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Utilizing the Low Energy Availability in Females Questionnaire (LEAF-Q) to Assess Female Athlete Triad in Collegiate Athletes

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BACKGROUND: The female athlete triad has a high prevalence in female athletes and is made up of three components: low energy availability, decreased bone mineral density and menstrual dysfunction. The triad is often recognized in the later stages in endurance sports such as cross country, track, and rowing, which causes significant health issues. The focus of this study is to use the Low Energy Availability in Females Questionnaire (LEAF-Q) to assess risk for the triad amongst all female collegiate endurance and non-endurance athletes, as previous studies have focused solely on endurance athletes.
METHODS: A total of 51 female collegiate athletes attending Nova Southeastern University who compete in basketball, cross country, golf, soccer, softball, swimming, tennis, rowing, and volleyball filled out the LEAF-Q on REDCap in a self-reported format. Athletes who completed the survey were divided into endurance or non-endurance groups. Independent t-tests were utilized to examine differences between endurance and non-endurance athletes for injuries, GI issues, and menstrual scores.
RESULTS: An average score of 8.36 was obtained from the LEAF-Q, with a value greater than or equal to 8 meaning an individual is at risk for the triad. Between the non-endurance athletes versus the endurance athletes, 60.0% of the non-endurance athletes and 58.3% of the endurance athletes were found to be at risk of the triad. No significant differences in injuries per athlete ($p = 0.135$), GI issues ($p = 0.352$), and menstrual ($p = 0.738$) scores were found which means both types of athletes had similar results of being at risk of the triad.
CONCLUSION: According to our findings, non-endurance athletes are at a similar risk of the triad compared to endurance athletes. Further research should be conducted on a larger number of female athletes from a variety of universities to increase the significance of the findings and to further the knowledge of the female athlete triad for athletes, coaches, and parents.

INTRODUCTION

The female athlete triad is made up of three aspects, including menstrual dysfunction, low energy availability, and decreased bone mineral density.[1,2] Due to the high prevalence of the triad in young female athletes, which can progress into multiple health issues, it is crucial for the athletic industry to understand and learn about this disorder. The female athlete triad, if not recognized early, can result in premature osteoporotic fractures and a loss of bone mineral density that can be challenging to regain.[3] Athletes who are nutrient deficient may have complications as a result that include menstrual dysregulation and a decreased basal metabolic rate.[4]

The different components that lead to the female athlete triad are interconnected. Having low energy availability decreases body fat and forces one's body to adapt to this high stress state. This change leads to neuroendocrine adaptations and energy redistribution that can impact bone development, including a decrease in bone formation and bone turnover, putting athletes at a higher risk of fractures.[5] Menstrual dysfunction further contributes to poor bone health due it causing a decrease in bone mineral density. Furthermore, changes in bone mineral density are associated more with eating habits and weight compared to weight-bearing exercises.[5] This decrease in bone mineral density for adolescent

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athletes who are impacted by the female athlete triad can lead to further health issues later in life from not reaching peak bone mass density by early adulthood which is attributed to an increased risk for osteoporosis.

Athletes who participate in sports that prioritize weight and thinness are seen to have unhealthy behaviors of eating disorders such as food restriction, binge eating episodes, vomiting, and laxative abuse.[4,6] Sports that value being thin for aesthetic appearance or performance include but are not limited to figure skating, gymnastics, and distance running.[4] Although athletes who participate in endurance or non-endurance sports train competitively, there are many differences between the two categories. One difference evaluated in a study by Ulrich et al. reports that total hemoglobin mass in elite endurance-trained athletes was significantly greater than total hemoglobin mass in non-endurance-trained athletes.[7] Additionally, athletes in endurance sports tend to place a large focus on their diet, including eating a high level of carbohydrates before competing and having a high protein need, while these diets do not have as significant of an impact on performance for non-endurance athletes.[8,9] As a result of endurance sports placing greater emphasis on physical appearance and diet, previous research has demonstrated that female endurance athletes are at an increased risk of the female athlete triad and energy deficiency.[10] Although the risk of female endurance athletes for the triad has been studied, it does not rule out the possibility that non-endurance female athletes may also be at risk of the triad.

The Low Energy Availability in Females Questionnaire (LEAF-Q) is a survey that includes questions regarding injuries, gastrointestinal (GI) function, and reproductive health, with a sensitivity of 78% and specificity of 90%.[11] While there are other screening tools that assess disordered eating in athletes, the lack of those screening tools incorporating self-reported physiological symptoms of low energy availability into their questions led to the development of the LEAF-Q. The goal of the questionnaire during its development was to focus on self-reported physiological symptoms and its relation to energy deficiency in order to assess individuals' risk of the triad.[11] Although the LEAF-Q has a high validity, it has only been tested in endurance athletes and needs further testing in other areas, such as aesthetic sports and weight and non-weight category sports.[11] The lack of utilization of the LEAF-Q in these sports displays the gap in knowledge of the prevalence of the female athlete triad in athletes other than female athletes of endurance sports.

Although the female athlete triad has severe consequences on athlete's health, athletic coaches may not be aware of what the triad is or know steps that can be taken to improve the health and performance of their athletes. It is possible that if coaches and athletes were educated about the female athlete triad, their awareness of risk factors and preventative steps may lead to a potential decrease in triad risk among athletes.[12] Therefore, an increase in education for coaches may promote early detection leading to improved treatment and management of the triad before long term consequences develop.[13]

Early recognition of the triad may minimize complications of the triad by assisting healthcare professionals with treatment and early prevention, potentially limiting the condition from worsening.[1] Therefore, this study identifies how the LEAF-Q can assist with identifying the risk of the female athlete triad in both endurance and non-endurance collegiate athletes. The data collected from this survey may better assist clinicians with developing educational programs for student athletes to help them learn the key characteristics to be aware of that could decrease their risk in obtaining the triad.

METHODS

Study Design

IRB approval was obtained to conduct this study. The validated LEAF-Q was used in the survey with additional questions added regarding participant's interest in education on the female athlete triad. A consent form was used prior to each athlete participating in the study followed by the LEAF-Q survey which was administered through REDCap. The questionnaire was a self-reported format which incorporated various factors related to the female athlete triad such as injury, GI function, and menstrual function. The entire survey took each player about 10-15 minutes to complete.

Participants

Inclusion criteria included being female, collegiate athlete at the respective university, and over the age of 18 years. Exclusion criteria included being a male, not an athlete at the respective university, and being under the age of 18. Athletes were considered female based on the official roster of all female collegiate athletes which was acquired

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through the athletic department of the respective university. The participants that were surveyed were based on the official roster of the female team from the college's athletic department email list; it was distributed by the assistant athletic director, using the athletic department email list using REDCap. The study utilized a total of 51 female collegiate athletes who participated in a variety of endurance and non-endurance sports: cross country, rowing, soccer, swimming, volleyball, softball, basketball, tennis, and golf (Table 1).

Statistical Analysis

Female athletes who completed the survey were divided into endurance or non-endurance groups based on endurance sports referring to activities that require sustained physical exertion over a long period of time, like cross country running, swimming, distance cycling, and triathlon. In comparison, non-endurance sports were those that involve more explosive movements and shorter bursts of activity, such as football, basketball, wrestling, and weightlifting, which prioritize strength and power over prolonged aerobic capacity.[9,14] The survey results were exported from REDCap into Microsoft Excel where the data was analyzed. Demographic data was presented using means and standard deviations. Independent t-tests were utilized to examine differences between endurance and non-endurance athletes for injuries, GI issues, and menstrual scores. Significance was set at $p \leq 0.05$. All data was analyzed using Microsoft Excel (Redmond, WA).

RESULTS

Demographics

From a total of 51 female athletes who completed the LEAF-Q, 70.6% (n=36) were endurance athletes and 29.4% (n=15) were non-endurance athletes. The endurance sports included cross country/track, rowing, soccer, swimming; while the non-endurance sports included volleyball, softball, basketball, tennis and golf. The average age of participants was 19.62 ± 1.47 years old which included athletes from freshman to senior year of college. The average height of athletes who completed the survey was 166.75 ± 7.58 cm, average weight was 62.89 ± 7.06 kg and the average amount of training per week was 14.50 ± 5.63 hours.

Injuries

Within the LEAF-Q, injuries were assessed including the total number of injuries, how many absences from participation due to the injury and what injuries were acquired (Table 2). Endurance athletes had an average of 1.47 injuries while non-endurance athletes had an average of 2.13 injuries. Within the endurance athletes who sustained injuries (n=16), 87.5% (n=14) were at risk of the triad, while non-endurance athletes who sustained injuries (n=9), 77.8% (n=7) were at risk of the triad. The types of injuries included but were not limited to ankle sprains, back pain, anterior cruciate ligament (ACL) tears, and shoulder impingement. All athletes that acquired injuries reported missing a range of one to 22+ days of practice. There were no significant differences in injuries per athlete between non-endurance and endurance athletes ($p = 0.135$) (Table 5)

Table 1. Distribution of participants per individual sport

Sport	*Total # of Athletes*	*Endurance versus Non-endurance*
Cross Country	13	Endurance
Rowing	11	Endurance
Soccer	8	Endurance
Swimming	4	Endurance
Volleyball	3	Non-endurance
Softball	3	Non-endurance
Basketball	4	Non-endurance
Tennis	4	Non-endurance
Golf	1	Non-endurance

Table 2. Athletes reporting injuries

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Athlete Type	*Total Athletes with Injuries (#)*	*Athletes Injured & at Risk (#)*	*Athletes Injured & at Risk (%)*
Endurance (N=36)	16	14	87.50
Non-endurance (N=15)	9	7	77.78

Table 3. Athletes reporting gastrointestinal issues

Athlete Type	*Total Athletes with GI Issues (#)*	*Athletes with GI Issues & at Risk (#)*	*Athletes with GI Issues & at Risk (%)*
Endurance (N=36)	**31**	**21**	**67.74**
Non-endurance (N=15)	**12**	**8**	**66.67**

GI, gastrointestinal

Gastrointestinal Issues

GI was utilized in the LEAF-Q which queried the athletes on their bowel movements, the consistency of their bowel movements, and gaseous/bloating or cramps that do not relate with their period (Table 3). Of the endurance athletes who had GI issues (n=31), 67.7% (n=21) were at risk of the triad. Of the non-endurance athletes who had GI issues (n=12), 66.6% (n=8) were at risk of the triad. There were no significant differences in GI issues score between non-endurance and endurance athletes (p = 0.352) (Table 5).

Menstruation

Of the 51 athletes who completed the survey, 11 used oral contraceptives and 8 used other forms of contraceptives including hormonal implants, ring, or coil. These athletes reported using contraceptives to reduce pain or mood changes, and not due to amenorrhea. All the athletes began their menstruation at a normal age (range: 12-14 years old) except one cross country athlete who had to gain weight to begin her period when she was older than 15 years old. A total of 14 endurance athletes have had their menstruation stop for three consecutive months or longer (besides pregnancy), and of those 14 athletes, two were currently experiencing that while completing the survey and 10 were at risk of the triad. In comparison, 6 non-endurance athletes have had their menstruation stop for three consecutive months or longer, with 5 of those athletes at risk for the triad. When asked if menstruation changes, including bleeding less, menstruation stops, or bleeding more, when there is an increase in exercise intensity, frequency, or duration, 19 endurance athletes reported "yes", with 15 of those athletes fitting the criteria for being at risk of the triad. Of the non-endurance athletes asked this question, 10 answered "yes" with six of those athletes at risk of the triad. See Table 4 for menstruation changes that occurred for endurance and non-endurance athletes. There were no significant differences in menstrual score between non-endurance and endurance athletes (p = 0.738) (Table 5).

Triad Risk and Education

The mean total score on the LEAF-Q among all athletes who completed the survey was 8.35. Endurance athletes had an average score of 8.36, compared to a score of 8.33 for non-endurance athletes. A score of 8 or above indicated the athlete was at risk for the triad, meaning 58.3% (n=21) endurance athletes were at risk and 60.0% (n=9) non-endurance athletes were at risk. When asked if athletes would be interested in receiving more information about the female athlete triad, 19 answered "yes" while 32 answered "no".

Table 4. Athletes reporting menstruation changes

Athlete Type	*Total Athletes with Menstruation Stopping for 3+ months (#)*	*Athletes with Menstruation Stopping for 3+ months & at Risk (#)*	*Total Athletes with Menstruation Changes (#)*	*Total Athletes with Menstruation Changes & at Risk (#)*
Endurance (N=36)	14	10	19	15
Non-endurance (N=15)	6	5	10	6

Table 5. Comparison of endurance versus non-endurance athletes

Variable	*Endurance*	*Non-endurance*	*P-value*
Injuries per Athlete	1.25 ± 1.73	2.14 ± 2.43	0.135
GI Issues Score	3.04 ± 2.24	2.48 ± 2.00	0.352
Menstrual Score	3.81 ± 2.91	4.04 ± 1.93	0.738

*Significance set at $p \leq 0.05$

DISCUSSION

The LEAF-Q was created to assist with identifying athletes at risk of the female athlete triad; however, this questionnaire has only been validated for endurance athletes.[11] There is a need for more research to be conducted on triad risk for both endurance and non-endurance athletes as was demonstrated by this study. Both types of athletes had an almost equivalent risk of developing the female athlete triad.

Most of the current studies regarding the triad are conducted on endurance athletes such as runners, soccer players, and triathletes. In a few studies, the LEAF-Q was used in both female competitive runners and recreational runners. These studies demonstrated that all types of runners are at risk of the triad.[15-18] Another study focused on female elite and recreational aesthetic sports such as trampolining, rhythmic gymnastics, aerobics, dance sport, cheerleading and dance, which found that there was risk of the triad in these aesthetic sports specifically in elite athletes.[19] Although the LEAF-Q was created to focus on competitive endurance athletes, the questionnaire should be utilized in other athletes such as recreational and non-endurance athletes based on the results of this study and other studies.

An additional study found that although triathletes did not have body weight abnormalities, they did experience menstrual dysfunction which led to an increase in injuries compared to the athletes that had normal menstrual function.[20] Both non-endurance and endurance athletes in this study had a similar number of injuries with no statistically significant difference between the two groups, with endurance athletes averaging 1.25 ± 1.73 injuries per athlete ($p \leq 0.135$) and non-endurance athletes averaging 2.14 ± 2.43 ($p = 0.135$) injuries per athlete. The increase in injuries in athletes with menstrual dysmenorrhea may be related to a decrease in estrogen. As seen in this study, many athletes had menstrual dysfunctions which could have a major impact on their increased risk of the triad. Menstruation is an area that can affect both endurance and non-endurance athletes, displayed by the lack of differences in menstrual score between the two groups of athletes included in this survey. Endurance athletes' menstrual scores averaged 3.81 ± 2.91 and non-endurance athlete's menstrual scores averaged 4.04 ± 1.93. Further studies should be conducted on both types of

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athletes' risk of the triad with regards to nutrition and menstruation.

Education about the triad is crucial for both types of athletes to understand their risks. One of the risk factors for the triad, GI issues, which was assessed in the survey displayed similar scores between endurance and non-endurance athletes, with endurance athletes having an average GI issue score of 3.04 ± 2.24 and a score of 2.48 ± 2.00 for non-endurance athletes. This demonstrates the importance of athletes being aware of the risk factors that contribute to the female athlete triad with both types of athletes having similar scores. In a study conducted by Akman et al., educating the female athletes on nutrition allowed for a decrease in LEAF-Q score due to positive body composition image, enhancing dietary intake, and improvement in their knowledge on healthy nutrition.[21] Many athletes are at risk for the triad but only a small majority know or understand what the disorder is, therefore, education about nutrition and ways to avoid developing risks of the triad, as well as regular screenings, are crucial.[22]

In this study, the LEAF-Q was utilized in both endurance and non-endurance female athletes which have led to some limitations. One limitation was that the questionnaire was validated for endurance athletes and not non-endurance athletes, which could have yielded variable results. A second limitation was that the LEAF-Q is a self-reporting style questionnaire which could lead to bias, participants having difficulty recalling answers to specific questions, or underreporting. A third limitation was the small sample size of 51 athletes with an unequal amount of endurance (n=36) versus non-endurance (n=15) athletes, and an unequal number of athletes per sport in the two categories. The unequal number of players have made it challenging to compare one type of athlete to the other displaying the need for a larger sample size. Although it is necessary for further research on injuries, GI, and menstrual score, overall, this study found that there is a risk for the triad in both endurance and non-endurance female collegiate athletes.

CONCLUSION

The female athlete triad is a condition that remains under-recognized in the athletic community, which may contribute to an increased risk of its development and lack of treatment. While most research has focused on the risk of this condition among female endurance athletes, this study shows the importance of understanding the triad's potential impact on non-endurance athletes as well. Results from this study demonstrate that both endurance and non-endurance female athletes are at risk of developing the triad. This study highlights the importance for future research to address the risks faced by athletes in both groups. From further study, clinicians may be able to develop educational programs for student athletes, their coaches and their parents to help them learn more about the key characteristics they should be aware of to decrease their risk of obtaining the female athlete triad.

Conflict of Interest Statement

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

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