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Energy Availability With or Without Eating Disorder Risk in Collegiate Female Athletes and Performing Artists

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Context: Female athletes and performing artists can present with low energy availability (LEA) from either unintentional (eg, inadvertent undereating) or intentional (eg, eating disorder [ED]) methods. Whereas LEA and ED risk have been examined independently, few researchers have examined them simultaneously. Awareness of LEA with or without ED risk may provide clinicians with innovative prevention and intervention strategies.

Objective: To examine LEA with or without ED risk (eg, eating attitudes, pathogenic behaviors) in female collegiate athletes and performing artists and compare sport type and LEA with the overall ED risk.

Design: Cross-sectional study.

Setting: Free living in sport-specific settings.

Patients or Other Participants: A total of 121 collegiate female athletes and performing artists (age = 19.8 ± 2.0 years, height = 168.9 ± 7.7 cm, mass = 63.6 ± 9.3 kg) participating in equestrian (n = 28), soccer (n = 20), beach volleyball (n = 18), softball (n = 17), volleyball (n = 12), and ballet (n = 26).

Main Outcome Measure(s): Anthropometric measurements (height, mass, body composition), resting metabolic rate, energy intake, total daily energy expenditure, exercise energy expenditure, Eating Disorder Inventory-3 (EDI-3), and EDI-3 Symptom Checklist were assessed. Chi-square analysis was used to examine differences between LEA and sport type, LEA and ED risk, ED risk and sport type, and pathogenic behaviors and sport type.

Results: Most (81%, n = 98) female athletes and performing artists displayed LEA and differences between LEA and sport type ($\chi^2_5 = 43.8$, $P < .001$). The majority (76.0%, n = 92) presented with an ED risk, but the ED risk did not differ by sport type ($P = .94$). The EDI-3 Symptom Checklist revealed that 61.2% (n = 74) engaged in pathogenic behaviors, with dieting being the most common (51.2%, n = 62). Most (76.0%, n = 92) displayed LEA with an ED risk. No differences were found in LEA by ED risk and sport type. Softball players reported the most LEA with an ED risk (82.4%, n = 14), followed by ballet dancers (76%, n = 19).

Conclusions: Our results suggested that a large proportion of collegiate female athletes and performing artists were at risk for LEA with an ED risk, thus warranting education, identification, prevention, and intervention strategies relative to fueling for performance.

Key Words: female athlete triad, pathogenic behaviors, disordered eating, ballet

Key Points

- More than 75% of female athletes and performing artists exhibited low energy availability with an eating disorder risk.
- Participants were engaging in high rates of pathogenic behaviors, specifically dieting and exercise to control their weight.
- Clinicians should implement appropriate recognition prevention, intervention, and treatment strategies for patients who are at risk for low energy availability, with or without an eating disorder, and engaging in pathogenic behaviors.

The importance of proper fueling for performance in female athletic populations has been highlighted for decades. Pressure to maintain a low body weight and a lean, aesthetic appearance in competitive sports and the performing arts has the potential to predispose athletes and performing artists to substantial health risks. Of these health risks, the *female athlete triad* (Triad), which includes low energy availability (LEA) with or without an eating disorder, functional hypothalamic amenorrhea, and osteoporosis, is a serious condition with potentially long-term, irreversible health consequences that can affect the athlete's cardiovascular, endocrine, reproductive, skeletal, gastrointestinal, renal, and central nervous systems and mental health.[1,2] In 2014, the International Olympic Committee (IOC) defined relative energy deficiency in sport (RED-S)[3] and expanded the Triad concept to encompass impaired physiological functions caused by relative energy deficiency. The *RED-S* condition includes but is not limited to impairments in metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health. The IOC has acknowledged both LEA and relative energy deficiency within its conceptual framework.[3] However, what differentiates RED-S from the Triad is the suggestion that LEA can occur even when energy intake (EI) and total daily energy expenditure (TDEE) are balanced, meaning no overall energy deficit exists.[2,3] Despite these differences, RED-S stresses the importance of examining the Triad components, specifically LEA with or without eating disorder and the disordered eating risk. Athletic trainers (ATs) are an integral part of the sports medicine team and are well positioned to prevent, identify, treat, and manage athletes with LEA. However, in a recent study, Kroshus et al[4] found that most ATs were aware of the Triad components primarily associated with disordered eating, which was a component in the 1997 definition.[5] Therefore, it is important for ATs to fully understand the interrelated components of the updated Triad and RED-S as they relate to LEA or energy deficiency.

Approximately 16% of physically active females demonstrated all 3 Triad components; 27% had 2 components and as many as 60% had at least 1 component.[6] Low energy availability is the most prevalent Triad component and the underlying cause of the physiological changes to both the reproductive system and bone seen in the Triad.[1–3] The prevalence of LEA has been documented predominately in college-aged athletes.[7–12] *Energy availability* (EA) is the amount of dietary energy that remains after exercise and is available for other physiological functions (eg, organs, muscles). Energy availability reaches low levels by either unintentional or intentional (ie, disordered eating, clinical eating disorder, inadvertent undereating) methods.[1–3,13] Unintentional LEA often occurs because individuals are unaware of the amount of energy needed to support the exercise in which they are participating. On the other hand, intentional LEA can occur when individuals intentionally increase their exercise energy expenditure (EEE) beyond EI or choose to reduce EI.[2] Methods of intentionally reducing EI include pathogenic behaviors, such as binge eating, purging, self-induced vomiting, using diet pills or laxatives, and excessively exercising and fasting.[14] Athletes using these pathogenic behaviors to lose weight may have additional health and performance consequences, including dehydration, electrolyte imbalances, and gastrointestinal problems.[15] Furthermore, these pathogenic behaviors can morph into clinical eating disorders if patients are not managed and treated appropriately.

The eating disorder prevalence is approximately 20% in adult female athletes, and the prevalence differs greatly among sports.[16–19] Overall, the eating disorder risk may be elevated when females participate in sports that emphasize appearance, weight requirements, or muscularity (eg, gymnastics, cheerleading). This risk stems from an overvalued belief that a lower body weight will enhance performance, social pressures in Western culture to be thin, early specialization in sport, physique-revealing uniforms, and pressure from coaches to lose weight.[17,18,20] Although the Triad and eating disorder risk have been researched for decades[2] and current LEA and eating disorder risks in females who participate in competitive sports and performing arts have been documented independently,[9,11,12,17–19,21] few researchers have examined LEA with or without an eating disorder risk simultaneously and within a free-living environment. Therefore, the primary purpose of our study was to examine LEA with or without eating disorder risk in females who participate in collegiate competitive sports and performing arts. A secondary purpose was to examine the differences between sport type and LEA with the overall eating disorder risk.

METHODS

We used a cross-sectional study design within a free-living environment (data collected during normal activities of daily living and not in a controlled laboratory setting). The data presented here are part of a larger investigation, and the procedures (eg, energy assessments for EA, eating disorder risk) are replicated from a study[22] conducted by our research team. A convenience sample of National Collegiate Athletic Association (NCAA) Division I female athletes and collegiate performing artists (N = 121) in the disciplines of equestrian (n = 28), soccer (n = 20), beach volleyball (n = 18), softball (n = 17), volleyball (n = 12), and ballet (n = 26) participated in this study. Recruits were included if they were female and currently training (ie, engaging in planned exercise with their team). Volunteers were excluded if they were not currently participating in a sport or performing art, had a previous eating disorder, had an injury preventing them from exercising, or did not fully complete all parts of the study. All participants provided written informed consent, and the University of South Carolina's Institutional Review Board approved the study.

Demographic and Anthropometric Measurements

Participants completed a basic demographic survey and self-reported measurements, providing age, sex, academic status (ie, freshman, sophomore, junior, senior), sport, height, weight, ideal weight, and mental weight (perceived weight if she did not try to control her weight), and pertinent health history. We used a stadiometer (Shorr Productions) to measure height to the nearest 0.1 cm and a scale (model 331S; Tanita) to measure weight to the nearest 0.01 kg with participants wearing minimal clothes. Body fat percentage was assessed using dual-energy x-ray absorptiometry (Lunar Prodigy densitometer; GE Healthcare).

Resting Metabolic Rate

We determined the participants' total calories used at rest by measuring the resting metabolic rate (RMR) via indirect calorimetry using the Microlite MedGem (HealtheTech). The MedGem has been clinically validated for assessing RMR and has an interclass reliability range of 0.91 to 0.97 (mean = 0.94).[23]

Energy Availability

Energy availability was calculated by subtracting the energy expended through the metabolic demand of exercise from the dietary EI. It is expressed in kilocalories per kilogram of fat-free mass (EA = [EI − EEE]/kg/FFM). *Low energy availability* was defined as an EA level ≤30 kcal/kg of fat-free fat mass.[2]

Energy Intake

Energy intake was assessed and analyzed using online daily food logs (ESHA Food Processor 8.0; FoodProdigy) for 7 consecutive days. Participants were instructed about portion sizes and provided with at-home examples for their logs. The food logs were assessed for total kilocalories and macronutrient intake (proteins, carbohydrates, and fats). We measured intake on 7 consecutive days to minimize daily bias.[24]

Total Daily Energy Expenditure and EEExpenditure

Total daily energy expenditure is the amount of energy required for essential life processes to occur; the energy expended to digest, absorb, and convert food; and the energy expended during physical activity and recovery. We used the SenseWear Armband (BodyMedia Inc) with an accelerometer to continuously monitor TDEE and EEE. The armband is valid for assessing energy expenditure in free-living conditions for adults (intraclass correlation = 0.81).[25] It was initiated using the manufacturer's software and synchronized with the metabolic measurements system. The sex, age, height, and weight of each person were programmed to her armband, which she was required to wear approximately 23 h/d for 7 consecutive days. Participants who were unable to wear the armband self-reported exercise and physical activity using FoodProdigy for 7 consecutive days. They recorded exercise duration, mode, and intensity, and we used the compendium of physical activity to determine the appropriate metabolic equivalent for the exercise performed.[26,27] Exercise energy expenditure was estimated using the following equation: EEE = duration (minutes) $\times$ 3.5 $\times$ weight (kilograms)/200.[28]

Eating Disorder Risk and Pathogenic Behavior

The eating disorder risk was assessed using the Eating Disorder Inventory-3 (EDI-3). This self-reported measure for identifying eating disorder patterns and associated psychological constructs[29] contains 91 items organized into scales: Drive for Thinness, Bulimia, Body Dissatisfaction, Low Self-Esteem, Personal Alienation, Interpersonal Insecurity, Interpersonal Alienation, Interoceptive Deficits, Emotional Dysregulation, Perfectionism, Asceticism, and Maturity Fears. The EDI-3 comprises 6 composites: eating disorder-specific (eating disorder risk) and general integrative psychological constructs (ineffectiveness, interpersonal problems, affective problems, overcontrol, and general psychological maladjustment). It is valid in individuals aged 13 to 53 years for identifying disordered eating patterns and has high reliability (Cronbach α mean = 0.94, range = 0.90–0.97).[29] The coefficient and median values for specific composites include $r = 0.98$ and median = 0.95 for eating disorder risk and $r = 0.97$ and median = 0.93 for general psychological maladjustment.[29] The EDI-3 Symptom Checklist (EDI-3 SC) was used to identify the symptoms associated with and frequency of eating disorder risk behaviors, such as binge eating; self-induced vomiting; exercise patterns; and use of laxative, diet pills, and diuretics. Participants must have at least 1 composite score at the typical clinical or elevated clinical level or meet the criteria for pathogenic behavior risk, or both, to be considered at risk for an eating disorder.

Procedures

Participants were recruited at a local NCAA Division I university through the sports medicine department during a formal recruiting meeting with each team to describe the study. Interested individuals completed a short survey to determine if they met the inclusion criteria. Another team meeting with interested individuals was scheduled to review the study details and sign the consent forms. Participants provided consent, completed anthropometric measurements, provided RMR, scheduled a dual-energy x-ray absorptiometry, and completed the EDI-3 and EDI-SC. We gave written and oral overviews of the weekly procedures, which included detailed instructions about using the food and exercise logs and the armband. They began self-reporting food and fluid consumption and any planned and intentional exercise in the online log starting at the end of the information session and continuing for 7 consecutive days. We emphasized the importance of continuing their normal exercise and sport-related practices and food and fluid consumption during the 7 days. After the 7 days, participants returned the armband and emailed the food and exercise logs to the researchers. All data collection was conducted during weeks without scheduled competitions or performances.

Data Analysis

We used SPSS (version 26; IBM Corp) for all statistical analyses and G*Power[30] (version 3.1.9.4; Heinrich-Heine Universität) software to calculate power. For an α level of .05 and a moderate effect size of 0.4, our calculation indicated we needed a sample of 103 total participants for an estimated power of 0.90. Using an α level of .05 and a large effect size of 0.6, our calculation indicated we needed a sample of 17 participants within each sport for an estimated power of 0.90. Descriptive statistics (mean $\pm$ SD) for all dependent variables were determined. The significance level was set at $P < .05$ for all analyses. Frequencies and proportions with 95% CIs were calculated for categorical variables (ie, EA risk, eating disorder risk, pathogenic behaviors) along with means $\pm$ SDs for continuous variables (ie, RMR, TDEE, EI, EEE, EA). Analyses of variance (ANOVAs) were conducted to examine differences between sport type and energy assessment variables (eg, RMR, EI, EEE) and among raw scores on the EDI-3. A post hoc Tukey test was applied to examine differences among sport types. Chi-square analysis was performed to determine the differences between LEA and sport type, LEA and eating disorder risk, eating disorder risk and sport type, and pathogenic behaviors and sport type.

RESULTS

Demographics and Anthropometric Measurements

Appropriate statistical power was achieved when 121 female athletes and performing artists completed the study. We also met power requirements for participants within each group for all sports except volleyball (n = 12). Anthropometric measurements and self-reported data can be found in Table 1. Most individuals were able to wear the Sensewear armbands throughout the study; only 7 had complications (eg, dead battery, needed to charge battery, forgot to put on after showering). Time without the armband ranged from 1 to 6 hours, and TDEE was calculated using the compendium of physical activities.[26,27]

Table 1. Participant Demographics (Mean ± SD)

Characteristic	All	Athletes or Performing Artists, Mean ± SD						*P* Value
		Equestrian	Soccer	Beach Volleyball	Softball	Volleyball	Ballet	
Age, y	19.8 ± 2.0	19.4 ± 1.3	19.8 ± 1.3	19.9 ± 1.5	19.6 ± 1.1	19.2 ± 1.3	20.5 ± 3.6	.43
Height, cm	168.9 ± 7.7	166.3 ± 5.2	168.0 ± 10.4	174.5 ± 5.6	168.6 ± 5.3	176.4 ± 6.3	165.3 ± 6.9	.001
Mass, kg	63.6 ± 9.3	61.8 ± 7.2	65.4 ± 9.3	63.3 ± 5.1	72.5 ± 11.2	68.4 ± 6.3	56.4 ± 7.0	.001
Body mass index	22.7 ± 3.5	24.1 ± 4.8	23.2 ± 2.5	20.8 ± 1.6	25.5 ± 3.4	22.0 ± 1.7	20.6 ± 1.8	.001
Ideal weight, kg	61.4 ± 8.0	58.8 ± 5.5	62.9 ± 6.7	63.5 ± 5.5	68.6 ± 9.4	67.1 ± 5.9	54.4 ± 5.5	.001
Current ideal weight, kg[a]	2.2 ± 3.9	3.0 ± 3.2	2.5 ± 5.3	−0.2 ± 3.0	3.9 ± 5.1	1.4 ± 3.4	2.0 ± 3.0	.03
Mental weight, kg	65.3 ± 9.0	63.2 ± 7.4	63.9 ± 7.8	66.0 ± 5.7	74.0 ± 12.0	69.1 ± 6.5	60.6 ± 7.9	.001
Current mental weight, kg[b]	−1.7 ± 4.7	−1.4 ± 3.1	1.4 ± 5.6	−2.7 ± 2.2	−1.5 ± 3.2	−0.7 ± 2.9	−4.2 ± 6.5	.001
Body fat, %	26.1 ± 5.4	29.4 ± 4.6	25.5 ± 5.4	20.4 ± 3.7	22.4 ± 5.2	22.1 ± 3.6	28.0 ± 3.7	.001
Fat-free mass, kg	48.4 ± 4.9	46.5 ± 4.0	49.0 ± 4.8	50.3 ± 3.5	50.6 ± 5.8	52.0 ± 3.7	45.6 ± 4.4	.001

[a] Current ideal weight was calculated as mass minus ideal weight.
[b] Current mental weight was calculated as mass minus mental weight.

Energy Assessment

Overall, 81% (n = 98) of participants displayed LEA. Differences occurred between sport type and LEA ($\chi^2_5 = 43.8$, $P < .001$), with the distribution among sport types as follows: ballet, 20.7% (n = 25); equestrian, 19.0% (n = 23); softball, 14% (n = 17); beach volleyball, 14.0% (n = 17); volleyball, 8.3% (n = 10); and soccer, 5% (n = 6). Within individual sport types, LEA was present in 100% (n = 17/17) of softball, 96.2% (n = 25/26) of ballet, 94.4% (n = 17/18) of beach volleyball, 83.3% (n = 10/12) of volleyball, 82.1% (n = 23/28) of equestrian, and 30% (n = 6/20) of soccer participants. One-way ANOVAs revealed differences between sport type and all energy assessment variables (eg, RMR, TDEE, EEE; Table 2). The EI for soccer was larger than that for all other sports ($P < .01$), whereas the EI for volleyball was different from that for all sports ($P < .01$) except equestrian. The EEE for soccer was different ($P < .01$) from that of all other sports.

Eating Disorder Risk and Pathogenetic Behaviors

Overall, 76.0% (n = 92) of participants presented with an eating disorder risk (based on the EDI-3, EDI-SC, or both) with no difference among sport types ($P = .94$). Within sport types, softball displayed the highest eating disorder risk (82.4%; 14/17), followed by equestrian (78.6%; 22/28), ballet (76.9%; 20/26), soccer (75%; 15/20), beach volleyball (72.2%; 13/18), and volleyball (66.7%; 8/12). Raw scores for the EDI-3 subscales are shown in Table 3. Differences were present between sport type and the Drive for Thinness raw score ($P = .03$), with ballet and beach volleyball participants displaying the highest scores, and Perfectionism ($P = .048$), with softball and equestrian athletes displaying the highest raw scores. No differences were noted between sport type and any other psychological scale raw scores; however, differences were demonstrated between bulimia scale risk frequency and sports and the performing arts ($\chi^2_5 = 13.8$, $P = .02$), with beach volleyball displaying the highest risk (50%, 9/18). Categorization of individuals by typical clinical and elevated clinical scores for the subscales is provided in Table 4. The EDI-3 SC revealed that 61.2% (n = 74) were at risk for an eating disorder because they engaged in pathogenic behaviors. Overall, 47.1% (n = 57) of female athletes and performing artists reported engaging in 1 to 2 pathogenic behaviors, 9.8% (n = 12) in 3 to 4, and 4.1% (n = 5) in >5. Dieting was the most common pathogenic behavior (51.2%, n = 62), followed by exercise to control weight (38%, n = 46), binge eating (19.8%, n = 24), and purging (12.5%, n = 15; Table 5). The only difference was between sport type and dieting ($\chi^2_5 = 12.4$, $P = .03$), with ballet having the largest overall percentage of participants dieting (69.2%, n = 18).

Energy Availability With or Without an Eating Disordered Risk

Values for LEA, eating disorder risk, and LEA with eating disorder risk are given in Table 6. When examining LEA with or without an eating disorder risk, we observed that 76.0% (n = 92) of all female athletes and artists displayed LEA with an eating disorder risk. No differences were found between sport type and LEA with eating disorder risk. However, LEA with an eating disorder risk was highest for softball (82.4%, n = 14), followed by ballet (76%, n = 19) participants.

DISCUSSION

Low Energy Availability

To our knowledge, we are the first to examine a variety of female collegiate competitive athletes and performing

Table 2. Participants' Energy Need Assessments Extended on Next Page

Energy Needs	All	Athletes or Performing Artists, Mean ± SD			
		Equestrian	Volleyball	Softball	Beach Volleyball
Resting metabolic rate, kcal	1459.4 ± 312.2	1444.3 ± 231.5	1408.3 ± 197.1	1873.5 ± 276.8	1477.8 ± 272.3
Total daily energy expenditure, kcal	2428.4 ± 144.7	2389.6 ± 116.7	2536.8 ± 113.9	2550.8 ± 172.4	2446.6 ± 86.1
Energy intake, kcal	1553.6 ± 862.7	1105.0 ± 164.2	1785.6 ± 460.1	1338.3 ± 313.5	1281.2 ± 106.8
Exercise energy expenditure, kcal	825.8 ± 350.3	403.2 ± 161.9	838.2 ± 77.6	811.2 ± 130.5	1108.7 ± 157.6
Energy availability, kcal/kg fat-free mass	19.5 ± 16.1	21.9 ± 9.9	18.6 ± 10.9	7.8 ± 6.4	12.44 ± 9.6

[a] Indicates difference ($P < .05$).

Table 3. Eating Disorder Characteristics

Scale and Subscale	Athletes or Performing Artists, Mean ± SD of Raw Scores						*P* Value
	Equestrian	Volleyball	Softball	Beach Volleyball	Ballet	Soccer	
Eating disorders risk subscales							
Drive for Thinness	8.1 ± 7.1	3.8 ± 4.7	3.6 ± 3.4	8.4 ± 7.1	8.5 ± 7.2	4.9 ± 6.3	.03[a]
Bulimia	2.6 ± 2.9	2.4 ± 3.6	1.4 ± 1.8	4.6 ± 4.5	2.8 ± 3.4	3.0 ± 3.2	.13
Body Dissatisfaction	11.1 ± 6.8	7.4 ± 6.7	9.2 ± 5.4	10.3 ± 8.3	14.3 ± 9.1	9.4 ± 7.8	.10
Psychological subscales							
Low Self-Esteem	6.4 ± 20.4	1.3 ± 1.8	2.2 ± 2.1	1.9 ± 3.4	3.8 ± 3.6	3.4 ± 4.4	.63
Personal Alienation	3.3 ± 3.5	2.6 ± 2.6	3.2 ± 3.5	3.5 ± 4.5	4.3 ± 3.9	3.6 ± 3.0	.81
Interpersonal Insecurity	5.3 ± 4.1	5.7 ± 6.1	6.7 ± 3.9	4.9 ± 5.6	6.1 ± 4.4	5.2 ± 3.8	.85
Interpersonal Alienation	6.9 ± 6.8	3.7 ± 2.6	4.2 ± 3.0	4.8 ± 3.9	4.2 ± 4.1	6.0 ± 4.5	.19
Interceptive Deficits	5.4 ±11.8	2.9 ± 3.0	5.4 ± 4.9	5.2 ± 6.0	4.2 ± 4.4	6.8 ± 5.1	.75
Emotional Dysregulation	1.8 ± 1.8	2.6 ± 3.7	3.0 ± 4.0	2.2 ± 2.8	1.7 ± 2.2	2.6 ± 2.0	.57
Perfectionism	13.2 ± 5.8	10.8 ± 4.3	15.1 ± 5.3	9.9 ± 4.8	12.0 ± 4.5	12.7 ± 4.7	.048[a]
Asceticism	4.3 ± 4.3	3.3 ± 2.4	4.1 ± 3.7	4.2 ± 2.7	5.5 ± 3.4	4.8 ± 2.9	.59
Maturity Fears	6.5 ± 3.7	8.4 ± 3.1	7.5 ± 4.1	6.9 ± 4.0	6.3 ± 3.4	8.5 ± 5.2	.36
Composite							
Eating disorder risk	95.9 ± 26.2	93.1 ± 16.3	93.5 ± 11.0	105.4 ± 20.6	107.1 ± 21.3	97.3 ± 19.1	.13
Ineffectiveness	66.0 ± 10.0	60.1 ± 10.0	65.4 ± 8.6	65.2 ± 12.7	69.8 ± 11.6	67.8 ± 11.4	.21
Interpersonal problems	81.0 ± 12.4	77.9 ± 12.9	77.1 ± 21.1	78.9 ± 15.6	79.8 ± 13.2	81.7 ± 13.7	.93
Affective problems	70.4 ± 9.1	72.9 ± 9.0	76.8 ± 12.1	75.2 ± 11.4	72.8 ± 8.1	77.5 ± 4.6	.12
Overcontrol	84.0 ± 1.2	78.3 ± 9.1	87.7 ± 13.2	78.6 ± 9.2	84.0 ± 11.6	84.1 ± 11.6	.22
General psychological maladjustment	346.1 ± 35.5	338.3 ± 27.4	355.7 ± 32.7	342.1 ± 41.0	349.7 ± 37.7	357.6 ± 30.8	.58

[a] Indicates difference ($P < .05$).

artists in a free-living environment (ie, real time) for LEA with or without a concurrent eating disorder risk. Comparatively, previous authors have primarily focused on LEA or eating disorder risk independently within individual sports and the performing arts (eg, indoor volleyball, soccer, gymnastics, ballet),[7–9,11,12,31] with limited research conducted on both LEA and eating disorder risk among multiple sports and within the collegiate setting.[21,32] Overall, our participants' LEA prevalence (81%) was higher than LEA levels reported in gymnasts (44.8%), soccer players during the preseason (26.3%) and midseason (33.3%), and in-season volleyball players (20%).[9,11,12] These investigators used methods similar to ours: EI and EEE were measured, and then EA was calculated. In comparison, Ackerman et al[21] used 3 eating disorder or disordered eating screening instruments as surrogates for determining the LEA risk and described a range of 12.3% to 39.1% for eating disorder risk. Our high LEA prevalence might have been due to several factors, including participants being part of an aesthetic sport or dance that required tight or revealing clothing (ie, equestrian, beach volleyball, volleyball, performing artists)[17,19] or engaging in unintentional energy expenditure, such as increases in EEE, decreases in EI, or intentional restriction. All softball athletes in our study reported LEA. Although softball is not considered an aesthetic sport, the pressure to maintain weight may also apply to these athletes. Those involved in activities that require or accept restriction of EI despite the high level of energy needed for the activity were at the greatest risk for LEA.[2,15,19] However, it is equally important to examine athletes who are not lean (eg, softball, soccer players), as they demonstrated the highest risk in our assessment.

Table 2. Extended From Previous Page

Athletes or Performing Artists, Mean ± SD		$F_{5,120}$ Value	*P* Value
Ballet	Soccer		
1155.8 ± 206.5	1537.6 ± 204.1	20.3	<.001[a]
2297.1 ± 127.3	2468.3 ± 61.4	13.4	<.001[a]
1473.9 ± 312.5	3214.3 ± 818.4	92.1	<.001[a]
810.9 ± 408.1	1187.2 ± 39.7	36.8	<.001[a]
12.2 ± 11.3	42.3 ± 18.4	22.1	<.001[a]

Softball athletes had the highest RMR values compared with participants in all other sports, which may have been due to their greater body mass. In comparison, ballet dancers displayed the lowest RMR and the lowest body mass. Although softball athletes had a higher RMR, their average daily EI was low, and they did not meet the minimal needs for RMR. Soccer athletes reported the highest EI (3214.3 ± 818.4 kcal) compared with participants in all other sports and the performing arts. This may have reflected the timing of data collection during their fall preseason; all soccer athletes were required to eat as a team in the dining hall 3 times per day and were not taking classes. Also, preseason training in extreme temperatures 2 times per day resulted in an increased energy demand. Whereas soccer had the highest EI compared with all other sport types, the value was consistent with the literature (eg, indoor volleyball, ballet, soccer, and gymnastics ranged from 1506 to 3435 kcal/d; Table 7).[7–12,31]

With respect to EEE, equestrian athletes described a lower EEE than all other participants. This may have been due to equestrian athletes training only 3 to 4 d/wk compared with athletes in other sports who trained 5 to 6 d/wk. Soccer and beach volleyball players indicated higher EEEs, but these may be attributed to soccer data being collected during preseason, when the team practiced 1 to 2 times per day, and beach volleyball requiring increased energy to run and jump in sand compared with traditional indoor volleyball. Collegiate ballet dancers engaged in higher EEE than did vocational ballet dancers (810.9 ± 408.1 versus 344 ± 98 kcal) and were similar to gymnasts

Table 4. Eating Disorder Characteristics for All Athletes and Performing Artists (N = 121)

Scale and Subscale	Raw Score, Mean ± SD	Score Frequency, % (No.)		
		Low Clinical	Typical Clinical	Elevated Typical
Eating disorders risk subcale				
Drive for Thinness	6.7 ± 6.6	90.1 (109)	8.3 (10)	1.7 (2)
Bulimia[a]	2.8 ± 3.3	79.3 (96)	20.7 (25)	0 (0)
Body Dissatisfaction	10.7 ± 7.7	90.9 (110)	8.3 (10)	0.8 (1)
Psychological subscale				
Low Self-Esteem	3.6 ± 10.2	90.1 (109)	9.9 (12)	0 (0)
Personal Alienation	3.5 ± 3.6	91.7 (111)	8.3 (10)	0 (0)
Interpersonal Insecurity	5.6 ± 4.5	63.6 (77)	32.2 (39)	4.1 (5)
Interpersonal Alienation	5.2 ± 4.7	64.5 (78)	30.6 (37)	5.0 (6)
Interceptive Deficits	5.1 ± 7.0	90.1 (109)	9.9 (12)	0 (0)
Emotional Dysregulation	2.2 ± 2.7	77.7 (94)	19.8 (24)	2.5 (3)
Perfectionism	12.4 ± 5.1	36.4 (44)	43.0 (52)	20.7 (25)
Asceticism	4.5 ± 3.4	87.6 (106)	11.6 (14)	0.8 (1)
Maturity Fears	7.2 ± 4.0	40.5 (49)	51.2 (62)	8.3 (10)
Composite				
Eating disorder risk	99.4 ± 20.9	96.7 (117)	3.3 (4)	0 (0)
Ineffectiveness	66.3 ± 11.0	93.4 (113)	6.6 (8)	0 (0)
Interpersonal problems	79.7 ± 14.6	70.2 (85)	26.4 (32)	3.3 (4)
Affective problems	73.9 ± 9.7	93.4 (113)	5.0 (6)	1.7 (2)
Overcontrol	83.2 ± 12.4	72.7 (88)	24.0 (29)	3.3 (4)
General psychological maladjustment	348.8 ± 34.9	92.6 (112)	7.4 (9)	0 (0)

[a] Difference between bulimia frequency risk and sport/performing art ($P = .02$).

(899.1 ± 222.4 kcal; Table 7).[7,9] Our indoor collegiate volleyball players' EEE was greater than that of varsity volleyball players during practice (838.2 ± 77.6 versus 511 ± 216 kcal),[11] whereas our soccer players' EEE was greater than that of soccer players during preseason in a previous study (1187.2 ± 39.7 kcal versus 786–913 kcal).[12] Overall, our EEE findings were consistent with those of previous researchers (Table 7), which demonstrates that our method of evaluation in a free-living environment was clinically relevant. The free-living environment allowed us to capture real-time data during activities of daily living and planned and intentional exercise (eg, practice, strength and conditioning workouts) compared with a structured laboratory design. Capturing EEE also enables clinicians to determine whether athletes and artists have LEA due to decreases in EI, increases in EEE, or both, which can help inform recommendations that athletes and performing artists increase EI or decrease EEE until they are energy balanced.

Eating Disorder Risk

Using a multidimensional approach, we concluded that 76% of female athletes and performing artists were at risk for eating disorders, which is a higher value than that reported in earlier studies of female athletes and dancers.[16–19] The Eating Attitudes Test,[33] Eating Disorder Diagnostic Scale,[34] Eating Disorder Examination Questionnaire,[35] and EDI-3 are commonly used assessment tools (22–31 questions) for identifying the eating disorder risk associated with attitudes and behaviors; however, they do not assess other comorbid psychological factors as the EDI-3 does. The higher risk in our study may be associated with the EDI-3 assessment tool. The EDI-3 and EDI-3 SC address psychological constructs for both

Table 5. Pathogenic Behaviors "At Risk" for Associated Behavior

Pathogenic Behavior	All (N = 121)	Athletes or Performing Artists, % (No.)						*P* Value[a]
		Equestrian (n = 28)	Volleyball (n = 12)	Softball (n = 17)	Beach Volleyball (n = 18)	Ballet (n = 26)	Soccer (n = 20)	
Dieting	51.2 (62)	57.1 (16)	16.7 (2)	47.1 (8)	61.1 (11)	69.2 (18)	35.0 (7)	.03[b]
Binge eating	19.8 (24)	25.0 (7)	8.3 (1)	17.6 (3)	16.7 (3)	19.2 (5)	25.0 (5)	.85
Purging	12.4 (15)	7.1 (2)	0.0 (0)	5.9 (1)	16.7 (3)	26.9 (7)	10.0 (2)	.13
Use of laxatives	3.3 (4)	7.1 (2)	0.0 (0)	0.0 (0)	5.6 (1)	0.0 (0)	5.0 (1)	.60
Use of diet pills	7.4 (9)	7.1 (2)	0.0 (0)	11.8 (2)	5.6 (1)	7.7 (2)	10.0 (2)	.89
Use of diuretics	1.7 (2)	3.6 (1)	0.0 (0)	0.0 (0)	0.0 (0)	3.8 (1)	0.0 (0)	.77
Exercise to control weight								<.001[b]
0% of time	28.1 (34)	14.3 (4)	50.0 (6)	23.5 (4)	27.8 (5)	15.4 (4)	55.0 (11)	
<25% of time	33.9 (41)	25.0 (7)	33.3 (4)	23.5 (4)	38.9 (7)	57.7 (15)	20.0 (4)	
25%–50% of time	24.8 (30)	17.9 (5)	16.7 (2)	47.1 (8)	22.2 (4)	26.9 (7)	20.0 (4)	
>75% of time	7.4 (9)	21.4 (6)	0.0 (0)	5.9 (1)	5.6 (1)	0.0 (0)	5.0 (1)	
100% of time	5.8 (7)	21.4 (6)	0.0 (0)	0.0 (0)	5.6 (1)	0.0 (0)	0.0 (0)	

[a] *P* value represents comparison of pathogenic behaviors measures within sport or performing art.
[b] Indicates difference ($P < .05$).

Table 6. **Distribution of Low Energy Availability, Eating Disorder, and Low Energy Availability With Eating Disorder Risk**

Athletes or Performing Artists	Low Energy Availability, % (n/N)	Eating Disorder Risk	Low Energy Availability With Eating Disorder Risk
		% (No.)	
All	81.0 (98/121)	76.0 (92/121)	76.0 (92/121)
Equestrian	82.1 (23/28)	78.6 (22/28)	73.9 (17/23)
Volleyball	83.3 (10/12)	66.7 (8/12)	70.0 (7/10)
Softball	100 (17/17)	82.4 (14/17)	82.4 (14/17)
Beach Volleyball	94.4 (17/18)	72.2 (13/18)	70.6 (12/17)
Ballet	96.2 (25/26)	76.9 (20/26)	76.0 (19/25)
Soccer	30 (6/20)	75.0 (15/20)	66.7 (4/6)

traditional (Drive for Thinness, Bulimia, and Body Dissatisfaction) and comorbid (eg, low self-esteem, maturity fears, interpersonal alienation) constructs as well as pathogenic behavior (eg, dieting, vomiting, using diet pills). Traditionally, we would assume that athletes in aesthetic sports would present with the highest overall eating disorder risk; however, softball players displayed the highest risk, followed by ballet and equestrian participants. Whereas no differences in eating disorder risk were observed across sports and performing arts, participants in aesthetic sports and performing arts (ie, equestrian, beach volleyball, ballet) presented with higher scores in eating disorder-specific scales (Drive for Thinness, Bulimia, and Body Dissatisfaction) and Eating Disorder Risk Composite compared with those in ball or team sports (eg, softball, volleyball). It may be argued that volleyball is not an aesthetic sport. Nonetheless, the nature of the form-fitting volleyball uniform may have enhanced the eating disorder risk, as volleyball players demonstrated similar raw scores on the Drive for Thinness subscale as ballet dancers and the highest frequency risk on the Bulimia scale.

Perfectionism is the extent to which an individual drives to meet high goals and standards for personal achievement or to meet the expectations of others (ie, teammates, coaches, parents).[29] Perfectionism in sports is often seen as a positive trait and may be necessary for enhancing sport performance. However, it is also considered multidimensional and is seen among those with eating disorder risks in that being healthy is associated with perfectionistic goals or being unhealthy is associated with perfectionistic concerns.[36] Often, the desire for perfection causes stress, anxiety, or compulsiveness, which may be comorbidities to eating disorders. Softball and equestrian athletes in our study not only had the highest Perfectionism raw scores and frequencies but also the greatest eating disorder risks. This may be attributed to the increased demands of collegiate athletics and the expectation of a society that believes athletes must maintain a lean physique to be successful in sports.

A total of 61.2% of female athletes and performing artists reported engaging in pathogenic behaviors to control their weight, which aligns closely with earlier investigations.[17–19,37] Female athletes and performing artists primarily engaged in dieting and exercise to control weight but described engaging in multiple pathogenic behaviors. Our sample revealed that a higher percentage of athletes and performing artists in aesthetic sports and performing arts pursued dieting to control their weight, which is consistent with a previous study[37] comparing aesthetic with endurance or team and anaerobic sports. Thirty-eight percent of female athletes and performing artists stated they performed additional exercise (outside of normal practice) to control their weight. It is concerning that these 2 behaviors were the most used, given that dieting may result in lower EI and excessive exercise may increase EEE, the 2 components of EA. Furthermore, female athletes who engaged in these pathogenic behaviors demonstrated increased risk for LEA with an eating disorder risk.

Energy Availability With or Without an Eating Disorder Risk

Our study demonstrated a high prevalence of LEA with an eating disorder risk in female athletes and performing artists. It was also evident that the participants not only had low EI but they engaged in a variety of pathogenic behaviors to lose or maintain weight. Only 24% of athletes and performing artists presented with LEA without an eating disorder risk. Those without an eating disorder risk may respond well to nutrition education designed to reverse LEA. Individuals with a low eating disorder risk may benefit from one-on-one counseling with a mental health practitioner in addition to nutrition education by a sports dietitian, whereas those with a high eating disorder risk may require intensive interdisciplinary attention (ie, physician, dietitian, behavioral health care provider) and treatment. Overall, education is the best evidence-based method for primary prevention and should include well-being and performance health strategies.[38] Education from a sports dietitian is recommended and can be delivered in a team setting to athletes and high-performance sports system personnel (eg, ATs, coaches, strength and conditioning specialists, support staff members, team physicians). All should undergo an initial comprehensive education program and regular sessions to review updated content. Educational content that emphasizes raising nutritional literacy, promoting a healthy relationship with food and body, educating about high-performance fueling strategies, improving body image, and informing about the potential health and performance consequences has been shown to be an effective method for preventing eating disorders.[38]

Given the effect of LEA on multiple physiological systems,[2,3] it is critical that ATs and other health care professionals know how to monitor and assess athletes and performing artists for EA and eating disorder risks. Both the Female Athlete Triad Coalition (Cumulative Risk Assessment)[2] and the IOC (Clinical Assessment Tool)[39] have created screening tools to assist health care providers in assessing athletes and performing artists with energy deficits. Both tools also supply clinicians with guidelines for return to play. These tools are fairly new, and evidence regarding their use and their outcomes for guiding patients' return to play is conflicting.[40,41] We encourage clinicians to use assessment tools as a diagnostic resource in conjunction with a multidisciplinary medical team.

LIMITATIONS

Although this study revealed substantial concerns about LEA and an increased eating disorder risk for female

Table 7. Energy Need Assessment Comparison Table (Mean ± SD) Extended on Next Page

Sport or Performing Art	Resting Metabolic Rate	Total Daily Energy Expenditure	Energy Intake	Exercise Energy Expenditure
	kcal			
Ballet[a] (n = 26)	1155.8 ± 206.5	2297.1 ± 127.3	1473.9 ± 312.5	810.9 ± 408.1
Ballet[26] (n = 7)	N/A	Training: 2344 ± 126 Competition: 2221 ± 254	Training: 1701 ± 580 Competition: 1506 ± 468	NA
Ballet[5] (n = 18)	1408 ± 61	2319 ± 221	2013 ±398	344 ± 98
Ballet[6] (n = 15)	1367 ± 27	N/A	1577 ± 89	NA
Gymnastics[7] (n = 67)	1137.4 ± 112.3	N/A	16–18 y: 1629.2 ± 344.8 19–26 y: 1802.9 ± 289.4	16–18 y: 695.9 ± 223.5 19–26 y: 899.1 ± 222.4
Equestrian[a] (n = 28)	1444.3 ± 231.5	2389.6 ± 116.7	1105.0 ± 164.2	403.2 ± 161.9
Beach Volleyball[a] (n = 18)	1477.8 ± 272.3	2446.6 ± 86.1	1281.2 ± 106.8	1108.7 ± 157.6
Volleyball[a] (n = 12)	1408.3 ± 197.1	2536.8 ± 113.9	1785.6 ± 460.1	838.2 ± 77.6
Volleyball[26] (n = 8)	N/A	Training: 2211 ± 191 Competition: 2396 ±190	Training: 1541 ± 311 Competition: 2346 ±766	NA
Volleyball[8] (n = 11)	N/A	3162 ± 421.3	Pretrial: 1756 ± 557 Posttrial: 2178 ± 491.8	NA
Volleyball[9] (n = 10)	N/A	3479 ± 604	3435 ± 1172	Practice: 511 ± 216 Warm-up: 402 ± 50 Game: 848 ± 155
Softball[a] (n = 17)	1873.5 ± 276.8	2550.8 ± 172.4	1338.3 ± 313.5	811.2 ± 130.5
Soccer[a] (n = 20)	1537.6 ± 204.1	2468.3 ± 61.4	3214.3 ± 818.4	1187.2 ± 39.7
Soccer[10]	N/A	N/A		
Preseason (n = 19)			LEA: 1776 ± 86 No LEA: 3003 ± 243	LEA: 913 ± 125 No LEA: 786 ± 64
Midseason (n = 15)			LEA: 1491.0 ± 99 No LEA: 2567 ± 109	LEA: 614 ± 52 No LEA: 638 ± 36

Abbreviations: LEA, low energy availability; NA, not available.
[a] Data from current study.

athletes and performing artists, the following limitations should be recognized. We assumed that all participants provided entirely accurate and honest answers when self-reporting information and completing questionnaires. This is particularly crucial for food-log validity because respondents can adjust the log to fit social norms. For example, participants may have become more conscious and aware of their food intake, and they may have underreported if their food intake was typically higher and perceived themselves as overweight or overreported their daily food intake if they were underweight. In addition, the low EI we observed could have been unintentional or an underestimation of caloric intake. Self-reporting diet may result in hypersensitivity during reporting, especially if a participant presents with an eating disorder or disordered eating behaviors. Our sample was limited to 7 collegiate sports and performing arts at 1 NCAA Division I institution; the energy-need profiles and eating disorder risk may vary by geographic region as well as institutional level.

CONCLUSIONS

A large proportion of female athletes and performing artists in our study displayed LEA with an eating disorder risk. Because most participants displayed LEA, athletes and performing artists should receive nutritional education regarding the importance of fueling to meet the energy demands of training. All health care providers will benefit from increased education on performance nutrition and the guidelines set forth by both the Female Athlete Triad Coalition and the IOC for assessing athletes and performing artists with EA and associated signs and symptoms and returning them to play. Recognition of LEA with or without an eating disorder risk will assist in preventing serious medical consequences during training and competition and improve safety for all female athletes and performing artists. Knowledge of the Triad components and its health implications is vital for pursuing the optimal multidisciplinary treatment approach for these athletes and performing artists.

Table 7. Extended From Previous Page

Energy Availability, kcal/kg^{-1} fat-free mass
12.2 ± 11.3 LEA (n = 25): 11.5 ± 10.9 No LEA (n = 1): 30.24 ± 0
NA
39.5 ± 10.8
3.75 ± 2.2
16–18 y: 32.9 ± 12.8 19–26 y: 29.8 ± 10.8
21.9 ± 9.9 LEA (n = 23): 19.0 ± 8.0 No LEA (n = 5): 35.3 ± 5.6
12.44 ± 9.6 LEA (n = 17): 11.3 ± 8.5 No LEA (n = 1): 32.3 ± 0
18.6 ± 10.9 LEA (n = 10): 15.4 ± 8.4 No LEA (n = 2): 35.4 ± .87
NA
Pretrial: 24.0 ± 8.6 Posttrial: 29.4 ± 7.5
42.5 ± 24.6
7.8 ± 6.4 LEA (n = 17): 7.8 ± 6.4 No LEA (n = 0)
42.3 ± 18.4 LEA (n = 6): 20.2 ± 8.1 No LEA (n = 14): 51.8 ± 12.2
LEA: 19.7 ± 4.3 No LEA: 52.3 ± 5.0
LEA: 19.5 ± 2.1 No LEA: 43.0 ± 3.2

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REFERENCES

1. Nattiv A, Loucks AB, Manore MM, Sanborn CF, Sundgot-Borgen J, Warren MP. American College of Sports Medicine position stand: the female athlete triad. *Med Sci Sports Exerc*. 2007;39(10):1867–1882. doi:10.1249/mss.0b013e318149f111
2. De Souza MJ, Nattiv A, Joy E, et al. 2014 Female Athlete Triad Coalition consensus statement on treatment and return to play of the female athlete triad: 1st International Conference held in San Francisco, California, May 2012 and 2nd International Conference held in Indianapolis, Indiana, May 2013. *Br J Sports Med*. 2014;48(4):289. doi:10.1136/bjsports-2013-093218
3. 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(7):491–497. doi:10.1136/bjsports-2014-093502
4. Kroshus E, DeFreese JD, Kerr ZY. Collegiate athletic trainers' knowledge of the female athlete triad and relative energy deficiency in sport. *J Athl Train*. 2018;53(1):51–59. doi:10.4085/1062-6050-52.11.29
5. Otis CL, Drinkwater B, Johnson M, Loucks A, Wilmore J. American College of Sports Medicine position stand: the female athlete triad. *Med Sci Sports Exerc*. 1997;29(5):i–ix. doi:10.1097/00005768-199705000-00037
6. Gibbs JC, Williams NI, De Souza MJ. Prevalence of individual and combined components of the female athlete triad. *Med Sci Sports Exerc*. 2013;45(5):985–996. doi:10.1249/MSS.0b013e31827e1bdc
7. Civil R, Lamb A, Loosmore D, et al. Assessment of dietary intake, energy status, and factors associated with RED-S in vocational female ballet students. *Front Nutr*. 2018;5:136. doi:10.3389/fnut.2018.00136
8. Doyle-Lucas AF, Akers JD, Davy BM. Energetic efficiency, menstrual irregularity, and bone mineral density in elite professional female ballet dancers. *J Dance Med Sci*. 2010;14(4):146–154.
9. Silva MR, Paiva T. Low energy availability and low body fat of female gymnasts before an international competition. *Eur J Sport Sci*. 2015;15(7):591–599. doi:10.1080/17461391.2014.969323
10. Valliant MW, Pittman Emplaincourt H, Kieckhaefer Wenzel R, Hilson Garner B. Nutrition education by a registered dietitian improves dietary intake and nutrition knowledge of a NCAA female volleyball team. *Nutrients*. 2012;4(6):506–516. doi:10.3390/nu4060506
11. Woodruff SJ, Meloche RD. Energy availability of female varsity volleyball players. *Int J Sport Nutr Exerc Metab*. 2013;23(1):24–30. doi:10.1123/ijsnem.23.1.24
12. Reed JL, De Souza MJ, Kindler JM, Williams NI. Nutritional practices associated with low energy availability in Division I female soccer players. *J Sports Sci*. 2014;32(16):1499–1509. doi:10.1080/02640414.2014.908321
13. Logue D, Madigan SM, Delahunt E, Heinen M, McDonnell SJ, Corish CA. Low energy availability in athletes: a review of prevalence, dietary patterns, physiological health, and sports performance. *Sports Med*. 2018;48(1):73–96. doi:10.1007/s40279-017-0790-3
14. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. American Psychiatric Publishing; 2013:329–354.
15. Joy E, Kussman A, Nattiv A. 2016 update on eating disorders in athletes: a comprehensive narrative review with a focus on clinical assessment and management. *Br J Sports Med*. 2016;50(3):154–162. doi:10.1136/bjsports-2015-095735
16. Sundgot-Borgen J, Torstveit MK. Aspects of disordered eating continuum in elite high-intensity sports. *Scand J Med Sci Sports*. 2010;20(suppl 2):112–121. doi:10.1111/j.1600-0838.2010.01190.x
17. Torres-McGehee TM, Monsma EV, Gay JL, Minton DM, Mady-Foster AN. Prevalence of eating disorder risk and body image distortion among National Collegiate Athletic Association Division I varsity equestrian athletes. *J Athl Train*. 2011;46(4):431–437. doi:10.4085/1062-6050-46.4.431
18. Torres-McGehee TM, Monsma EV, Dompier TP, Washburn SA. Eating disorder risk and the role of clothing in collegiate cheerleaders' body images. *J Athl Train*. 2012;47(5):541–548. doi:10.4085/1062-6050-47.5.03
19. Greenleaf C, Petrie TA, Carter J, Reel JJ. Female collegiate athletes: prevalence of eating disorders and disordered eating behaviors. *J Am Coll Health*. 2009;57(5):489–495. doi:10.3200/JACH.57.5.489-496
20. Cafri G, Yamamiya Y, Brannick M, Thompson JK. The influence of sociocultural factors on body image: a meta-analysis. *Clin Psychol*. 2005;12(4):421–433.
21. Ackerman KE, Holtzman B, Cooper KM, et al. Low energy availability surrogates correlate with health and performance

consequences of relative energy deficiency in sport. *Br J Sports Med*. 2019;53(10):628–633. doi:10.1136/bjsports-2017-098958
22. Torres-McGehee TM, Emerson DM, Moore EM, et al. Energy balance, eating disorder risk, and pathogenic behaviors among athletic trainers. *J Athl Train*. 2021;56(3):311–320. doi:10.4085/0228-20
23. McDoniel SO. A systematic review on use of a handheld indirect calorimeter to assess energy needs in adults and children. *Int J Sport Nutr Exerc Metab*. 2007;17(5):491–500. doi:10.1123/ijsnem.17.5.491
24. Ortega RM, Pérez-Rodrigo C, López-Sobaler AM. Dietary assessment methods: dietary records. *Nutr Hosp*. 2015;31(suppl 3):38–45. doi:10.3305/nh.2015.31.sup3.8749
25. St-Onge M, Mignault D, Allison DB, Rabasa-Lhoret R. Evaluation of a portable device to measure daily energy expenditure in free-living adults. *Am J Clin Nutr*. 2007;85(3):742–749. doi:10.1093/ajcn/85.3.742
26. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*. 2000;32(suppl 9):S498–S504. doi:10.1097/00005768-200009001-00009
27. Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011 Compendium of physical activities: a second update of codes and MET values. *Med Sci Sports Exerc*. 2011;43(8):1575–1581. doi:10.1249/MSS.0b013e31821ece12
28. Gibson AL, Wagner DR, Heyward VH. Designing cardiorespiratory exercise programs. In: Gibson AL, Wagner DR, Heyward VH, eds. *Advanced Fitness Assessment and Exercise Prescription*. 8th ed. Human Kinetics; 2019:125–158.
29. Garner DM. *EDI-3—Eating Disorder Inventory: Professional Manual*. Psychological Assessment Resources, Inc; 2004.
30. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Res Meth*. 2007;39(2):175–191.
31. Hassapidou MN, Manstrantoni A. Dietary intakes of elite female athletes in Greece. *J Hum Nutr Diet*. 2001;14(5):391–396. doi:10.1046/j.1365-277x.2001.00307.x
32. Koehler K, Achtzehn S, Braun H, Mester J, Schaenzer W. Comparison of self-reported energy availability and metabolic hormones to assess adequacy of dietary energy intake in young elite athletes. *Appl Physiol Nutr Metab*. 2013;38(7):725–733. doi:10.1139/apnm-2012-0373
33. Garner DM, Olmsted MP, Bohr Y, Garfinkel PE. The eating attitudes test: psychometric features and clinical correlates. *Psychol Med*. 1982;12(4):871–878. doi:10.1017/s0033291700049163
34. Stice E, Fisher M, Martinez E. Eating disorder diagnostic scale: additional evidence of reliability and validity. *Psychol Assess*. 2004;16(1):60–71. doi:10.1037/1040-3590.16.1.60
35. Berg KC, Peterson CB, Frazier P, Crow SJ. Psychometric evaluation of the eating disorder examination and eating disorder examination-questionnaire: a systematic review of the literature. *Int J Eat Disord*. 2012;45(3):428–438. doi:10.1002/eat.20931
36. Prnjak K, Jukic I, Tufano JJ. Perfectionism, body satisfaction and dieting in athletes: the role of gender and sport type. *Sports (Basel)*. 2019;7(8):181. doi:10.3390/sports7080181
37. Beals KA, Manore MM. Disorders of the female athlete triad among collegiate athletes. *Int J Sport Nutr Exerc Metab*. 2002;12(3):281–293. doi:10.1123/ijsnem.12.3.281
38. Wells KR, Jeacocke NA, Appaneal R, et al. The Australian Institute of Sport (AIS) and National Eating Disorders Collaboration (NEDC) position statement on disordered eating in high performance sport. *Br J Sports Med*. 2020;54(21):1247–1258. doi:10.1136/bjsports-2019-101813
39. Mountjoy M, Sundgot-Borgen J, Burke L, et al. RED-S CAT. Relative Energy Deficiency in Sport (RED-S) Clinical Assessment Tool (CAT). *Br J Sports Med*. 2015;49(7):421–423. doi:10.1136/bjsports-2015-094873
40. Koltun KJ, Strock NCA, Southmayd EA, Oneglia AP, Williams NI, De Souza MJ. Comparison of Female Athlete Triad Coalition and RED-S risk assessment tools. *J Sports Sci*. 2019;37(21):2433–2442. doi:10.1080/02640414.2019.1640551
41. Holtzman B, Tenforde AS, Parziale AL, Ackerman KE. Characterization of risk quantification differences using Female Athlete Triad Cumulative Risk Assessment and Relative Energy Deficiency in Sport Clinical Assessment Tool. *Int J Sport Nutr Exerc Metab*. 2019;29(6):569–575. doi: 10.1123/ijsnem.2019-0002.

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