The Role of Social Factors in Relative Energy Deficiency Risk for Female Collegiate Athletes

Lauren Masden, BA[1], Allison Tripure BA, CSCS[1], Sara Mahoney, PhD, FACSM[1]

[1] *Department of Exercise Science, Bellarmine University, Louisville, Kentucky, USA*

BACKGROUND: Relative Energy Deficiency in Sport (RED-S) refers to compromised functioning of one's metabolism, reproductive system, immune system, cardiovascular system and more due to a relative energy deficiency. Most prevailing RED-S research has focused on its physiological symptoms, yet little data exists regarding the psychological and social aspects that might contribute to its development. The purpose of this study is to determine the role of psychosocial factors in RED-S risk for female collegiate athletes.
METHODS: 105 female collegiate athletes under National Collegiate Athletic Association (NCAA) jurisdiction were surveyed representing a variety of varsity sports. All participants were assessed for low energy availability using the Low Energy Availability in Females Questionnaire (LEAF-Q) through an online survey battery, which also included sources of nutrition information scale (SONI scale), the revised group environment questionnaire (GEQ), and the revised exercise group social provisions scale (EXSPS questionnaire). The participants were sorted into an at-risk (AR) and not at-risk (NAR) group based on their LEAF-Q scores. One-tailed independent t-tests and chi square tests were used to determine the difference between AR and NAR for dependent measures, and multiple linear regression determined the relationship between risk of LEA and GEQ, EXSPS, and SONI.
RESULTS: Overall, 66 participants (62.8%) were at risk for LEA based on LEAF-Q scores. Significant differences were identified between the AR (11.5%; 66.7%) and NAR (40.0%; 37.0%) groups regarding comfort with discussing nutrition with coaches or teammates, respectively ($p = 0.034$, $p = 0.035$). However, none of the social measures predicted LEA risk (group cohesion: $R = 0.04$, $p = 0.92$; social support: $R = 1.85$, $p = 0.09$; SONI: $p = 0.136$) Awareness of RED-S (using a Yes (1) or No (0) question) was also found to be not significantly different between the AR (0.28 ± 0.45, 29%) and NAR (0.39 ± 0.50, 41%) groups ($p = 0.12$).
CONCLUSION: Overall, risk for RED-S is high in female collegiate athletes, however group cohesion, social support, and the athletes' sources of nutrition information did not predict RED-S incidence.

INTRODUCTION

Over the past decade, Relative Energy Deficiency in Sport (RED-S) has received increasing global attention. Prevalence ranges from 22% to 58%, however, a lack of comprehensive evidence, variability in methods used to measure low energy availability (LEA), and unclear clinical criteria make it difficult to accurately estimate the prevalence of this condition.[1] RED-S originated from the Female Athlete Triad, a condition affecting physically active females with three interacting components: poor bone density, amenorrhea, and disordered eating.[2] RED-S, however, is more holistic, including all genders and recognizing that the effects of energy deficiency are more widespread among body systems.[3,4] The International Olympic Committee issued public warnings about the dangers and implications of RED-S in 2014 and again in 2018, calling for further research.[3,4] The syndrome is characterized by impairments of physiological functioning including detriments to metabolism, reproductive function, cardiovascular health, gastrointestinal functioning, bone health and more.[3-5] LEA is well-established as the etiological cause of RED-S.[1,3,4,6-8] LEA occurs because of inadequate calorie intake, excessive energy use, or both. The risk factors for developing LEA are less understood, but evidence suggests that

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higher training volume, participating in weight sensitive sports, pressure of competition, body dissatisfaction, and lack of nutritional knowledge may all play a role.[8,9]

Although many athletes experience energy deficiency and its symptoms unintentionally, some athletes develop pathological eating behavior as they intentionally restrict caloric intake for various reasons.[3,5,10] The existing literature is conflicting regarding the role of sport in the development of eating disorders; there is evidence that female athletes are at increased risk compared to their non-athlete peers, however in some cases it appears that participating in sports can have a protective effect.[11] Athletes who participate in sports that emphasize leanness such as running, swimming, and gymnastics, however, may be at a greater risk for eating disorders.[11] Internal personality factors that are more prominent in athletes such as perfectionism and desire for control have been identified as causes of eating disorders as well. External factors have also been identified including negative influences on self-esteem, hurtful relationships, hurtful role models, and sport performance.[8,9]

Additionally, the environment of competitive sport has been shown to make athletes more susceptible to developing eating disorders than non-athletes because of performance pressures, certain coaching styles, and modeling of pathological eating behaviors by other athletes.[11-14] Perceptions of normal behaviors based on what an athlete encounters with his or her teammates daily also play an important role.[13] Several studies have examined the competitive sports environment as a breeding ground for mental health issues in general, finding compelling evidence about the potential damages of competitive athletics on mental health.[11,12,14] Additionally, athletes are at increased risk for mental health conditions, compared to the general population.[12,14] One contributing factor towards the mental health of college students could be levels of social support. Hefner and Eisenburg found that college students who reported lower levels of social support were more likely to experience mental health problems.[15] Many of the mental health problems associated with lower reported levels of social support also happen to be risk factors for LEA. Body dissatisfaction, exercise dependence, and general poor mental health were all associated with lower social support scores.[7-9,15,16] Given that many of the risk factors for LEA, the root cause of RED-S, are associated with lower levels of social support, it is logical to question whether social support on collegiate teams plays a role in the prevalence of RED-S. Team environment is created by team members, coaches and other members of athletic departments Although some research has examined individual risk factors, no prior studies have investigated the role of team culture on the prevalence of RED-S itself. The purpose of this study was to investigate the relationship between an athlete's perceived level of group cohesion and social support and their risk for RED-S. We also examined the potential relationship between sources of nutritional knowledge and risk for RED-S. We hypothesize that those with greater social support and group cohesion will be at lower risk for RED-S, and that less reliable sources of information may impact nutrition knowledge, and therefore risk.

METHODS

Participants were recruited via targeted messaging sent to accounts with a large following of collegiate athletes on the social media platform, Instagram, to complete an online survey battery. Prior to dissemination, the study underwent institutional review board approval. All participants met the following criteria to be considered eligible: 1) aged ≥18 years; 2) English-speaking; 3) a current female National Collegiate Athletic Association (NCAA) athlete, in any sport recognized by the NCAA. Each survey began with obtaining informed consent from the participant.

Survey Battery

The survey battery was designed to measure the athlete's risk for RED-S, knowledge of RED-S, sources of nutritional knowledge and her perception of the group culture among her team. The battery consisted of the following: a demographic questionnaire, the Low Energy Availability in Females Questionnaire (LEAF-Q), the Sources of Nutritional Information Questionnaire (SONI), the Group Environment Questionnaire (GEQ),[17] and the Exercise Social Provisions Scale (EXSPS).[18]

In the demographic questionnaire, participants were asked to provide their age, gender, NCAA division, and sport. Additionally, a series of Likert-type scale questions were used to assess participant knowledge level about RED-S and comfort level discussing nutrition and menstruation with their coaches and teammates. Athletes were asked to rate

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how comfortable they were discussing their menstrual cycle with their teammates and, in a separate question, with their coaches. Similar format was used to survey comfort discussing nutrition. The LEAF-Q was used to assess the physiological symptoms of LEA by examining injury history, gastrointestinal, and reproductive function in order to determine whether the risk for RED-S exists. The LEAF-Q has been validated as a successful screening tool for detecting the Female Athlete Triad, however it has not been validated as a screening tool specifically for RED-S.[19] Its utility for evaluating LEA has also been investigated, and it was found to have negative predictive value and satisfactory ability to rule out LEA-associated conditions. The SONI questionnaire was used to assess seven common sources of sport-related nutritional information, as well as various beliefs and practices associated with each. The SONI has not yet been validated but has been previously used in athletic populations.[20,21] Participants were asked to rate how likely they were to use each source of information on a three-point Likert scale.

The GEQ was used to measure both sources and types of social support within an exercise group using four subscales: Individual Attractions To The Group-Task Cohesion, Individual Attractions To The Group-Social Cohesion, Group Integration-Task Cohesion, and Group Integration-Social Cohesion. The Individual Attractions To The Group scales measure the individual group member's perception of what attracts her to the group socially and related to the group task. The Group Integration scales measure the individual's perception of how the group works as a team socially and related to the group task. The EXSPS measures individual social support using six categories of social provisions as originally described by Robert Weiss in 1974. Participants respond to a negative and positive statement about each provision–attachment, social integration, reassurance of worth, reliable alliance, guidance, and opportunity for nurturance.[18]

Statistical Analysis

A multiple regression was performed between the LEAF-Q and the GEQ, EXSPS (model 1), and SONI category scores (model 2) to determine if the latter surveys predicted risk for LEA. A one-tailed, independent t-test was performed on the survey scores to determine if there was a significant difference between the scores of the at-risk (AR) and not at-risk (NAR) group for demographic factors and chi-squared was performed to measure the influence of athletes' comfort discussing nutrition and menstruation with their coaches on the risk for LEA. Mean ± standard deviations are reported, $\alpha = 0.05$.

RESULTS

A total of 105 NCAA female athletes consented to participate. Participants represented multiple sports including basketball (n=14), cross country and track (n=41), field hockey (n=4), golf (n=1), lacrosse (n=3), rowing (n=1), soccer (n=17), softball (n=2), swimming (n=17), tennis (n=2) and volleyball (n=3). The majority of participants were competing at Division I level (63%), with less participation from Division III level (28%), and even less at the Division II level (9%). Of the 105 study participants, 62.8% were at risk for developing RED-S based on LEAF-Q scores. Table 1 displays the number of at-risk and not at-risk athletes, divided by sport and division. Cross country and track had the highest number of overall participants (n=41) and highest crude number of at-risk athletes (n=26). Basketball had the highest percentage of at-risk athletes (78%).

Knowledge of RED-S

The demographic survey included the question "Have you ever heard of RED-S?" to measure the participant's familiarity with the syndrome. Prior awareness of RED-S was not found to be significantly different between the AR (0.28 ± 0.45, 29%) and NAR (0.39 ± 0.50, 41%) groups ($p = 0.12$).

Assessment of Team Culture

Team culture was assessed using the GEQ and EXSPS. The average scores for the GEQ and EXSPS for both the AR and NAR groups are shown in table 2. No significant differences were detected between the AR (129.1 ± 26.5, 77.4 ±8.6) and NAR (129.1 ± 24.2, 78.9 ± 10.0) groups regarding group cohesion and social support, respectively ($p = 0.50$; $p = 0.21$). The average GEQ and EXSPS scores for Division I participants compared to Divisions II and III participants are shown in Table 3. No significant differences were found between Division I (131.6 ± 25.3, 78.3 ± 8.7) and Divisions II and III (124.6 ± 25.6, 77.5 ± 10.0) participants regarding the GEQ and EXSPS, broadly. The GEQ items are grouped into four clusters, and the average score for each cluster for both groups is displayed in Table 4. No significant differences were detected between the AR (7.8 ± 1.5, 7.2 ± 1.6, 7.1 ± 1.8, 6.5 ± 1.7) and NAR (7.6 ± 1.6, 7.5 ± 1.1, 6.8 ± 1.9, 6.6 ± 1.7) groups for any

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of the four clusters. The average scores for each of the clusters comparing Division I and Divisions II and III are reflected in Table 5. Division I (6.9 ± 1.6) scored significantly higher than Divisions II and III (6.2 ± 1.8) for Group Integration-Tasks (GIT). No significant differences were detected between the Division I (7.8 ± 1.6, 7.5 ± 1.5, 7.2 ± 1.7) and Divisions II and III (7.7 ± 1.5, 7.1 ± 1.3, 6.7 ± 2.0) participants in the other GEQ clusters.

Table 1. Number and percentage of athletes at risk for RED-S divided by sport and division

Athletes	*At Risk for RED-S N (% of Sport/Division)*	*Not At Risk for RED-S N (% of Sport/Division)*
All Athletes	66 (63)	39 (37)
By Sport		
Basketball	11 (78.6)	3 (21.4)
XC/Track	26 (63.4)	15 (36.6)
Field Hockey	3 (75)	1 (25)
Golf	0 (0)	1 (100)
Lacrosse	2 (66.7)	1 (33.3)
Rowing	1 (100)	0 (0)
Soccer	8 (47.1)	9 (52.9)
Softball	2 (100)	0 (0)
Swimming	11 (64.7)	6 (35.3)
Tennis	1 (50)	1 (50)
Volleyball	1 (33.3)	2 (67.7)
By Division		
Division I	42 (63)	25 (37)
Division II	6 (67)	3 (33)
Division III	18 (62)	18 (62)

RED-S, relative energy deficiency syndrome; XC, cross country

Table 2. Mean scores of at-risk versus not at-risk athletes on the Group Environment Questionnaire (GEQ) and Exercise Social Provisions Scale (EXSPS)

	GEQ	*EXSPS*
At-Risk Athletes	129.07	78.94
Not At-Risk Athletes	129.11	77.43

No statistical differences were found between groups (p>0.05)

Table 3. Mean scores of Division I versus Divisions II & III athletes on the Group Environment Questionnaire (GEQ) and Exercise Social Provisions Scale (EXSPS)

	GEQ	*EXSPS*
Division I	131.66	78.27
Division II & III	124.57	77.52

No statistical differences were found between groups. (p>0.05)

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Table 4. Mean Group Environment Questionnaire (GEQ) cluster scores of at-risk versus not at-risk athletes

	At-Risk	*Not At-Risk*
Individual Attraction to The Group-Social (ATGS)	7.80	7.65
Individual Attraction to The Group-Tasks (ATGT)	7.20	7.52
Group Integration-Social (GIS)	7.10	6.83
Group Integration-Tasks (GIT)	6.50	6.69

No statistical differences were found between groups (p>0.05)

Table 5. Mean Group Environment Questionnaire (GEQ) cluster scores of Division I versus Divisions II & III athletes

	Division I	*Divisions II & III*
Individual Attraction to The Group-Social (ATGS)	7.76	7.71
Individual Attraction to The Group-tasks (ATGT)	7.46	7.08
Group Integration-Social (GIS)	7.19	6.72
Group Integration-Tasks (GIT)	6.85*	6.16

**Division I scored significantly higher than Divisions II & III for Group Integration-Tasks (GIT) (p=0.02). No other statistical differences were found between Division I and Divisions II & III (p>0.05).*

Table 6. Differences in Sources of Nutritional Information (SONI) scores (based on likelihood athletes would use each source on a scale of 0-3) between At-Risk (AR) and Not At-Risk (NAR) athletes

	Friends	*Social Media*	*Coaches*	*Peer Reviewed Literature*	*Elites*	*Books*	*Health Professionals*
At Risk	2.04	2	1.5	1.58	1.54	1.14	2.15
Not At Risk	2.11	1.79	2.5	1.41	1.54	1.54	1.97
P-values	0.35	0.08	0.39	0.12	0.50	0.42	0.14

No differences were found for any information source between AR and NAR (p>0.05 for all)

Sources of Nutritional Information

The SONI questionnaire was used to assess the sources by which athletes seek out nutritional information. There were no significant differences in SONI scores between the AR and NAR groups for any of the sources, as illustrated in Table 6.

Athlete Comfort Level with Coaches and Teammates

The demographic survey included a series of Likert questions to investigate each participant's comfort level (1=not at all comfortable, 5=very comfortable) discussing nutrition and menstruation with teammates and coaches. Overall, this sample showed low comfortability with discussing both

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nutrition (2.0 ± 1.2; 2.8 ± 0.9) and menstruation (1.2 ± 1.1; 3.0 ± 1.0) with coaches and teammates, respectively. Chi-squared tests demonstrated a significant difference between AR and NAR athletes discussing nutrition with teammates, as seen in Table 7 (p = 0.035). A significant difference was also found between AR and NAR athletes discussing nutrition with their coaches (p = 0.034). Those at risk were more likely to be comfortable discussing nutrition with their teammates, but less likely to be comfortable discussing nutrition with their coach. No significant differences were found regarding comfort level discussing menstruation with teammates or coaches, as displayed in Table 8.

Table 7. Number of athletes comfortable or not comfortable with discussing nutrition

	Nutrition with Coaches		*Nutrition with Teammates*	
	At-Risk	***Not At-Risk***	***At-Risk***	***Not At-Risk***
Comfortable	3	6	16*	10
Not Comfortable	23*	9	8	17

**With coaches, chi square = 4.49, p = 0.034; with teammates: chi square = 4.46, p = 0.035*

Table 8. Number of athletes comfortable or not comfortable with discussing menstruation

	Discussing Menstruation with Coaches		*Discussing Menstruation with Teammates*	
	At Risk	***Not at Risk***	***At Risk***	***Not at Risk***
Comfortable	2	2	26	14
Not Comfortable	43	25	4	3

No statistical differences were found between groups (p > 0.05)

Predicting RED-S Risk

Multiple linear regression was used to determine if EXSPS and GEQ predicted LEA risk, and if the sources of nutrition information predicted LEA risk. Neither model significantly predicted LEA risk (Model 1 [GEQ and EXSPS], R = 0.04, p = 0.92; Model 2, R = 1.85, p = 0.09).

DISCUSSION

RED-S can cause widespread health detriments and inhibits peak performance. However, its risk factors, especially psychosocial ones, are not well understood or thoroughly explored. In this study, we investigated the role of psychosocial factors in the development of RED-S. Of the 105 athletes surveyed, 66 were at risk for developing RED-S (62.8%). No significant differences were identified between at-risk and not at-risk athletes regarding RED-S awareness, group cohesion, social support, or sources of nutrition information. Division I athletes scored significantly higher (p = 0.02) on the GIT cluster of the GEQ, which measures the athlete's perception of how well their team works towards the group's tasks. At-risk athletes reported lower levels of comfort talking about nutrition with their coach and higher levels of comfort talking about nutrition with their teammates compared to the not at-risk athletes. Overall, the psychosocial factors surrounding RED-S remain undetermined.

Current evidence indicates that the prevalence of RED-S among female athletes is between 22-58%.[1] Due to unclear classification criteria and a lack of comprehensive evidence, it is difficult to accurately estimate the prevalence of this syndrome. Among our study participants, nearly two thirds were at risk of developing RED-S. The high percentage in our sample may reflect an underestimation by prior studies. LEA is the established etiology of RED-S and occurs when caloric expenditure exceeds caloric intake.[1,3,4,6-8]

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Risk factors for LEA are less clear but training volume, participating in weight sensitive sports, pressure of competition, body dissatisfaction, and lack of nutritional knowledge are thought to be involved.[8,9] Sports with multiple risk factors such as endurance running, swimming, and gymnastics are considered higher risk for developing LEA and subsequently RED-S.[11] Recent reviews of RED-S data emphasize the importance of improving syndrome knowledge, however little evidence exists to support the notion that improving RED-S knowledge among athletes will decrease its prevalence.[1] We examined the relationship between their awareness and their LEAF-Q score. At-risk and not at-risk athletes did not differ significantly in their level of previous awareness of RED-S. This suggests that awareness of the syndrome's existence alone is not enough to be protective against developing it. Future investigations into RED-S knowledge and educational interventions should focus on preventing risk factors such as maintaining appropriate caloric intake, managing pressure, body dissatisfaction and nutritional knowledge.

Additionally, education interventions for other sports medicine topics, such as sports concussions and nutritional knowledge, that are aimed at athletes have improved knowledge levels, but failed to improve long-term outcomes.[23] Some evidence exists in support of concussion educational interventions aimed at coaches. A prospective study from 2017 found that the CDC's Heads Up program, which provided education to coaches of teams in the experimental group, successfully reduced sports-related concussions and concussion severity compared to the control group.[24] A systematic review of nutritional knowledge interventions for athletes found that the evidence of dietary intake improvement after educational interventions was limited and low-quality.[25] With this in mind, future educational interventions for RED-S might be more effective if designed for coaches and athletic trainers, rather than for athletes.

Team culture is a complicated entity that consists of the attitudes, beliefs and behaviors shared between team members and their coaches. Culture determines what is acceptable or not within the team, and can have important impacts on performance, member satisfaction, and health of the team.[26] We evaluated team culture using the GEQ and the EXSPS, measuring group cohesion and levels of social support within the group, respectively. The GEQ and EXSPS did not predict LEAF-Q risk level. Group cohesiveness and social support, or a lack of, are not mutually exclusive with having shared maladaptive behaviors that might contribute to RED-S. This means that while the at-risk athletes may have reported similar levels of cohesion to their not at-risk counterparts, that does not rule out the possibility that being teammates with another at-risk athlete might predispose an individual to developing RED-S as well. Prior studies have illustrated the importance of an athlete's perception of their teammates eating behaviors, in particular, and thus more exploration into the factors that may cause teammates to influence one another's behaviors is necessary.[13]

Finally, we assessed athlete comfort level discussing menstruation and nutrition with their team. At-risk athletes reported lower levels of comfort talking about nutrition with their coaches and higher levels of comfort talking about nutrition with their teammates compared to the not at-risk athletes. Further investigation into why athletes do not feel comfortable talking about nutrition with coaches is warranted. While at-risk athletes did report higher comfort discussing nutrition with their teammates, it is important to note that this does not ensure the discussions taking place were healthy ones. As previously mentioned, prior studies have demonstrated the strong influence of team behaviors on one another, and the higher comfortability discussing nutrition among at-risk athletes may be related to these athletes being more accepting of unhealthy or extreme nutritional practices.[13] This also emphasizes the importance of an athlete's access to health professionals such as registered dieticians, who could help guide their nutritional choices. There were no differences in comfort levels talking about menstruation. The effects of the menstrual cycle or amenorrhea on performance are important for the success of female athletes. In the past, the menstrual cycle has been perceived as a taboo topic of conversation and may be difficult for some athletes to discuss with their coach.[28] A normal cycle is an important indicator of physiological health and energy balance for female athletes, and therefore we wanted to understand each participant's comfort level discussing menstruation. Although there were no differences between the two groups, the average comfort level discussing menstruation for both at-risk and not at-risk athletes was low. Coaches and athletic trainers should consider how to make athletes feel

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comfortable having conversations about their cycle when needed.

Some limitations exist within this study. Firstly, participant recruitment was accomplished via social media, meaning it is a possibility that athletes who already knew of RED-S were more likely to participate. However, we do note that awareness did not differ between the two risk groups. Secondly, the representations of various sports were not equivalent, and future studies should attempt to involve participants from different sports in a more even distribution. Future research should investigate the potentially modifiable psychological and environmental elements surrounding the syndrome. Qualitative research with the athletes affected by these issues may prove useful.

Overall, risk for RED-S is high in female collegiate athletes, including those in team sports. Psychosocial components that contribute or protect against the syndrome remain unknown and warrant further investigation. Interventions that aim to improve communication between athletes and coaching staff may be beneficial. Given the high prevalence and detrimental effects on physiology and psychology, more attention must be given to understanding all aspects of RED-S.

Conflicts of Interest

The authors declare no conflicts of interest with the contents of this study.

Corresponding Author:
Sara E. Mahoney, PhD, FACSM
2001 Newburg Road
Louisville, Kentucky 40205
Email: smahoney@bellarmine.edu
Telephone: 502-272-7607

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