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Age-Related Differences in the Risk of the Female Athlete Triad Among Collegiate Athletes

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Abstract

Background: The female athlete triad is a condition many female athletes either experience or are at high risk for and is now considered part of the broader Relative Energy Deficiency in Sports (RED-S) framework. It includes the three components of decreased bone mineral density, low energy availability, and menstrual dysfunction. The longer an individual suffers from the female athlete triad, the more severe the impact they have on their health, such as an increased risk of fractures and osteoporosis later in life. While it is known that the female athlete triad is a prevalent issue in collegiate athletes, the triad risk of athletes based on age and whether their risk decreases once they are aware of the issue is not well studied. The purpose of this study is to assess the association between age and total Low Energy Availability in Females Questionnaire (LEAF-Q) score. The secondary aim is to describe LEAF-Q sub-score patterns by age and explore individual athletes' changes who had previously completed the survey.

Methods: This was a voluntary, single-institution, cross-sectional survey. The LEAF-Q was emailed to the roster of female collegiate athletes at Nova Southeastern University (NSU) (N = 356), and 96 athletes (response rate 27%) completed the LEAF-Q on REDCap in a self-report format. A total LEAF-Q score ⩾8 was defined as a positive screen. The association between age and total LEAF-Q score was assessed with Spearman correlation. Changes in individual athletes with a prior LEAF-Q result were described descriptively.

Results: Fifty-two of 96 athletes (54.2%) had a positive LEAF-Q screen, and positive screens occurred in each represented age group. The total LEAF-Q score was not significantly associated with age group (ρ = 0.06, 95% CI -0.14 to 0.26, p = 0.54); the confidence interval does not exclude small positive and negative associations. Compared to younger athletes, older athletes did not demonstrate a greater risk of triad, with no linear trend in risk by age observed. Additionally, of the 11 athletes who previously completed the LEAF-Q, six athletes had an increase in their screening results the following year compared to five athletes who had a decrease in screening results.

Conclusion: In this convenience sample of 96 female collegiate athletes, 54.2% had a positive LEAF-Q screen for symptoms associated with low energy availability and triad-related conditions. The total LEAF-Q score was not significantly associated with age; however, the cross-sectional design, small age variations, voluntary participation, and lack of direct clinical assessment limit inferences about age-related risk. These findings support further longitudinal research. It is crucial for early screening and awareness about this health issue, and education to athletes along with mental and nutritional support may greatly benefit female collegiate athletes' health and mitigate long-term health consequences.

Categories: Sports Medicine, Physical Medicine & Rehabilitation, Internal Medicine
Keywords: female athlete, female athlete triad, leaf-q, low bone mineral density, low energy availability, menstrual dysfunction

Introduction

The female athlete triad is a clinical condition characterized by the interrelationship between low energy availability (LEA) (with or without disordered eating), menstrual dysfunction, and decreased bone mineral density [1]. The triad has various degrees of severity and reflects the body's adaptation to insufficient energy intake relative to energy expenditure [1,2]. LEA is considered the key underlying factor and contributes to the suppression of the hypothalamic-pituitary-gonadal axis, leading to altered gonadotropin release and menstrual dysfunction that may range from subtle abnormalities to functional hypothalamic amenorrhea [2,3].

The female athlete triad is now understood as one component of the Relative Energy Deficiency in Sport (RED-S) framework, which recognizes that LEA in athletes of all sexes can impair multiple physiological systems, including endocrine, metabolic, skeletal, cardiovascular, and immune function [4,5]. The female athlete triad was kept as the primary framework for this study for three reasons. First, the sample consisted exclusively of female collegiate athletes. Second, the LEAF-Q was developed and validated specifically to

screen for symptoms associated with LEA and triad-related conditions (injury, gastrointestinal, and menstrual function). Third, the study aimed to describe these screening domains rather than the full range of RED-S health outcomes. Findings were therefore interpreted in the context of the triad, with references to RED-S where it is relevant.

The consequences that can result from the triad are particularly significant for skeletal health. Prolonged exposure to the triad during young adulthood increases the risk of stress fractures, impaired bone health, and osteoporosis later in life [6]. Estrogen deficiency, combined with inadequate nutritional support, impairs bone formation and promotes increased bone resorption, eventually leading to decreased bone mineral density and undetected osteoporosis [1,7,8]. As a result, female athletes with one or more components of the triad are at increased risk for bone injuries, including traumatic injury, stress reactions, and stress fractures [7,9]. Furthermore, peak bone mass is achieved primarily during adolescence and early adulthood [10]. Prolonged exposure to triad-related risk factors during the critical bone growth time period may result in long-term deficits in bone health and an increased future risk of osteopenia and osteoporosis [1].

Collegiate female athletes represent a high-risk population for the development of the triad. Transitioning to the high rigor of collegiate athletics is frequently associated with increased training intensity, competitive demands, and pressures related to performance and body composition [2,11]. In addition, inadequate energy intake relative to exercise expenditure may occur intentionally or unintentionally in collegiate athletes and can contribute to LEA [3]. Studies have demonstrated that components of the triad are prevalent among female athletes, with menstrual dysfunction reported in up to 70% of certain athletic populations and LEA affecting a substantial proportion of athletes across different sports [12].

The association between the triad and bone stress injuries has been well established, with evidence suggesting that risk increases with the number and severity of triad components that are present [7,13]. Early identification of athletes who are at risk for the triad is therefore critical. The Low Energy Availability in Females Questionnaire (LEAF-Q) is a validated screening tool used to identify female athletes at risk for LEA and associated triad conditions, demonstrating strong sensitivity and specificity in athletic populations [14]. It is a screening instrument and does not establish a clinical diagnosis of LEA or the triad.

Despite increased awareness of the triad and the development of screening tools, important gaps remain in the literature. Most studies have focused on cross-sectional prevalence, providing limited information on how triad risk changes over time. Few studies have examined how LEAF-Q screening scores vary by age within the collegiate years, and the consistency of screening results within individual athletes over time is not well described.

The primary aim was to assess the association between age and total LEAF-Q score. Secondary aims were to describe LEAF-Q sub-score patterns by age and explore changes in individual athletes who had previously completed the survey.

This article was previously presented as a poster presentation at the 2026 ACSM Southeast Chapter Annual Meeting on February 26, 2026.

Materials And Methods

Study design

A survey was created in REDcap consisting of the validated LEAF-Q and additional questions regarding participants' interest in education on the Female Athlete Triad. NSU's Institutional Review Board (IRB) determined the study to be IRB-exempt (category 2, protocol number 2024-276) and prior to beginning the survey, each athlete read through a consent form. The questionnaire used a self-report format and incorporated various factors relating to the triad including injuries, gastrointestinal function, and menstrual function. The LEAF-Q is a self-report questionnaire with three domains (injury, gastrointestinal function, and menstrual function) whose scores are summed to a total score; a total score ⩾8 indicates a positive screen, as defined in the original validation study [14]. The completion of all LEAF-Q items was required for inclusion. Participation was voluntary. The full item-by-item questionnaire is not reproduced here as it is available in the cited validation study [14]. In addition to the LEAF-Q, athletes reported age, height, weight, sport, academic year, medication use, weekly training hours, and prior LEAF-Q completion.

Participants

Participants were recruited through convenience sampling. The survey was emailed to 356 rostered female collegiate athletes at NSU, and 96 athletes completed the questionnaire (response rate of 27%). Eligibility criteria were age ⩾18 years, enrollment as a rostered female collegiate athlete at Nova Southeastern University, and completion of all required LEAF-Q items. Exclusion criteria included being male, not an athlete at NSU, being younger than 18 years old, and not completing the survey in its entirety. The official roster of all female collegiate athletes at NSU was used to determine which athletes received the survey through email and this roster was acquired through the NSU athletic department. The survey was distributed by the assistant athletic director using the athletic department email list. The survey was voluntary and was

open for five months (September 2025 to January 2026).

Repeat-response subgroup

Athletes who had completed the LEAF-Q in a previous year were identified via name and email addresses; to ensure confidentiality, these identifiers were immediately replaced with unique, non-identifying participant ID codes. The interval between the two surveys was 11-12 months with no confirmed education received after the first survey.

Analysis

The results were exported from REDcap into Excel to code and analyze the data. Participant characteristics were summarized using means and standard deviations for continuous variables and counts and percentages for categorical variables. The primary analysis was a Spearman rank correlation between age and total LEAF-Q score, reported with an approximate 95% confidence interval. A positive LEAF-Q screen, indicating symptoms associated with LEA and triad-related conditions, was defined as a total score ⩾8 [14]. Sub-scores were summarized descriptively and expressed as a percentage of each domain's maximum possible score to allow comparison across domains with different score ranges. Changes among athletes with a prior LEAF-Q result were described descriptively. Secondary analyses were exploratory, and no adjustment was made for multiple comparisons. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 29 (Released 2023; IBM Corp., Armonk, New York, United States), with significance set at $p < 0.05$.

Results

Demographics

A total of 96 female NSU collegiate athletes, aged 18-24 years, completed the LEAF-Q and were included in the analysis. The response rate was 27% of the 356 athletes invited. Athletes competed in nine sports (cross country/track, rowing, soccer, swimming, volleyball, softball, basketball, tennis, and golf); numbers by sport, academic year, hormonal contraceptive use, and prior LEAF-Q participation are shown in Table *1*. The average age of participants was 19.53 ± 1.41 years. The average height was 168.74 ± 7.39 cm, the average weight was 63.4 ± 7.7 kg (139.83 ± 16.90 lb.), and the average amount of training per week was 15.29 ± 6.75 hours. Eleven athletes (11.5%) had previously completed the LEAF-Q.

Characteristic	Value
Age, years, mean ± SD	± 1.41
Height, cm, mean ± SD	± 7.39
Weight, kg (lb.), mean ± SD	± 7.7 (139.83 ± 16.90)
Training, hours per week, mean ± SD	15.29 ± 6.75
Sports, n (%)	
Cross country/track	26 (27.1%)
Rowing	16 (16.7%)
Soccer	15 (15.6%)
Swimming	8 (8.3%)
Volleyball	9 (9.4%)
Softball	8 (8.3%)
Basketball	5 (5.2%)
Tennis	6 (6.3%)
Golf	3 (3.1%)
Academic year, n (%)	
First year	33 (34.4%)
Second year	21 (21.9%)
Third year	25 (26.0%)
Fourth year or later	17 (17.7%)
Hormonal contraceptive use, n (%)	
Yes	21 (21.9%)
No	75 (78.1%)
Previously completed the LEAF-Q, n (%)	
Yes	11 (11.5%)
No	85 (88.5%)

TABLE 1: Participant Characteristics (N = 96)

Triad risk

Age-stratified descriptive statistics for total LEAF-Q scores and sub-scores are presented in Table 2. Across all the athletes who completed the survey, the mean total LEAF-Q score was 8.23 ± 3.20 (95% CI 7.58-8.88). Fifty-two of 96 athletes (54.2%; 95% CI 44.2%-63.8%) scored ⩾8, meeting the LEAF-Q threshold for a positive screen for symptoms associated with LEA and triad-related conditions.

Age	N (%)	Total LEAF-Q Score	Injury Sub-score	GI Sub-score	Menstrual Sub-score
18	31 (32%)	7.61 ± 3.76	1.06 ± 1.50	3.55 ± 2.19	3.00 ± 2.13
19	18 (19%)	8.50 ± 5.62	2.28 ± 2.49	3.12 ± 2.09	3.28 ± 3.21
20	24 (25%)	9.04 ± 4.71	2.50 ± 2.55	2.91 ± 1.88	3.75 ± 2.69
21	14 (15%)	7.64 ± 3.18	1.93 ± 2.23	2.36 ± 1.74	3.36 ± 1.98
22	7 (7%)	9.57 ± 3.10	2.57 ± 2.57	2.57 ± 1.72	4.43 ± 1.40
23-24	2 (2%)	6.00 ± 2.83	1.00 ± 1.41	1.00 ± 1.41	4.00 ± 0.00

TABLE 2: LEAF-Q Total and Sub-scores Averages by Age Group (Mean ± SD)

GI: Gastrointestinal; LEAF-Q: Low Energy Availability in Females Questionnaire; possible score ranges: injury 0-7, GI 0-12, menstrual 0-29

Associations between age and LEAF-Q scores

Spearman correlation analysis demonstrated no significant association between age and total LEAF-Q score (ρ = 0.06, 95% CI -0.14 to 0.26, p = 0.54). Because this interval includes small positive and small negative correlations and the age strata were small, the data cannot exclude a modest association with age; a non-significant result does not demonstrate that risk is unrelated to age. Mean total scores were numerically highest at age 20 and 22 years and lowest in the 23-24-year group (n = 2) but did not change uniformly with age (Table *2*, Figure *1*). Athletes were categorized as having a positive screen (LEAF-Q ⩾8) or a negative screen (LEAF-Q <8). In this convenience sample, positive LEAF-Q screens occurred in each represented age group; no statistically significant association was observed between age and total LEAF-Q score.

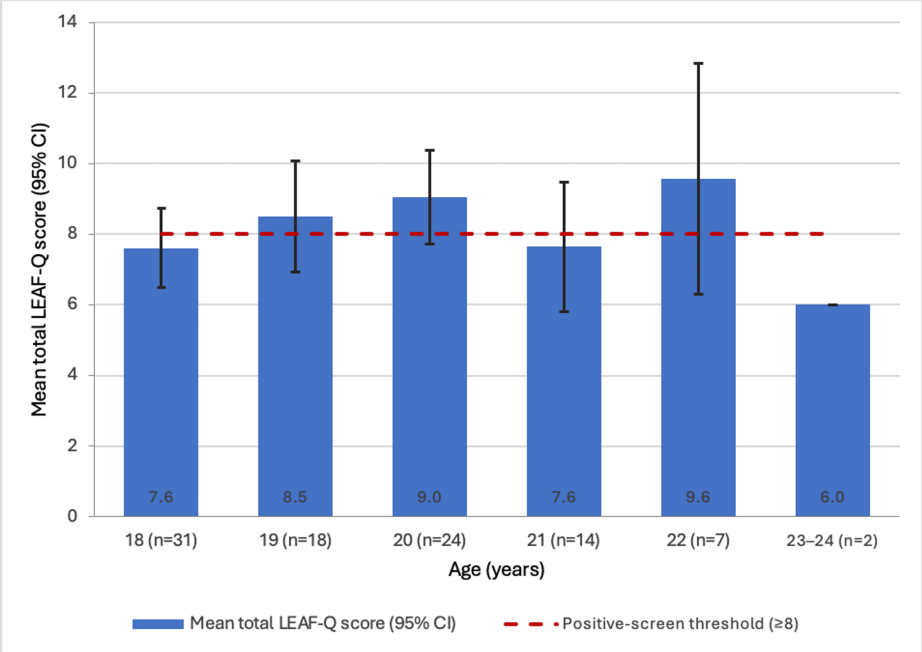


FIGURE 1: Mean Total LEAF-Q Score (95% Confidence Interval) by Age Group

The dashed line marks the positive-screen threshold (≥8). The confidence interval for the 23-24-year group (n = 2) is not shown because it is not informative.

Group sizes: 18 y, n = 31; 19 y, n = 18; 20 y, n = 24; 21 y, n = 14; 22 y, n = 7; 23-24 y, n = 2. LEAF-Q ≥8 = positive screen.

LEAF-Q: Low Energy Availability in Females Questionnaire

Sub-score patterns across age groups

Due to the three domains having different possible score ranges (injury 0-7, gastrointestinal 0-12, menstrual 0-29), raw sub-scores are not directly comparable across domains. Across the full sample, mean sub-scores were approximately 1.88 for injury, 3.01 for gastrointestinal function, and 3.42 for menstrual function, corresponding to roughly 27%, 25%, and 12% of each domain's maximum possible score, respectively. Although the menstrual domain contributed the most points to the total score, this reflects its larger possible range rather than a greater relative burden. Within domains, mean sub-scores differed numerically by age group (Table *2*): gastrointestinal sub-scores were highest at age 18 and lower in older groups, whereas injury and menstrual sub-scores were lowest at age 18 but did not change uniformly with age. No inferential tests were performed for these patterns, and the small age strata limit their interpretation.

Exploratory repeat-response subgroup

Among the 11 athletes (11.5%) who completed the LEAF-Q previously, six had a higher and five had a lower result than at their prior survey. The interval between surveys was 11-12 months. Three athletes changed from <8 to ⩾8, two changed from ⩾8 to <8, four remained ⩾8, and two remained <8. These observations are descriptive only; with 11 athletes and no information on intervening exposures, they cannot be used to infer causes or the effects of education or screening.

Discussion

Principal findings

In this single-university convenience sample of 96 female collegiate athletes, 54.2% had a positive LEAF-Q screen (score ⩾8) for symptoms associated with LEA and triad-related conditions. The total LEAF-Q score was not significantly associated with age ($\rho = 0.06$, 95% CI -0.14 to 0.26, $p = 0.54$), and positive screens occurred in each represented age group. The high proportion of positive screens suggests that screening-detected symptoms are common in this sample, but the LEAF-Q does not diagnose the triad or RED-S.

Interpretation

A non-significant correlation does not rule out a potential effect of age on Female Athlete Triad risk, nor does it establish that risk remains stable across the collegiate years. The 95% confidence interval for the correlation (-0.14 to 0.26) is compatible with small positive and small negative associations; the strata at ages 22 (n = 7) and 23-24 (n = 2) were very small, and the study was not designed or powered to detect small age-related differences; therefore, it cannot prove the absence of an age effect. Sub-score differences across age groups were descriptive and untested, and means in small strata are unstable, so they should not be read as age-related trends. Raw sub-scores also cannot be compared across domains because the domains have different possible ranges: the menstrual domain contributed the most points to total scores, but its mean was a smaller proportion of its maximum possible score (approximately 12%) than the injury (27%) and gastrointestinal (25%) domains. Any explanation for the absence of a significant age association is speculative, because training demands, schedules, diets, sport type, and other exposures were not analyzed in relation to age. Physiological, behavioral, and environmental factors, including training volume, physical appearance expectations, academic stress, and nutrition access, may all contribute to energy-availability-related symptoms, but they were not included in the LEAF-Q.

Comparison with prior studies

One research article that studied the relationship in female collegiate athletes between disordered eating, body dissatisfaction, and LEA, a core component of the triad, observed a high prevalence (64%) of LEA risk in the athletes based on the LEAF-Q, similar to this research [15]. Furthermore, a systematic review examining LEA in all collegiate athletes found that 44.2% of female athletes had LEA across a total of 59 studies [16]. The athletes with LEA had hindered athletic performances, including decreased endurance, response speeds, coordination, agility, and concentration, along with impaired bone health and a greater risk of bone-related injuries [16]. Menstrual dysfunction is also common in some athletic populations; one study reported functional hypothalamic amenorrhea in 60% of female track and field athletes [17]. Menstrual dysfunction is an established marker of LEA that can contribute to impaired bone health and injury; however, the present data do not show that it contributed more than the injury or gastrointestinal domains.

The positive-screen prevalence of 54.2% found in this study falls within the wide range reported in the literature. Logue et al. found that LEA prevalence ranged from 22% to 58% across studies of female athletes, and attributed much of this variability to differences in how energy availability was measured rather than to true differences in risk [3]. Similarly, Gibbs et al. found that prevalence of any one triad component ranged from 16% to 60% across 65 studies, and that athletes in lean sports had a higher prevalence of menstrual dysfunction and disordered eating (6.8% - 57.8%) compared to athletes in non-lean sports (5.4% - 13.5%) [5]. This suggests that some of the variation in reported triad prevalence, including the difference between this study's rate and other reported rates, may be explained by the specific sports studied rather than by a true difference in risk. Since the athletes in this study represented a mix of sports, the prevalence found here

may not generalize directly to populations with different sports compositions. Sport type was not analyzed, and risk profiles may differ among endurance, aesthetic, weight-sensitive, team, and other sports. Menstrual dysfunction is frequently reported in athletes with LEA [10,12]. However, because domain scores were not standardized, the present data do not show that it was the largest contributor, and prevalence estimates vary by sport and methodology.

Prior studies rarely examined risk of the triad based on age differences within collegiate years. The absence of a statistically significant association with age in this study is not inconsistent with the prior report described below, but given the limited precision of this estimate, it should not be taken as evidence that risk is stable across age. One cross-sectional study of female athletes aged 15 - 40 found that lean sport participation and body image played a larger role in triad risk than age [18]. It is possible that these findings do not contradict each other. Lean sport participation and body image concerns can affect athletes of any age, while younger athletes may need more energy on top of those factors, not instead of them.

Published studies describe menstrual dysfunction as an indicator of LEA. A study focused specifically on menstrual disturbances and energy availability threshold found that LEA increased the chance of experiencing menstrual disturbance by 50% in female athletes [19].

Exploratory repeat-response subgroup

In addition to a lack of research on triad risk by age, there are also limited data on within-athlete changes in screening over time. In this study, 11 athletes had a prior LEAF-Q result, and their results changed in both directions; because this subgroup was small and intervening exposures were not measured, these changes are described only and do not support causal or intervention-related inferences. Fluctuating training load, injuries, and dietary changes may explain the changes observed in this study. One case series of seven female collegiate runners, with a majority meeting criteria for moderate triad risk, studied them across the duration of their athletic season. This study documented fluctuations in many health components, including body mass, vitamin D, ferritin, and resting metabolic rate, displaying how changes in training load may impact triad risk [20]. This highlights how there are many factors that play a role in the triad and a holistic approach needs to be taken to help prevent triad complications.

Strengths and limitations

Use of the validated LEAF-Q supported standardized screening; however, self-report and voluntary participation may have affected measurement and selection bias. One potential explanation for why age may not influence triad risk in collegiate athletes is that these athletes undergo similar training demands as well as potentially follow similar schedules and diets. Although the athlete's triad risk did not vary by age, many of the athletes were considered at risk of the triad which is from various lifestyle components. Physiological, behavioral, and environmental factors all play a role in triad risk, examples include training volume, physical appearance expectations, academic stress, and nutrition access. These various factors as well as the mixed longitudinal triad risk changes observed in this study display how the risk for triad is dynamic.

A strength of this study is the use of a validated screening instrument, the LEAF-Q, which supported standardized screening of athletes across several sports. However, the use of a validated instrument does not by itself make the results valid or reliable in this sample. The self-report format and voluntary participation may have affected the results and caused a selection bias.

This study has several limitations. First, the response rate was 27%, and voluntary participation may have introduced self-selection and non-response bias in either direction; optional participation does not minimize self-report bias. Second, the study was conducted at a single university, which limits external validity. Third, because the study collected data at one point in time, it cannot establish cause- and-effect relationships or determine how risk changes as athletes progress through their collegiate years. Fourth, age strata were small, particularly at ages (n = 7) and 23-24 (n = 2), which limits precision and power. Fifth, athletes represented several sports with potentially different risk profiles (endurance, aesthetic, weight-sensitive, and team sports), and sport type was not analyzed; these differences may have confounded age-related differences, and the inclusion of multiple sports should not be assumed to improve generalizability. Sixth, hormone contraceptive use (n = 21) could suppress or alter menstrual patterns and affect the menstrual sub-score. Seventh, the study did not measure bone mineral density or directly measure energy availability and had no clinical or diagnostic confirmation; the LEAF-Q identifies symptoms associated with LEA and triad-related conditions but cannot diagnose the triad or its components. Eighth, the repeat-response subgroup was small (n = 11), and prior LEAF-Q completion does not indicate awareness, knowledge, or behavioral change, none of which were measured. Finally, sub-score comparisons across domains were descriptive and limited by unequal score ranges.

Clinical implications and future research

There are a variety of clinical and practical implications of this study. The high proportion of positive screens in this sample suggests that athletes with positive LEAF-Q screens may benefit from clinical evaluation and individualized nutritional, menstrual, and bone-health assessment. The LEAF-Q is a

screening tool and cannot diagnose the triad or RED-S. The repeat-response data (n = 11) is too limited to support recommendations about screening frequency; whether repeated screening improves outcomes was not tested here and warrants prospective study. Furthermore, broader discussions of integrated sports-health services have considered the roles of multiple practitioners in athlete care [21]. The prevalence of positive screens shows that athletic trainers, coaches, nutritionists, and other professionals who assist the athletes should be aware of the female athlete triad. This will benefit the athletes because they can have multidisciplinary support in their athletic care.

Future directions of this research can focus on including multiple universities in the study to improve generalizability, larger samples within each age group, and analyses stratified by sport type and hormonal-contraceptive use. Also, different measures besides the LEAF-Q can be used such as the DEXA scan, hormonal lab work, and dietary assessments that would provide more direct measures of bone health, hormonal status, and energy availability. Another future direction can consist of tracking female athletes across all four years in university, using linked identifiers and consistent follow-intervals, to better characterize changes in screening results in individual athletes. Lastly, intervention studies can be conducted to assess education and nutrition programs and whether they change LEAF-Q scores or clinical outcomes in athletes.

Conclusions

Over half of athletes screened positive on the LEAF-Q among the female collegiate athletes studied, suggesting that symptoms of LEA may be prevalent in this population and warrant increased screening and education. The total LEAF-Q score was not significantly associated with age; however, the cross-sectional design, small age strata, voluntary participation, and lack of direct clinical assessment limit inferences about age-related risk. These findings support further multicenter longitudinal research and suggest that athletes with positive LEAF-Q screens may benefit from clinical evaluation and individualized nutritional, menstrual, and bone-health assessment.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Sydney T. Schneider, Pradeep Vanguri

Acquisition, analysis, or interpretation of data: Sydney T. Schneider

Drafting of the manuscript: Sydney T. Schneider

Critical review of the manuscript for important intellectual content: Sydney T. Schneider, Pradeep Vanguri

Supervision: Pradeep Vanguri

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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References

1. Nazem TG, Ackerman KE: The female athlete triad. Sports Health. 2012, 4:302-11. 10.1177/1941738112439685
2. Smith AD: The female athlete triad: causes, diagnosis, and treatment . Phys Sportsmed. 1996, 24:67-86. 10.3810/psm.1996.07.1407
3. Logue DM, Madigan SM, Melin A, Delahunt E, Heinen M, Donnell SM, Corish CA: Low energy availability in

athletes 2020: an updated narrative review of prevalence, risk, within-day energy balance, knowledge, and impact on sports performance. Nutrients. 2020, 12:10.3390/nu12030835

4. Mountjoy M, Sundgot-Borgen J, Burke L, et al.: The IOC consensus statement: beyond the Female Athlete Triad--Relative Energy Deficiency in Sport (RED-S). Br J Sports Med. 2014, 48:491-7. 10.1136/bjsports-2014-093502
5. Mountjoy M, Ackerman KE, Bailey DM, et al.: 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). Br J Sports Med. 2023, 57:1073-97. 10.1136/bjsports-2023-106994
6. Ackerman KE, Misra M: Bone health and the female athlete triad in adolescent athletes . Phys Sportsmed. 2011, 39:131-41. 10.3810/psm.2011.02.1871
7. Gibbs JC, Williams NI, De Souza MJ: Prevalence of individual and combined components of the female athlete triad. Med Sci Sports Exerc. 2013, 45:985-96. 10.1249/MSS.0b013e31827e1bdc
8. Ng GS, Lee LY, Chu EC: Undiagnosed osteoporotic vertebral fractures in an octogenarian during the coronavirus disease pandemic. Cureus. 2023, 15:e38585. 10.7759/cureus.38585
9. Chu EC, Yun SM, Huang KH: Fifth distal phalanx avulsion fracture in a high-level marathon runner . Cureus. 2023, 15:e37468. 10.7759/cureus.37468
10. Chin WL, Chu EC, Chiang R: Screening and diagnosing osteoporosis among postmenopausal women in primary care settings in Malaysia: a systematic review. Maedica (Bucur). 2022, 17:492-504.
11. Edama M, Inaba H, Hoshino F, Natsui S, Maruyama S, Omori G: The relationship between the female athlete triad and injury rates in collegiate female athletes. PeerJ. 2021, 9:e11092. 10.7717/peerj.11092
12. Almousa S, van Loon AB: Female athlete triad epidemiology among adult athletes: a systematic review . Sci Sports. 2024, 39:227-40. 10.1016/j.scispo.2023.04.004
13. Miller Olson E, Sainani KL, Dyrek P, et al.: The association between overuse and musculoskeletal injuries and the female athlete triad in Division I collegiate athletes. PM R. 2024, 16:1290-7. 10.1002/pmrj.13201
14. Melin A, Tornberg AB, Skouby S, Faber J, Ritz C, Sjödin A, Sundgot-Borgen J: The LEAF questionnaire: a screening tool for the identification of female athletes at risk for the female athlete triad. Br J Sports Med. 2014, 48:540-5. 10.1136/bjsports-2013-093240
15. Fields JB, Jones MT, Kitts SE, King EL, Jagim AR: Relationships between disordered eating, body dissatisfaction, and low energy availability in women collegiate athletes. J Strength Cond Res. 2026, 40:e164-71. 10.1519/JSC.0000000000005281
16. Gallant TL, Ong LF, Wong L, Sparks M, Wilson E, Puglisi JL, Gerriets VA: Low energy availability and relative energy deficiency in sport: a systematic review and meta-analysis. Sports Med. 2025, 55:325-39. 10.1007/s40279-024-02130-0
17. Melin AK, Heikura IA, Tenforde A, Mountjoy M: Energy availability in athletics: health, performance, and physique. Int J Sport Nutr Exerc Metab. 2019, 29:152-64. 10.1123/ijsnem.2018-0201
18. Amoruso I, Fonzo M, Barro A, Scardina C, Titton F, Bertoncello C, Baldovin T: Determinants of menstrual dysfunction in the female athlete triad: a cross-sectional study in Italian athletes. Psychol Sport Exerc. 2024, 73:102653. 10.1016/j.psychsport.2024.102653
19. Salamunes ACC, Williams NI, De Souza MJ: Are menstrual disturbances associated with an energy availability threshold? A critical review of the evidence. Appl Physiol Nutr Metab. 2024, 49:584-98. 10.1139/apnm-2023-0418
20. Hooper DR, Mallard J, Wight JT, et al.: Performance and health decrements associated with relative energy deficiency in sport for division I women athletes during a collegiate cross-country season: a case series. Front Endocrinol (Lausanne). 2021, 12:524762. 10.3389/fendo.2021.524762
21. Lin AF, Piong SZ, Wan WM, Li P, Chu VK, Chu EC: Unlocking athletic potential: the integration of chiropractic care into the sports industry and its impact on the performance and health of athletes and economic growth in China and Hong Kong. Cureus. 2023, 15:e37157. 10.7759/cureus.37157