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Original Research

Relative Energy Deficiency in Sport (REDs): Risk Assessment in Collegiate Female Athletes

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Abstract

International Journal of Exercise Science 19(6): 6004, 2026. Alterations in energy intake (EI) and exercise energy expenditure (EEE) may increase low energy availability (LEA) risk in Division II female collegiate athletes. Chronic LEA can transition to problematic LEA, leading to Relative Energy Deficiency in Sport (REDs). The purpose of this study was to assess the current severity and prevalence of REDs using the REDs Clinical Assessment Tool 2 (CAT2) and the Female Athlete Triad Cumulative Risk Assessment tool (FAT CRA) in Division II collegiate female ball sport athletes. Twenty-seven female athletes (volleyball, soccer, basketball, and rugby) at Central Washington University were included. Participants reported demographics; history of injuries, depression, and eating disorders (EDs); Eating Disorder Examination Questionnaire (EDE-Q), Low Energy Availability in Females Questionnaire (LEAF-Q) and dual X-ray absorptiometry (DXA) of the lumbar spine, hips, and whole body to determine REDs risk using the REDs CAT2 Tool and Triad risk using the FAT CRA. 85.2% (n=23) of athletes had no or low risk of REDs, while 15% (n=4) had a mild risk. An elevated EDE-Q score had a higher prevalence in the yellow group ($p<0.001$), and global and shape concern were strongly associated with ($r_s(25) = 0.61$, $p<0.001$), ($r_s(25) = 0.6$, $p<0.001$) an increased REDs risk. In this cohort of athletes, REDs risk was low, with an elevated EDE-Q global score serving as the most prevalent primary indicator contributing to risk for REDs. Our findings suggest that disordered eating risk may be just as influential as physiological markers in identifying athletes at risk for REDs.

Keywords: Problematic low energy availability, disordered eating, ball sport athletes, female athletes.

Introduction

Athletes are driven by strong internal and external pressures to perform at a high level.[1] Performance pressure can contribute to situations that may intentionally or unintentionally alter energy intake and exercise energy expenditure, resulting in low energy availability (LEA).[1] These scenarios include eating disorders, disordered eating (DE), and unintentional under fueling.[2] Unintentional under fueling can be due to suppression of appetite after high or moderate intensity training, lack of sports nutrition knowledge, body composition manipulation, periods of increased training, and competition loads involving a large exercise energy expenditure.[1,2] These situations may result in problematic LEA, the prolonged or chronic exposure to LEA associated with greater and constant disruption of several body systems leading to Relative Energy Deficiency in Sport (REDs).[1] REDs is a multifactorial syndrome characterized by the accumulation of negative physiological and performance outcomes such as menstrual dysfunction; low BMD; impairments of numerous body systems, aspects of metabolism,

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growth and development, skeletal muscle function.[1] These outcomes can lead to decreased athlete availability, training response, recovery, cognitive performance/skill, motivation, muscle strength, endurance performance, power performance, and increased injury risk.[1]

There is no single, validated diagnostic test to diagnose REDs.[3] However, a recently developed clinical assessment tool (CAT) can provide a framework for clinicians with an evidence-based approach to diagnosing and treating REDs.[3] The REDs CAT2 Tool, which is an updated version of the RED-S CAT tool, is a clinical tool used to identify the current severity of REDs risk comprised of the accumulation of primary and secondary indicators of REDs.[3] The REDs CAT2 Tool identifies risk along a spectrum characterized by a traffic-light continuum for healthy (green), mild (yellow), moderate (orange), to severe (red) and provides sport participation guidelines for each level.[3] Most of the REDs CAT2 Tool can be completed with answers from the LEAF-Q and EDE-Q along with bone mineral density (BMD) Z-score assessed using the dual X-ray absorptiometry (DXA), the clinical gold standard for bone imaging and bone mineral density.[4]

Several studies have examined the prevalence of REDs symptoms in endurance,[5–8] swimmers,[9] winter endurance athletes,[4,10] and other sports with a lean stereotype. However, studies have yet to examine the risk of REDs in Division II collegiate team ball sport athletes despite the high intensity nature, variable position demands, and mismatch between energy intake and exercise energy expenditure as noted in endurance sports. Thus, it remains unclear whether ball sport athlete follow a similar REDs risk or whether unique physiological, or psychological variable may contribute to risk within this population. Furthermore, previous literature has focused on risk for LEA or Triad, and few studies have employed the REDs CAT2 Tool to assess REDs risk.[1] Therefore, the purpose of this study was to assess the current severity and prevalence of REDs using the REDs CAT2 Tool and the Triad using the FAT CRA in Division II collegiate female volleyball, basketball, soccer, and rugby athletes.

Methods

Participants

This cross-sectional study was conducted at Central Washington University (Ellensburg, WA. USA: May, September-October 2024) where Division II collegiate athletes' risk for REDs using the REDs CAT2 Tool was assessed. Each athlete completed a questionnaire and dual energy X-ray absorptiometry (DXA; Hologic, Horizon-A, Dalbury, Connecticut).

Participants, ages 18-24, were recruited from Central Washington University (CWU) athletics in women's volleyball, soccer, basketball, and rugby teams. A total of twenty-seven athletes participated in the study (age: 19.9 ± 1.2; height 172 ± 8.5; weight 72.8 ± 9.7, 88% white, 7.4% non-Hispanic black, and 3.7% Asian. Due to participant recruitment from a convenient Division II athlete population, a power analysis was not performed. Furthermore, previous REDs/LEA studies reported similar sample sizes.[11–13] Inclusion criteria included CWU athletes currently participating in training in any of the four sports. Exclusion criteria included those who were pregnant, males, and non-ball sport female athletes. Participants were informed about the study design and consented prior to participation. This study was approved by the CWU Human Subjects Committee (HSRC). This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science.[14]

Protocol

Participants were given a questionnaire that included demographics, history of bone stress injuries (BSI); absence from training due BSI; depression; eating disorders; disordered eating risk using the Eating Disorder Examination Questionnaire (EDE-Q), and LEA risk using the Low Energy Availability in Females Questionnaire (LEAF-Q) on an online survey software, Qualtrics (CWU, WA, 2024). The LEAF-Q is a 25-item questionnaire identifying athletes at-risk for LEA utilizing subsets from gastrointestinal symptoms, injury frequency, and menstrual dysfunction.[15] The LEAF-Q was previously validated and produced an acceptable 78% sensitivity and 90% specificity in able-bodied athletes.[15] Participants that score ≥8 are at risk for LEA and participants <8 are considered low risk. The 28-item Eating Disorder Examination Questionnaire (EDE-Q) (version 6.0) assessed behaviors and attitudes towards disordered eating and eating disorders over the last 28 days based on subsections of dietary restraint, eating concern, shape concern, and weight concern.[16] The EDE-Q was also validated in healthy participants with 83% sensitivity and 96% specificity.[17] Scoring is based off a global score, which is the average of each subsection.[17] According to the REDs CAT2 Tool, at risk on the EDE-Q is considered ≥2.3 and not at risk is <2.3. Lastly, menstrual cycle phases and hormonal contraception were not controlled in this study.

The DXA (Hologic, Horizon-A, Dalbury, Connecticut) was used to measure bone mineral density (BMD) for each participant using the lumbar spine, total hip, and whole-body scans. The whole-body scan also determined each athlete's body composition including fat free mass (FFM), fat mass (FM), and body fat percentage (BF%). Using the REDs CAT2 Tool criteria, a low BMD is identified of a Z-score of ≤-1.0 at either the lumbar spine, total hip, or femoral neck.[3] The DXA was previously validated measuring BMD in team sport athletes.[18] To prevent confounding variables, scans were done in a fasted and rested state before exercise.

The REDs CAT2 Tool was used to identifying the current severity of REDs assessing the accumulation of primary and secondary indicators.[3] Each athlete's history of stress fracture; training missed due to BSI; depression; menstrual function, EDE-Q and DXA results were used to determine risk of REDs using this tool. See Table 1 for minor assessment modifications. Risk ranges from red (severe), orange (moderate), yellow (mild), and green (low or no risk). Participants on hormonal birth control didn't have their menstrual function assessed.

The Female Athlete Triad Cumulative Risk Assessment (FAT CRA) was used to identify the current risk of the Triad based on the accumulation of risk factors including LEA with or without DE, low BMI, delayed menarche, oligomenorrhea and/or secondary amenorrhea, low BMD, and stress fractures and/or fractures.[19] Each athlete's menstrual history from the LEAF-Q, BSI history, EDE-Q, BMI, and DXA results were used to determine risk for the Triad. Each risk factor ranges from low risk (zero points), moderate risk (one point), and high risk (two points). To be considered at risk based on the FAT CRA, an athlete would score ≥2 points. Low risk (0-1 point), moderate risk (2-5 points), high risk (≥6 points).

Statistical Analysis

Statistical analysis was analyzed using Statistical Package for Social Sciences (SPSS) (Version 29, IBM, Chicago, Illinois, USA). Descriptive data reported as mean ± standard deviation. Chi-square test of independence used to assess relationships between presence or absence of indicators of EDE-Q global score, BSI, training absence, depression, LEAF-Q risk, REDs risk status, and Triad risk status. Independent t-test was used to compare means between REDs risk status (green and yellow) for participant characteristics, BMD, sport, EDE-Q and LEAF-Q total and subscale scores.

Spearman's rank order correlation performed to determine correlations between mean EDE-Q global, dietary restraint, shape concern, and weight concern scores and REDs risk. A One-way Analysis of Variance (ANOVA) performed to compare means between REDs risk status between sports for BMD, BSI, menstrual dysfunction, EDE-Q and LEAF-Q total and subscale scores. A Bonferroni post hoc test was used to control type I errors by making multiple comparisons to determine significant differences. The alpha level was set at $p<0.05$.

Table 1. The International Olympic Committee (IOC) REDs CAT2 list of severe primary, primary, and secondary indicators for assessment for the REDs risk/severity.

REDs indicator as described in the IOC REDs CAT2 Tool	Current Study Methodology
Severe primary (counts as 2 primary indicators in REDs CAT2 scoring)	
Primary amenorrhea: failure to menstruate by age 15 in the presence of normal secondary sexual development	Self-report* questionnaire from LEAF-Q.
Prolonged secondary amenorrhea: absence of 12 or more consecutive menstrual cycles due to FHA	Self-report* questionnaire from LEAF-Q.
Primary	
Secondary amenorrhea: absence of 3-11 consecutive menstrual cycles caused by FHA	Self-report* questionnaire from LEAF-Q.
History of ≥1 high-risk (femoral neck, sacrum, pelvis) or ≥2 low-risk BSI (all other locations) within the previous 2 years or absence of ≥6 months from training due to BSI in the previous 2 years	Self-report* questionnaire of BSI and training absence history.
BMD Z-score <-1 at lumbar spine, total hip, or femoral neck	DXA scan of lumbar spine, left hip, right hip, and whole body.
An elevated EDE-Q global score (≥2.3) and/or clinically diagnosed with DSM-5-TR-defined eating disorder	Self-report* questionnaire from EDE-Q.
Secondary	
Oligomenorrhea caused by FHA (>35 days between periods for a maximum of 8 periods per year)	Self-report* questionnaire from LEAF-Q.
History of 1 low-risk BSI within the previous 2 years and absence of <6 months from training due to BSI in the previous 2 years	Self-report* questionnaire of BSI and training absence history.
Clinically diagnosed depression	Self-report* questionnaire

This list was reproduced from the IOC 2023 Consensus Statement[1] and Review of IOC REDs CAT2 Tool,[3] and includes minor modifications from original version. Testosterone, T3, deviation of growth trajectory, and total and LDL cholesterol not included in current study.
*Self-report was used in the REDs CAT2 and collected using an online survey tool (Qualtrics, CWU, WA, 2024).
REDs: Relative Energy Deficiency in Sport; CAT2: Clinical Assessment Tool 2; LEAF-Q: Low Energy Availability in Females Questionnaire; BMD: bone mineral density; DXA: Dual-Energy Absorptiometry; BSI: bone stress injury; FHA: functional hypothalamic amenorrhea; DSM-5: Diagnostic and Statistical Manual of Mental Health Disorders; EDE-Q: Eating Disorder Examination Questionnaire; IOC: International Olympic Committee; T3: Triiodothyronine; LDL: low density lipoprotein.

Results

CWU athletes (n=27; volleyball: n=7, soccer: n=9, basketball: n=7, and rugby: n=4) completed the study. Participants were grouped according to REDs risk status based on the accumulation of primary and secondary indicators of REDs using the REDs CAT2 Tool (Table 1). Specifically, menstrual dysfunction, BMD, BSI, training absence, elevated EDE-Q, and depression. Athletes who had no risk or low risk for REDs were placed in the green group (n=23) and those with a mild risk of REDs in the yellow group (n=4). Differences in participant characteristics between REDs risk groups (green vs. yellow) are displayed in Table 2. No athletes had a moderate (orange) or severe (red) risk of REDs. One athlete's DXA scan of their lumbar spine and whole body, FFM, FM, BF% were excluded due to spinal fusion surgery. One athlete's LEAF-Q, GI, injury, and menstrual scores weren't included due to it being incomplete.

Table 2. Participant descriptive characteristics between athletes in the green vs. yellow REDs risk group.

	All Females	Green	Yellow	p-value
N (%)	27	23 (85.2)	4 (15)	
Age (years)	19.9 ± 1.2	20 ± 1.2	19.5 ± 1.3	0.50
Height (cm)	172.3 ± 8.5	171.9 ± 8.1	172.6 ± 11.8	0.89
Weight (kg)	72.9 ± 9.7	72.6 ± 10	74.1 ± 8.7	0.78
BMI (kg/m²)	24.6 ± 2.8	24.6 ± 2.9	25 ± 3	0.79
FFM (kg)	49.6 ± 5.7	49.4 ± 5.9	50.4 ± 5.3	0.89
FM (kg)	22.8 ± 5.1	22.8 ± 5.3	22.9 ± 4.2	0.97
BF%	31.3 ± 3.5	31.3 ± 3.7	31.2 ± 2.9	0.94
BMD (Z-score)				
Lumbar	1.2 ± 1.1	1.2 ± 1.1	0.7 ± 0.8	0.31
Left Hip				
Total	1.4 ± 1.0	1.5 ± 1.0	0.9 ± 0.5	0.25
Neck	1.5 ± 1.3	1.7 ± 1.3	0.7 ± 0.8	0.16
Right Hip				
Total	1.4 ± 1.0	1.5 ± 1.1	0.7 ± 1.5	0.15
Neck	1.6 ± 1.4	1.8 ± 1.4	0.6 ± 1.0	0.12
Whole Body	0.8 ± 0.9	0.9 ± 1.0	0.3 ± 0.3	0.04*
Sport n (%)				
Volleyball	7	6 (85.7)	1 (14.3)	
Soccer	9	9 (100)	0 (0)	
Basketball	7	5 (71.4)	2 (28.6)	
Rugby	4	3 (75)	1 (25)	

Data presented as Mean ± SD. Green: no risk or low risk and Yellow: mild risk; BMI: body mass index z-score; FFM: fat-free mass; FM: fat mass; BF%: body fat percentage; BMD: bone mineral density. *Indicates significant differences between athletes in the green vs. yellow group at $p<0.05$.

An elevated EDE-Q score was the only primary indicator present in this sample with 3 yellow athletes (11.1%) and 0 green athletes (0%, Figure 1A) at risk for DE/ED. Among all the athletes, 40.7% (n=11) were not on hormonal contraception while 59.3% (n=16) were on hormonal contraception. Menstrual dysfunction cannot be assessed in athletes on hormonal contraception and therefore their menstrual dysfunction section on the REDs CAT2 was unscored. A previous history of primary amenorrhea (PA) was reported in 3 green athletes (11.1%) and 2 yellow athletes (7.4%). Two volleyball (28.6%), 1 soccer (11.1%), 2 basketball (28.6%), and 0 rugby athletes reported a previous history of PA. Prolonged secondary, short-term secondary, and oligomenorrhea were not present in either group. Low risk BSI and training absence of <6 months were the most prevalent secondary indicators with 1 yellow athlete and 2 green athletes (Figure 1C). Each athlete who had a low-risk BSI also reported an absence of less than 6 months. Clinical depression was present in 1 yellow athlete and 1 green athlete (Figure 1D). According to the LEAF-Q, 50% of green athletes (n=11) and 50% of yellow athletes (n=2) were at risk for LEA (Figure 1B).

Figure 2 shows the mean scores between groups for the EDE-Q, LEAF-Q, and each subscale. An elevated EDE-Q score had a higher prevalence in the yellow group ($p<0.001$) (Figure 1) and global and shape concern were strongly associated with (r_s (25) = 0.61, $p<0.001$), (r_s (25) = 0.6, p<0.001) (Figure 2) with an increased REDs risk. Furthermore, there were moderate correlations between increased REDs risk and weight concern (rs (25) = 0.55, p=0.003) and restraint (rs (25) = 0.59, p=0.001) subscale scores.

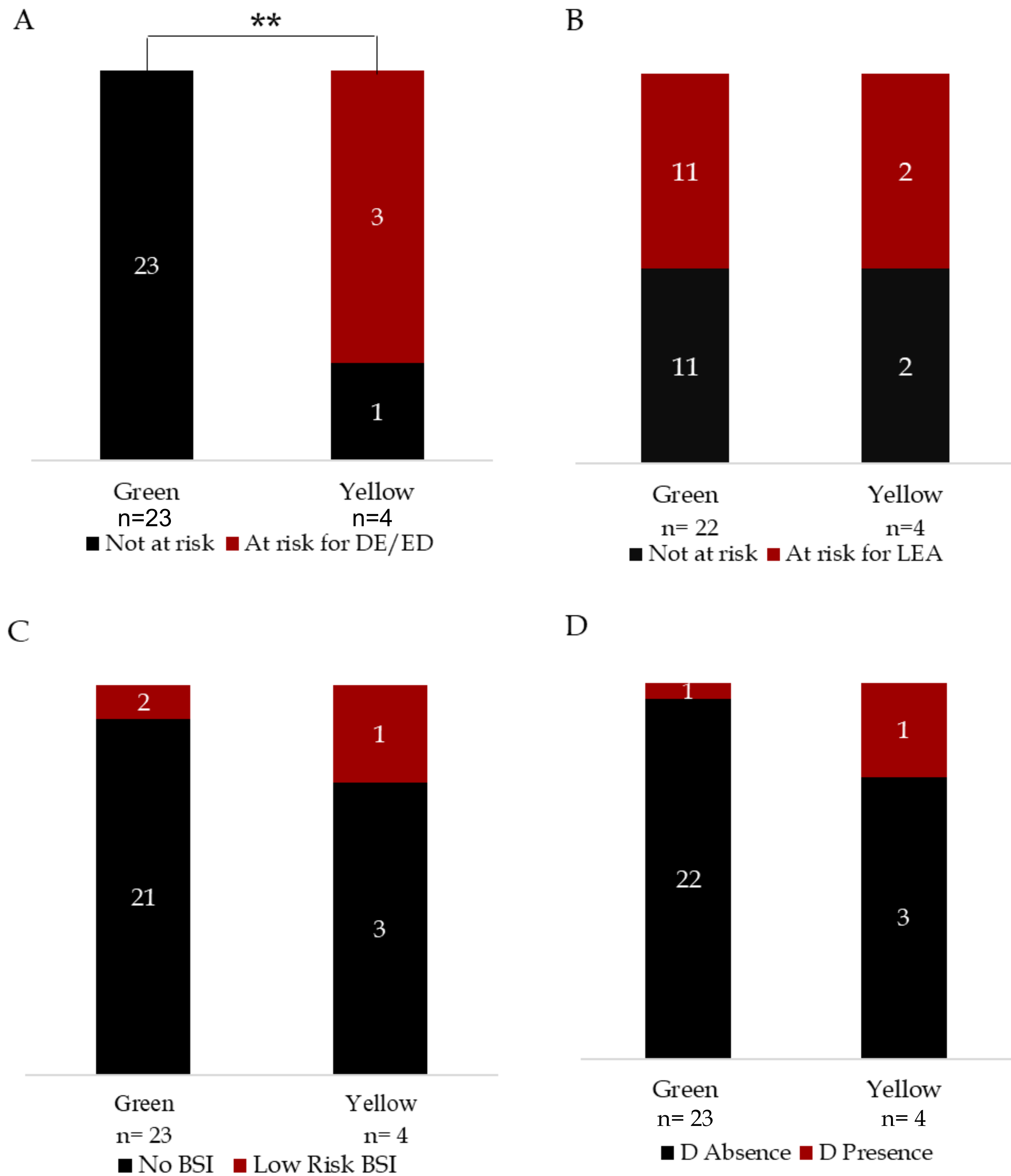

Figure 1. Prevalence of REDs indicators between Green and Yellow Groups. A: Frequency of Elevated EDE-Q Global Score (**<0.001). B: Frequency of At Risk for LEA based on LEAF-Q (p=1.0). C: Frequency of Athletes with Low-Risk BSI and <6 months Training Absence (p=0.34). D: Frequency of Athletes with Depression (D) (p=0.15). Black indicates either not at risk or absence of indicator and red indicates at risk or presence of indicator. *p<0.05, **p<0.001 significant differences between green and yellow groups.

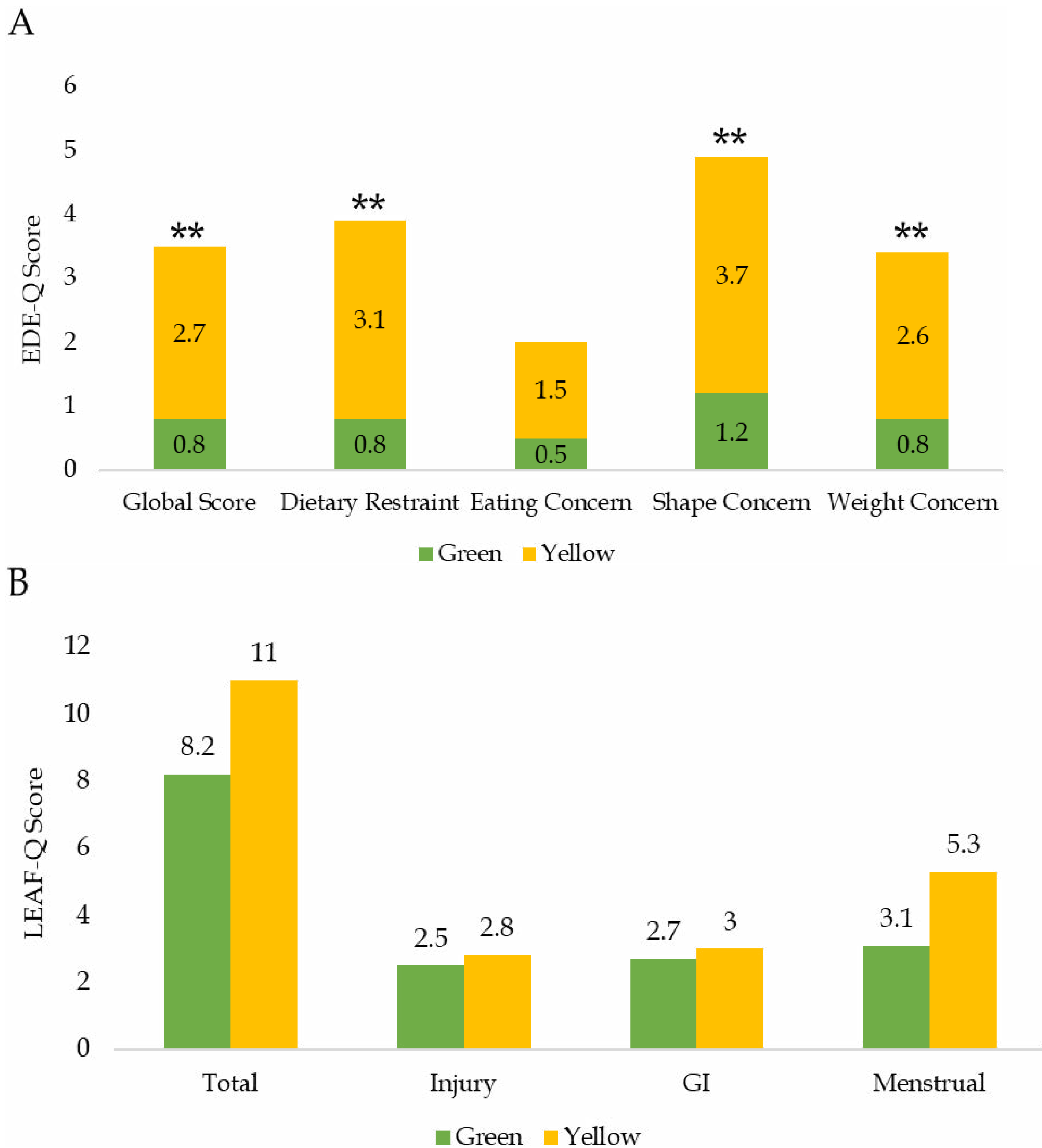

Figure 2. Means of EDE-Q global and subscale scores (A) and total LEAF-Q and subscale scores (B) between green and yellow groups.**p<0.001.

Table 3 displays the number of athletes not at risk and at risk for the Triad or REDs using the Female Athlete Triad Clinical Risk Assessment (FAT CRA) and the REDs CAT2 Tool.

Table 3. Athletes not at risk and at risk for FAT or REDs using FAT CRA vs REDs CAT2.

	Not at risk	At risk
FAT CRA	24 (88.9)	3 (11.1)
REDs CAT2	23 (85.2)	4 (15)

Data are number (%) of athletes not at risk or at risk for the Triad or REDs. FAT: Female Athlete Triad; FAT CRA: Female Athlete Triad Clinical Risk Assessment; REDs CAT2: Relative Energy Deficiency in Sport Clinical Assessment Tool 2.

Table 2 displays the frequency of athletes in the green and yellow group based on their sport. Figure 3 displays EDE-Q global and subscale scores between sports. Figure 4 displays the mean LEAF-Q scores between sports. Basketball had the highest mean EDE-Q global and subscale scores, while rugby had the highest mean LEAF-Q total and subscale scores but not significant.

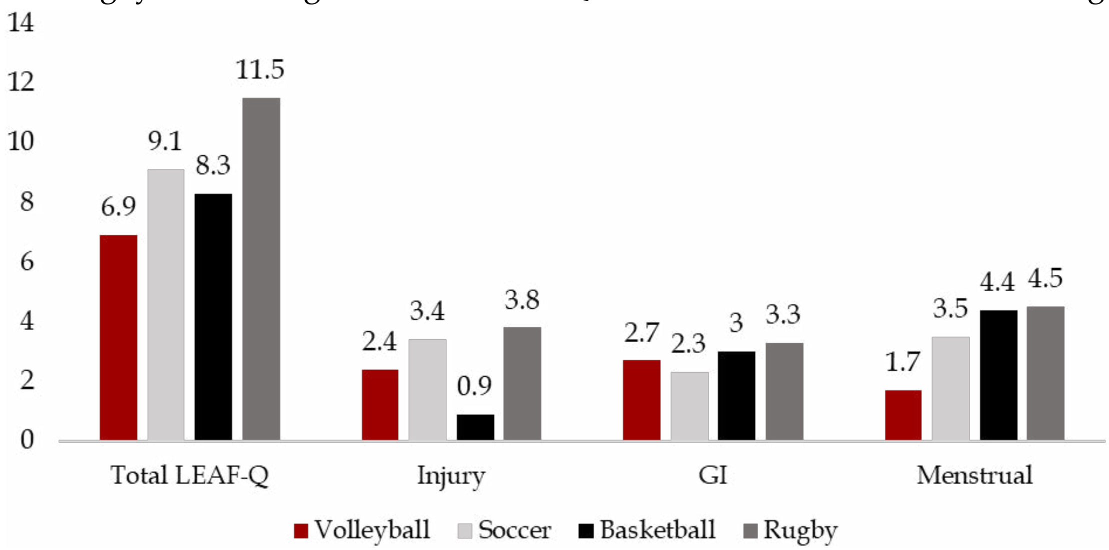

Figure 3. EDE-Q Mean Global and subscale Scores Between Sports. *p<0.05.

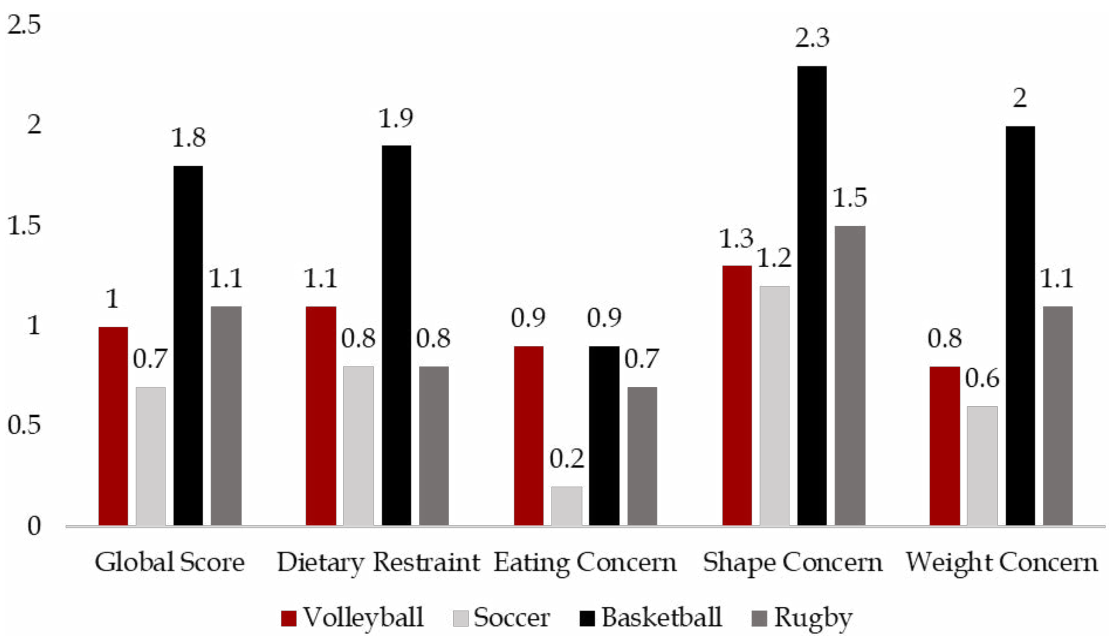

Figure 4. Total LEAF-Q and subscale mean scores between sports. *p<0.05.

Discussion

To our knowledge, the current study was one of the first to utilize the REDs CAT2 Tool and assess the current severity and prevalence of REDs in Division II collegiate female athletes competing in team ball sports. The current study found a small portion of female collegiate athletes (15%) with a mild risk of REDs while the majority (85%) had no risk or low risk (green) for REDs based of the REDs CAT2 Tool. No athletes were categorized with a moderate (orange) or severe (red) risk of REDs. The EDE-Q was the primary predictor variable elevating the risk for REDs. Furthermore, a higher REDs risk was strongly associated with a higher EDE-Q global and shape concern scores and moderately associated with increased dietary restraint and weight concern subscale scores.

Based on the REDs CAT2 Tool, 15% of Division II collegiate ball sport athletes were categorized as yellow (mild risk), which is lower than previously reported research using the REDs CAT2 Tool. Heikura et al.(2024) examined 213 elite/world-class athletes, male and female, from a variety of sports including rugby, volleyball, and soccer and found 45% (36% yellow, 5% orange, and 4% red) were at risk for REDs.[20] Heikura et al.(2024) also used self-reported questionnaires, DXA, and blood concentrations of testosterone, T3, total and LDL cholesterol to complete the REDs CAT2 Tool.[20] Another study using the REDs CAT2 Tool suggested 28% (n=14) of athletes were at risk for REDs, but focused on female elite and recreational endurance athletes.[11] Participants completed the LEAF-Q and BEDA-Q, BOD POD, blood concentrations, indirect calorimetry, and clinical interviews to determine REDs risk using the REDs CAT2 tool.[11] Lastly, the REDs CAT2 Tool was used in a study of 60 female elite soccer players using the LEAF-Q, EDE-Q-11, DXA, BSI fracture history, indirect calorimetry, and blood analysis of T3, total and LDL cholesterol, IGF-1, ferratin, leptin, T4, TSH, glucose, cortisol, CTX-1, and P1NP as indicators.[21] Similar to our findings, authors found that 78% had no or low risk for REDs (green) and 22% were at risk for REDs (17% mild, 3% moderate, and 2% severe).[21] Based on this study, the researchers concluded that female soccer players have a low risk for REDs, but individuals can be susceptible.[21] Finally, the discrepancies between risk prevalence between the current study and previous studies may be due to differences in sample sizes, populations of athletes, and use of different indicators for assessing REDs risk.

There is a lack of LEA and REDs research in ball sport collegiate athletes with the majority of research conducted in endurance athletes.[22] This could be due to endurance sports being classified as lean and aesthetic and/or having the belief that a lower body weight leads to better performance; which can lead to an increased risk of DE and LEA.[23,24] However, ball sports require a combination of both aerobic and anaerobic endurance, speed, agility, strength, and power.[25] Therefore, ball sport athletes have high energy demands, leading to an increased risk of LEA and REDs.[8,26,27] Dasa et al. (2024) reported the majority of female soccer players (78%) had no or low risk of REDs based on the REDs CAT2 Tool, similar results to the current study.[21] Furthermore, Puscheck et al. (2025) evaluated the prevalence of ED and LEA risk in Division I collegiate athletes in aesthetic (n=39), endurance (n=25), and ball sports (n=112) using the Eating Disorder Screen for Athletes (EDSA) and LEAF-Q.[23] The authors reported that 64% (n=53) of female ball sport athletes were at risk for LEA with 53% of female soccer athletes at risk with a mean LEAF-Q score of 8.5.[23] However, women's volleyball, basketball, and rugby were not included in that study.[23] Vardardottir et al. (2024) reported 50% of ball sport athletes were at risk for LEA and had low carbohydrate patterns due to a lack of sports nutrition knowledge and/or dietary restrictions, rather than higher EEE.[24] The authors also reported their findings support that REDs prevalence isn't limited to a certain type of sport, but rather individual characteristics and external factors.[24]

An elevated EDE-Q global score was the primary indicator for athletes having a mild risk of REDs in the current study. Heikura et al. (2024) found amenorrhea rather than risk of DE was the most prevalent primary indicator of REDs risk.[20] Similar to the current study, the authors reported that an elevated EDE-Q global score was more prevalent and athletes had higher mean global scores in higher-risk groups.[20] Wasserfurth et al. (2025) used the BEDA-Q, a brief, nine item questionnaire, rather than the EDE-Q in their study assessing the current severity of REDs in endurance female athletes.[11] Out of their sample, 44% (n=22) of athletes were at risk for DE, but of the 22 athletes, 10 were at risk for REDs based on the REDs CAT2 Tool.[11] In the current study, 11.1% (n=3) were at risk for DE. This discrepancy could be due to the BEDA-Q being used rather than the EDE-Q. Furthermore, Dasa et al. (2024) found secondary amenorrhea (30%) rather than risk of DE as the most prevalent indicator of REDs in female soccer athletes.[21] The authors reported the other aspects of the Triad were less prevalent with 10% of athletes at risk for DE and 2% had a clinically low BMD Z-score.[21] These discrepancies between the current study and previous studies may be due to the high hormonal contraceptive use in the current study which does not allow us to detect menstrual dysfunction in the majority of athletes.

The EDE-Q has also been used in studies assessing the risk of LEA. Fahrenholtz et al. (2022) used the LEAF-Q, EDE-Q, and the Exercise Addiction Inventory (EAI) to examine the risk of LEA, DE, exercise addiction, and food intolerances in female endurance athletes, using a cut off of ≥2.5 at risk for DE based on the EDE-Q and found 21.3% (n=43) had DE behaviors and of those athletes, there was a higher frequency of being at risk for LEA.[5] Lastly, Kampouri et al. (2019) assessed the prevalence of DE in elite female team sports players compared to non-athletes and compared DE prevalence in elite female basketball, volleyball, and water polo players.[28] 175 athletes completed the EDE-Q and physical activity questionnaire.[28] Using a global score of ≥2.3, 6.2% (n=) of all athletes were at risk for DE.[28] Similarly, the current study suggests 11.1% (n=3) of athletes were at risk for DE using the ≥2.3 cutoff per the REDs CAT2 Tool recommendation. The EDE-Q global score cut off is ≥4 at risk for DE, but several studies use different cut offs, which can affect the number of athletes at risk for DE. Ro et al. (2015) reported there is evidence from clinical settings showing nearly half of patients diagnosed with an ED report a global score of <4, and using the ≥4 can lead to underestimating the prevalence of DE/ED.[29]

The current study found no significant differences in BMD Z-scores of the lumbar spine, total, and femoral neck of the right and left hips between low/no risk (green) and mild risk (yellow). However, the yellow group had lower whole-body BMD scores than the green group. The IOC REDs CAT2 Tool suggest using BMD Z-scores of the lumbar spine, total hip, and/or femoral neck for pre-menopausal females and males, as whole body BMD is not used for diagnosing osteopenia or osteoporosis due to its imprecision.[30] In previous studies, a DXA scan of the whole body was used for body composition purposes only.[20,21,31] Furthermore, in the current study, mean BMD Z-scores of the lumbar spine, total hip, and femoral neck were close to 1.0 in both groups with no athletes with clinically low (<-1.0) BMD Z-scores. Of note, two green athletes and one yellow athlete reported a low-risk BSI and <6 months of training missed in the previous 2 years, despite normal BMD. Furthermore, using the reference range < -1 Z-score may overlook athletes in different sports with repetitive load on the bones, where a normal BMD could be higher than the average population.[32] Stangerup et al.(2025) found explosive sports with MD had normal BMD, while endurance athletes with MD had low BMD.[33] In the current study, athletes with a low-risk BSI were volleyball (n=2) and basketball (n=1) athletes, both sports that involve repetitive load on the bones from jumping and could potentially lead to an increased normal BMD. Finally, previous studies highlight that even though an athlete has "normal" BMD, they may still be at risk for BSIs.

The current study compared the REDs CAT2 Tool and FAT CRA to determine differences in risk assessment. Both tools assess similar risk factors, with the REDs CAT2 Tool focusing on primary indicators such as indicators include PA, prolonged SA, high risk BSI, absence of training of >6 months, SA, DE, and low BMD,[3] while the FAT CRA assess LEA with or without DE, low BMI, PA, OA and/or amenorrhea, low BMD, and BSI, focusing on the relationship between LEA, MD, and low BMD.[19,34] In the current study, two yellow athletes (n=1 basketball and n=1 rugby) had a mild risk of REDs and a low risk for the Triad. One athlete had a low-risk BSI, <6 months training missed, and clinically diagnosed depression while the other athlete had an elevated EDE-Q score. Lastly, one athlete (volleyball) with a low, no risk for REDs had a moderate risk of the Triad due to a previous history of PA and BSI incidence. Overall, 15% of athletes had a mild risk for REDs, while 11.1% were at a moderate risk for the Triad suggesting similar results between assessments, with one exception as one athlete was at a moderate risk for REDs (but not for the Triad) based on clinically diagnosed depression. Similarly, another study in 1,000 female athletes found that 54.7% of athletes had a moderate risk and 7.9% high risk for the Triad based on the FAT CRA, while 63.2% had a moderate risk and 33% high risk for REDs based on the RED-S CAT.[34] The FAT CRA and REDs CAT2 Tool appear to assess athletes similarly, but vary in agreement on level of risk.[34]

The present study is not without limitations or challenges. Most of the data was based on self-reported information with a possibility of inaccurate information due to response bias, survey fatigue, over-reporting, or under-reporting. Additionally, it's suggested to combine questionnaires with a clinical interview in step 1 to clarify uncertainties in questionnaire answers and allows for further questioning.[3] Furthermore, data was taken during pre-or-post season due to the athletes' schedules. Assessing the risk of REDs at one time point doesn't consider increased training loads of competition season. Next, the current study had a smaller sample size compared to other studies due to athletes' schedules and the required time commitment. Lastly, since this study completed the REDs CAT2 with self-reported data with hormonal contraceptives not controlled, participant's menstrual function may not have been accurate due to potential false positives and negatives of the LEAF-Q. If hormonal contraception was excluded and blood was taken for each athlete determining their estrogen, progesterone, testosterone, and LH hormone, it would give a more accurate representation of their current menstrual function. Furthermore, measuring total and LDL cholesterol, glucose, insulin, cortisol, iron, and T3 would also have provided more assessment indicators and perhaps a larger picture of REDs risk.

In conclusion, the current study suggests that most Division II ball sport collegiate athletes had a low risk of REDs according to the 2023 IOC REDs CAT2 with comparable results using the FAT CRA. Furthermore, an elevated EDE-Q global score was the most prevalent primary REDs indicator and athletes with a higher REDs risk were more likely to have a higher EDE-Q global, restraint, shape, and weight concern subscale scores. These findings underscore that disordered eating risk may be just as important as physiological symptoms in the identification of athletes at risk for REDs. Furthermore, lower NCAA Divisions (II and III) may not have access to a sports dietitian thus, it's important to provide education for coaches and practitioners on the signs of LEA and REDs.[1] Education focusing on DE/ED factors, DE behaviors, and REDs with coaches, practitioners, and athletes has been shown to increase nutrition knowledge and decrease the likelihood of dieting and body image concerns.[1] Lastly, future research is needed in ball sport athletes in lower NCAA Divisions and examining the efficacy of nutrition education interventions on the prevention and identification of LEA and REDs.

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