=13) had clinical LEA with <30 kcals/kg of FFM/day. Energy intake was assessed during a 3-day food log, and EE was assessed by accelerometers and a 3-day physical activity log. Menstrual health was evaluated using pre-formulated questionnaires that had been used in related research. Forty percent of the female athletes were amenorrhoic, and 36% had irregular menstrual cycles, with their periods starting more than 10 days later than expected (Day et al., 2015).

Melin and colleagues (2014) examined the prevalence of FHA, EA and BMD in 45 endurance athletes (age=26.2 ± 5.5 years, body mass index (BMI)=20.6 ± 2.0 kg/m^2, body fat 20.0 ± 3.0%). Energy availability was determined through an assessment of EI and EEE. Energy intake was assessed using daily food logs, while EEE was assessed wearing heart rate monitors, based on individual prediction equations from measured heart rate. Eight participants (20%) had minimal EA, 42.5% (n=17) had decreased EA, and 37.5% (n=15) subjects had optimal current EA. Menstrual function was determined by an experienced gynecologist through a trans-vaginal ultrasound examination. Sixty percent (n=24) were diagnosed with menstrual dysfunction; oligomenorrhea (n=6), primary FHA (n=4), and secondary FHA (n = 14). Sixty-seven percent of participants with MD had LEA (Melin et al., 2014). Similarly, in two additional studies on self-reported MD in high school runners, there was a higher prevalence of MD in endurance runners (56%), compared to sprinters (23%) and jumpers (24%) (Ikedo et al., 2016; Sygo et al., 2018). This evidence suggests endurance runners may be more prone to LEA, which in turn puts them at risk for MD.

This evidence supports that LEA forces the human to prioritize its available energy away from reproductive function and towards more necessary tissue for sustaining its own life. Reproductive health may be restored by increasing EA over time by increasing EI or decreasing EE, or a combination of both.

Low Bone Mineral Density and Stress Fractures

Energy availability plays a crucial role in bone health. There are multiple factors that affect bone health including genetics, hormones, vitamin D, and calcium, which can all be impacted by LEA. When the body is experiencing LEA, it prioritizes crucial organ functions over non-essential processes like bone remodeling. LEA impacts bone quality through endocrine responses that favor bone resorption over formation. Estrogen, progesterone and Insulin-like Growth Factor (IGF-1) stimulate the development and production of new bone tissue by having anabolic effects on bone tissue. These hormones may be reduced when energy is limited, which might result in less bone production and possibly more bone resorption. In addition to the suppressed secretion of estrogen and progesterone that affect the menstrual cycle, LEA may decrease the secretion of IGF-1. Low concentrations of IGF-1 suppresses osteoblast activity to support bone formation (Barrack et al., 2014). This leads to imbalance in bone turnover making it more difficult to repair damaged bones or lay down newly formed bone (Barrack et al., 2014). Estrogen stimulates the activity of osteoblasts, the cells that make new bone, which is essential for maintaining bone density. It aids in controlling the ratio of bone resorption, or the decomposition of bone tissue, to bone synthesis. It accomplishes its beneficial effects on bones by vitamin D-related intestinal calcium absorption and suppression of bone resorption (Seifert-Klauss & Prior, 2010). On the other side, progesterone plays an active role as an important partner hormone in women's bone health through bone formation pathways (Seifert-Klauss & Prior, 2010).

LEA is also associated with lower or inconsistent dietary intakes of bone health nutrients, especially when dietary energy intake is restricted or limited. In fact, it is commonly known that calcium and vitamin D increase BMD and lower the risk of fracture. Vitamin D plays a crucial role in the mineralization of skeletal bone and the control of calcium. In its active form, 1,25(OH)D3, vitamin D increases serum calcium levels and stimulates intestinal calcium absorption through its endocrine activity. Vitamin D levels of below 30 ng/mL causes an enhanced parathyroid hormone level resulting in enhanced osteoclastic (degenerating) activity in bone leading to low BMD (Goolsby & Boniquit, 2016). Calcium provides strength and structure to the skeleton. Accumulation of calcium during the first decades in life plays a crucial role in peak BMD. An essential physiological mechanism for preserving calcium homeostasis and bone mineralization is intestinal calcium absorption. Calcium absorption requires appropriate energy for active transport out of the enterocytes of the small intestine. Less calcium entering the blood elicits the bone to release its calcium stores to support appropriate blood calcium levels (Diaz de Barboza et al., 2015). LEA may also be associated with a low intake of bone health nutrients such as vitamin D and calcium. Athletes who are at risk for LEA may be more susceptible to stress fractures and muscle strains due to low BMD. Bone mineral density reaches its peak in early adulthood and starts to progressively decrease around the age of 30 in both men and women. Because estrogen is essential for maintaining bone density, it tends to drop in women after menopause, which speeds up the loss of bone density. Therefore, exercise plays a key role in bone forming during adolescence and childhood (Goolsby & Boniquit, 2016). The idea that physical bone deformation directly encourages bone growth is fundamental in the development and adaptability of bones. The deformation of bone can happen through the stress of variable, dynamic, and progressive bone loading obtained through exercise (Goolsby & Boniquit, 2016). However, when an individual is persistently experiencing LEA, low BMD can occur. In these instances, the stress acquired from the loading through exercise might lead to stress fractures and bone injuries.

Research has shown a higher rate of stress fractures in female military recruits (9.2%) and athletes (9.7%), compared to male military recruits (3%) and athletes (6.5%) (Wentz et al., 2011). The cause of higher rates of stress fractures in females compared to males is unknown.

Even though it is most likely influenced by different factors, the latest theories include nutrition's relationship with stress fracture susceptibility (Prather et al., 2016). Athletes with stress fractures have been found to restrict calorie intake, consume low-calorie diet products, avoid food high in fat, have lower percentages of ideal body weight, or have self-reported an eating disorder (Prather et al., 2016). The risk of developing a stress fracture in female athletes who have LEA is three times greater than in athletes who do not exhibit LEA (Barrack et al., 2014; Edama et al., 2021; McCormack et al., 2019).

Another study was done on bone stress injury and the FAT components in female athletes (n= 259, age, 18.1± 0.3 years) (Barrack et al., 2014). In one year, 10.8% of the athletes (n=28) developed stress fractures, 64.3% 18 (n=18) were endurance athletes, 32.1% (n=9) were track and field, and 3.6% (n=1) was a dancer. Eighty nine percent (n=25) of these athletes who developed bone stress fractures exercised >12h/wk, 32% (n=9) of the athletes that developed bone stress injuries exhibited dietary restraints, and 36% (n=10) had oligomenorrhea or amenorrhea (Barrack et al., 2014). Another study compared BMD in a group of female runners (n=27) who experienced at least one stress fracture, to a group of female runners (n=32) who had not experienced a stress fracture, in order to determine possible predictors of stress fractures (Wentz et al., 2012). Surprisingly, there was no difference in dietary intake, menstrual status, or bone measurements between the two groups (Wentz et al., 2012). However, current calcium intake, poor BMD, MD, hard training surface, and lengthy history of training duration were the most significant predictors of stress fractures. Servings of milk throughout middle school years ($p = 0.010$) were favorably associated with femur BMD sites, while current coffee intake had inverse association to femur BMD ($p = 0.010$). This supports the claim that calcium intake during adolescence has a significant influence on bone development (Wentz et al., 2012).

Collectively, these findings support the notion that low BMD may be affected by the presence of LEA, which may be attributable to low EI with excessive and prolonged exercise.

Decreased Performance

Besides bone injuries and menstrual disturbances, LEA can also lead to decreased muscle mass and strength, which can negatively impact athletic performance. With LEA, the body adjusts by saving energy and giving priority to energize vital biological activities when it does not receive enough (De Souza et al., 2014). Due to this adaptation, performance may suffer (De Souza et al., 2014). According to Melin et al, (2019) LEA can indirectly or directly impact athletic performance through the reduction of glucose levels, muscle glycogen levels, mood disturbances, decreased anabolic and androgenic hormones, and injuries.

Blood glucose and muscle glycogen are the primary sources of energy when performing physical activity (Murray & Rosenbloom, 2018). When a person does not consume enough carbohydrate rich food or engages in prolonged exercise repeatedly (chronic exercise), glycogen stores deplete, causing a decrease in muscular strength and endurance. Furthermore, low EI in addition to depleted glycogen stores can lead to a breakdown of muscle tissue and decrease the daily integrated myofibrillar protein synthesis rate in order to create ATP for energy production, which may impact performance especially if LEA is chronic (Oxfeldt et al., 2023).

A study done by Kettunen and his colleague (2020) on female cross-country skiers (n=19, age=16.7 ± 0.7) during a 5-day training camp, examined their energy requirements and changes in performance due to insufficient EI. Energy intake was assessed through a 48-hour food log, while EEE was assessed through calculating METs from training, and activity logs. Food and exercise logs were recorded during the second and third day of the training camp. Additionally, athletes utilized the LEAF-Q for additional measures of risk of LEA. Mean EA was 40.3 ± 17.3

kcal/FFM/day, but 37% (n=7) of the athletes had LEA. The LEAF-Q identified 26% (n=5) of the athletes at risk for LEA. Pre and post-blood lactate, heart rate, rating of perceived exertion, submaximal treadmill running test, jump height from countermovement jump, and power from a reactive jump test was assessed. Pre and post-fasting levels of hemoglobin, leptin, triiodothyronine (T3), insulin, insulin-like growth factor 1 (IGF-1), and glucose were also measured and out of 19 participants, 37% had LEA, and 53% had suboptimal carbohydrate intake. Some improvements were noticed, such as a decrease in heart rate, however, this study also resulted in a decrease in countermovement jump and a small non-significant decrease in reactive jump (Kettunen et al., 2020).

Additionally, a study with 30 competitive female athletes exercising at least 5 days a week compared neuromuscular performance in eumenorrheic (EUM) (n= 16, age= 27.6 ± 5.6) and secondary functional hypothalamic amenorrhoeic (SFHA) female athletes (n= 14, age= 26.1 ± 5.6). Energy availability was assessed through EI and EEE logs. To determine neuromuscular performance, the participants performed VO2max test, reaction time test, and knee muscular strength and endurance test. Sex hormones and metabolic characteristics were determined through a series of clinical testing such as DXA scan and blood work. This study showed that SFHA female athletes exhibited poorer neuromuscular performance compared to EUM female athletes. There was a significant difference (p=0.043) in the sum of knee flexion and extension at 60 degrees between groups, and total work (30 repetitions) at 180 degree (p=0.007) (Tornberg et al., 2017). This suggests that when the body is deprived of energy to support high quality training and recovery, neuromuscular performance declines.

The evidence presented in these studies demonstrates that LEA impacts athlete's health and performance LEA contributes to early fatigue, poor neuromuscular functioning, weakened muscles, and decreased endurance, all of which will impact training effectiveness negatively, adversely affecting health and sports performance outcomes.

Prevalence of LEA in Endurance Sports

Due to high EEE and the need for a lean appearance, or lower body weight for improved performance, there is an abundance of evidence on endurance athletes with LEA (Fahrenholtz et al., 2022). Although soccer is a team sport including various running intensities, endurance is of great importance for the overall performance of these athletes. A combination of anaerobic and aerobic activities in a game lasting at least 90 minutes, might put the athlete at risk of LEA due to increased EE. Therefore, studies done on soccer athletes will also be included in this section. Eight studies that have examined the prevalence of LEA in endurance athletes from 2014 to 2022 are shared in this section.

A study done by Reed and colleagues (2014) examined the nutritional practices of Division 1 female soccer players (n=19, age=19 ± 1). They assessed the EI, EE, and LEA during the pre-, mid-, and postseason. EI was measured through a three-day diet log, and EE was measured through a polar FT4 heart rate monitor and purposeful exercise was recorded in logs during team sessions and non-team sessions. They observed inadequate carbohydrate intake and low energy intake during their meals. They concluded that 26% (n=5) had LEA in the preseason, 33% (n=5) during the in-season, and 16% (2) had LEA during the postseason (Reed et al., 2014).

Similarly, Magee and colleagues (2020) examined the prevalence of LEA in Division III college female soccer players (n=18) by using the LEAF-Q and having the athletes log their food intake in an electronic commercially available nutrition analysis program. Energy Expenditure was assessed using wearable monitoring devices (Polar TeamPro). They examined their general and sports nutrition knowledge via the Abridged Sports Nutrition Knowledge Questionnaire (ANSKQ). The LEAF-Q classified 56.3% (n=10) of the athletes at risk for LEA, however, the food log identified 67% (n=12) as at risk for LEA (Magee et al., 2020). Although the LEAF-Q underestimated the total number of athletes at risk of LEA, college female soccer players exhibited high prevalence of LEA.

In order to assess the prevalence of FAT in a group of young female soccer players (n=34), Łuszczki and her colleagues (2021) implemented the LEAF-Q. Bone mineral density, resting EE, as well as body composition was assessed using the DEXA. LEAF-Q identified 64.7% (n=22) at risk for FAT. Energy intake was determined by a 24-day food log, and there was no statistical difference for EI between groups determined by the LEAF-Q. Seventy-five percent (n=26) of the soccer players did not meet the standard for food recommendation, however, the Goldberg cut-off method revealed that 67.6% of girls were underreporting their EI.

Endurance sport athletes have been the first cohort to be studied for LEA due to the nature of the sport. Because endurance sports are physically taxing, it is possible for an athlete to reach a state where their EE outweighs their EI, resulting in LEA. Melin and her colleagues (2014) examined the potential effects of LEA as well as the prevalence of the FAT in female endurance athletes (n=40; age= 26.2 ± 5.5 years). The methods included gynecological examination, evaluation of bone health, indirect respiratory calorimetry, seven-day food and activity records to gauge EA, examination for eating disorders (ED) and blood work. Twenty percent (n=8) exhibited LEA, and 43% (n=17) had reduced EA (<45 kcal/kg/FFM). Athletes with LEA reported much lower EI compared to the athletes without LEA. Additionally, they reported higher EEE (1222 kcal/day) as well as total EE (3266 kcal/day) compared to the athletes without LEA (711 kcal/day; 2865 kcal/day). Additionally, 45% (n= 18) had impaired bone health from which three were diagnosed with osteoporosis, and 38% (n=15) had low BMD. Sixty percent (n=24) were diagnosed with MD. Twenty-five percent (n=6) of the athletes diagnosed with MD presented with oligomenorrhea, 17% (n=4) had primary FHA, and 58% (n=14) had secondary FHA (Melin et al., 2014).

Heikura and her colleagues (2018) assessed the EA of elite distance runners (n=59, 35F, 24M). Energy availability was assessed through a 7-day EI (food logs) and EEE (training logs), BMD was assessed through DEXA, blood samples for hormonal testing, and LEAF-Q was used as an additional measurement of the LEA components. Thirty-one percent (n=11) of the females had LEA (24+/- 6 kcal/kg/FFM/day), while 69% (n=24) had moderate EA (38+/-8 kcal/kg/FFM/day). Thirty-seven percent (n=13) of the females had amenorrhea and 17% (n=6) had low BMD. Additionally, female athletes who were amenorrhoeic had higher scores on the LEAF-Q (12 +/- 4.8) compared to the female athletes that did not have MD (8.3+/-3.7). Amenorrhoeic athletes reported running more (100+/- 28 km/week) compared to non-amenorrhoeic athletes (90+/-30 km/week) (Heikura et al., 2018).

Fahrenholdz et al (2022) implemented an online survey comprising LEAF-Q, Exercise Addiction Inventory (EAI), Eating Disorder Examination Questionnaire (EDE-Q), and food intolerance questions in female endurance athletes (n=202). According to the LEAF-Q, 65% (n=131) were at risk for LEA. Twenty-six and a half percent (n=35) of the LEA had disordered eating, compared to the female athlete who did now have LEA 11.4% (n=15) (p=0.013). However, there was a non-significant difference (p=0.293) between athletes at risk for LEA who also had exercise addiction 71.4%, compared to the athletes who were not at risk for LEA 59.4%. These results might indicate that EI is the leading cause of LEA in this group of athletes.

Similarly, Day and her colleagues (2015) assessed the EI of college female runners (n=25) (distance runners 45.2%, sprinters 54.8%) pre-implementation of nutrition education as well as post. Energy intake was assessed during a 3-day food log, and EE was assessed by accelerometers and a 3-day physical activity log. Menstrual health was assessed by pre-developed questions previously utilized in similar studies. Ninety-two percent (n=23) had lower than optimal EA (<45 kcal/kg/FFM/day), from which 52% (n=13) had a LEA (<30 kcal/kg/FFM/day). Prior to the intervention based on the participant's 3-day diet recall, the EI was 2211 ± 582 kcal. Following nutrition instruction, the 3-day diet recall showed an average EI of 2208 ± 598 kcal, showing no significant difference between pre and post intervention (p=0.979). This study showed that nutritional education might not be the most beneficial intervention to prevent the risk of LEA.

On the other hand, McCormick and his colleagues (2019) attempt to assess the BMD of male and female cross-country runners (n=60; 27M; 33F) and compare it to a non-athletic population of similar age (n=47; 23M; 24F). Additionally, they screened for EA, EEE and disordered eating patterns. Bone mineral density as well as body composition was assessed using DEXA scan, EA was assessed through the Food Frequency Questionnaire (FFQ), EEE was determined by exercise and physical activity logs, while disordered eating patterns was assessed through the Eating Disorder Examination Questionnaire (EDEQ). When comparing the EA of the female runners (36.9 ± 21.3kcal/kg/FFM/day) to the female control group (39.7 ± 21.3kcal/FFM/day), both groups fell short from the optimal EA (45 kcal/kg/FFM/day), with the female runners exhibiting lower EA than controls. Surprisingly, female runners had a 5.2% greater total BMD than female controls (p<0.05). This may be explained by the possibility that weight-bearing exercise speeds up BMD accretion at the hip and throughout the body (McCormack at el., 2019).

Prevalence of LEA in Mixed Cohort Athletes

It is essential to evaluate LEA risk and prevalence in a variety of athletic endeavors, labeled mixed cohorts, in order to maximize the health, performance, and general well-being of all athletes. This section includes 5 studies that have examined the prevalence or risk of LEA in a variety of athletes.

A study by Meng et al (2020) assessed risk for LEA and eating disorders in female aesthetic sport athletes (n=166) grouping them by elite status (n=52, age=20 ± 3), and recreational status (n=114; age=20 ± 2). The elite group consisted of athletes from 3 different sports (trampolining, rhythmic gymnastics, aerobics), while the recreational group participated in 5 different sports (rhythmic gymnastics, aerobics, dance sport, cheerleading and dance). Both groups used two questionnaires to assess the risk of LEA and eating disorders: the LEAF-Q was used to assess LEA and the Eating Disorder Inventory-3 Referral Form was used to assess the risk for an eating disorder. They found that 41.6% (n=69) of the athletes were at risk for LEA and 57.2% (n=95) were at risk of an eating disorder. The risk of LEA was significantly higher (p=0.012) in the elite athletes (55.8%) compared to the recreational athletes (35.1%), as well as the risk of eating disorders in elite athletes (59.1%) compared to recreational athletes (59.6%). Additionally, 67.3% of the elite athletes (n=35) experienced MD, compared to 43.9% (n=50) of the recreational athletes (Meng et al., 2020).

Rogers and her colleagues (2021) utilized the LEAF-Q to detect markers of LEA in a variety of female athletes (n=75) from 8 different sports: athletics (n = 1), basketball (n = 4), boxing (n = 2), netball (junior n =22), rowing (n = 7), triathlon (n = 13), water polo (n = 17), and weightlifting (n = 9). The study implemented the LEAF-Q to determine LEA risk, and used DEXA scan to determine BMD and body composition. Disordered eating was assessed through the SCOFF Questionnaire. Fifty-five percent (n=41) of the participants were at risk for LEA. According to the LEAF-Q, participants were divided into "at risk" and "low risk". The "at risk" group presented higher scores on the SCOFF Questionnaire Each subcategory of LEAF-Q was compared to objective measured (blood, hormonal statues, MD). The LEAF-Q showed not be used to classify athletes "at risk" for LEA given the low value of predictability of each LEAF-Q subcategory (Gastrointestinal function 6.9%; Injuries 7%; Menstrual Disfunction 30.8%). However, it can be a useful tool to determine athletes at low risk for LEA.

Similarly, a study done on energy deficiency in a National Kayaking Team (n=33) was conducted using the LEAF-Q during the pre-competition period (3 months prior to the first competition). Additionally, they measured body composition using a medical Body Composition Analyzer (Seca device mBCA 515). The LEAF-Q determined that 3% (n=1) scored ≥8 on the LEAF-Q meeting the criteria for each subcategory of the questionnaire. According to the scores obtained from the Menstrual Function and Used of Contraceptives subcategory of the LEAF-Q, 15% (n=5) of the athletes were at risk for MD. Additionally, the athletes who were at risk for MD also had a lower non-significant Basal Metabolic Index (p=0.340), and Body Fat Percentage (p= 0.175) compared to the athletes who were not at risk. This study indicated that the LEAF-Q is a useful screening tool for LEA (Witkoś et al., 2022).

One method that has been reported to be frequently used to achieve an athlete's particular weight or performance goal is by restraining food intake. To support the idea that dietary restrain (DR) might lead to LEA, a study was done on exercising women with high and normal DR. Participants (n= 86) performed ≥2 h/wk of purposeful exercise, and reached a peak oxygen uptake (VO2peak) ≥40 mL·kg−1·min−1. The effect of DR on EA categorized the participants into 2 groups: high DR (n=30), and normal DR (n=56) using the Three-Factor Eating Questionnaire responses. Energy intake was assessed during a 3-day food log, while EEE was determine from 7-dayrecorded exercise via heart rate monitors (Polar S610 or RS400). Body composition and BMD was assessed via DEXA scan, and MD was determined through a menstrual cycle screening. Energy availability was lower in the group with high DR (35.0 ±12.9 kcal/kg/FFM) compared to the group with normal DR (42.0 ± 12.9 kcal/kg/LBM) and the group with higher DR showed a higher frequency of menstrual dysfunction (75%) than the group with normal DR (51.1%) This study showed that DR exercising women are at risk for LEA due to restricting EI (Gibbs et al., 2013).

Another study was done on LEA in female college athlete and performing artists (n=121) participating in 6 different sports: equestrian (n =28), soccer (n =20), beach volleyball (n =18), softball (n=17), volleyball (n=12), and ballet (n =26). Energy intake was assessed using daily food logs for 7 days, and EE was assessed via accelerometer (SenseWear Armband) worn 23h for 7 days. Additionally, eating disorder risk was assessed via Eating Disorder Inventory-3 (EDI-3). Eighty-one percent (n=98) of the athletes exhibited LEA, with ballet, 20.7% (n= 25) and equestrian 19.0% (n=23) reporting the highest prevalence of LEA. Additionally, 76% (n=92) of the total participants were at risk for eating disorders according to the EDI-3 questionnaire (Torres-McGehee et al., 2020).

Prevalence of LEA in Weight-class Sport Athletes

Weight-class sports place an emphasis on maintaining or achieving a particular weight category while also requiring fuel to meet the demands of training and competition. When looking at LEA and its consequences in weight-class sports, only four studies were identified.

In a study aimed to investigate the physical and psychosocial impact of RED-S from the personal perspective of lightweight rowers, investigators placed an advertisement on Twitter about their research to recruit elite adult lightweight rowers. Eight of the 12 participants were female and age ranged 19-24y. This study had 100% prevalence of LEA due to deduction by data reported in the article that was collected by phone interview by researchers. All athletes described restricting calorie intake to lose weight for lightweight rowing competitions and their weight loss tactics included strict dieting, rituals/routines and fasting in between training. All athletes also reported an increased energy expenditure during weight loss prior to weighing in, involving additional high-intensity cardiovascular exercise on top of 2–3 training sessions each day. The rowers reported that their increased energy expenditure was not matched with their calorie intake. This LEA was regarded as desirable and necessary to compete in lightweight rowing from the athletes' perspectives. Although participation was low and a limited sample were attracted to the add on Twitter, this research suggests this weight-class sport is not without LEA risk (Gillbanks et al., 2022).

Scheffer and her colleagues (2023) assess the risk of LEA, as well as BMD and eating disorder in elite female rowers (n=25). The second aim of the study was to determine if LEAF-Q and brief eating disorder in athletes-questionnaire (BEDA-Q) can differentiate athletes at LEA risk. DEXA was used to measure FFM (kg) for the calculation of EA, as well as BMD. Energy availability was assessed through EI determined via food logs, and EE was determined via heart rate monitors. Sixty-five percent (n=16) of the athletes had LEA. BEDA-Q indicated 56% (n=14) at risk for LEA, while the LEAF-Q identified 48% (n=12) at risk for LEA. The BMD of the female rowers was above their respective age-group population despite the prevalence of LEA ($z=1.6 \pm 0.6$) , and there was no association between their EA and Z-score. This study suggests that utilizing the BEDA-Q might be more appropriate for a group of elite female rowers when assessing risk of LEA.

Thomas and her colleagues (2021) investigated the relationship between weight cutting habits and the risk of developing the FAT in female combat sport athletes (n=102). The athletes competed in boxing (n=30), kickboxing (n=12), and mixed martial arts (n=60). In order to determine the risk of FAT, LEAF-Q was administered, while in order to assess weight cutting practices the Rapid Weight Loss Questionnaire (RWLQ) was administered. Thirty-eight percent (n=39) of the athletes were at risk for LEA based on the LEAF-Q. There was a statistically significant correlation between LEAF-Q and RWLQ scores (p=0.013) suggesting that frequent weight-cutting practices may promote FAT/RED-s.

In summary, to determine how many athletes may have LEA or be at risk of LEA, researchers have explored a variety of different athletic populations using a variety of different methods to assess EA. Some of this research has attempted to measure energy, both intake and expenditure, but not without error, and some research has attempted to assess athletes' risk of LEA using a questionnaire. The prevalence of LEA or the risk of LEA in different athletic populations shows that LEA is an issue for athletes of a variety of sports and levels of competition.

Lack of Research on LEA in Female Wrestlers

As college level female wrestling is an emerging weight-sensitive sport, research in college female wrestlers is lacking. Wrestling athletes often face unique challenges when it comes to maintaining their weight and managing their nutrition (Pettersson et al., 2013). This sport relies on body weight to determine competition levels and athletes are required to make weight before competitions within a specific weight range (Castor-Praga et al., 2021; Pettersson et al., 2013). Coaches and spectators have elevated the pressure to perform and look a specific way, which in turn, places female athletes at risk for restrictive eating patterns and additional training and conditioning on their own (Magee et al., 2020). High exercise volume and intensity can also contribute to LEA, particularly if athletes are not consuming enough calories to support their energy needs (Barrack et al., 2014). Therefore, understanding the signs and symptoms of LEA and accordingly assigning an appropriate exercise volume and intensity is necessary for the training staff to recognize. As a result, many female wrestlers may adopt certain dietary strategies to achieve their desired weight for competition. Some research suggests that prior to and during the competitive season, a change in eating habits or food consumption is common practice (Daneshvar et al., 2013). Weight management techniques used by wrestlers have been shown to have detrimental impacts on their immunological function, their nutritional condition, and their hormonal state (Daneshvar et al., 2013).

Only one study was identified in a literature search for female wrestlers with LEA. This study examined menstrual function and the consequences of LEA in a group of various professional female athletes that included wrestlers (Dadgostar et al., 2009). Athletes were divided into 5 sports categories: 1. Sports in which performance is subjectively scored 2. Endurance sports 3. Body contour sports 4. Weight-class sports 5. Sports emphasizing prepubertal physical build. Athletes with amenorrhea or oligomenorrhea had a mean age of 20.1 ± 4.4, while the eumenorrhea group had a mean age of 21.1 ± 4.5, and out of 788 female athletes, 71 (9%) had menstrual dysfunction Twenty-four athletes who reported amenorrhea/oligomenorrhea belonged to the weight-class sports category (Dadgostar et al., 2009). The prevalence of amenorrhea/oligomenorrhea in the weight-class category may indicate a prevalence of LEA, as inadequate energy intake can disrupt the normal hormonal balance in the body affecting the hormones associated with the menstrual cycle. Although it is difficult to discern the specific menstrual disturbances in female wrestlers as the data was not provided for these specific athletes, this study does indicate that the sports in the weight-class category need to be further evaluated. Little is currently known about the risk of LEA in female wrestlers.

There is a clear knowledge gap in our understanding of the significance and consequences of LEA in weight-class athletes, considering the majority of research in the field has mostly focused on endurance athletes. While endurance athletes have received a lot of attention, there have been surprisingly few studies on weight-class athletes, and only one study that included female wrestlers (Table 1). Furthermore, in the study that did include female wrestlers, EA was not directly measured, LEA risk was not assessed and the wrestlers' data were not separated from the weight-class athlete group results. Therefore, the prevalence and risk of LEA in female wrestlers is currently unknown.

Table 1: Summary of LEA studies with female athletes published between 2014-2023

Study	**Population**	**Duration**	**Component**	**Outcome n (%)**
Endurance Sports				
Fahrenholds et al (2020)	Female endurance athletes (n=202)	N/A	LEA (LEAF-Q)	131 (65%)
Heikura et al., (2018)	Endurance runners (n=59, 35F)	7 Days	LEA (Logs)	11 (31%)
Kettunen et al., (2020)	Female Cross-country skiers (37)	N/A	LEA(LEAF-Q)	7 (37%)
Magee et al., (2020)	Division III female soccer (n=18)	3 Days	LEA (LEAF-Q) LEA (Log)	10 (56%) 12 (67%)
Melin et al., (20140	Female Endurance athletes (n=40)	1 Day	LEA (Log) MD	8 (20%)

				24 (53%)
McCormick et al., (2021)	Cross country runners (n=60; 33F)	3 Days	LEA (Food Frequency Questionnaire)	M=36.9 ± 21.3
Reed et al., (2014)	Division I female soccer (n=19)	1 Year	LEA Pre-season (log) LEA In-season (log) LEA post-season (log)	5 (23%) 6 (33%) 2 (16%)
Łuszczki et al., (2021)	Female soccer players (n=34)	N/A	LEA (LEAF-Q)	22 (64.7%)
Mixed Cohort				
Gibbs et al., (2013)	Exercising women (n=86)	N/A	Dietary restraint (DR)	30 (35%)
Meng et al., (2020)	Elite and recreational female athletes (166)	N/A	LEA (LEAF-Q)	69 (41.6%)
Rogers et al., (2021)	Female athletes (n=75)	N/A	LEA (LEAF-Q)	41 (55%)
Torres-McGehee et al., (2020)	Female college athletes (n=121)	7days	LEA (log) Disordered eating	98 (81%) 92 (76%)
Witkos et al., (2022)	Kayaking athletes (n=33)	N/A	LEA (LEAF-Q) MD (LEAF-Q)	1 (3.3%) 5 (15%)
Weight-class Sports				
Gillbanks et al., (2022)	Lightweight Rowers (n=12, f=8, m=4)	N/A	LEA (Phone interview)	12 (100%)
Scheffer et al., (2023)	Elite female rowers (n=25)	3 Days	LEA (logs) LEA (LEAF-Q) LEA (BEDA-Q)	16(65%) 12 (48%) 14(56%)
Thomas et al., (2021)	Female combat sports (n=121)	1 Day	LEA(LEAF-Q)	39 (38%)

CHAPTER 3: METHODS

Introduction

Survey Overview

To achieve the proposed objectives (to examine the number of Division II female college wrestlers at risk for LEA during in-season training and to explore additional characteristics that may have relevance to those at risk), a web-based survey was employed through Qualtrics; a software platform used to develop the survey questions (*Qualtrics XM //Seattle, WA. 2002).*

The survey included the LEAF-Q, which contains 25 questions used to assess females at risk for LEA. Specifically, it is designed to assess symptoms of insufficient EI in female athletes (Melin et al., 2014). Additionally, the survey included 20 supplementary questions that aided in describing the female wrestler cohort “at risk” for LEA. These questions included demographic, behavioral, and lifestyle characteristics. This tool has been validated using female endurance athletes (n=45; age=26.6 ±5.4 years) by comparing its results to already-established measures of the above-mentioned LEA factors. The questionnaire was considered valid with 78% sensitivity and 90% specificity (Melin et al., 2014). After the creation and validation of the LEAF-Q in 2014, multiple studies have used this tool to assess of the risk of LEA in a variety of female athletes (Melin et al., 2014; Łuszczki et al., 2021; Witkoś et al., 2023). Therefore, when screening female athletes at risk for LEA to determine quick identification and quick intervention, the LEAF-Q has been shown to be an effective tool.

Participants

The student investigator identified a total of 23 NCAA Division II female wrestling teams. Participants of these teams were recruited via email sent to NCAA Division II University athletic directors, coaching and athletic training staff, athletes, and university social media platforms. The emails were achieved through a search of online publicly available sources such as university team websites; social media; online directories. Additionally, the research plan was shared through personal networking, such as local Division II colleges that the student researcher had already established contacts with. The email invitation to participate in this research informed all NCAA Division II female wrestlers of the study details, their risks and benefits if they chose to participate, as well as included the student researcher's contact information. The email also included a URL link that directed the athletes to the informed consent, which is the first page of the survey.

To participate in the study the inclusion criteria stated that participants must be a minimum of 18 years old, be a part of an NCAA Division II female wrestling team, be actively competing at the time of assessment, or be actively preparing to start competing within the following two weeks. Additionally, they must have agreed to the informed consent. The survey excluded participants who were younger than 18 years old, were not actively competing during time of assessment nor were planning to participate in the following two weeks. Additionally, the survey excluded all participants who did not complete the survey by the end date.

Procedures

Upon agreement, the participants were redirected to the survey. The survey contained 45 questions, took no longer than 10-minutes to finish, and was available to complete from

November 7th until December 13th, 2023. For a duration of five weeks, the participants were able to access the survey and answer the questions. The answers were saved until they were submitted, or the survey reached its closing date. Participants were able to exit the survey at any given point after reviewing the questions and/or the consent. The informed consent explicitly stated that participation is voluntary. Individuals who were not interested in participating were able to ignore the survey. They were not coerced into being involved in any way. They were able to advance through the survey and decide to quit at any given time. Once it closed on December 13th, participants were not able to re-enter the survey. There were no costs associated with this study, and there was no compensation for participating.

The 25-item LEAF-Q questionnaire was comprised of three subgroups including gastrointestinal symptoms, injury, and menstrual functions and use of contraceptives. Questions within these subgroups helped identify individuals at risk of LEA. To score the 25 question LEAF-Q, each question was coded to a score system, depending on how the participant answered. The highest total score equaled 49 points. A score ≥ 8 points, by meeting the following subcategory points (2 ≥ for GI; 2 ≥ for injuries; 4 ≥ for MD) indicated “at risk” for LEA (Melin et al., 2014). Participants scoring 7 points or less were considered “low risk”.

All participant responses were anonymous and assigned an ID number. This information was stored in a password encrypted file. All data was unidentifiable by sharing only frequencies, percentages, and/or mean values. After data is disseminated, all personal information will be permanently and securely erased from the storage device through the operating system's built-in file management tools and data distribution software.

Statistical analysis

For the expected prevalence for female collegiate wrestlers at risk of LEA of20%, the required sample size was estimated at 141 wrestlers. This included the margin of error or absolute precision of ±7% in estimating the prevalence with 95% confidence as well as considering the potential of incomplete surveys of 10%. With this sample size, the anticipated 95% CI is (13%, 27%). This estimated sample size goal was calculated using the Scalex SP calculator (Naing et. al., 2022).

The data was analyzed using IBM's SPSS software version 28.0 (Armonk, NY) with the alpha set at $p<0.05$. Descriptive statistics were presented using mean ± standard deviation or percent frequencies. The prevalence of wrestlers at risk of LEA was reported as a percentage of the sample size, based on the validated LEAF-Q scoring. Table 2 summarizes the statistical methods that determined the outcomes from the survey questions.

Table 2. *Supplementary questions on the survey, inquiring information, and appropriate statistical analysis to determine the outcome.*

Question:	**Looking for:**	**Statistical Analysis:**
What is your age?	Mean age for "at risk" and "low risk" group	Independent-Samples t-Test
What is your height?	Mean height for "at risk" and "low risk" group	Independent-Samples t-Test
What is your weight?	Mean weight for "at risk" and "low risk" group	Independent-Samples t-Test
What is your ethnicity?	Ethnicity in % for the female wrestlers as a whole, and "at risk" and "low risk" separately.	Descriptive statistics - Frequencies
What is your current university student status?	How many of the wrestlers in the "at risk" group were freshmen, sophomore, junior, senior, super senior, graduate, post-baccalaureate.	Descriptive statistics - Frequencies
How many years have you participated in collegiate sports?	How many of the "at risk" wrestlers had 1 year of college experience, how many had 2, 3, 4, 5, and >5.	Descriptive statistics - Frequencies

How many years in total have you been competing in wrestling?	How many of the “at risk” wrestlers had 1 year of total experience in wrestling, how many had 2, 3, 4, 5, 6, 7, 8, 9, 10, >10.	Descriptive statistics - Frequencies
Are you an athlete for an additional sport at your college/university other than wrestling? (yes, no)	How many of the athletes in the “at risk” group are an athlete for an additional team in college.	Descriptive statistics - Frequencies
Have you ever been unable to compete while in college due to a low GPA (grade point average)? (yes/no)	How many of the wrestlers in the ‘at risk” group have been unable to compete due to low GPA	Descriptive statistics - Frequencies
Have you ever been unable to compete due to not meeting the required weight in your weight category while in college (yes/no)	How many of the wrestlers in the “at risk group have been unable to compete due to not meeting the weight-class requirements.	Descriptive statistics - Frequencies
Are you currently exercising outside practice and assigned workouts in an attempt to meet your weight-class criteria? (yes/no)	How many of the wrestlers in the “at risk group are currently exercising outside of the assigned practice and workouts.	Descriptive statistics - Frequencies
Are you currently using any type of tobacco product? (yes/no)	How many of the wrestlers in the “at risk group use tobacco products.	Descriptive statistics - Frequencies
Do you use any medication (excluding oral contraceptives)? (yes/no)	How many of the wrestlers in the “at risk group use medication (excluding contraceptives).	Descriptive statistics - Frequencies
How often do you stress about your grades?	How many wrestlers in the “at risk” group (Always/Most of the time/ About half the time/Sometimes/Never) stress about their grades.	Descriptive statistics - Frequencies
While in college have you ever experienced pressure from coaches or peers to perform superior?	How many wrestlers in the “at risk” group (Always/Most of the time/ About half the time/Sometimes/Never) experience pressure from coaches or peers to perform superior.	Descriptive statistics - Frequencies
While in college have you ever worried about eating too much food during your wrestling competitive season?	How many wrestlers in the “at risk” group (Always/Most of the time/ About half the time/Sometimes/Never) worry about eating too much food during their competitive season.	Descriptive statistics - Frequencies
While in college have you ever worried about not eating enough food during your wrestling competitive season?	How many wrestlers in the “at risk” group (Always/Most of the time/ About half the time/Sometimes/Never) worry about not eating enough food during their competitive season.	Descriptive statistics - Frequencies
Do you ever feel like you do not have enough time to eat due to having a busy schedule as a college student?	How many wrestlers in the “at risk” group (Always/Most of the time/ About half the time/Sometimes/Never) feel like they do not have time to eat.	Descriptive statistics - Frequencies

Timeline

The IRB approval for this project was obtained in April 2023. The thesis proposal took place during the first week of September 2023 by presenting the topic and idea to the selected committee members. The survey was disseminated during the first week of November with the start of the DII female wrestling season and remained open for answers simultaneously. The survey closed in five weeks from the date it was disseminated. Data interpretation and thesis formation began in December 2023 with the thesis submitted to the College of Graduate Studies and Research in April 2024.

CHAPTER 4: RESULTS

Survey participants

Out of 76 participants that initially began the survey, 68 completed it. Four participants did not finish the survey at their own discretion, and four participants were not presently engaged in competition, nor did they have plans to compete in the subsequent two weeks. This automatically rendered them ineligible to complete the rest of the survey. The mean age for the survey participants was 19.08 ± 1.13 years (M ± SD). The average height of the survey participants was 64.31 ± 3.21 inches, and the mean weight was 144.66 ± 29.45 pounds. The ethnicity of the wrestlers who completed the study was predominately White: 63% (n=43), but also included Multi ethnic: 16% (n=11), Other: 12% (n=6), African American: 7% (n=5), Asian: 3% (n=2), and Indian or Alaskan Native: 1% (n=1).

LEAF-Q

Fifty three percent (n=36) of the total participants that completed the survey scored ≥2 in the injuries' subcategory of the LEAF-Q, 78% (n=53) scored ≥ 2 in the gastrointestinal function subcategory, and 54% (n=37) scored ≥4 in the menstrual function and use of contraceptives subcategory (MD). Subsequently, 29% (n=20) of the total participants scored ≥8 by meeting the criteria for each of the three subcategories of the LEAF-Q and therefore were placed in the "at risk" group. On the contrary, 71% (n=48) of the participants scored ＜8 or did not meet the criteria for each of the three subcategories, which placed them in the "low risk" category. Table 4 shows the three LEAF-Q subcategories, the number of wrestlers with a "low risk" or "high risk" score, and the total number of wrestlers at risk or low risk for LEA according to the appropriate scoring assessment scheme (≥ 2 for injuries; ≥ 2 for gastrointestinal function; ≥ 4 for menstrual function and use of contraceptives).

Table 3. *LEAF-Q subcategories outcomes*

LEAF-Q Subcategories		
	LOW RISK	HIGH RISK
1. Injuries	< 2 **n=32**	≥ 2 **n=36**
2. Gastrointestinal Function	< 2 **n=15**	≥ 2 **n=53**
3. Menstrual function and use of contraceptives	< 4 **n=31**	≥ 4 **n=37**
Total	< 8 **n=48**	≥ 8 **n=20**

The mean age of the "at-risk" group was 19.10 ± 1.33 years, while the "low-risk" group reported a mean age of 19.08 ± 1.05 years, indicating no significant difference between the groups (p = .334). Moreover, the average height and weight of both groups did not show any significant disparities (p =.618; p=.893). The mean height for the "at-risk" group was 64.60 ± 3.19 inches, while for the "low-risk" group, it was 64.27 ± 3.29 inches. Similarly, the mean weight for the "at-risk" group was 146.10 ± 29.25 pounds, and for the "low-risk" group, it was 144.10 +/- 30.43 lbs. Fifty- three percent (n=10) were Freshmen and 32% (n=6) Sophomores. Upperclassmen students consisted of 5% Juniors (n=1), 11% Seniors (n=2), and 5% Graduate students (n=1). The student status of the “low risk” group were also predominantly underclassmen with 43% Freshmen (n=21), and 37% Sophomores (n=18), 14% Juniors (n=7), 2% Seniors (n=1), and 2% Graduate students (n=1).

When looking at the total years of experience in wrestling, 90% (n=18) of the “at risk” wrestlers had ≥3 years of experience. None of the athletes in the “at risk” group participated in an additional collegiate athletic team, nor were they unable to compete in wrestling due to having a low-grade point average. Surprisingly, 30% of the “at risk” wrestlers (n=6) were unable to compete due to not meeting the weight-class requirements, and 85% (n=17) reported that they were currently exercising outside of the assigned practice and workouts. The reported tobacco use was 15% (n=3), and 30% (n=6) used medication (excluding contraceptives).

Table 4 displays the number of female wrestlers in the “at risk” group and how they answered the similar Likert scale questions.

Table 4. Complementary questions featuring the same answer choice in the “at risk” group indicated by the number of athletes that mark the response.

“At risk” group (n=20)					
Answer choices:	Stress about grades.	Experience pressure from coaches or peers to perform superiorly.	Worries about eating too much food during their competitive season.	Worries about not eating enough food during their competitive season.	Not having time to eat.
Never	2	0	0	1	1
Sometimes	5	7	1	7	10
About half the time	3	2	3	3	4
Most of the time	5	7	3	3	2
Always	5	4	13	6	3

CHAPTER 5: DISCUSSION AND CONCLUSION

Discussion

The primary purpose of the study was to assess the number of NCAA Division II Female Wrestlers at risk for LEA during in-season training and competition. Given that the beginning of the competition phase is when wrestlers typically undergo the most significant weight cuts, assessing LEA during this time most likely would capture athletes at their most vulnerable time frame for LEA risk (Castor-Praga et al., 2021). Since the NCAA DII competitions start at the beginning of November, assessing LEA risk during this month was most appropriate. The initial invitation was sent via email on November 7th, 2023 and extended through December 13th, 2023 with the intent to allow for as many responses as possible in the first few weeks of the competitive phase of the DII wrestling season. With the goal of 141 responses for appropriate statistical power, the risk of true representation of DII wrestlers at risk of LEA may not be reflective in this study with the 68 complete responses received and only 20 earning an 'at risk' score. Furthermore, the survey coincided with a week-long Thanksgiving break, potentially impacting the availability and engagement of the athletes during that time. Nonetheless, the variance in their weights (144.66 +/- 29.45 pounds) accurately mirrored the extensive spectrum of weight categories prevalent in the survey. The mean time for the participants that fully completed the survey was 8.00 +/- 3.74 minutes, indicating that the length of the survey did not appear to be a contributing factor to the lower-than-expected response rates.

The LEAF-Q identified 29% (n=20) of the wrestlers "at risk" for LEA. This exceeded our hypothesis that 20% of the wrestlers would be at risk for LEA. When compared to the prevalence of LEA in Division III soccer players (56.3%), recreational (35.1%), elite athletes (55.8%), and young American football players (64.7%) identified by LEAF-Q wrestlers in the present study had a lower risk of LEA (Łuszczki et al., 2021; Magee et al., 2020; Meng et al., 2020). When compared to the prevalence of LEA risk in female kayaking athletes (3.3%), and recreational female runners (19%) identified by LEAF-Q (Karlsson et al., 2023; Witkoś et al., 2022), the Division II female wrestlers were at a higher LEA risk.

The considerable variability in LEA prevalence among various team sports could, to some extent, be linked to the restricted availability of sports nutrition education and provisional food resources, such as fueling stations. However, these nutritional resources might only be available to professional and elite-level athletes, and more so in the Division I level well-funded universities (Magee et al., 2020). Furthermore, research has shown that LEA is more prevalent in endurance and aesthetic athletes, potentially due to the requirements of the sport and the physical demands put on the body (Jesus et al., 2021). Endurance sports such as cross-country running, soccer, cross-country skiing, tend to have higher EEE due to the higher volume and intensity. Sports that require aesthetics such as gymnastics, or diving, might yield a higher prevalence of LEA due to the pressure put on the athletes to maintain a certain body composition. These sports also have historically relied on the ratio of work per mass, meaning the lower the mass, the less work required to move the body. Additionally, weight-class sports might have a higher prevalence of LEA compared to other sports due to the requirements to attain a certain body weight to compete in a specific weight class. Finally, team and coaching culture might influence a higher prevalence of LEA in some sports caused by pressure placed on athletes to achieve a certain physique. These factors might alter athlete’s eating habits and promote excessive exercising (Magee et al., 2020).

The secondary purpose of our study was to explore additional characteristics that may be related to the “at risk” group. When examining the three subcategories of the LEAF-Q, it was observed that the prevalence of gastrointestinal function was the highest, with 78% (n=53) of the participants exhibiting related symptoms. The notable high scores based on the answers in the gastrointestinal function subcategory were most likely due to irregular stools, constipation, and extreme sensitivity to certain food and smell after weight-cutting practices that were all reported by these participants in the area they could type in their own responses.

Specifically, combat sport athletes often undergo substantial weight reduction through acute weight loss strategies such as restriction of fluids and food, sweating in sauna, training with rubber suits, and training in heated training rooms (Artioli et al., 2010; Thomas et al., 2021).The rigorous nature of weight cutting can impact the body's digestive system, leading to potential challenges and disruptions in gastrointestinal function. Thomas and colleagues (2021) highlighted the impact of weight-cutting practices, revealing a notable correlation between scores on the LEAF-Q and the Rapid Weight Loss Questionnaire (RWLQ). Their findings underscore a positive relationship, indicating that combat athletes who exhibit elevated scores on the RWLQ also tend to score higher on the LEAF-Q. Moreover, the research suggested that professional athletes, in particular, demonstrate higher scores on the RWLQ, signifying a more pronounced involvement in the rigorous practice of weight cutting compared to recreational athletes.

To underscore the depth of weight loss efforts, a significant 85% of athletes in the "at-risk" group reported engaging in workouts beyond the designated practices and team sessions. The high response rate to participating in additional workout sessions may suggest a deliberate effort to undergo intense weight-cutting and rapid weight-loss. When these practices are repeatedly performed or prolonged, the chances of problematic RED-s may occur (Mountjoy et al., 2023). The adverse effects of RED-s include a range of outcomes, such as diminished energy metabolism, reproductive function, musculoskeletal health, immunity, glycogen synthesis, and cardiovascular and hematological well-being. These factors, individually and collectively, may reduce athletic performance and heighten the susceptibility to injuries (Mountjoy et al., 2023). When questioned about the frequency with which athletes concern themselves with overeating, a substantial 65% of the “at risk” group indicated that they always experience such worries. On top of reporting fear of eating too much, 30% of the “at risk” group also reported that they have not met the weight category, and therefore were not eligible to compete in that particular meet. Not meeting the desired weight category might further expand the fear of food, prompting the athlete to restrict their caloric intake. In a study done on lightweight rowers, athletes reported that the pressure of making weight negatively affected their relationship with food, experiencing anxiety and guilt when being around food (Gillbanks et al., 2022). A majority, 54% (n=37) of the participants answered questions that indicated menstrual disturbances according to the LEAF-Q. Regardless of all participants (n=68) reporting normal menstrual cycle, 6% (n=4) reported having 6-8 menstrual periods in the last year, 1% (n=1) reported 3-5 menstrual periods, and 1% (n=1) reported having 0-2 menstrual periods in the last year. When wrestlers consume less food and attempt multiple acute weight-loss practices, or, they undergo a chronic weight-loss practice, the endocrine system might suffer. As previously noted, leptin regulates the reproductive system and therefore affects the menstrual cycle. A lower levels of blood circulating leptin has been noticed in early food deprivation (Areta et al., 2021). The fear of eating too much might deprive the athlete from eating for prolonged periods of time, affecting the levels of leptin in the blood.

Acute weight loss strategies that include excessive workouts, combined with inadequate nutrition, may increase the risk of injuries. Ten percent (n=2) of the “at risk” group reported getting injured 5 times or more during the past year (365 days), and 15% (n=3) reported getting injured 3 or 4 times. Additionally, those who reported more frequent injury rates, also reported longer recovery times (>8 days). Further exploration through the additional questions on our survey revealed that 90% (n=18) of the "at-risk" athletes had accumulated more than three years of wrestling experience. This observation suggests a potential connection between the duration of athletic engagement and the likelihood of meeting the injury criteria of the LEAF-Q (≥2). Prior research has identified a relationship between the duration of an athlete's experience, training frequency, and the incidence of injuries (Wentz et al., 2012). This implies that as athletes engage in a sport over a longer period or increase their training intensity on a daily or weekly basis, the likelihood of sustaining injuries may increase.

Limitations

While our research has contributed novel insights for a previously unexplored aspect for female wrestlers, it is crucial to acknowledge certain limitations present in our study. The intended sample size of 141 participants, which was necessary to ensure statistical power and accurately represent DII collegiate female wrestlers, was not reached due to logistical issues, believed to be attributed to the distribution technique. The survey was primarily distributed to coaches and athletic staff, who in turn were responsible for distributing it to their athletes. The survey's distribution and accessibility were probably impacted by indirect dissemination methods, which added to the survey's low participation rate. Furthermore, reliance on self-reported data introduced a potential source of bias, as athletes might have provided information based on subjective interpretations or difficulty recalling information regarding menstrual cycle, food consumption, or injuries. We assumed that all athletes answered with honesty and appropriate interpretations of the questions while completing the survey. Additionally, the representation of the study sample, predominantly consisting of freshmen and sophomore student- athletes, might have not adequately represented the whole population of Division II female wrestlers. The study's scope may not adequately capture the diversity of experiences across different divisions and different levels of competition.

The LEAF-Q utilized in the research has been previously validated (Łuszczki et al., 2021; Melin et al., 2014; Witkoś et al., 2022; Witkoś et al., 2023), it is important to acknowledge that its efficacy as a singular measure of Low Energy Availability (LEA) has been questioned (Klein et al., 2023; Magee et al., 2020). When the results yielded from the LEAF-Q were compared to a true assessment of EA, LEAF-Q underestimated the number of athletes at risk for LEA, emphasizing the need for additional measurements of LEA with further investigation. The current status of true EA among college female wrestlers is still unknown. In our study, we employed the LEAF-Q to identify a level of risk in these athletes. Moving forward, it is imperative to conduct EA assessments throughout an entire season to gain a comprehensive understanding of EA in female collegiate wrestlers.

Conclusion

The survey used to assess the risk of LEA among NCAA Division II female wrestlers provided valuable insights, despite facing challenges in response rates. The obtained data revealed that 29% of the surveyed female wrestlers were identified as "at risk" for LEA, surpassing the initial hypothesis of 20%. Comparing this prevalence to other sports, Division II female wrestlers demonstrated a lower risk than Division III soccer players, combat sport athletes, elite athletes, and young American football players, but a higher risk than female kayaking athletes and recreational female runners. The secondary objective of the study, exploring characteristics related to the "at-risk" group, revealed weight-cutting practices, food intake concerns, pressure from coaches, and substantial wrestling experience. The prevalence of gastrointestinal symptoms (78%) among participants highlighted the impact of the in-season regimen, which typically involves substantial weight reduction. This study also highlighted the psychological aspects of weight-cutting practices, with athletes in the "at-risk" group expressing concerns about overeating, not meeting weight categories, and engaging in extra workouts.

While facing challenges in survey distribution, the study provided valuable insights into the prevalence of LEA risk among Division II female wrestlers and their characteristics that may play a role in their LEA risk. These findings underscore the necessity for further research on female wrestlers, particularly, precise assessments of Energy Availability (EA) throughout the sport season. This study also shed light on the need for targeted interventions and educational efforts to address the unique challenges faced by collegiate female wrestlers, such as not making competition weight, food worries, pressure from coaches, and additional workouts to lose weight.

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Appendix A: LEAF-Q

The low energy availability in females questionnaire (LEAF –Q), focuses on physiological symptoms of insufficient energy intake. The following pages contain questions regarding injuries, gastrointestinal and reproductive function. We appreciate you taking the time to fill out the LEAF-Q and the reply will be treated as confidential.

Name: ____________________

Address: ____________________

____

E-mail: ____________________

Cell: ____________

Profession: ____________________

Education: ____________________

Age: ________(years)

Height: ________(cm) Weight: ________(kg)

Your highest weight with your present height: ________(kg)
(excluding pregnancy)

Your lowest weight with your present height: ________(kg)

Do you smoke? Yes ☐ No ☐

Do you use any medication (excluding oral contraceptives)? Yes ☐ No ☐

If yes, what kind of medication?____________________

Your normal amount of training (average) – number of hours per week and what kind of exercise, such as running, swimming, bicycling, strength training, technique training etc.:

____

____

____

Comments or further information regarding exercise:____________________

____

____

1. Injuries **Mark the response that most accurately describes your situation**

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

☐ No, not at all ☐ Yes, once or twice ☐ Yes, three or four times ☐ Yes, five times or more

A1: 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 ☐ 8-14 days ☐ 15-21 days ☐ 22 days or more

A2: If yes, what kind of injuries have you had in the last year? ____________________

____

Comments or further information regarding injuries: ____________________

____

____

2. Gastro intestinal function

A: Do you feel gaseous or bloated in the abdomen, also when you do not have your period?

☐ Yes, several times a day ☐ Yes, several times a week

☐ Yes, once or twice a week or more seldom ☐ Rarely or never

B: Do you get cramps or stomach ache which cannot be related to your menstruation?

☐ Yes, several times a day ☐ Yes, several times a week

☐ Yes, once or twice a week or more seldom ☐ Rarely or never

C: How often do you have bowel movements on average?

☐ Several times a day ☐ Once a day ☐ Every second day

☐ Twice a week ☐ Once a week or more rarely

D: How would you describe your normal stool?

☐ Normal (soft) ☐ Diarrhoea-like (watery) ☐ Hard and dry

Comments regarding gastrointestinal function: ______________________________

____

3. Menstrual function and use of contraceptives

3.1 Contraceptives

Mark the response that most accurately describes your situation

A: Do you use oral contraceptives?

☐ Yes ☐ No

A1: If yes, why do you use oral contraceptives?

☐ Contraception ☐ Reduction of menstruation pains ☐ Reduction of bleeding

☐ To regulate the menstrual cycle in relation to performances etc..

☐ Otherwise menstruation stops

☐ Other____

____

A2: If no, have you used oral contraceptives earlier?

☐ Yes ☐ No

A2:1 If yes, when and for how long?____

____

____

B: Do you use any other kind of hormonal contraceptives? (e.g. hormonal implant or coil)

☐ Yes ☐ No

B1: If yes, what kind?

☐ Hormonal patches ☐ Hormonal ring ☐ Hormonal coil ☐ Hormonal implant ☐ Other

____

3.2 Menstrual function

Mark the response that most accurately describes your situation

A: How old were when you had your first period?

☐ 11 years or younger ☐ 12-14 years ☐ 15 years or older ☐ I don't remember

☐ I have never menstruated (If you have answered "I have never menstruated" there are no further questions to answer)

B: Did your first menstruation come naturally (by itself)?

☐ Yes ☐ No ☐ I don't remember

B1: If no, what kind of treatment was used to start your menstrual cycle?

☐ Hormonal treatment ☐ Weight gain

☐ Reduced amount of exercise ☐ Other

C: Do you have normal menstruation?

☐ Yes ☐ No **(go to question C6)** ☐ I don't know **(go to question C6)**

C1: If yes, when was your last period?

☐ 0-4 weeks ago ☐ 1-2 months ago ☐ 3-4 months ago ☐ 5 months ago or more

C2: If yes, are your periods regular? (Every 28th to 34th day)

☐ Yes, most of the time ☐ No, mostly not

C3: If yes, for how many days do you normally bleed?

☐ 1-2 days ☐ 3-4 days ☐ 5-6 days ☐ 7-8 days ☐ 9 days or more

C4: If yes, have you ever had problems with heavy menstrual bleeding?

☐ Yes ☐ No

C5: If yes, how many periods have you had during the last year?

☐ 12 or more ☐ 9-11 ☐ 6-8 ☐ 3-5 ☐ 0-2

3.2 Menstrual function

Mark the response that most accurately describes your situation

C6: If no or "I don't remember", when did you have your last period?

- ☐ 2-3 months ago
- ☐ 4-5 months ago
- ☐ 6 months ago or more
- ☐ I'm pregnant and therefore do not menstruate

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

- ☐ No, never
- ☐ Yes, it has happened before
- ☐ Yes, that's the situation now

E: Do you experience that your menstruation changes when you increase your exercise intensity, frequency or duration?

- ☐ Yes
- ☐ No

E1: If yes, how? (Check one or more options)

- ☐ I bleed less
- ☐ I bleed fewer days
- ☐ My menstruations stops
- ☐ I bleed more
- ☐ I bleed more days

Appendix B: LEAF-Q SCORING KEY

1\. A: **0** No, not at all, **1** Yes, once or twice, **2** Yes, three or four times, **3** Yes, five times or more

1\. A1: **1** 1-7 days, **2** 8-14 days, **3** 15-21 days, **4** 22 days or more

2\. A: **3** Yes, several times a day, **2** Yes, several times a week, **1** Yes, once or twice a week or more seldom,

0 Rarely or never

2\. B: **3** Yes, several times a day, **2** Yes, several times a week, **1** Yes, once or twice a week or more seldom,

0 Rarely or never

2\. C: **1** Several times a day, **0** Once a day, **2** Every second day, **3** Twice a week, **4** Once a week or more rarely

2\. D: **0** Normal, **1** Diarrhoea-like, **2** Hard and dry

3.1 A1: **0** Contraception, **0** Reduction of menstruation pains, **0** Reduction of bleeding,

0 To regulate the menstrual cycle in relation to performances etc.., **1** Otherwise menstruation stops

3.2 A: **0** 11 years or younger, **0** 12-14 years, **1** 15 years or older, **0** I don't remember,

8 I have never menstruated

3.2 B: **0**Yes, **1** No, **1** I don't remember

3.2 B1: **1** Hormonal treatment, **1** Weight gain, **1** Reduced amount of exercise, **1** Other

3.2 C: **0** Yes, **2** No (go to question 3.2 C6), **1** I don't know (go to question 3.2 C6)

3.2 C1: **0** 0-4 weeks ago, **1** 1-2 months ago, **2** 3-4 months ago, **3** 5 months ago or more

3.2 C2: **0** Yes, most of the time, **1** No, mostly not

3.2 C3: **1** 1-2 days, **0** 3-4 days, **0** 5-6 days, **0** 7-8 days, **0** 9 days or more

3.2 C4: **0** Yes, **0** No

3.2 C5: **0** 12 or more, **1** 9-11, **2** 6-8, **3** 3-5, **4** 0-2

3.2 C6: **1** 2-3 months ago, **2** 4-5 months ago, **3** 6 months ago or more

0 I'm pregnant and therefore do not menstruate

3.2 D: **0** No, never, **1** Yes, it has happened before, **2** Yes, that's the situation now

3.2 E: **1** Yes, **0** No

3.2 E1: **1** I bleed less, **1** I bleed fewer days, **2** My menstruations stops, **0** I bleed more, **0** I bleed more days

Appendix C: IRB Approval

NORTHERN MICHIGAN UNIVERSITY

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Memorandum

TO: Lanae Joubert
Rafaela Rafajlovska
Department of Health and Human Performance

FROM: Lisa Schade Eckert
Dean, Graduate Studies and Research Northern Michigan University

DATE: April 19, 2023

SUBJECT: **IRB Proposal HS23-1383**
"Utilizing the LEAF Questionnaire to determine the risk of Low Energy Availability in Division II college female wrestlers"
IRB Approval Date: 4/19/2023
Proposed Project Dates: 9/1/2023-4/1/2024

Your proposal "Utilizing the LEAF Questionnaire to determine the risk of Low Energy Availability in Division II college female wrestlers" has been approved by the Northern Michigan University Institutional Review Board. Please include your proposal number (HS23-1383) on all research materials and on any correspondence regarding this project.

If you find that modifications of investigators, methods, or procedures are necessary, you must submit a Project Modification Form for Research Involving Human Subjects before collecting data. Any changes or revisions to your approved research plan must be approved by the IRB prior to implementation.

Until further guidance, per CDC guidelines, the PI is responsible for obtaining signatures on the COVID-19 Researcher Agreement and Release and COVID-19 Research Participant Agreement and Release forms.

All forms can be found at the NMU Human Subjects Research webpage.