The RED-S Protocol: A Standardized Approach for Female College Athletics

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I have no known conflict of interest to disclose.

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Abstract

Relative Energy Deficiency in Sport (RED-S) is an insidious but sinister condition that will affect a significant amount of female college athletes during their careers. Despite its prevalence, there is no standardized approach to screening for and managing this disorder in college athletics. In a novel protocol implemented at a college in the Mountain West, 86% (n=44) of the total female student-athlete population was screened for RED-S and its precursors using validated questionnaires (LEAF-Q and EAT-26). Inclusion criteria were all female athletes over the age of 18. Following the screening questionnaires, subjects were encouraged to attend a follow-up interview to discuss their results. The questionnaires identified 70% (n=31) of participants deemed at risk for this syndrome and should receive follow-up guidance. Of the 70% considered at risk, only 41% (n=13) attended the follow-up interview. Only 3% (n=1) sought help from the Wellness Center or Athletic Trainer after the interview. The results of this project confirmed that female college athletes are at risk for this threatening condition and are not receiving appropriate screening and care. This project also showed that a standardized approach to RED-S is a critical yet efficient and feasible option to improve the health and performance of female college athletes.

Keywords: *Relative Energy Deficiency in Sport, RED-S, Low Energy Availability, screening questionnaires, female college athletes*

The RED-S Protocol: A Standardized Approach for Female College Athletics

The Female Athlete Triad is a well-known and well-researched syndrome that affects female athletes. Unfortunately, Relative Energy Deficiency in Sport (RED-S) is not as widely known, even though it impacts significantly more athletes. Most athletes do not realize they are suffering from this disorder, and most providers do not know about it or how to screen for it.

Background and Significance

RED-S and its causative issue, Low Energy Availability (LEA), are precursors to the Female Athlete Triad (FAT). FAT is characterized by low energy due to disordered eating (DE) or eating disorders (ED), osteoporosis or osteopenia, and menstrual cycle dysfunction (Cabre et al., 2022; Logue et al., 2020). A substantial literature review and synthesis showed that although RED-S has been public knowledge for nearly a decade, it was not until the last four years that RED-S became a focal point of discussion and study (see Appendices A and B).

RED-S is a deficiency in caloric intake compared to energy expenditure that prevents an athlete's body from functioning optimally (Cabre et al., 2022; Logue et al., 2020; Mehta et al., 2018). Five days of LEA can lead to symptom onset and complications (Cabre et al., 2022; Mehta et al., 2018). Unrecognized LEA/RED-S can lead to long-term complications, including osteoporosis, osteopenia, amenorrhea, cardiovascular dysfunction, immune system suppression, muscular atrophy, orthostatic hypotension, infertility, anemia, anxiety, depression, poor athletic performance, and other comorbidities (Cabre et al., 2022; Mehta et al., 2018; Melin et al., 2018).

As a result of inconsistent definitions of RED-S, non-standardized questionnaires and their use, reporting bias in the responses to screening questionnaires, and a general lack of awareness of RED-S/LEA, it is difficult to obtain an accurate estimate of RED-S and LEA in female college athletes (Cabre et al., 2022; De Souza et al., 2014, Logue et al., 2020; Mehta et

al., 2018). However, Logue et al. (2020) state that 22-58% of female athletes will experience LEA or RED-S during their athletic careers. In 2022, the National Collegiate Athletic Association (NCAA) published a student demographic report for the last 50 years demonstrating a continuous increase in the number of female athletes participating in college sports. As more females participate in collegiate athletics, it should be assumed that more female athletes will suffer from LEA or RED-S. This is partly because female athletes, compared to male athletes and the general population, have a higher risk of developing RED-S secondary to an ED or DE because of the pressure to perform well, the public scrutiny of their bodies in form-fitting and revealing uniforms, misinformation about healthy eating as an athlete, and mental illnesses (Mehta et al., 2018; Melin et al., 2019).

Screening questionnaires are the most common interventions to assist in identifying ED/DE, RED-S, and LEA (Mehta et al., 2018; Melin et al., 2019; Rogers et al., 2021; Sim & Burns, 2021). Nevertheless, they are under-utilized in the college female athlete population, most likely due to the unfamiliarity with RED-S and its prevalence and a high level of discomfort in treating the syndrome among healthcare professionals (Logue et al., 2020; Mehta et al., 2018; Tenforde et al., 2020). Mehta et al. (2020) reported that 63% of physicians were unaware of RED-S, and Tenforde et al. (2020) reported that 73% of sports medicine healthcare providers were unaware of it. There is a problem with this lack of familiarity, as providers can neither screen for nor treat a syndrome if they are unaware of it.

Setting and Stakeholders

A small college in the western United States envisions its students entering with a passion and leaving with a purpose. They pride themselves in offering affordable and quality education to traditional, non-traditional, non-degree-seeking, and trade school students. They serve an

estimated 3,000 students annually. Of those 3,000 students, there are 75 student-athletes, and roughly 50 are female athletes who play basketball, soccer, or volleyball. There are no protocols or regulations for screening female athletes for RED-S/LEA or ED/DE in the athletics department.

Numerous stakeholders are involved in this project: coaches and coaching staff, athletic director, athletic trainer, institution administration, and wellness center counselors. The coaches and coaching staff are stakeholders invested in the success of this project since it has the potential to positively impact their athletes both on and off the playing field. Coaches, trainers, and staff who support the project can advocate for its continued use, and it will serve as the first line of defense against RED-S. With the trainer's support, athletes, coaching staff, and all other parties involved will be more convinced of the project's success. Due to the athletic director's commitment to improving the health and well-being of student-athletes at the institution, she is a stakeholder in this project. In addition to assisting with institutional administration, she and the site champion are on hand to navigate administrative hurdles. The wellness center counselors are another critical stakeholder in this project. Counselors are more likely to support the project if they are aware of the prevalence and importance of these disorders. Athletes determined to be at risk for RED-S or ED/DE will be referred to counselors for an initial therapeutic intake exam. Institution administration is the gatekeeper for implementing the project. If they believe in the project and understand the positive impact that it will have on the athletics program, they have the power and authority to approve it and ensure the athletics department has the appropriate resources to maintain it.

Project Purpose

The purpose of this quality improvement project was to increase the awareness and management of RED-S and LEA among female college athletes and athletic staff by establishing a protocol at a small institution in the Southwest United States. This protocol had three components: an educational seminar, appropriate screening questionnaires, and a standardized treatment plan that utilized campus resources. By following the protocol, RED-S was identified and awareness increased, thus decreasing long-term complications.

PICO Question

A review of the literature leads to the clinically relevant PICOT question: For a college athletics program, how does implementing a RED-S education and screening protocol compare with no education and screening during the competitive sports season provide an accurate assessment of athletes at risk for Relative Energy Deficiency in Sport?

Search Strategy and Literature Review

To best answer the PICO question, an intensive literature review exhausted three databases: SAGE Journals, CINAHL, and PubMed. All three databases are peer-reviewed and only publish articles that meet their standards. By systematically searching these three databases for articles relevant to the PICO question, there is little doubt that all applicable studies were discovered and reviewed.

Initial and Final Search Yields

All searches were limited to the English language, full-text, and published within the last five years. The initial search contained the phrases: *female athletes or women athletes and relative energy deficiency in sport or RED-S.* This search yielded 175 results in PubMed, 689 in SAGE Journals, and 70 in CINAHL. The terms *college athletes and LEA or low energy availability and screening*, *test*, *management, diagnosis, or assessment* were added to refine the

search. These additions produced 300 PubMed results, 52 in SAGE Journals, and 101 in CINAHL. To encompass a broader range of studies, the term *eating disorder* was added to the PubMed and CINAHL databases, which yielded 520 and 431 articles, respectively. One last search was performed in all three databases where the population term *female athletes or women athletes* was changed to *junior college athletes or community college athletes,* which produced zero results overall. Gray literature was reviewed but was excluded due to poor design or methodology, published more than five years ago, or significant bias. After reviewing the titles and abstracts of the results, 80 articles were selected for further review. After completing a rapid critical appraisal checklist, the top 10 most relevant studies were selected for inclusion.

Limitations, Inclusion, and Exclusion Criteria

Explicit inclusion and exclusion criteria were used to identify all potentially relevant studies. The inclusion criteria included studies that were (1) published in the English language; (2) were limited to human subjects; (3) available in full text; (4) and performed from 2001 to 2023. The exclusion criteria comprised of studies that were (1) not available in full text; (2) had poor design or methodology; (3) and had significant bias. The ten studies included: two systematic reviews, one randomized controlled trial, and seven cross-sectional studies. There is a paucity of high-quality level one and two evidence due to the only recent significant interest in RED-S and LEA, which is why level three evidence is sufficient for this literature review.

Critical Appraisal and Evidence Synthesis

The articles selected for inclusion were graded on strength and quality by a rapid critical appraisal tool (Melnyk & Fineout-Overholt, 2019). All studies that underwent appraising were quantitative, with two systematic reviews for level one evidence, one randomized controlled trial for level two evidence, and seven cross-sectional studies for level four evidence (see Appendix A

Table A1). There is a paucity of high-quality level one and two evidence due to the only recent significant interest in RED-S and LEA, which is why having a majority of level four evidence is sufficient for this literature review.

The focus of each study has a wide range of heterogeneity; three studies examined the prevalence of RED-S/FAT in female athletes, three studies explored RED-S/FAT knowledge among athletes, coaches, and trainers, and both systematic reviews explored the efficacy of screening questionnaires to identify RED-S/FAT/ED/DE (see Appendix A Table A2). One study examined the relationship between the LEAF-Q and biophysical manifestations of RED-S/FAT (Rogers et al., 2019). The final study examined the relationship between ED symptom severity and a discussion-based intervention (Steward et al., 2019). While most studies used validated instruments for measurement, a small portion created tools because a validated one does not exist yet. Note that the internally created tools were based on valid instruments but were modified to fit the study's goal and to gather the appropriate data.

Prevalence and intervention-based studies had a homogenous population of females aged 17-44 at various levels of athletic competition, from recreational to professional. Two studies were international; one occurred in Ireland, one in the United Kingdom, and the rest in the United States. The knowledge-based studies introduced more heterogeneity to the demographic pool by including healthcare professionals and coaches, which introduced males and individuals >44 years old.

After carefully reviewing the top 10 most relevant studies, three themes became apparent and should be focused on. One, there is a high risk of RED-S/FAT in female athletes, with increasing prevalence in higher levels of competition, thus putting college athletes at significant risk for LEA and RED-S. Two, the ability to identify, prevent, and treat LEA/RED-S/FAT is low

among athletes, coaches, and healthcare professionals, leading to poor outcomes if not addressed. Three, screening questionnaires are an appropriate and validated tool to identify athletes at risk for LEA/RED-S/FAT/ED/DE, providing a feasible intervention to prevent or improve poor outcomes. Based on the main themes, it should be assumed that validated tools used to screen college athletes for LEA/RED-S/FAT/ED/DE will identify high-risk individuals who should be referred to a healthcare provider with experience managing those conditions, thus improving outcomes for female athletes.

Theory and Theoretical Framework Application

Orem's Self-Care Theory assumes a balance between Self-Care, Self-Care Agency, and Self-Care Demands after adjusting for age, ability, socioeconomic status, and other variables (Gonzalo, 2023; Petiprin, 2023) (see Appendix B Figure B1). Self-Care is the actions taken to maintain health, and Self-Care Agency is the ability of an individual to perform those actions. Self-Care Demands are the volume of actions that must occur in a certain amount of time to maintain health and wellness (Gonzalo, 2023; Petiprin, 2023). When there is an imbalance in one of those areas, it is termed Self-Care Deficit, and that is when Nursing Agency comes into effect. Essentially, this means the nurse determines how to get an individual to be self-reliant again by correcting the imbalance in self-care (Gonzalo, 2023; Petiprin, 2023). Some fundamental tenets of universal Self-Care principles are to have an appropriate food intake, a proper ratio of activity and rest, and to prevent self-harm (Gonzalo, 2023; Petiprin, 2023). These tenets describe LEA/RED-S/FAT almost exactly, as they result from a deficient calorie intake coupled with an inappropriate ratio of activity and rest which can lead to self-harm. When an athlete is in a Self-Care Deficit, i.e., when experiencing LEA/RED-S/FAT, this theory recommends that Nursing Agency be employed to fix the deficit and help the athlete return to a homeostatic state.

Nursing Agency actions can be Wholly Compensatory, Partial Compensatory, or part of a Supportive-Education System (Gonzalo, 2023; Petiprin, 2023). Wholly Compensatory is when the nurse does everything for an individual. Partial Compensatory actions assist an individual in completing their tasks, and Supportive-Education System actions are when a nurse educates the individual on how to perform the actions independently (Gonzalo, 2023; Petiprin, 2023). By understanding the scope of actions that a nurse can take to correct a Self-Care Deficit, an appropriate intervention can be created to combat LEA/RED-S/FAT.

This project falls into the Supportive-Education System because it educates athletes with a Self-Care Deficit about available resources so they can manage their disorders with or without professional help. As this project becomes engrained in the foundation of the athletic network over the next few years, it could become a Partial Compensatory action. This means that after an athlete is identified as at-risk for RED-S, the nurse would take a more hands-on approach to ensure the athlete is utilizing available resources and helping to manage the condition.

Implementation Framework

Rosswurm and Larrabee (1999) created a Quality Improvement Framework model to implement organizational change based on best practices and evidence (see Appendix B Figure B2). In summary, the model involves identifying a need within an organization, linking the problem with desired outcomes, synthesizing the best evidence, developing a proposed intervention, implementing and evaluating the proposed intervention and outcomes, and finally integrating and maintaining the intervention if it is beneficial to the organization (Rosswurm & Larrabee, 1999). This framework is ideal for creating an organizational change targeting LEA/RED-S/FAT.

According to our assessment of the institution's needs, there is a deficiency in screening for LEA, RED-S, and ED among female athletes. Linking this deficit with the desired end-state, healthy athletes that perform well academically and athletically, the evidence search and literature review showed that screening tools effectively and efficiently identify athletes at risk for these conditions. The next step is to create and implement a protocol that uses validated screening tools to identify high-risk athletes and standardize the treatment and management process. After that intervention is implemented on a trial basis, it is reviewed for effectiveness and value. If deemed valuable to the organization, it is integrated into the standard operating procedure and will be continually evaluated for benefit and effectiveness, with changes and modifications made as needed.

Methods

This project was approved by the WWCC and Arizona State University's Institutional Review Board (IRB), with final approval granted on November 1st, 2023. It was noted to pose minimal to no risk to participants who receive the education and survey. Three ethical principles guided this project: respect for person(s), beneficence, and justice.

Participants and Recruitment

The coaches, support staff, athletic director, athletic trainer, and student-athletes received an email requesting their help with this project at the following intervals prior to initiation of the project: one month, one week, one day, and the day of the project.

Participants were asked to complete an informed consent form, and no monetary compensation was given. All participants were encouraged to act in their independent interest, free from coercion or other prerogatives. The principles of veracity and fidelity were demonstrated by communication, transparency, informed participation, and advocacy. All

stakeholders were encouraged to maintain transparency and open communications during the project. Additionally, there was an open-door policy for questions, concerns, and clarifications for all participants.

The student-athletes participated in a short presentation that defined RED-S, the Female Athlete Triad, Eating Disorders, and Low Energy Availability. It discussed the epidemiology of these disorders, common signs and symptoms, potential long-term complications, and when to see a medical provider. As a result of the presentation, participants understood the possible adverse effects of these disorders, why screening is important, and should be more comfortable talking about these disorders with coaches and healthcare professionals. The presentation took place in a large conference room at the project site and lasted approximately 45 minutes.

Data Collection and Outcomes Management

Student-athletes who enrolled in the study completed the Low Energy Availability in Females Questionnaire (LEAF-Q) (Appendix C Figure 1) and the Eating Attitudes Test- 26 (EAT-26) (Appendix C Figure 2). The LEAF-Q is a validated and sensitive instrument that screens for self-reported symptoms potentially caused by low energy availability, including frequent injury, gastrointestinal dysfunction, and menstrual dysfunction. A score is generated based on the participant's response to questions in those domains. A score ≥8 indicates the individual is at risk for LEA (Melin et al., 2014).

The EAT-26 is a validated and sensitive instrument that measures eating behaviors to identify individuals who might be at risk for an eating disorder. The EAT-26 measures participants' self-reported behaviors and beliefs about food and eating to generate a score with a score of ≥20 indicating a potential eating disorder or disordered eating (Garner et al., 1982). It also screens for red flag eating behaviors such as binge eating, vomiting after eating, laxative or

diuretic use to control weight, and excessive exercise. A positive response to any of those questions was deemed a high-risk behavior (Garner et al., 1982).

As part of these questionnaires, demographic information such as age, ethnicity, sport, and grade was also collected. It was possible for participants to skip questions they did not wish to answer. The questionnaires were answered directly after the presentation and took approximately 20 minutes.

In order to prevent student-athletes from feeling pressured to participate, coaches and athletic trainers were not allowed to attend the presentation or follow-up interview. Coaches, staff, athletic trainers, and the Wellness Center did not receive individual results of the screenings unless a participant voluntarily disclosed them. Student-athletes were also reminded that their participation in the project, or non-participation, would not impact their playing time, scholarships, or other benefits associated with competing at this institution. At the end of the competitive season, a report, with de-identified information, was provided to the coaches, staff, and athletic trainer detailing which percentage of participants are considered at-risk for these syndromes. However, it did not include personally identifiable information.

The project investigator reviewed, scored, keyed, and de-identified the questionnaires after all participants completed them. To clarify any questions that participants may have regarding the results of the questionnaires, follow-up interviews were scheduled, lasting approximately 15 minutes. Participants considered at risk for these syndromes were encouraged to use the appropriate resources at the project site. Participants at risk for Low Energy Availability or RED-S were encouraged to meet with the Athletic Trainer to create food logs and increase caloric intake. Participants at risk for eating disorders were encouraged to meet with the Wellness Center to discuss management and prevention. All participants identified as at risk for

any disorder were encouraged to follow up with a primary care provider for further evaluation and comprehensive management. Those not at risk for these syndromes were provided with information regarding campus resources. It should be noted that these questionnaires and interviews were not sufficient for the diagnosis of these disorders; rather, they were only designed to identify student-athletes at risk for developing these disorders.

After all the data was collected and de-identified, it was entered into a statistics software program for data analysis. Data analysis was done to identify which age groups, college grade levels, and sports teams have the highest percentage of at-risk athletes.

The prospective outcomes of this project included identifying the student-athletes experiencing these syndromes, educating student-athletes on available resources, and ways to prevent the progression of the issues, as well as aggregate data regarding student-athletes who contacted the appropriate resource within one month of the initial screening. At the conclusion of the competitive season, the athletic staff received the results after analyzing the collected data. Following their review, a short meeting was held with the key stakeholders to discuss the outcomes and recommendations for how to improve the protocol. Appendix D provides a brief overview of the project.

Budget and Funding

The budget for this project was maintained by the project investigator. It included the cost of gas for travel, investigator meals and lodging, and printing costs for the surveys (See Appendix E).

Results

Introduction

Intellectus statistics was used to manage all data and analysis. Descriptive statistics analysis was utilized for all analyses.

Demographics

A total of 86% (n=44) of the total female student-athlete population participated in the project protocol, which included an educational seminar, two screening questionnaires, a follow-up interview, and referral to other resources as needed. An analysis of descriptive statistics was conducted on participants and is presented in the following Table 1 (See Appendix F Table 1).

Each of the 44 athletes completed the LEAF-Q and EAT-26 screening questionnaires. The LEAF-Q utilizes injury history, and gastrointestinal and menstrual functions to generate a score. A score ≥8, out of a possible 49, indicates the individual is at risk for LEA (Melin et al., 2014). The LEAF-Q scoring does not indicate the severity of symptoms. The score should only be used to identify not-at-risk and at-risk athletes (Melin et al., 2014). The average LEAF-Q participant score was 8.50. There was a high score of 19, and one participant scored 0. (See Appendix E Table 2).

The EAT-26 measures participants' self-reported behaviors and beliefs about food and eating to generate a score with a score of ≥20 indicating a potential eating disorder or disordered eating (Garner et al., 1982). In contrast to the LEAF-Q, the EAT-26 score does correlate to the severity of behaviors and attitudes. A higher score indicates a more disordered relationship with food and eating. The average EAT-26 score was 8.07. The highest score was 37, and 10 participants scored 0. Seven participants scored ≥20. Additionally, it screens for red flags related to eating behavior, such as binge eating, vomiting after eating, laxative or diuretic use to control weight, and excessive exercise. A positive response to any of those questions was deemed a high-risk behavior (Garner et al., 1982). Among the participants, 22.7% (n=10) of participants

responded positively to one or more questions about high-risk behavior. EAT-26. (See Appendix E Table 2).

ANOVAs

An analysis of variance (ANOVA) was conducted to determine whether there were significant differences in EAT-26 Score by Ethnicity, Grade, and Sport. A second ANOVA was conducted to determine whether there were significant differences in LEAF-Q Score by Ethnicity, Grade, and Sport.

Before interpreting the results of the ANOVAs, they were evaluated for normality, homoscedasticity, and outliers. Significant deviations from the predicted or theoretical data could indicate an unreliable data set (Field, 2017; Osborne & Waters, 2002; Pituch & Stevens, 2015). After reviewing the Q-Q scatterplots, homoscedasticity scatterplots, and Studentized residuals plots, the data was deemed appropriate and reliable for analysis and interpretation. (See Appendix E Figures 1-6).

Results

The first ANOVA evaluating the relationship between EAT-26 Score and Ethnicity, Grade, and Sport was examined based on an alpha value of .05. The results of this ANOVA were not significant, $F(8, 35) = 0.85$, $p = .565$, indicating the differences in EAT-26 Score among the levels of Ethnicity, Grade, and Sport were all similar. (See Appendix E Table 3). The main effect, Ethnicity was not significant, $F(4, 35) = 0.62$, $p = .652$, indicating there were no significant differences of EAT-26 Score by Ethnicity levels. The main effect, Grade was not significant, $F(1, 35) = 0.58$, $p = .451$, indicating there were no significant differences of EAT-26 Score by Grade level. The main effect, Sport was not significant, $F(3, 35) = 0.76$, $p = .524$, indicating there were no significant differences of EAT-26 Score by Sport levels.

The second ANOVA evaluating the relationship between LEAF-Q Score and Ethnicity, Grade, and Sport was examined based on an alpha value of .05. The results of this ANOVA were not significant, $F(8, 35) = 1.67$, $p = .142$, indicating the differences in LEAF-Q Score among the levels of Ethnicity, Grade, and Sport were all similar. (See Appendix E Table 4). The main

effect, Ethnicity was significant, $F(4, 35) = 2.98$, $p = .032$, $\eta_p^2 = 0.25$, indicating there were statistically significant differences in LEAF-Q Score by Ethnicity levels and will be evaluated post-hoc. (See Appendix E Figure 7). The main effect, Grade was not significant, $F(1, 35) = 0.12$, $p = .734$, indicating there were no significant differences of LEAF-Q Score by Grade levels. The main effect, Sport was not significant, $F(3, 35) = 0.53$, $p = .667$, indicating there were no significant differences of LEAF-Q Score by Sport levels.

Post-hoc

There were no significant effects in the model for the first ANOVA. As a result, posthoc comparisons were not conducted.

For the second ANOVA, a *t*-test was calculated between each group combination to further examine the differences between LEAF-Q score and Ethnicity, Grade, and Sport based on an alpha of .05. The Tukey HSD p-value adjustment was used to correct for the effect of multiple comparisons on the family-wise error rate. For the main effect of Ethnicity, the mean of LEAF-Q Score for White ($M = 7.74$, $SD = 4.22$) was significantly smaller than for Other ($M = 15.33$, $SD = 3.51$), $p = .036$. No other significant effects were found.

Fisher's Exact Tests

Introduction

A Fisher's exact test was conducted to examine whether Sport and Scores Indicated Referral were independent. The variable, Scores Indicated Referral, means that one of the two questionnaires the participants filled out classified the participant as high risk (LEAF-Q ≥ 8, EAT-26 ≥ 20, or Red Flag Eating Behaviors). There were four levels in Sport: Volleyball, Basketball, Soccer, and Multi-Sport. There were two levels in Scores Indicated Referral: No and Yes.

A second Fisher's exact test was conducted to examine whether Grade and Scores Indicated Referral were independent. There were two levels in Grade: Freshman and Sophomore. There were two levels in Scores Indicated Referral: No and Yes.

A third Fisher's exact test was conducted to examine whether Ethnicity and Scores Indicated Referral were independent. There were five levels in Ethnicity: White, Black, Other, American Indian or Alaskan Native, and Multi-Ethnic. There were two levels in Scores Indicated Referral: No and Yes.

Results

The results of the first Fisher exact test were not significant based on an alpha value of .05, $p = .937$, suggesting that Sport and Scores Indicated Referral could be independent of one another. This implies that the observed frequencies were not significantly different than the expected frequencies. (See Appendix E Table 5).

The results of the second Fisher exact test were not significant based on an alpha value of .05, $p = .170$, suggesting that Grade and Scores Indicated Referral could be independent of one another. This implies that the observed frequencies were not significantly different than the expected frequencies. (See Appendix E Table 6).

The results of the Fisher exact test were not significant based on an alpha value of .05, $p = .211$, suggesting that Ethnicity and Scores Indicated Referral could be independent of one another. This implies that the observed frequencies were not significantly different than the expected frequencies. (See Appendix E Table 7).

Follow Up Interview

Out of the 44 participants, 70% (n=31) had scores that indicated referral or further evaluation. Only 39% (n=17) of all participants attended the follow-up interview to review their

results with the primary investigator. Of the 31 participants with a score indicating referral, 42% (n=13) participated in the follow-up interview. Only one person utilized campus resources (athletic trainer or Wellness Center) for education or help after the follow-up interview.

The follow-up interview was important because it allowed the principal investigator to ask clarifying questions and identify areas of interest that were not previously known. All three participants who marked their Ethnicity as "Other" were international students and participated in the follow-up interview. "Other" students have higher LEAF-Q scores when compared to "White" students: 15.33 compared to 7.74. When reviewing their LEAF-Q scores, it became apparent that their gastrointestinal dysfunction was less likely related to RED-S/LEA and more likely associated with the drastic change in diet after moving to the United States.

Project Impact- Clinical Significance

The implementation of the RED-S Protocol had a significant impact on the project site. In the educational seminar, most female athletes at the project site were taught the warning signs of RED-S and LEA and the importance of increasing calorie intake. In the follow-up interviews, participants made multiple comments that indicated retention and learning for the project investigator despite the absence of a pre- and post-test to assess understanding and retention.

After analyzing the project data and notifying the athletic department staff that 70% of female athletes, irrespective of grade, sport, and ethnicity, were at risk for RED-S and LEA, they immediately began to discuss how to assist them. A discussion surrounding the process to implement the protocol at the beginning of the next school year when sports resume has begun. Additionally, they began working to make it part of the athletic department's standard practices. This process included tentatively planning dates to educate and screen the athletes when they

return to campus in August 2024. It also included solidifying the roles and responsibilities of the athletic department staff members in the protocol.

Discussion

There are four key findings from this project. First, the average female college athlete at the project site is experiencing RED-S/LEA. Seventy percent of participants were deemed at risk. According to the literature, the majority of female athletes experience these syndromes throughout their careers (Logue et al., 2022). Second, student-athletes are not seeking help for these syndromes. Only 39% of student-athletes met with the principal investigator to receive their results and get appropriate guidance for their next steps. Only one participant utilized the Wellness Center after meeting with the project investigator. No participant met with the Athletic Trainer for direction, help, and support. Third, female athletes are at high risk for developing an eating disorder or disordered eating. Twenty three percent of participant female athletes engaged in red flag eating behaviors that could be concerning for an eating disorder. Fourth, screening questionnaires are an efficient and cost-effective way to identify at-risk athletes and refer them to the appropriate resources.

An additional finding found was those students who classified their Ethnicity as “Other” were international students who scored higher on the LEAF-Q. If those students had not participated in the follow-up interview, it could have been assumed that “Other” students were at higher risk of developing RED-S/LEA. However, it is more likely that their LEAF-Q score was falsely elevated due to the change in diet after moving to the United States, subjectively causing increased bloating and cramping.

A significant limitation of this project was the low participation rate in the follow-up interview. By not participating in the follow-up interview, student-athletes did not receive their

scores and guidance if they were deemed at risk. This project flaw could have been mitigated by collecting contact information to briefly discuss the participant's scores and the appropriate next steps without requiring a follow-up interview.

Identifying the reasons why participants may hesitate to participate in follow-up interviews is one of the objectives of future studies. Future studies should also explore the barriers athletes must overcome to use free campus resources. In this project, only one participant used campus resources.

RED-S is a common yet underdiagnosed syndrome that impacts a majority of female athletes. This efficient and cost-effective protocol educates athletes about the signs and symptoms of RED-S, LEA, and ED/DE and how to prevent or recover from them. It uses validated screening tools to identify at-risk athletes and standardizes the management of females suffering from these insidious syndromes. Immediate implementation of this protocol in all institutions with female athletes is needed to safeguard them from short- and long-term complications.

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Appendix A Table A1
Evaluation Table for Quantitative Studies

Citation	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
Feltner et al., (2022), Screening for eating disorders in adolescents and adults: Evidence report and systematic review for the US Preventative Services Task Force **Country**: US **Funding**: Agency for Healthcare Research and Quality, US Department of Health and Human Services **Bias**: not explicitly stated or implied	**Design:** Systematic Review **Purpose:** Review the literature to understand the benefits and harm of screening adults and adolescents for EDs	**N= 57** **Demographics:** English, adolescent or adult population, primary care type settings, countries that are very high on the United Nations Human Development Index	**IV1:** ED screening tests **DV1:** Accuracy of screening tests for ED **DV2:** Effectiveness of interventions for improving health outcomes **DV3:** Harms of interventions	**Tools:** SCOFF questionnaire Yale-Brown Obsessive Compulsive Scale **Validity/ Reliability:** Both tests are highly reliable and have been validated in multiple populations	**Statistical Tests Used:** None were explicitly stated in the article, but the reviewed literature used statistical tests and analysis.	**DV1:** SCOFF test was researched most often and has a high specificity/sensitivity for ED. Screening tools are valid clinical instruments. False positive rate 20% **DV2:** Lisdexamfetamine and topiramate are effective in reducing ED symptom severity. Guided self-help was more effective than unguided self-help. **DV3:** Pharmacologic interventions were associated with adverse effects such as tremors, nausea, vomiting, & confusion.	**LOE:** 1 **Strengths**: Broad literature search. Thorough. **Weakness**: 2 key questions were not answered due to a lack of research **Application**: Screening questionnaires are an easy next step that can be applied in any setting.
Kroshus et al., (2018), Collegiate	**Design:** Cross-sectional study	**N= 285** **Demographics:** Head athletic	**IV1:** Gender of athletic trainer	**Tools: Internally created survey**	**Statistical Tests Used:**	**DV1:** Women trainers had greater knowledge/awareness	**LOE:** 1

athletic trainers' knowledge of the female athlete triad and relative energy deficiency in sport **Country:** US **Funding:** Not stated **Bias:** Possible b/c authors are likely employed at schools that participated in the study. Funding was not stated, so bias could also be attributed to this.	**Purpose:** To determine Head Athletic Trainers' knowledge of FAT and RED-S and to see the variability of screening and referral actions among the different national collegiate athletic association institutions	trainers at National Collegiate Athletic Association institutions **Setting:** Collegiate athletic training departments **Exclusion:** It was not stated but implied that non-head ATs were prohibited from participating. **Attrition: 0%**	**IV2:** Institution Level **DV1:** FAT/RED-S Knowledge **DV2:** Referral **DV3:** Screening for ED/DE/LEA/RED-S **DV4:** Prescribe hormonal contraception **Definitions:** Institution Level is either Division 1, 2, or 3 in the National Collegiate Athletic Association Referral: Pt referred to a sports medicine physician, counselor, psychologist, nutritionist, or dietitian	**Validity/ Reliability:** Not stated	**Fisher Exact test** **Mann-Whitney Test** **Kruskal-Wallis Test**	of FAT, including diagnostic criteria. Four men had not heard of it. Over 60% of respondents had not heard of RED-S. **DV2:** 47% of schools always refer to a sports medicine provider if there is menstrual dysfunction. Division 1 schools were more likely to refer athletes to nutritionists. **DV3:** Division 1 schools screen for ED/DE more often than 2 and 3 schools (70% vs. 48% vs. 49%). Division 3 schools had a higher frequency of annual screenings (80%) than 1 and 2 schools (71% and 57%). Division 2 and 3 schools were more likely never to assess menstrual function (14.3% and 16.9% vs. 4.7%) **DV4:** Division 1 schools were more likely to prescribe hormonal contraception.	**Strengths:** Large sample size. Addressed many variables. **Weakness:** Limited response rate possibly overestimates RED-S awareness. The internal survey is not validated and could cause response bias. **Feasibility:** At larger institutions, it is more feasible to implement screenings because of the availability of staff to review screenings and meet with athletes. The US Preventative Services Task Force cautions against screenings if there is no plan to refer and care for an individual at risk for LEA/RED-S. **Application:** With a clear and proper protocol, it should be easily applicable at institutions. Especially if partnering with campus health services or community partners.
Lodge et al., (2022), Knowledge of the female athlete triad and relative energy deficiency in	**Design:** Cross-sectional **Purpose:** Understanding the depth and breadth of knowledge about FAT/RED-S	**N= 260** **Demographics:** 175 athletes 55 coaches 30 trainers	**IV1:** Survey **DV1:** FAT/RED-S knowledge of athletes **DV2:** FAT/RED-S knowledge of coaches	**Tools:** Internally created a survey using questions from multiple validated surveys. **Validity/**	**Statistical Tests Used:** Shapiro-wilk Komogorov-smirnov test 1-way analysis of variance	**DV1:** lowest knowledge and confidence scores of all three groups. The only group that scored higher on RED-S knowledge than FAT knowledge	**LOE:** 4 **Strengths**: Looked at three different groups of people, a large sample size from diverse locations **Weakness**: Limited to cross country, used a non-

sport among female cross-country athletes and support staff **Country**: US **Funding**: Not stated **Bias**: None noted	amongst college cross-country athletes, coaches, and trainers	**Setting:** National Collegiate Athletic Association schools **Exclusion:** had to be currently involved in a cross-country program **Attrition:** 81 surveys were improperly filled out	**DV3:** FAT/RED-S knowledge of trainers	**Reliability:** Not stated	Tukey post hoc analysis Paired-samples t-test Independent t-tests	**DV2:** The majority of coaches had little knowledge of FAT and RED-S **DV3:** Trainers had more knowledge of FAT than RED-S	validated tool for information gathering. **Feasibility**: Interventions need to be aimed at all three levels of impact **Application**: Create high-impact players to create the most change
Logue et al., (2019), Screening for risk of low energy availability in athletic and recreationally active females in Ireland **Country**: Ireland **Funding**: Irish Research Council and Sport Ireland **Bias**: None noted	**Design:** Cross-sectional **Purpose:** Screening for risk of LEA in different competition levels of athletes in Ireland	**N= 833** **Demographics:** 18-44 y/o; international, provincial/inter-county, competitively, and recreational athletes; many sports **Setting:** self-administered online questionnaire **Exclusion:** failing to finish the questionnaire Provincial/inter-county athletes are similar to semi-pro or D1 college athletes. Competitive athletes are comparative to lower levels of college athletes.	**IV1:** LEAF-Q **DV1:** LEA risk in international athletes **DV2:** LEA risk in provincial/inter-county athletes **DV3:** LEA risk in competitive athletes **DV4:** LEA risk in recreational athletes	**Tools:** LEAF-Q sensitivity 78% specificity 90% **Validity/ Reliability:** Validated in athletes	**Statistical Tests Used:** Chi-square analysis Logistic regression analysis	**DV1:** 45% at risk **DV2:** 47% at risk **DV3:** 38% at risk **DV4:** 33% at risk 40% of total participants were at risk for LEA Every extra hour of practice a week increases the risk of LEA by 1.06x	**LOE:**4 **Strengths**: large sample size, many different sports, results are consistent with current literature **Weakness**: Utilized non-validated questions to gather more information, self-selection, and response bias **Feasibility**: LEAF-Q is an easy tool to screen for LEA in athletes **Application**: Easy to apply to college programs as a preparticipation physical or during periods of intense activity

Rogers et al., (2021), The utility of the low energy availability in females questionnaire to detect markers consistent with low energy availability-related conditions in a mixed-sport cohort **Country:** Australia **Funding:** AIS High Performance Research Fund, University of Canberra Research Institute for Sport and Exercise **Bias:** Many authors work for or with the AIS, which could be a source of bias due to the pressure to produce favorable results.	**Design:** Cross-sectional study **Purpose:** Determining if the LEAF-Q can identify biological manifestations of LEA or FAT in elite and pre-elite female athletes	**N= 75** **Demographics:** 18-32 (mean 23) years old, Female, elite or pre-elite athletes, members of a national sporting organization (athletics, basketball, boxing, netball, rowing, water polo, weightlifting) **Setting:** Australian Institute of Sport **Exclusion:** Not explicitly stated **Attrition: 0%**	**IV1:** LEA/FAT **DV1:** LEAF-Q Score **DV2:** DXA Scan **DV3:** Energy Availability **DV4**: Psychiatric Conditions **DV5**: DE **DV6**: Menstrual function **DV7**: Bloodwork **DV8**: Time loss **Definitions:** **DXA Scan –** dual-energy x-ray absorptiometry to calculate fat/lean/muscle mass in individuals **Energy Availability –** calorie availability based on resting metabolic rate and fat-free mass. **Time Loss**- missed training/competition time due to gastrointestinal issues, illnesses, or physical injuries	**Tools:** - LEAF-Q (sensitivity 78%, specificity 90%) - SCOFF Questionnaire (validated in female athletes) - Internally created questionnaire (Not validated) - DXA Scan (validated in a wide range of populations) - Semistructured diagnostic psychiatric interview using an abridged version of the Mini International Neuropsychiatric Interview - Blood test	**Statistical Tests Used:** Spearman's correlation coefficient Wilcoxon rank sum Fisher's Exact Test	**DV1:** LEAF-Q scores cannot diagnose an LEA/RED-S but have a high negative predictive value. **DV2:** Lumbar and Femoral Z scores are highly predictive of LEA/RED-S **DV3:** True energy availability was difficult to calculate due to poor calorie tracking and expenditure compliance in certain sports. <30 kcal/kg fat-free mass/day was indicative of LEA **DV4:** 70% of participants did not have a mental health diagnosis. **DV5:** Increased DE risk correlated w/ a LEAF-Q score >8 **DV6:** Menstrual dysfunction has a negative predictive value of 94.7%. A positive value of 30.8%. 80% sensitivity and 59.3% specificity. **DV7:** Time loss 100% negative predictive value **DV8: Blood works** 100% negative predictive value for low free triiodothyronine.	**LOE:** 4 **Strengths:** Large sample size and results are consistent with the current literature. It was one of the first studies to examine multiple sports at one time and increase the validity of the LEAF-Q in non-endurance sports athletes. **Weakness:** Difficult to determine actual EA. **Feasibility:** Using the LEAF-Q to determine which athletes are at low risk for RED-S is very feasible, and it is a relatively short survey with extremely high negative predictive value. **Application:** Initial screening is easily applicable, and the follow-up for not low-risk athletes would be more time and resource-intensive.
Sharps et al., 2021.	**Design:** cross-sectional study	**N=112** **Demographics:**	**IV1:** Age **IV2:** Sport Level	1. Female athlete screening tool	Shapiro Wilks	16% of athletes were at risk for ED. 44%	**LOE:** 4

Prevalence of Disordered Eating, Eating Disorders, and Risk of Low Energy Availability in Professional, Competitive, and Recreational Female Athletes based in the United Kingdom **Country** UK **Funding:** No funding was received **Bias is** unlikely due to the subject population and relationship to researchers, and the researchers do not stand to gain anything from a specific result.	**Purpose:** To determine the prevalence of ED/DE and LEA in female athletes in the UK and if age and level of competitiveness (recreation, competitive, professional) are indicators for ED/DE or LEA	Female athletes in the UK. Age 18-40. Rec, competitive, and professional athletes in many different sports. **Setting:** Online, anonymous questionnaire **Exclusion:** incomplete questionnaire **Attrition:** 0% 129 responses, 17 incomplete = total 112 participants	**DV1:** LEA **DV2:** ED/DE Risk	(validated in female athletes) 2. Low energy availability in females – questionnaire (sensitivity 78%, specificity 90%)	One way ANOVA Fischers Exact Spearmans Rank Correlation	were at risk for DE. 53% were at risk for LEA. Pro athletes have higher rates of ED and LEA. Comp athletes have higher rates of DE. 25-30-year-olds had the highest rate of ED and LEA; 32%, 61%. 18-24-year-olds had the highest rate of DE, 56%. All competitive levels of female athletes are at risk for DE and LEA.	**Strengths:** Utilized validated screening tools. Data is consistent with other studies. A wide variety of sports are represented. **Weakness:** Anonymous, convenience sample, which could lead to false responses. The sample sizes of pro athletes and general athletes were both small. **Conclusions:** 16% of athletes were at risk of ED. 44% likely had DE. 53% had LEA. **Feasibility:** Implementing these screenings is highly feasible. Low cost and minimal time requirements can help prevent long-term, lasting damage to athletes.
Sim et al., 2021, Review: questionnaires as measures for low energy availability (LEA) and relative energy deficiency in sport (RED-S) in athletes	Systematic Review **Purpose:** To identify and critique validated LEA/RED-S risk questionnaires	**N= 13** **Demographics:** Unique questionnaires that were focused on athletes and were meant to identify LEA/RED-S/FAT/ED/DE	**IV1:** Individuals w/ LEA/RED-S/FAT/DE/ED **DV1:** Screening Questionnaires **Definitions:** See study one for LEA/ED/DE definitions. RED-S is a syndrome characterized by	**Tools:** 1. Brief Eating Disorder in Athletes Questionnaire — 82.1%, & 84.6% 2. Eating Disorder Examination Questionnaire- 83% & 96% 3. Eating Disorder Inventory- Drive for	**Statistical Tests Used:** This paper did not use statistical tests because the questionnaires had already been evaluated.	1. Validated in elite female adolescent athletes. 2. Good tool to look for LEA and possibly RED-S in males and females. 3. LEA can be inferred based on the scores.	**LOE:** 1 **Strengths:** Thorough and the first systematic review of these screenings. Addresses their shortcomings. **Weakness:** Only searched one database. **Feasibility:** Depends on the screening that is used. Some are lengthy, while some are short. Overall, it

Country: Not stated **Funding:** None **Bias:** Likely none. Not attached to an organization, no competing interests, or obvious opportunities to benefit from a specific result.		**Exclusion:** Had to be within the last 10 years, English, and full-text **Attrition: NA**	low-calorie intake, high-calorie output, and physiological manifestations of calorie deficiency FAT is the Female Athlete Triad, a syndrome that presents with amenorrhea, osteoporosis, and an ED.	Thinness Score 86% & 80% 4. Eating Disorder Screening for Primary Care- 100% & 71% 5. Female Athlete Triad Risk Scale – NV 6. Female Athlete Triad Screening Questionnaire- NV 7. Low Energy Availability in Females Questionnaire- 78% & 90% 8. Meal Attitudes and Body Weight Questions- NV 9. RED-S Risk Measurement for Cyclists- NV 10. RED-S Specific Screening Tool (female version)- Female version validated 11. Sport-specific Energy Availability Questionnaire and Interview- Validated internally 12. Three-Factor Eating Questionnaire – Dietary Cognitive Restraint- 72% & 70.1% 13. Triad Consensus Panel Screening Questions by the Female Athlete Coalition- NV		4. Best used with another screening tool. 5. Not validated, but great potential for mass screening 6. Measures triad risk before the competitive season. 7. Used in large groups. It is best if used with ED/DE screening tools as well. 8. Not validated but has the potential for easy mass screening. 9. Short and concise. It is not validated and focuses only on symptoms. 10. Produces risk score. Designed for both sexes and a wide age range, which fits a gap in the literature but needs more validation. 11. Specific to cycling. Attempts to fill a gap in the literature for male screening. It is not validated. 12. May underestimate the risk of LEA in females. 13. Pre-participation screen but cannot be used independently without follow-up assessments. Not validated.	is an easy intervention to implement in any sports training program. **Application:** Highly applicable. Finding the right screening tool could be challenging, but it is easy to apply when it is found.

Stewart et al., (2019), The female athlete body project study: 18-month outcomes in eating disorder symptoms and risk factors **Country**: US **Funding**: National Institute of Mental Health **Bias**: Funding is from a mental health organization, and so there could be a benefit to the authors to conclude that this intervention benefits mental health	**Design:** RCT **Purpose:** Does the Female Athlete Body project reduce the symptoms, severity, and occurrence of EDs	**N= 481** **Demographics:** Female college athletes, 17-27 **Setting:** 3 colleges across the US **Exclusion:** failure to attend follow-up meetings, being removed from an athletic team or the school **Attrition: 24% at 18 months**	**IV1:** Female Athlete Body Project intervention **DV1:** EDE-Q scores **DV2:** objective/subjective binge eating episodes **DV3:** New onset ED	**Tools:** EDE-Q **Validity/ Reliability:** EDE-Q values are not explicitly stated, but it is a valid and reliable tool	**Statistical Tests Used:** Priori power analysis Power calculations Linear mixed-effects models	**DV1:** All scores were lower, but the only statistically significant subscore was dietary restraint **DV2:** There were fewer episodes of objective/subjective binge-eating episodes **DV3:** Prevention levels were lower but not statistically significant	**LOE:** 2 **Strengths**: A large sample size helps fill a gap in the literature. **Weakness**: Most of the data is related to binge eating or bulimia, anorexia, and other disorders are not mentioned **Feasibility**: It would be a great tool to implement, but it is not commercially available due to continued research. **Application**: Peer-led group discussions can positively impact ED severity and symptoms.
Tenforde et al. (2020), Awareness and comfort treating the female athlete triad and relative energy deficiency in sport among healthcare providers. **Country**: US **Funding**: No funding was provided except for Dr.	**Design:** cross-sectional **Purpose:** Ascertain the awareness and comfort in treating RED-S/FAT in healthcare professionals	**N= 163** **Demographics:** 20-60+. 54% female. 33% were physicians, 60% were allied health professionals **Setting:** Sports Medicine Conference **Exclusion:** Had to be a certified health professional	**IV1: S**creening tool **DV1:** Knowledge of FAT **DV2:** Knowledge of RED-S **DV3:** Comfort treating FAT **DV4:** Comfort treating RED-S	**Tools:** Internally created survey **Validity/ Reliability:** It is not stated, but it is based on valid and reliable questionnaires	**Statistical Tests Used:** Chi-squared testing Wilcoxon rank sum	**DV1:** 76% had heard of it. **DV2:** 29% had heard of it. Physicians were most likely to have heard of it, especially with a fellowship. **DV3:** International practitioners were more comfortable than US practitioners **DV4:** Physicians and non-physicians had similarly low rates.	**LOE:**4 **Strengths**: Fits a gap in the literature. Decent sample size. **Weakness**: Response bias and overrepresentation of specific populations in the study. Did not use a validated tool. **Application**: Interventions should be aimed at educating providers.

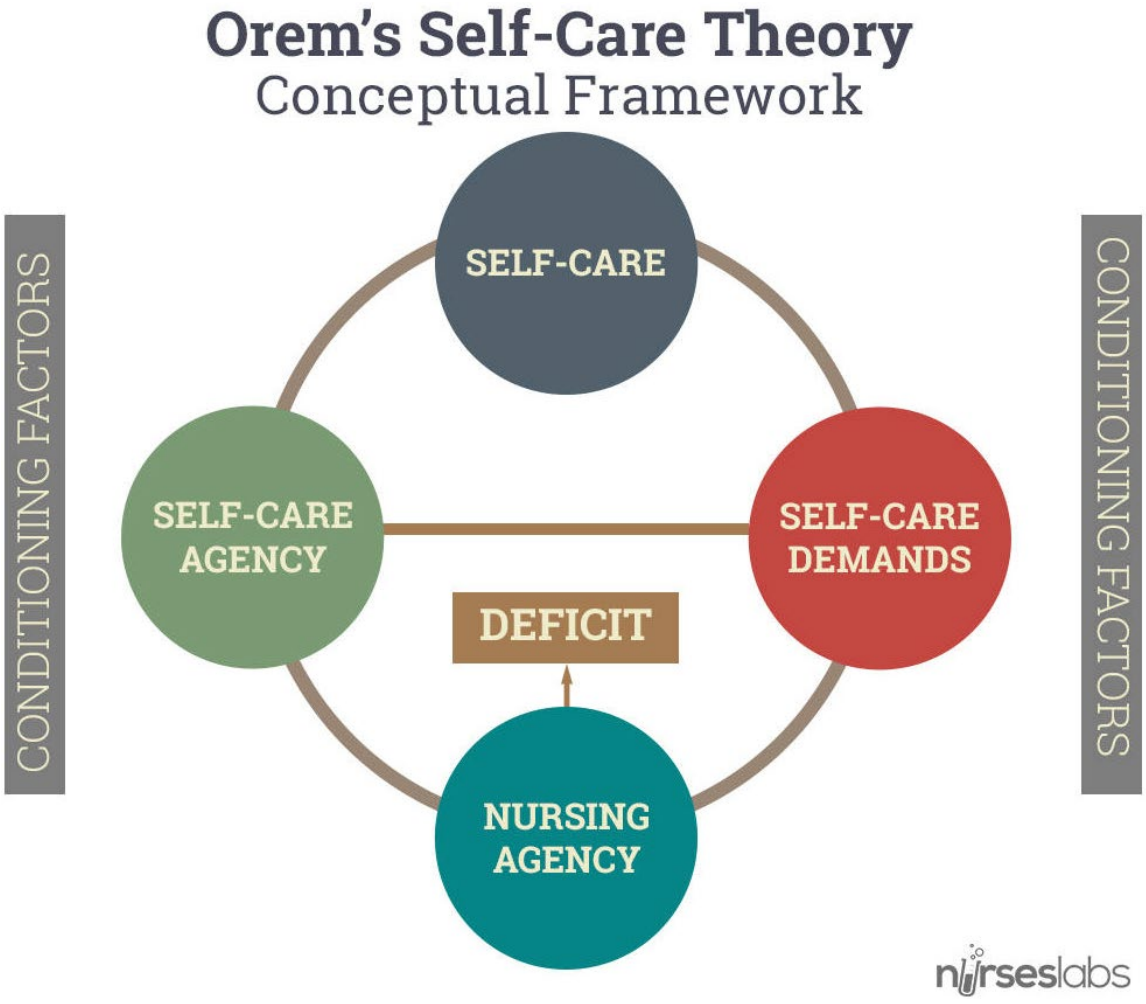
Hollander's participation. **Bias**: None noted							
Torres-McGehee et al., 2021. Energy Availability With or Without Eating Disorder Risk in Collegiate Female Athletes and Performing Artist**s** **Country:** US **Funding:** not stated **Bias:** All authors are athletic trainers, and all the subjects came from one school. There could be bias with an athletic trainer skewing results at their school for recognition, funding, or other imponderables.	**Design:** Cross-sectional study **Purpose:** Determine LEA with and without ED risks in college athletes.	**N= 121** **Demographics:** D1 female athletes and ballet dancers 17-22 y/o **Setting:** Free living in sport-specific settings at a D1 university in the US **Exclusion:** not a current athlete/artist, history of eating disorder, injury preventing them from exercising, or did not complete the study **Attrition: 0%**	**IV1:** Calories consumed **DV1:** LEA **DV2:** ED Risk **Definitions:** LEA: when energy intake is less than energy output in an athlete, putting them in a low energy availability state ED Risk is when a subject presents with attitudes and behaviors that may put them at risk for having or developing an eating disorder. ED is a diagnosed eating disorder such as anorexia, bulimia, etc. DE is disordered eating, which is a subclinical eating disorder.	**Tools:** 1. Microlite MedGem 2. ESHA food processor 3. Sensewear armband 4. Eating Disorder Inventory-3 5. Eating disorder inventory-3 symptom checklist **Validity/ Reliability:** 1. Reliability 0.91-0.97 2. Not reported 3. 0.81 4. 0.90-0.97 5. Not reported	**Statistical Tests Used:** ANOVAs Post hoc Tukey test Chi-square analysis	**DV1:** 81% displayed LEA **DV2:** 76% had ED risk	**LOE:** 4 **Strengths:** Controls in place to eliminate response bias from subjects. Very thorough. Utilized highly reliable instruments. Obtained a substantial sample size—0% attrition. **Weakness:** Only at one institution. Possible response bias on food logs. It occurred during the pre-season for one team and the season for the other teams—length of monitoring. **Conclusions:** Most female athletes at D1 schools suffer from LEA and ED risk. **Feasibility:** This would be hard to implement at other institutions with smaller budgets. The energy expenditure tools cost money. The Eating Disorder Inventory-3 and symptom checklist are lengthy and could lead to inaccurate responses.

Appendix A Table A2
Synthesis Table

Study (Author, year)	Feltner et al., 2022	Kroshus et al., 2018	Lodge et al., 2022	Logue et al., 2019	Rogers et al., 2021	Sharps et al., 2021	Sim et al., 2021	Stewart et al., 2019	Tenforde et al., 2020	Torres-McGehee et al., 2021
Design	Systematic Review	Cross-sectional	Cross-sectional	Cross-sectional	Cross-sectional	Cross-sectional	Systematic Review	Randomized controlled trial	Cross-sectional	Cross-sectional
Purpose	Understand the benefit and harm of screening for ED	FAT/RED-S knowledge, screening rates, and referral actions	FAT/RED-S knowledge	Understand the LEA risk for different levels of competition for FAs	Can the LEAF-Q identify biological manifestations of LEA/FAT	Prevalence of LEA/ED/DE	Identify and critique screening questionnaires for LEA/RED-S/ED/DE	Female Athlete Body project influence on ED symptoms and severity	Ascertain the awareness and comfort of treating RED-S/FAT	Prevalence of LEA w/ and w/o ED risks
Sample										
n subjects	57	285	260	833	75	112	13	481	163	121
M-Age	N/A	N/A	18-47	18-44	18-32	18-40	Within ten years	17-27	20-65+	17-22
Other variables	ED	Head AT (D1-D3)	College Cross-country FAs, Coaches, and ATs	Ireland International Provincial-Inter- County Competitive Recreational	Elite and Pre-Elite Athletes	FA in the UK (3 levels)	6 -ED 3 -FAT 2- LEA 2- REDS	3 D1 Schools with a Broad Array of Sports Teams	Healthcare Professionals	D1 FA and Dancers
Target Demographic										
Athletes	X		X	X	X	X	X	X		X
Coaches	X		X		X		X			
Health Professionals	X	X	X		X		X	X	X	
Screening Tools										
LEAF-Q				X	X	X	X			
Other Valid Survey	X					X	X	X		X
Internal Survey		X	X						X	
Measured Outcomes										
LEA Prevalence				X		X				X
RED-S/FAT Knowledge		X	X						X	

Appendix B
Models and Frameworks

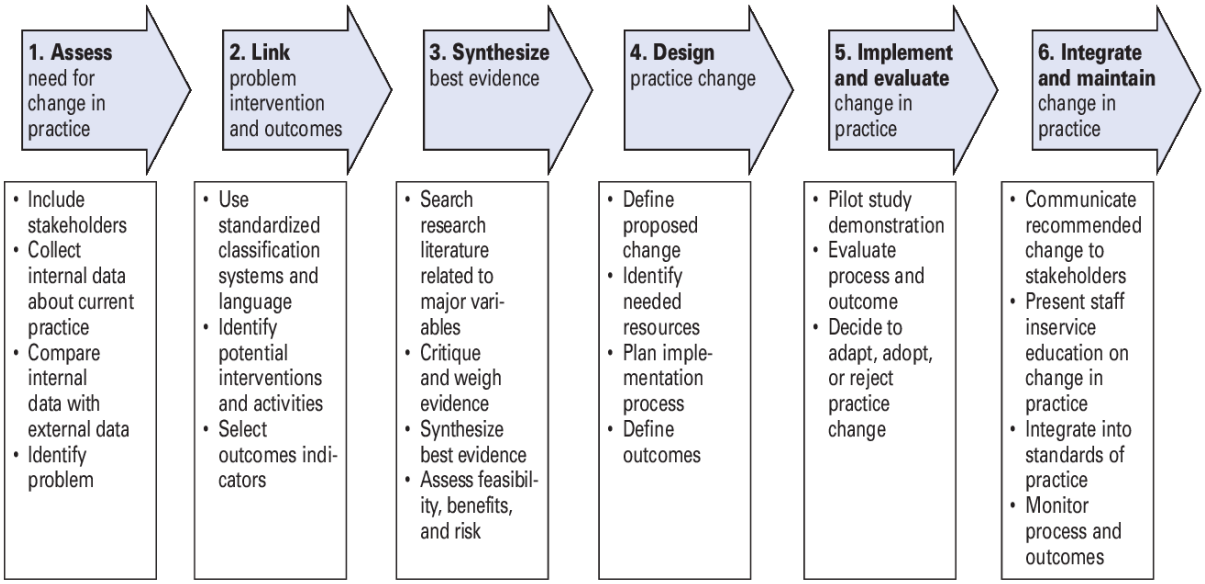
Figure B1
Orem's Self-Care Nursing Theory



(Gonzalo, 2023)

Appendix B

Figure B2
Rosswurm and Larrabee's Model for Evidence-Based Practice



(Rosswurm & Larrabee, 1999)

Appendix C
Questionnaires

Figure C1
Athlete Questionnaires

Subject ID:_____ Date:_____ 1

LEAF-Q

Demographics: We would like to know a little more about you. Please answer the following

Age:_____ (years)

Please place a ***checkmark*** next to the appropriate response

Ethnicity:

__White
__Black or African American
__American Indian or Alaskan Native
__Asian
__Native Hawaiian or Pacific Islander
__Other

Circle one: Freshman | Sophomore **Sport:_____**

1. Injuries

A: Have you had absences from your training, or participation in competitions during the last year due to injuries?

___ No, not at all ___ Yes, once or twice ___ Yes, three or four times ___ Yes, five times or more

A1: If yes, for how many days absence from training or participation in competition due to injuries have you had in the last year?

___ 1-7 days ___ 8-14 days ___ 15-21 days ___ 22 days or more

A2: If yes, what kind of injuries have you had in the last year? _____
_____
_____

2. Gastrointestinal Function

A: Do you feel gaseous or bloated in the abdomen, also when you do not have your period?

__Yes, several times a day __Yes, several times a week __Yes, once or twice a week or more seldom __Rarely or never

B: Do you get cramps or stomach aches which cannot be related to your menstruation?

__Yes, several times a day __Yes, several times a week __Yes, once or twice a week or more seldom __Rarely or never

C: How often do you have bowel movements on average?

__Several times a day __Once a day __Every second day __Twice a week __Once a week or more rarely

Data Entry_____ Data Validation_____ Data Analysis_____

Subject ID:_____ Date:_____ 2

D: How would you describe your normal stool?

__Normal (soft) __Diarrhea-like (watery) __Hard and dry

Comments regarding gastrointestinal function: _____

_____

_____

3. Menstrual function and use of contraceptives

3.1 Contraceptives

A: Do you use oral contraceptives? __Yes __No

A1: If yes, why do you use oral contraceptives?

__Contraception __Reduction of menstruation pains __Reduction of bleeding
__To regulate the menstrual cycle in relation to performance etc.. __Otherwise menstruation stops
Other_____

A2: If no, have you used oral contraceptives earlier? __Yes __No

A2:1 If yes, when and for how long? _____

B: Do you use any other kind of hormonal contraceptives? (e.g. hormonal implant or coil) __Yes __No

B1: If yes, what kind? __Hormonal patches __Hormonal ring __Hormonal coil __Hormonal implant
Other_____

3.2 Menstrual Function

A: How old were when you had your first period? __11 years or younger __12-14 years
__15 years or older __I don't remember __I have never menstruated (If you have answered "I have never menstruated" there are no further questions to answer)

B: Did your first menstruation come naturally (by itself)? __Yes __No __I don't remember

B1: If no, what kind of treatment was used to start your menstrual cycle?

__Hormonal treatment __Weight gain __Reduced amount of exercise __Other

C: Do you have normal menstruation? __Yes __No (go to question C6) __I don't know (go to question C6)

C1: If yes, when was your last period? __0-4 weeks ago __1-2 months ago __3-4 months ago
__5 months ago or more

C2: If yes, are your periods regular? (Every 28th to 34th day) __Yes, most of the time __No, mostly not

C3: If yes, for how many days do you normally bleed? __1-2 days __3-4 days __5-6 days __7-8 days
__9 days or more

C4: If yes, have you ever had problems with heavy menstrual bleeding? __Yes __No

Data Entry_____ Data Validation_____ Data Analysis_____

C5: If yes, how many periods have you had during the last year?

__12 or more __9-11 __6-8 __3-5 __0-2

C6: If no or "I don't remember", when did you have your last period? __2-3 months ago
__4-5 months ago __6 months ago or more __I'm pregnant and therefore do not menstruate

D: Have your periods ever stopped for 3 consecutive months or longer (besides pregnancy)?

__No, never __Yes, it has happened before __Yes, that's the situation now

E: Do you experience that your menstruation changes when you increase your exercise intensity, frequency or duration? __Yes __No

E1: If yes, how? (Check one or more options) __I bleed less __I bleed fewer days
__My menstruations stops __I bleed more __I bleed more days

Figure C2

Eating Attitudes Test

Eating Attitudes Test (EAT-26)©

Instructions: This is a screening measure to help you determine whether you might have an eating disorder that needs professional attention. This screening measure is not designed to make a diagnosis of an eating disorder or take the place of a professional consultation. Please fill out the below form as accurately, honestly and completely as possible. There are no right or wrong answers. All of your responses are confidential.

Part A: Complete the following questions:

1) Height ~~Feet :~~	Inches:		
2) Current Weight (lbs.):		3) Highest Weight (excluding pregnancy):	
4) Lowest Adult Weight:		5) Ideal Weight:	

Part B: Check a response for each of the following statements:		Always	~~Usually~~	Often	Some times	Rarely	Never
1.	Am terrified about being overweight.	☐	☐	☐	☐	☐	☐
2.	Avoid eating when I am hungry.	☐	☐	☐	☐	☐	☐
3.	Find myself preoccupied with food.	☐	☐	☐	☐	☐	☐
4.	Have gone on eating binges where I feel that I may not be able to stop.	☐	☐	☐	☐	☐	☐
5.	Cut my food into small pieces.	☐	☐	☐	☐	☐	☐
6.	Aware of the calorie content of foods that I eat.	☐	☐	☐	☐	☐	☐
7.	Particularly avoid food with a high carbohydrate content (~~i.e.~~ bread, rice, potatoes, etc.)	☐	☐	☐	☐	☐	☐
8.	Feel that others would prefer if I ate more.	☐	☐	☐	☐	☐	☐
9.	Vomit after I have eaten.	☐	☐	☐	☐	☐	☐
10.	Feel extremely guilty after eating.	☐	☐	☐	☐	☐	☐
11.	Am preoccupied with a desire to be thinner.	☐	☐	☐	☐	☐	☐
12.	Think about burning up calories when I exercise.	☐	☐	☐	☐	☐	☐
13.	Other people think that I am too thin.	☐	☐	☐	☐	☐	☐
14.	Am preoccupied with the thought of having fat on my body.	☐	☐	☐	☐	☐	☐
15.	Take longer than others to eat my meals.	☐	☐	☐	☐	☐	☐

Data Entry_____ Data Validation_____ Data Analysis_____

Subject ID:_____ Date:_____ 5

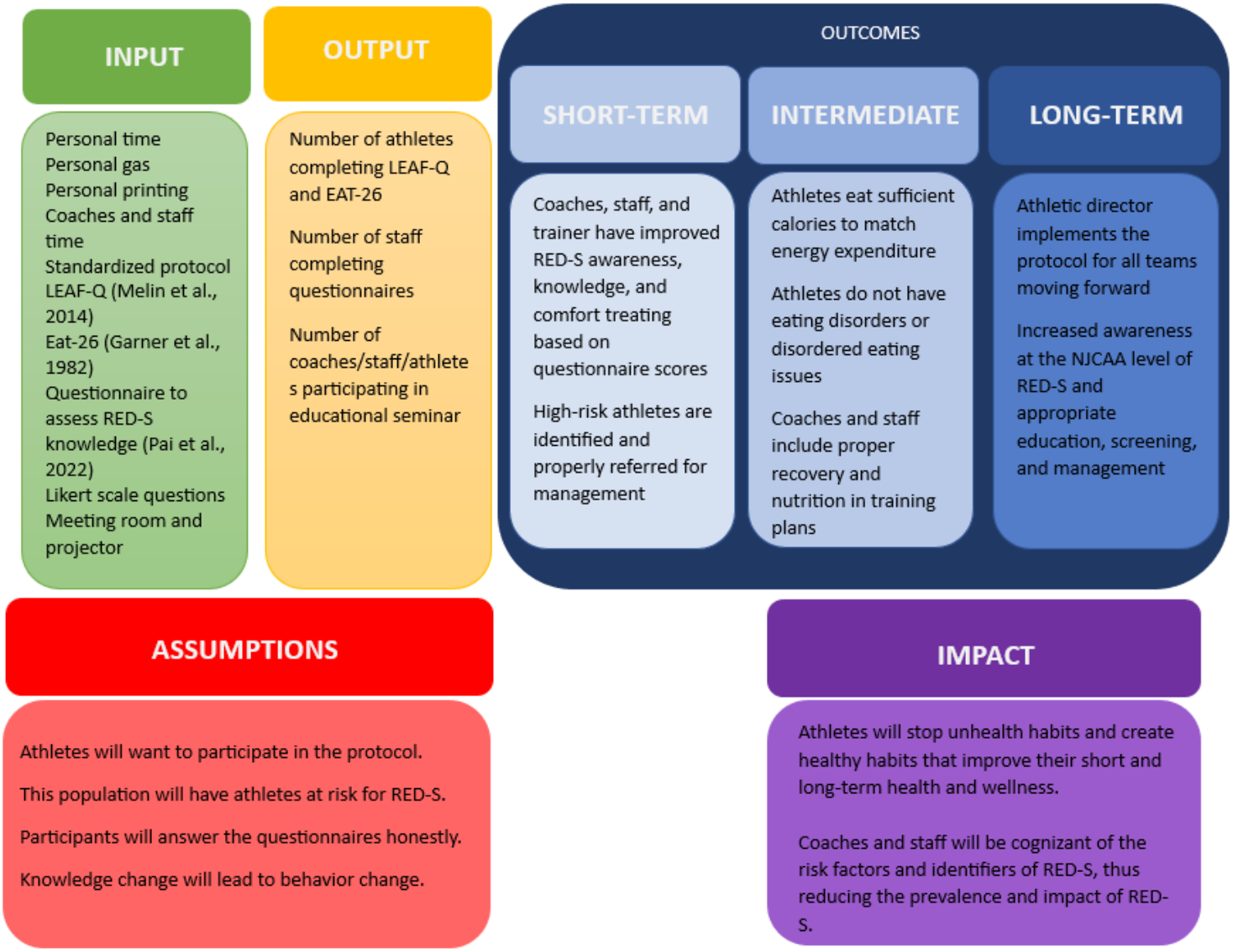
16.	Avoid foods with sugar in them.	◻	◻	◻	◻	◻	◻
17.	Eat diet foods.	◻	◻	◻	◻	◻	◻
18.	Feel that food controls my life.	◻	◻	◻	◻	◻	◻
19.	Display self-control around food.	◻	◻	◻	◻	◻	◻
20.	Feel that others pressure me to eat.	◻	◻	◻	◻	◻	◻
21.	Give too much time and thought to food.	◻	◻	◻	◻	◻	◻
22.	Feel uncomfortable after eating sweets.	◻	◻	◻	◻	◻	◻
23.	Engage in dieting behavior.	◻	◻	◻	◻	◻	◻
24.	Like my stomach to be empty.	◻	◻	◻	◻	◻	◻
25.	Have the impulse to vomit after meals.	◻	◻	◻	◻	◻	◻
26.	Enjoy trying new rich foods.	◻	◻	◻	◻	◻	◻

Part C: Behavioral Questions: **In the past 6 months have you:**		Never	Once a month or less	2-3 times a month	Once a week	2-6 times a week	Once a day or more
A	Gone on eating binges where you feel that you may not be able to stop? *	◻	◻	◻	◻	◻	◻
B	Ever made yourself sick (vomited) to control your weight or shape?	◻	◻	◻	◻	◻	◻
C	Ever used laxatives, diet pills or diuretics (water pills) to control your weight or shape?	◻	◻	◻	◻	◻	◻
D	Exercised more than 60 minutes a day to lose or to control your weight?	◻	◻	◻	◻	◻	◻
E	Lost 20 pounds or more in the past 6 months	Yes ◻		No ◻			

* Defined as eating much more than most people would under the same circumstances and feeling that eating is out of control

Data Entry_____ Data Validation_____ Data Analysis_____

Appendix D
RED-S Protocol Logic Model



Appendix E
RED-S Protocol Budget Breakdown

Item	Cost Breakdown	Total Cost
Gas	Approx 400 miles/24 mpg = 16.7 gallons 16.7 gallons*$4.21/gallon =	**$70.2**
Investigator Meals	$15/meal * 3 meals	**$45**
Survey Printing	3 Coach/Staff Questionnaire Pages * 15 people = 45 prints *$0.58 = $26.10 2 Athlete Questionnaire Pages (double sided) *75 people = 150 double-sided prints * $0.56 = $84	**$110.10**
Participant Snacks	3 Cases of water from Costco*$3.50 3 Variety boxes of chips from Costco *$23.99	**$82.47**
Investigator Lodging (if needed)	IHG Hotel Military Rate 1 Night	**$119**
Coach/Staff Time	Unknown Rate * 1-2 Hrs	
Wellness Center Counseling	Salary Employees, Unknown Quantity of Time	
Athletic Trainer	Salary Employee, Unknown Quantity of Time	
		Total ~$426.77

Appendix F

Statistical Tables and Figures

Table F1
Descriptive Statistics of Participants

Descriptive Statistics of Participants

Variable	*n*	*%*
Ethnicity		
White	34	77.27
Black	1	2.27
Other	3	6.82
American Indian or Alaskan Native	1	2.27
Multi-Ethnic	5	11.36
Grade		
Freshman	30	68.18
Sophomore	14	31.82
Sport		
Volleyball	9	20.45
Basketball	13	29.55
Soccer	21	47.73
Multi-Sport	1	2.27

Note. Due to rounding errors, percentages may not equal 100%.

Table F2
Questionnaires Scores and Distribution

Questionnaires Scores and Distribution

Variable	*M*	*SD*	*n*	Min	Max
LEAF-Q Score	8.50	4.44	44	0.00	19.00
EAT-26 Score	8.07	8.95	44	0.00	37.00

Table F3
ANOVA Table for EAT-26

ANOVA Table for EAT-26 Score by Ethnicity, Grade, and Sport

Term	*SS*	*df*	*F*	*p*	η_p^2
Ethnicity	204.16	4	0.62	.652	0.07
Grade	47.79	1	0.58	.451	0.02
Sport	187.84	3	0.76	.524	0.06

Residuals	2,883.60	35	

Table F4

ANOVA Table for LEAF-Q

ANOVA Table for LEAF-Q Score by Ethnicity, Grade, and Sport

Term	*SS*	*df*	*F*	*p*	η_p^2
Ethnicity	208.56	4	2.98	.032	0.25
Grade	2.05	1	0.12	.734	0.00
Sport	27.67	3	0.53	.667	0.04
Residuals	613.27	35			

Table F5

Observed and Expected Frequencies for Fisher's Exact Test For Scores Indicated Referral and Sport

Observed and Expected Frequencies of the First Fisher's Exact Test

	Scores Indicated Referral		
Sport	No	Yes	*p*
Volleyball	2[2.66]	7[6.34]	.937
Basketball	4[3.84]	9[9.16]	
Soccer	7[6.20]	14[14.80]	
Multi-Sport	0[0.30]	1[0.70]	

Note. Values formatted as Observed[Expected].

Table F6

Observed and Expected Frequencies for Fisher's Exact Test For Scores Indicated Referral and Grade

Observed and Expected Frequencies of the Second Fisher's Exact Test

	Scores Indicated Referral		
Grade	No	Yes	*p*
Freshman	11[8.86]	19[21.14]	.170
Sophomore	2[4.14]	12[9.86]	

Note. Values formatted as Observed[Expected].

Table F7

Observed and Expected Frequencies for Fisher's Exact Test For Scores Indicated Referral and Ethnicity

Observed and Expected Frequencies of the Third Fisher's Exact Test

	Scores Indicated Referral		
Ethnicity	No	Yes	*p*

White	12[10.05]	22[23.95]	.211
Black	0[0.30]	1[0.70]	
Other	0[0.89]	3[2.11]	
American Indian or Alaskan Native	1[0.30]	0[0.70]	
Multi-Ethnic	0[1.48]	5[3.52]	

Note. Values formatted as Observed[Expected].

Figure F1

Q-Q scatterplot for normality of the residuals for the regression model in ANOVA 1

Q-Q scatterplot for normality of the residuals for the regression model in ANOVA 1

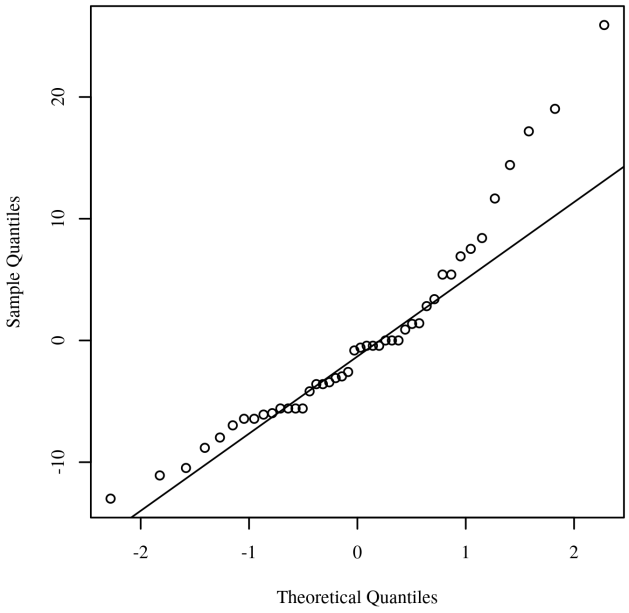


Figure F2

Q-Q scatterplot for normality of the residuals for the regression model in ANOVA 2

Q-Q scatterplot for normality of the residuals for the regression model in ANOVA 2

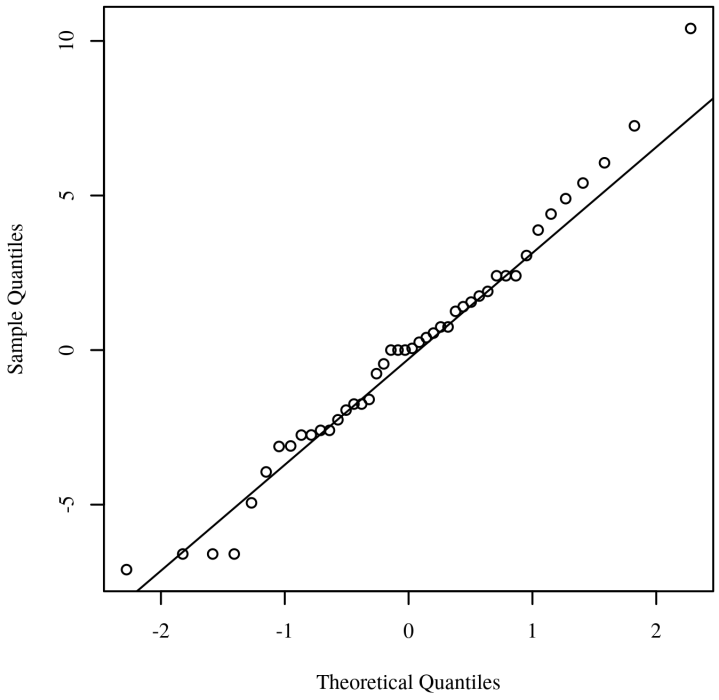


Figure F3

Residuals scatterplot testing homoscedasticity in ANOVA 1

Residuals scatterplot testing homoscedasticity in ANOVA 1

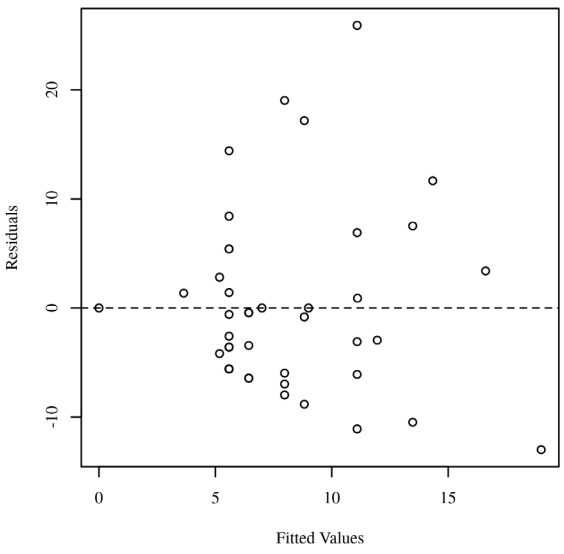


Figure F4

Residuals scatterplot testing homoscedasticity in ANOVA 2

Residuals scatterplot testing homoscedasticity in ANOVA 2

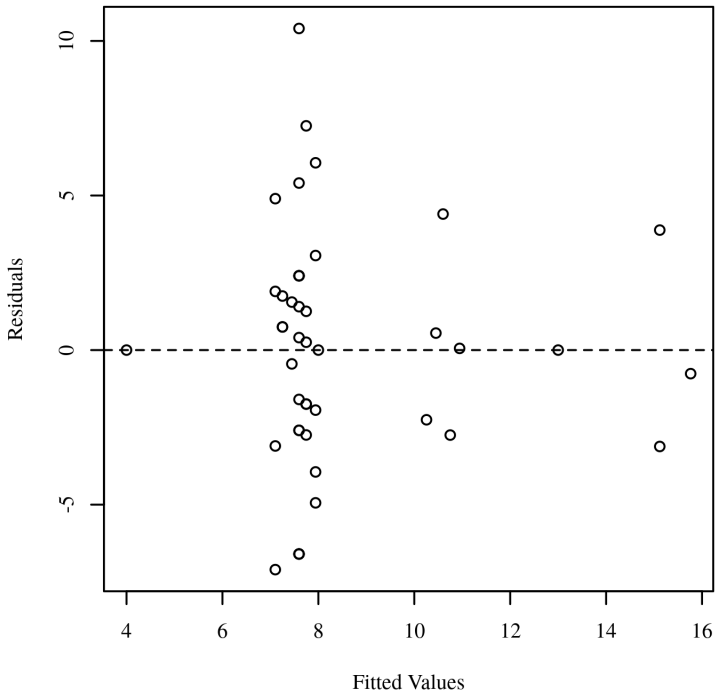


Figure F5

Studentized residuals plot for outlier detection in ANOVA 1

Studentized residuals plot for outlier detection in ANOVA 1

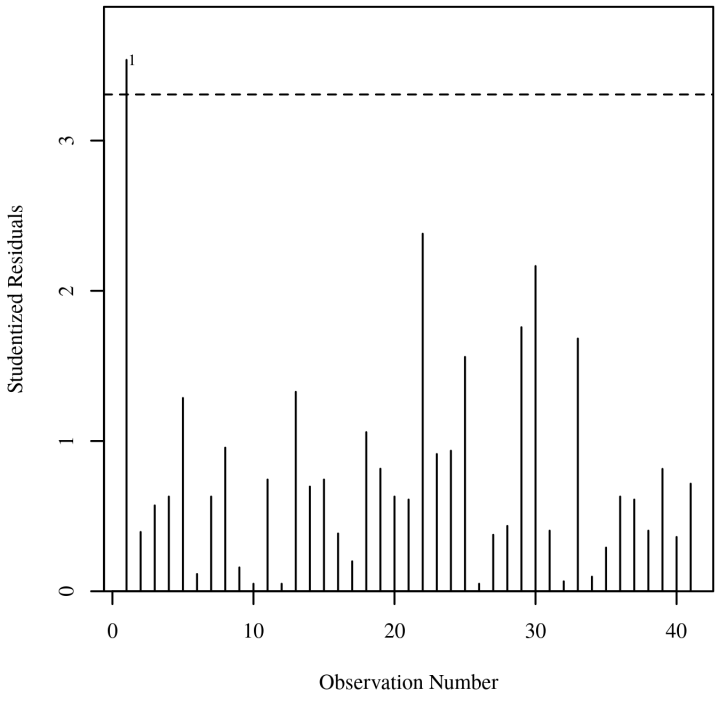


Figure F6

Studentized residuals plot for outlier detection in ANOVA 2

Studentized residuals plot for outlier detection

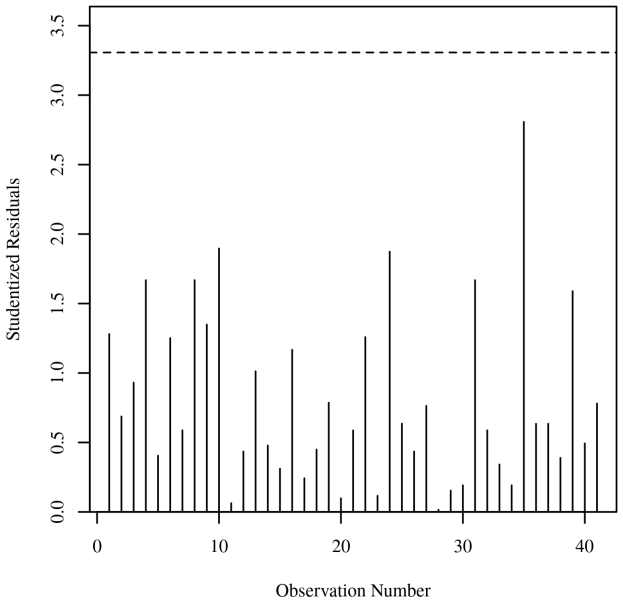
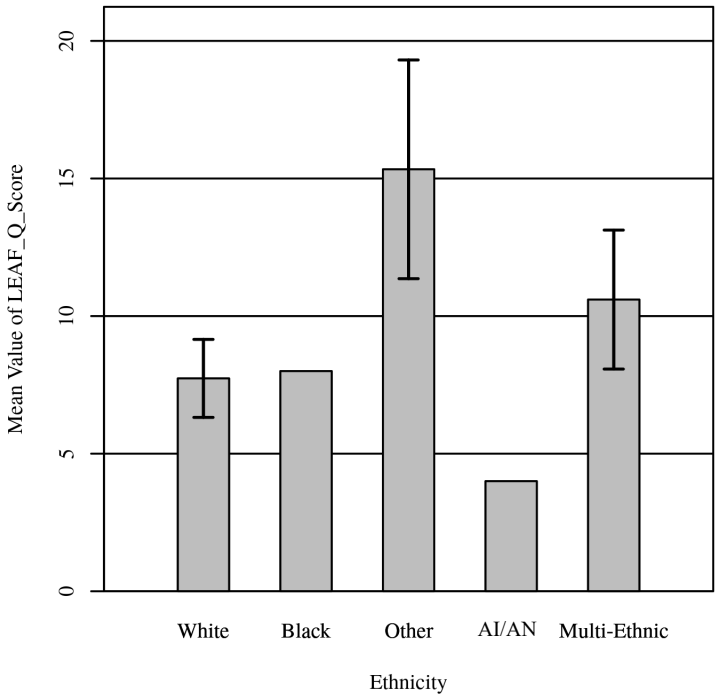


Figure F7
Means of LEAF-Q Score by Ethnicity with 95.00% CI Error Bars

Means of LEAF-Q Score by Ethnicity with 95.00% CI Error Bars



Note. AI/AN are abbreviations for American Indian/Alaskan Native