Knowledge of Triad and RED-S in Female Cross-Country Athletes and Support Staff

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ABSTRACT

CONTEXT: Female endurance athletes exhibit an increased risk of Female Athlete Triad (Triad) and Relative Energy Deficiency in Sport (RED-S). Triad and RED-S are conditions that explore the health and performance consequences of low energy availability (LEA). Few studies to date have assessed the knowledge that athletes, coaches, and athletic trainers (ATs) have regarding Triad/RED-S. Proper education has been shown to be effective in increasing knowledge of sports medicine concerns for athletes. Yet, there are no known continuing education programs for Triad/RED-S at collegiate institutions. OBJECTIVE: The primary purpose of this study was to assess the knowledge, confidence, and impact of identifying, screening, treating, and preventing Triad/RED-S. DESIGN: Cross-sectional study. SETTING: An evidence-based online survey was developed and administered via Qualtrics™. PARTICIPANTS: Female collegiate cross-country athletes (n = 275; 20 ± 1 yrs.), collegiate cross-country coaches (n = 55, 34 ± 9 yrs.), and ATs working with cross-country teams (n = 30, 36 ± 11 yrs.). MAIN OUTCOME MEASURE: Knowledge, confidence, and impact scores were assessed between groups using ANOVA. Independent t-tests were used to determine differences in impact scores between people who had or had not received education. RESULTS: Female cross-country athletes’ total knowledge, confidence, and impact scores (mean scores of 25.00 ± 5.27, 95.42 ± 28.83, 18.81 ± 7.05 respectively) were significantly different from scores of coaches (mean scores of 26.92 ± 5.02, 111.35 ± 24.14 and 22.41 ± 6.33) and ATs (mean scores of 28.66 ± 4.02, 117.67 ± 22.53, and 23.93 ± 5.69) (p < 0.05). CONCLUSIONS:
athletes and highest in ATs. These findings support the call for education, which should be regarded as the primary tool to increase knowledge to improve the prevention and treatment of Triad/RED-S.

**KEYWORDS:** Female Athlete Triad (Triad), Relative Energy Deficiency in Sport (RED-S), Athletic Trainers (ATs), Knowledge, Education, Running

**WORD COUNT:** Abstract (294 words), Manuscript Body (3998 words)

**KEY POINTS:**
1) Female cross-country athletes’ total scores (knowledge, confidence, and impact) were significantly lower compared to coaches’ and ATs’ total scores.
2) Coaches’ and ATs’ knowledge, confidence, and impact scores were not significantly different.
3) Education remains paramount in addressing the gaps in knowledge translation, improving prevention and treatment methods of Triad and RED-S, and enacting meaningful policy change to protect athletes.
Female cross-country athletes report the highest occurrence of stress fractures across all National Collegiate Athletic Association (NCAA)-sanctioned sports. A 2017 study reported an incidence of 1.35 stress fractures per female cross-country team, per year. There is an increased likelihood of bone stress injury (BSI), inclusive of stress fracture, in the presence of Female Athlete Triad (Triad) and Relative Energy Deficiency in Sport (RED-S). Triad and RED-S are both concepts that illustrate the health and performance consequences in the presence of low energy availability (LEA) among athletes. A prospective study of exercising girls and women reported BSI incidence of 11%, with the highest occurrence in distance running. The presence of one Triad factor increased BSI incidence to 15-21% in participants, two factors increased BSI incidence to 21-30%, and the presence of three factors increased BSI incidence to 29-50%.

Current research supports the role of education to ensure proper prevention and intervention to manage these conditions. Knowledge is necessary to identify, treat, and prevent Triad/RED-S in order to reduce BSI risk and the myriad of health- and performance-related consequences. Few studies have demonstrated the impact of education on subsequent knowledge of Triad and RED-S in participants. Studies that have assessed knowledge illustrate a lack of Triad knowledge among athletic trainers (ATs) and an even greater lack of knowledge among coaches. ATs are certified healthcare professionals, often serving as the first point of contact in the management of athlete cases, such as primary care, injury and illness prevention, clinical examination, wellness education, amongst other functions. However, very few studies present data on knowledge of athletes. Therefore, it is important to study the present knowledge of athletes and support staff in order to properly direct education efforts.

Since the expansion of Triad to RED-S in 2014, there is little available literature on knowledge of both Triad and RED-S in one study design. Furthermore, no studies have assessed
knowledge, confidence, and education pertaining to Triad and RED-S in athletes and support staff simultaneously. The purpose of this study was to determine knowledge, confidence, and educational impact of Triad and RED-S among three distinct populations: collegiate female cross-country athletes, collegiate cross-country coaches, and ATs working with collegiate cross-country teams. An additional goal was to assess the current education of participants to better understand and inform next steps for education, institutional practices, and future research.
METHODS:

Study Design. A cross-sectional study design was used to examine knowledge, confidence, and impact related to Triad and RED-S.

Participants. Participants were collegiate female cross-country athletes, collegiate cross-country coaches, and ATs working with collegiate cross-country teams. Subject participation included one-time completion of an online survey via Qualtrics™. Participants were recruited from collegiate women’s cross-country teams via emails to coaches and ATs, accessed through university team webpages. Four hundred and forty schools across NCAA and National Association of Intercollegiate Athletics (NAIA) programs from the United States were directly invited to participate. Coaches and ATs were asked to distribute the link to the online survey to their female cross-country athletes. Recruitment also included online flyers and use of social media. Recruitment lasted 44 days and the survey was open to responses for 57 days. Online informed consent was obtained from all participants. The XXXXX University Institutional Review Board approved this study.

Inclusion Criteria. Participants had to be 18 years of age or older to participate. Participants were included in the study if they identified as belonging to one of the following categories: current collegiate female cross-country athletes, collegiate cross-country coaches, or ATs working with collegiate cross-country teams.

Exclusion Criteria. Participants were excluded if they did not self-identify as a member of one of the categories above. Furthermore, incomplete survey responses were excluded from data analysis.

Survey Development. The online survey (Appendix 1) was multi-faceted. It was designed to assess Triad and RED-S knowledge, confidence regarding level of knowledge, and other
participant characteristics, including education. Elements of the present survey were adapted from a previous survey which sought to characterize Triad knowledge\textsuperscript{15}. This survey was tested for content validity, instrument reliability, and concurrent validity\textsuperscript{15}. In the current survey, the previous survey was expanded to include questions specific to RED-S. The scoring protocol was also based on the prior survey. Three scores were calculated: knowledge, confidence, and impact scores. Detailed explanations on how scores were calculated are discussed in the scoring section below. The entire survey was reviewed by three content experts: 1) Medical doctor in sports medicine and endocrinology; 2) Certified sports dietitian in clinical athlete care; 3) PhD researcher in female physiology and nutrition education. These experts reviewed the original survey and suggested changes to better assess knowledge of both Triad and RED-S, participant characteristics, and prior education related to Triad and RED-S. Following content validation, the survey was tested for test-retest reliability via internal consistency, Cronbach’s alpha, with four non-collegiate female cross-country athletes and two non-collegiate coaches of female cross-country athletes. Though our reliability participation sample is low, the previous survey was tested for reliability among 12 collegiate coaches\textsuperscript{15}. ATs were recruited for current survey reliability testing. However, response rates were low as reliability testing occurred at the start of the COVID-19 pandemic. The scored knowledge portion of the survey, tested for reliability, was the same across populations. The 38-item survey was administered to reliability participants twice, within 48 hours, at a minimum of six hours apart. Reliability participants were asked to not complete any education searches on Triad and RED-S between responses. The Cronbach’s score (alpha = 0.799) indicated acceptable reliability. The item with the weakest reliability correlation was removed, the item was a multiple-choice question asking about the definition of
RED-S. This increased the Cronbach’s score (alpha = 0.914), indicating excellent reliability with high internal consistency. This final survey of 37-items was used in data collection.

**Scoring (Knowledge, Confidence, Impact).** The scoring protocol was also based on the prior survey. Three scores were calculated: knowledge, confidence, and impact scores. Questions Q16 through Q52b were used to calculate knowledge, confidence and impact scores; all additional survey data were supplementary to our understanding and were not included in the scoring calculations.

The total knowledge score was determined by summing all 37 knowledge questions (Q16-Q52). One point was added for a correct answer and one point was subtracted for an incorrect answer. If the answer selected was “I don’t know”, it was scored as zero. Questions of a “choose all that apply” nature were also awarded one point, with each possible sub-answer considered individually. If all sub-answers were selected correctly, a full point was awarded; if not all sub-answers were selected correctly, a partial point was awarded proportionally. Therefore, the total knowledge score could range from +37 (highest knowledge score) through -37 (lowest knowledge score).

The total confidence score was determined by summing all 37 confidence questions (Q16b-Q52b). Participants selected confidence level from a scale of 0 (no confidence) to 4 (completely sure) for each knowledge question. Therefore, the total confidence score could range from 0 (lowest confidence score) through +148 (highest confidence score). Using each individual confidence score, a confidence factor was calculated as the quotient of the confidence score divided by four. For example, a confidence score of 4 equals a confidence factor of 1 and a confidence score of 1 equals a confidence factor of 0.25. The sum of the confidence factors was used to determine impact, described next.
The impact score model was adapted from the scoring previously reported, in which a factored, composite score of impact was reported\textsuperscript{15}. The knowledge and confidence scores were combined to create a total impact score (Q16-Q52b). The total impact score is the product of the knowledge score and confidence factor (see Table 1). Therefore, an impact score for each question ranges from -1 to +1. The total impact score could range from +37 (highest impact score) through -37 (lowest impact score). One point for impact was given for the correct answer and high confidence and one impact point was subtracted for the incorrect answer and high confidence. The score of each question was reduced when the respondent had lower confidence in their answer.

Creating a factored composite score allows for greater understanding of the potential dissemination of information. A low level of confidence has been correlated to a lack of application of one’s knowledge\textsuperscript{16}. For example, the highest impact scores resulted from a participant who selected the correct knowledge answer with high confidence, as the participant is more likely to disseminate correct information. Lower impact scores resulted from a participant who selects the correct knowledge answer but expressed low confidence, as the participant is less likely to disseminate information based on that knowledge. An impact score of zero resulted from answers selected as “I don’t know” or a confidence of zero. The lowest impact scores resulted from a participant who selected the incorrect knowledge answer with high confidence, as the participant is more likely to disseminate incorrect information. This is weighted more heavily, as it is potentially dangerous to confidently believe in incorrect information.

Scores are presented for questions specific to Triad and questions specific to RED-S in order to assess any significant differences in knowledge and impact. Scores for the Triad-specific questions (n = 2) and RED-S-specific questions (n = 3) were presented as percentages in order to...
directly compare the scores. A percentage of Triad-specific knowledge and impact scores were calculated from a range of -2 to +2. A percentage of the RED-S-specific knowledge and impact scores were calculated from a range of -3 to +3.

Each population was asked if their current institution provided education training on Triad/RED-S and types of education they take part in at least once a year related to Triad/RED-S and the education provided by their institution. In addition, female cross-country athletes were asked if their athletic departments or coaching staff had a policy in place that specifies what to do if an athlete suspects they or a teammate may be suffering from Triad/RED-S.

**Statistical Analyses.** All variables were tested for non-normality using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality, before statistical hypothesis tests were performed. Participant characteristics were analyzed using descriptive statistics. All scores between population groups were analyzed using a one-way ANOVA; a Tukey Post Hoc Analysis was performed in the presence of a significant main effect. Paired samples T-tests were used to assess significant differences in Triad- and RED-S-specific knowledge. Independent T-tests were used to assess differences in impact scores among individuals who had or had not received education on Triad and RED-S from their athletic department. Education on Triad and RED-S were assessed using independent T-tests to examine differences in impact scores in individuals who had or had not received education. A significance level was set at $p \leq 0.05$ *a priori*. All data were presented as means ± standard deviation. IBM Statistical Package for the Social Sciences (SPSS) was used for data analysis.
RESULTS:

Participant Characteristics. Three-hundred and forty-one participants accessed the survey and consented to participate. 81 respondents did not complete the survey (50 collegiate female cross-country athletes, 21 collegiate cross-country coaches, and 10 ATs working with collegiate cross-country teams). Thus, a total of 260 complete surveys were included in data analysis: 175 collegiate female cross-country athletes, 55 collegiate cross-country coaches, and 30 ATs. Participant characteristics are shown in Table 2.

Assessment of Knowledge, Confidence, & Impact. Scores for each group are shown in Table 3. Female cross-country athletes had significantly lower scores for knowledge (p = 0.047), confidence (p = 0.001), and impact (p = 0.05) compared to coaches. Female cross-country athletes had significantly lower scores for knowledge (p = 0.001), confidence (p < 0.001), and impact (p = 0.001) compared to ATs. There were no significant differences in scores between coaches and ATs.

Triad-specific knowledge (p = 0.002) and impact (p = 0.0004), and RED-S-specific knowledge (p = 0.02) and impact (p = 0.002), were lower in female cross-country athletes compared to ATs. Only the Triad-specific impact score was significantly lower in female cross-country athletes compared to coaches (p = 0.018). RED-S-specific knowledge was significantly higher than Triad-specific knowledge in female cross-country athletes (p < 0.001). There was no significant difference between Triad and RED-S knowledge scores among coaches or ATs.

Characterization of Education. The proportion of female cross-country athletes who indicated they had not received education on Triad and RED-S was 68% and 78%, respectively (Figure 1, 2). The proportion of coaches who indicated they had not received education on Triad and RED-S was 65% and 70%, respectively (Figure 1, 2). The proportion of ATs who indicated they had
not received education on Triad and RED-S was 13% and 40%, respectively (Figure 1, 2).

Across population groups, 69% of female cross-country athletes, 52% of coaches, and 51% of ATs reported not receiving education on Triad and RED-S from their athletic departments.

Female cross-country athletes who received Triad education had higher impact scores (21.03 ± 6.86) compared to those who did not receive Triad education (18.12 ± 6.82) (p = 0.014) (Figure 1). However, impact scores did not significantly differ in cross-country athletes who had or had not received RED-S education. Impact scores were significantly higher in coaches who received Triad education (25.10 ± 4.50) versus coaches who did not (20.10 ± 6.75) (p = 0.021; Figure 1). In addition, impact scores were significantly higher in coaches who received RED-S education (25.81 ± 4.41) versus those who did not (21.06 ± 6.52) (p = 0.009; Figure 2). Among ATs, impact scores were not different based on Triad or RED-S education. Furthermore, impact scores did not differ among participants who had or had not received education provided by the athletic department on Triad or RED-S, across all study population groups.

Eighty-four percent of female cross-country athletes, 89% of coaches, and 71% of ATs reported receiving no training from their current institution on Triad/RED-S. Female cross-country athletes engaged in online searches of information as a primary education source of Triad/RED-S. Coaches reported reading textbooks related to coaching, physiology, and nutrition and ATs consulted professionals, such as physicians and dietitians as a primary education source. Policies regarding Triad or RED-S concerns provided by athletic department or coaching staff were identified by 4% and 7% of collegiate female cross-country athletes, respectively.
DISCUSSION:

Using a cross-sectional study design, we examined the knowledge, confidence, and impact of Triad and RED-S in collegiate female cross-country athletes, coaches, and ATs. Female cross-country athletes’ scores were significantly lower than the scores of coaches and ATs for knowledge, confidence, and impact. There was no significant difference between the scores of coaches versus ATs for knowledge, confidence, impact, or Triad- and RED-S-specific knowledge and impact. Triad and RED-S-specific knowledge and impact were significantly lower in female cross-country athletes compared to ATs. Female cross-country athletes scored significantly lower compared to coaches on Triad-specific impact. There is an opportunity for coaches and ATs to help increase Triad/RED-S knowledge and confidence in female cross-country athletes. Coaches and ATs are more likely to belong to professional groups and attend professional conferences, where their exposure to education of Triad and RED-S may be increased. Student-athletes often rely on education provided by their athletic departments or their formal education. Due to the lack of mandated education at the athletic department level, student-athletes are at the greatest risk for a lack of knowledge. This is supported by the significantly lower scores in cross-country athletes versus the other groups.

It was assumed that participants would score higher on Triad-specific questions compared to RED-S-specific questions because the development and research of Triad, proposed in 1992, is more robust compared to RED-S, proposed in 2014. However, female cross-country athletes scored higher on RED-S-specific knowledge versus Triad-specific knowledge (p < 0.05) and there was no significant difference in Triad- and RED-S-specific impact scores. RED-S-specific knowledge scores may have been higher due to the wording of the questions, the newer term being more familiar to a younger population, or a shift in terminology for LEA in the sports
community. These relationships should be further assessed with a greater number of questions specific to Triad and RED-S to explore the differences in knowledge and impact across conditions.

There is currently a limited availability of education programs on Triad and RED-S. The present study illustrates that a majority of participants, across all population groups, have not received continuing education from their athletic departments on Triad and RED-S. Impact scores of female cross-country athletes and coaches who received Triad education were significantly higher than those who did not. Overall, participants were more likely to receive education on the Triad than RED-S. Participants were also less confident in RED-S knowledge, given there were no differences in impact scores despite a difference in knowledge scores. Since RED-S is the more inclusive model concerned with identifying several other consequences related to LEA, Triad-only education is likely to overlook the additional potential health and performance consequences outlined by RED-S.

Future education should focus on the inclusion of both Triad and RED-S, emphasizing the importance of related symptomology and consequences. In order to address disparities in knowledge and provide quality treatment for athletes, policies should be implemented at the collegiate institutional and team level to mandate education. Education programs should be developed and tested with the aim to increase knowledge and impact in collegiate athletes, coaches, and healthcare team members. Education programs, such as concussion training, have proven effective in increasing awareness, knowledge, and treatment of athletes and support staff members. The established programs should be taken into consideration when developing and testing Triad and RED-S education. Future studies should explore the most effective and efficacious method of delivery (e.g., in-person seminar, online program), frequency (e.g.,
weekly, monthly, annually), and time of training (e.g., synchronous vs. asynchronous). Overall, education training and resources should focus on increasing knowledge and confidence of Triad and RED-S, as well as the modality that most effectively maintains the highest degree of knowledge post-education.

Cross-sectional studies have investigated Triad and/or RED-S awareness or knowledge in athletes\textsuperscript{18}, high school coaches\textsuperscript{19}, and ATs\textsuperscript{10}. Tosi et al. found that 29\% of adolescent and young adult runners had heard of Triad and 84\% were categorized as having “low knowledge” of Triad\textsuperscript{18}. “Low knowledge” of Triad was not explicitly defined in this study\textsuperscript{18}. A recent study of 123 high school coaches, illustrated that only 24\% had heard of Triad and even fewer, 14\%, were able to correctly identify all components\textsuperscript{19}. Furthermore, more than 85\% of coaches said they would not know how to recognize or intervene if signs and symptoms of Triad were present\textsuperscript{19}. A 2018 study by Kroshus et al. reported that 99\% of collegiate AT respondents to an online survey had heard of Triad and 33\% had heard of RED-S. However, only 13.33\% of participants correctly identified energy imbalance or energy deficiency as a component of Triad\textsuperscript{10}.

These previous studies, combined with our results, underscore the importance of expanding the framework of Triad to RED-S due to the lack of coach and AT awareness and knowledge of RED-S compared to Triad, which is already low\textsuperscript{10,18,19}. Kroshus et al. identified a greater inability of AT participants to identify energy deficiency as a component of Triad, which is at the center of the RED-S model leading to several other health and performance consequences, not specifically outlined in Triad\textsuperscript{10}. The conceptualization of both Triad and RED-S should be included in a comprehensive approach to screening, treatment, and education for these conditions in athletes. Education of Triad and RED-S for all members of the athlete...
community (e.g., athletes, coaches, ATs, sports physicians) is essential for proper recognition, screening, referral, and treatment of clinical cases of Triad and RED-S.

Collegiate female cross-country athletes indicated a lack of policies from their institutions and/or coaching staff. Policies may include instructional information on the referral, treatment, and management of athletes with cases of Triad and RED-S. The lack of policies from collegiate institutions or coaching staff provides an opportunity to improve the quality and standard of care for athletes, especially when it is suspected an athlete may be suffering from Triad or RED-S. Inclusive policies and protocols to screen and treat athletes, particularly after a diagnosis of menstrual irregularity and/or bone stress injury, should be established by collegiate institutions. The Triad Coalition and International Olympic Committee developed the Triad Coalition Cumulative Risk Assessment Score and RED-S Clinical Assessment Tool (RED-S CAT), respectively, to stratify athletes into categories of low, moderate, and high risk. In both models, it is suggested that athletes at low risk may be cleared for sport participation, whereas high risk athletes may not be cleared for sport participation. Collegiate institutions are uniquely positioned to establish and enforce formal policies and protocols, such as these, to evaluate and screen for athletes presenting with Triad and RED-S components.

**Limitations.**

Strengths of this study include multiple population groups and the incorporation of the more robust entity “RED-S” in our knowledge testing, as it is a newer term gaining popularity in the sports community. Collegiate female cross-country athletes, coaches, and ATs were included, which allowed us to assess scores within and between groups. Calculation of an impact score provides further insight into the potential dissemination of information, which is important to understanding the translation of knowledge on Triad and RED-S among athletes and their
support staff. Despite our novel findings, there are limitations to the study. There are no established reference values of total knowledge, confidence, or impact scores to classify respondents into high or low categories. Our reliability participant sample was small and did not include ATs. The cross-sectional design does not allow us to adequately explore causal relationships. Thus, a longitudinal study design may provide insight into significant changes in scores due to education practices. Additional limitations include selection bias. It is possible that those who chose to participate may have a higher interest in, and more existing knowledge of, Triad and RED-S compared to non-respondents. As a result, our findings are likely to overestimate the scores on this topic in our target population. Our target populations do not fully represent the average of all collegiate athletes and staff. Female coaches comprised 47% of our coach sample (head and assistant coaches), whereas a report of NCAA DI institutions reported only 17% of head cross-country coaches were female. Extrapolation of results to other sporting populations should be carefully considered.

**Future Directions.**

More research is required to establish reference values for the scores. It is necessary to discern additional associations and potential reasons for significant differences in scores. Other sporting populations should be evaluated on their knowledge and confidence of Triad and RED-S. It is likely that sporting populations with a lesser risk of developing Triad and RED-S score lower on the Triad and RED-S survey. In this event, education should address sport-specific context in order to best educate, treat, and prevent Triad and RED-S in each population.

The role of registered sports dietitians and mental health specialists on staff should be further explored at collegiate institutions. These medical professionals could assist in the
screening, recognition, treatment, and prevention of Triad and RED-S and coaches and ATs would be able to refer out to these medical professionals more effectively.

Conclusion.

In the current study, we examined the knowledge, confidence, and impact of Triad and RED-S among collegiate female cross-country athletes, coaches, and ATs. Female cross-country athletes’ total scores of knowledge, confidence, and impact were significantly lower compared to the total scores of coaches and ATs. Total scores of knowledge, confidence, and impact were not significantly different between coaches and ATs. In addition, female cross-country athletes and coaches who received education on Triad, as well as coaches who received education on RED-S had significantly higher impact scores compared to those who did not receive education. Education remains chiefly important in increasing knowledge in order to improve identification, treatment, and prevention of Triad and RED-S. Future research is necessary to determine effective methods of education among various populations.
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Table 1: Scoring method sample.

| Participant | Selected response: | Knowledge Score | Confidence Score | Confidence Factor | Impact Score |
|-------------|---------------------|-----------------|------------------|------------------|-------------|
| A           | Low energy availability | +1              | 2                | 0.5              | +0.5        |
| B           | Low energy availability | +1              | 0                | 0                | 0           |
| C           | Amenorrhea          | -1              | 4                | 1                | -1          |

Table 1: Illustration of the scoring method as an example for an individual scored question on Triad and RED-S survey. The confidence scores correspond to the following confidence factor: Confidence score of 4 = 1 point (confidence factor), Confidence score of 3 = 0.75 points (confidence factor), Confidence score of 2 = 0.5 points (confidence factor), Confidence score of 1 = 0.25 points (confidence factor), Confidence score of 0 = 0 point (confidence factor).
Table 2. Descriptive Participant Characteristics.

|                           | Collegiate Female Cross-Country Athletes (n = 175) | Collegiate Cross-Country Coaches (n = 55) | Athletic Trainers of Collegiate Cross-Country Teams (n = 30) |
|---------------------------|---------------------------------------------------|-------------------------------------------|-------------------------------------------------------------|
| Age (y)                   | 20 ± 1.0                                          | 36 ± 11.0                                  | 34 ± 9.0                                                   |
| Total years of experience (y) | 8.95 ± 4.0                                      | 11.80 ± 7.8                               | 11.6 ± 7.4                                                |
| Years at present institution (y) | 3.25 ± 1.9                                      | 8.36 ± 6.9                                 | 8.40 ± 7.8                                                |
| Current mileage (miles/week) | 41.54 ± 15.3                                   | n/a                                       | n/a                                                       |
| Peak career mileage (miles/week) | 56.11 ± 12.9                                   | 71.27 ± 22.8                              | n/a                                                       |
| Lifetime bone stress injury diagnoses | 1.22 ± 1.8                                     | 1.37 ± 3.2                                 | 0.15 ± 0.8                                                |
| Female (%)                | 100                                              | 47%                                       | 90%                                                       |
| NCAA DI (%)               | 55                                               | 55%                                       | 45%                                                       |
| NCAA DII (%)              | 16                                               | 17%                                       | 21%                                                       |
| NCAA DIII (%)             | 23                                               | 25%                                       | 28%                                                       |
| NAIA (%)                  | 5                                                | 13%                                       | 10%                                                       |
| Race (% white)            | 91                                               | 91%                                       | 97%                                                       |
| Related academic area of study (%) | 15                                             | 15%                                       | 100%                                                      |

Table 2: Descriptive and Frequency indicate the averages (mean ± SD) for continuous variables and the frequency (%) for categorical variables among each population group. Related academic area of study includes degrees related to health and performance, such as exercise science, kinesiology, biology, physiology, pre-medical studies, nutrition, dietetics, health studies, athletic training, physical therapy, chiropractic, and nursing.

(NCAA: National Collegiate Athletic Association, DI: Division I, DII: Division II, DIII: Division III, NAIA: National Association of Intercollegiate Athletics)
Table 3. Participant Scores (Knowledge, Confidence, and Impact).

|                                      | Collegiate Female Cross-Country Athletes (n = 175) | Collegiate Cross-Country Coaches (n = 55) | Athletic Trainers of Collegiate Cross-Country Teams (n = 30) |
|--------------------------------------|---------------------------------------------------|------------------------------------------|----------------------------------------------------------|
| Triad-specific knowledge (%)         | 57.48 ± 28.7                                      | 66.70 ± 30.25                           | 77.14 ± 22.0*                                           |
| Triad-specific impact (%)            | 58.45 ± 21.65                                     | 68.06 ± 26.24^*                        | 75.68 ± 21.03^*                                        |
| RED-S-specific knowledge (%)         | 70.52 ± 17.58#                                    | 70.93 ± 17.85                          | 79.80 ± 17.43^*                                        |
| RED-S-specific impact (%)            | 61.41 ± 12.72                                     | 63.93 ± 15.07                          | 70.66 ± 14.15^*                                        |
| Total knowledge score                | 25.00 ± 5.27                                      | 26.92 ± 5.02^*                         | 28.66 ± 4.02^*                                         |
| Total confidence score               | 95.42 ± 28.83                                     | 111.35 ± 24.14**                       | 117.67 ± 22.53^*                                       |
| Total impact score                   | 18.81 ± 7.05                                      | 22.41 ± 6.33^^                         | 23.93 ± 5.69^^                                         |

Table 3: A one-way ANOVA indicates significant differences between groups on: Triad-specific knowledge, Triad-specific impact, RED-S-specific knowledge, RED-S-specific impact, total knowledge scores, total confidence scores, and total impact scores. Paired samples T-tests indicates significant differences between groups on Triad specific scores and RED-S specific scores. Mean ± standard deviations, ^ p < 0.05 significance, *Versus collegiate female cross-country athletes, #Versus Triad specific knowledge.
Figure 1: Bar chart indicating if each population group has received training on the subject of the Triad as an individual entity. Assessment of impact scores via independent samples T-tests, ^p < 0.01 significance, *p < 0.05 significance. *Versus participants who did not receive training
Figure 2: Bar chart indicating if each population group has received training on the subject of RED-S as an individual entity. Assessment of impact scores via independent samples T-tests, ^p < 0.01 significance, *p < 0.05 significance. *Versus participants who did not receive training