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The Impact of Intensive Physical Activity on the Menstrual Cycle Disturbances in Adolescent and Young Adult Females: A Review of Current Evidence

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Abstract

Background

Regular menstrual cycles are an important indicator of health in adolescent and young adult females. Pubertal maturation of the hypothalamic–pituitary–ovarian axis is a sensitive process that may be disrupted by intensive physical activity, particularly when energy intake is insufficient. Female

athletes exhibit a higher prevalence of menstrual disturbances, which may adversely affect bone, metabolic, and reproductive health.

Aim
This review aims to summarize current evidence on the association between intensive physical activity and menstrual cycle disturbances in adolescent and young adult females, with particular focus on prevalence, underlying mechanisms, and health consequences, including the Female Athlete Triad and Relative Energy Deficiency in Sport (RED-S).

Materials and Methods
A narrative review of peer-reviewed literature, including clinical studies, meta-analyses, and guidelines, was conducted. Research addressing menstrual function, energy availability, bone health, and endocrine adaptations in young female athletes was analyzed.

Results
Menstrual disturbances occur more frequently in athletes, especially in endurance, aesthetic, and weight-class sports. Low energy availability emerged as the primary etiological factor, leading to suppression of reproductive hormones and menstrual dysfunction. These disturbances are associated with reduced bone mineral density, increased stress fracture risk, and metabolic consequences. The RED-S model expands the Triad by addressing multisystem effects and a broader athletic population.

Conclusions
Intensive training combined with inadequate energy intake significantly increases the risk of menstrual disturbances in young female athletes. Early detection, education, and multidisciplinary management focusing on nutrition and training load optimization are essential to protect long-term health.

Keywords:

menstrual disturbances; adolescent athlete; low energy availability; Female Athlete Triad; RED-S

Introduction

Regular menstrual cycles serve as a key indicator of overall health in adolescent and young adult females. At the onset of puberty, neuroendocrine, hormonal, and metabolic factors activate the hypothalamic–pituitary–ovarian (HPO) axis, leading to the development of secondary sexual characteristics and the initiation of menarche. In the initial years after puberty, the HPO axis matures gradually, leading to natural variability in menstrual cycles, including irregular cycles, longer cycle lengths, and anovulation. This process typically stabilizes within two to three years after menarche.

However, in young female athletes, especially those engaged in high-intensity or endurance sports, normal menstrual development is frequently disrupted. Numerous studies indicate that the prevalence of menstrual disturbances, including oligomenorrhea and functional hypothalamic amenorrhea, is significantly higher in athletes than in non-athletic peers [2, 6]. Intensive training, psychological stress, low energy intake, and inadequate recovery can disrupt hormonal function, thereby contributing to reproductive health disturbances [3,7].

In recent years, research in sports endocrinology has emphasized two primary concepts: the Female Athlete Triad, which comprises low energy availability, menstrual dysfunction, and impaired bone health, and the broader syndrome of Relative Energy Deficiency in Sport (RED-S), as recognized by the International Olympic Committee [4]. Both frameworks highlight the complex relationship between physical training demands and the body's energy and endocrine systems.

Adolescence represents a particularly vulnerable developmental period characterized by rapid linear growth, hormonal maturation, and peak bone mass acquisition. Menstrual disturbances during this stage may have long-term consequences that extend into adulthood [8,9,10]. Therefore, understanding the prevalence, underlying mechanisms, and consequences of menstrual irregularities in young athletes is essential for clinicians, coaches, families, and policy-makers.

Research Objectives

This review critically examines current scientific evidence concerning the complex relationship between intensive physical activity in adolescents and young adults and their menstrual cycles. The article explores how high-intensity training affects hormonal changes and the hypothalamic-pituitary-ovarian axis during puberty, as well as the irregularities in menstrual cycles observed in young athletes. It draws on endocrinological, physiological, and epidemiological perspectives to provide a comprehensive overview of mechanisms, risk factors, and long-term effects. Particular attention is given to two key concepts in sports endocrinology: the Female Athlete Triad and Relative Energy Deficiency.

By synthesizing findings from randomized controlled trials, meta-analyses, and clinical guidelines, this review aims to emphasize the necessity of a cautious approach to training young female athletes during critical periods of bone and reproductive system development. Additionally, it identifies existing research gaps and informs future exercise recommendations.

Prevalence of Menstrual Disturbances in Adolescent Athletes

During puberty in girls, neuroendocrine, hormonal, and metabolic changes activate the hypothalamic–pituitary–ovarian (HPO) axis. This process leads to secondary sexual characteristics

and the onset of menarche, followed by regular menstruation. However, because the HPO axis is still maturing, menstrual disorders are common in adolescents, with secondary amenorrhea occurring in 2.6–8.5% and irregular menstruation in 11.3–26.7% of cases [11]. Most cycles last 21 to 45 days [1,2]. By the third year after menarche, 60–80% of cycles are 21 to 34 days long, which is typical for adults [5].

Research consistently demonstrates a higher prevalence of menstrual disturbances among athletes than among non-athletic controls [12]. Rates vary widely depending on sport type, training load, and methods of measurement, but numerous studies report menstrual dysfunction in 20–60% of athletes participating in endurance or aesthetic sports [4]. Aesthetic disciplines such as gymnastics, ballet, figure skating, and rhythmic gymnastics show some of the highest prevalence rates [13,16]. These sports often emphasize leanness, flexibility, and low body mass, which may increase the likelihood of insufficient energy intake relative to expenditure—one of the primary drivers of menstrual disturbances in adolescent athletes [14,15].

High-school and collegiate runners represent another high-risk group. Research on distance runners has revealed that adolescent athletes with menstrual irregularities have significantly lower bone mineral density and higher rates of stress fractures compared with eumenorrheic counterparts [15,17]. Team sports such as volleyball or soccer generally show lower prevalence, likely due to different training structures, more varied movement patterns, and less pressure to maintain very low body mass [20].

Importantly, early sports specialization—a trend increasingly common among adolescents—may further elevate risk. Intensive, year-round training from a young age may interfere with normal maturation of the HPO axis [18]. Some studies suggest that female athletes who experience delayed menarche or prolonged irregular cycles during puberty are more likely to remain amenorrheic or oligomenorrheic in young adulthood [13,19]

3. Physiological Mechanisms: The Role of Low Energy Availability

3.1. Low Energy Availability as the Primary Mechanism

A substantial amount of evidence identifies low energy availability (LEA) as the primary mechanism linking intensive physical activity to menstrual disturbances [21]. LEA decreases circulating levels of leptin, insulin, glucose, and triiodothyronine (T3), which are essential metabolic signals that indicate nutritional adequacy to the hypothalamus [22]. When these signals drop below critical thresholds, the hypothalamus suppresses the pulsatile secretion of gonadotropin-releasing hormone (GnRH) [23]. It then leads to a reduction in luteinizing hormone (LH) pulse frequency, causing disruption of follicular development and ovulation and ultimately leading to irregular or absent menstruations [24].

Human experimental studies show that even short-term LEA can significantly alter LH pulsatility [22]. In longer-term scenarios, which are more common among adolescent athletes, sustained LEA results in hypoestrogenism, anovulation, and functional hypothalamic amenorrhea [25].

3.2. The Interaction Between Physical Stress and Hormonal Regulation

Intensive training increases cortisol levels, which may further block hypothalamic reproductive signals [23]. Other possible factors are inflammation from exercise, and changes in the sympathetic nervous system [26]. While psychological stress can sometimes contribute, most evidence points to physiological energy imbalance as the main cause in adolescent athletes [27].

3.3. Body Composition and Growth Considerations

Adolescents have high energy requirements due to growth and pubertal development. Intense exercise increases total calorie requirements, which may be not able or willing to eat [28]. Competitors in aesthetic sports often maintain very low body fat percentage, which can lead to reduced leptin concentrations - a hormone closely connected to reproductive health and regulation [29]. Lower leptin levels and decreased fat levels may be associated with delayed maturation, anovulatory cycles, and functional hypothalamic amenorrhea in adolescent athletes [25,28].

Female Athlete Triad

The Female Athlete Triad is a medical syndrome first formally defined in the 1990s, characterized by the interrelationship of three components: low energy availability (with or without disordered eating), menstrual dysfunction, and impaired bone health [30]. While initially conceptualized as three distinct clinical outcomes, the Triad is now recognized as a spectrum in which physiological disruption intensifies as energy availability decreases [32]. Adolescents and young adults are especially susceptible due to ongoing bone mass development and reproductive maturation.

Low energy availability is the primary driver of the Triad. While eating disorders such as anorexia nervosa or bulimia nervosa represent intentional causes, many female athletes without a formal diagnosis may still engage in disordered eating behaviors. Inadequate energy intake is often unintentional. Low energy availability due to disordered eating leads to menstrual dysfunction and decreased bone mineral density [42]. Menstrual disturbances include luteal phase defects, oligomenorrhea, and functional hypothalamic amenorrhea, all of which are associated with reduced estrogen levels [41]. The resulting hypoestrogenism causes impairment of bone formation and an increase in bone resorption, ultimately leading to a decrease in bone mineral density and a rise in the risk of stress fractures [42].

The prevalence of the Triad differs by sport, with highest rates in endurance, aesthetic, and weight-class disciplines [40].To help identify athletes who may be at risk and to support decisions about their safe return to sport, it is recommended to use screening tools such as the Female Athlete Triad Cumulative Risk Assessment [32]. Management involves restoring adequate energy through nutrition, reducing training load as needed, and monitoring bone health. Multidisciplinary teams of physicians, sports dietitians, coaches, and mental health professionals have been shown to improve outcomes [43].

Relative Energy Deficiency in Sport (RED-S)

Relative Energy Deficiency in Sport (RED-S) was introduced by the International Olympic Committee (IOC) in 2014 as an expanded concept of the Female Athlete Triad to encompass athletes of all genders and across all sports disciplines [44]. In this model, low energy availability is recognized as the key underlying factor, with wide-ranging consequences for metabolic, cardiovascular, gastrointestinal, endocrine, immune, and psychological function [44]. RED-S helps to overcome several limitations of the original Triad concept by encompassing male athletes, non-weight-lifting sports, and a wider spectrum of clinical signs beyond menstrual disturbances. Persistent low energy availability interferes with normal hormonal pathways, leading to decreases in leptin, insulin, IGF-1, and triiodothyronine, as well as elevated cortisol levels [46]. These alterations delay recovery, deteriorate training adaptations, reduce muscle protein synthesis, and increase susceptibility to injury. As a result, athletes may experience impairment in endurance, concentration, strength, and coordination [48].

Adolescents may be at greater risk because of the increased energy demands associated with growth and maturation. Studies show that young athletes with RED-S indicators display delayed growth, impaired bone development, and altered pubical development [47]. Early detection requires closely monitoring energy intake, training loads, growth patterns, menstrual cycles in females, and any changes in performance.

Management focuses on correcting energy imbalance, often requiring an increased caloric intake or a reduction of training intensity. A multidisciplinary approach is often needed, involving sports physicians, dietitians, psychologists, and strength-conditioning specialists [47]. Education is key for prevention, especially for coaches and parents who shape training and nutrition habits.

5. Health Consequences of Menstrual Disturbances in Young Athletes

5.1. Bone Health and Stress Fractures

Functional hypothalamic amenorrhea leads to low estrogen levels, impairing bone formation and accelerating bone turnover, which is particularly harmful during adolescence, a critical period for bone mineral development and growth [30]. Multiple studies have linked menstrual irregularities in young athletes to decreased bone mineral density (BMD), reduced peak bone mass, and an increased risk of stress fractures.

Athletes with persistent amenorrhea demonstrate significantly higher rates of tibial and metatarsal stress fractures compared to eumenorrheic peers [31]. It is a dangerous situation, as the restoration of normal menstrual function may not always result in some improvement in bone mineral density; complete recovery to expected levels is not always achieved [32].

5.2. Metabolic and Endocrine Effects

Adolescents experiencing Relative Energy Deficiency in Sport (RED-S) or Female Athlete Triad symptoms often develop particular metabolic adaptations, such as reduced resting metabolic rate, decreased IGF-1 levels, and suppressed thyroid function [27]. These hormonal changes lead to fatigue, impaired training potential, and increased injury risk.

Psychological consequences may include intensified pressure around body weight, perfectionism, or disordered eating — they have also been documented, especially in sports underscoring leanness [33].

5.3. Reproductive and Long-Term Health Implications

The long-term reproductive impact of prolonged hypothalamic dysfunction during adolescence remains incompletely understood. However, chronic hypoestrogenism has been associated with reduced peak bone mass and potential fertility challenges in adulthood [25]. While most athletes resume normal cycles after improving energy availability and reducing training intensity, evidence suggests that a subset may continue to experience irregular menstruation or persistent ovulatory dysfunction [34].

6. Prevention and Management

6.1. Education and Early Detection

Early education for athletes, parents, and coaches is widely regarded as the most effective preventive strategy [4]. Many adolescents do not recognize menstrual irregularities as a health concern, often

normalizing cycle disruptions due to sport participation. Encouraging athletes to track their menstrual cycles can help identify early warning signs of low energy availability and functional hypothalamic amenorrhea [32].

6.2. Ensuring Adequate Energy Intake

Interventions typically focus on increasing caloric intake, optimizing macronutrient distribution, and ensuring nutrition supports both growth and training demands [35]. Collaboration with sports dietitians is essential for maintaining energy availability above the critical threshold required for normal reproductive function [22].

6.3. Training Modifications

Reducing training volume or intensity may restore menstrual regularity, particularly when combined with improved energy intake [30]. Coaches should avoid overly rapid increases in training load and recognize that performance may decline if energy intake is inadequate [4]. Periodized training and monitoring for early clinical signs of RED-S are recommended.

6.4. Multidisciplinary Care

Optimal management involves coordinated care among coaches, sports physicians, psychologists, and nutritionists. Regular screening for Female Athlete Triad symptoms or RED-S is recommended, particularly in high-risk sports such as gymnastics, long-distance running, and ballet [37].

7. Gaps in Current Research

Although the Female Athlete Triad and RED-S have been extensively studied, several gaps remain. More longitudinal studies are needed to understand how adolescent menstrual dysfunction affects long-term bone and reproductive health [25]. Additionally, psychological factors — including stress, disordered eating, body image concerns, and perfectionism — require greater examination in relation to energy availability [37].

Cultural and socioeconomic influences, training environments, and coaching styles may also affect the risk of menstrual disturbances, but these factors are underrepresented in current literature [38]. Research exploring early-sport specialization and its effects on maturation of the HPO axis is also limited [39].

Conclusion

The evidence overwhelmingly demonstrates that intensive physical activity, particularly when combined with low energy availability, disrupts menstrual function in adolescent and young adult female athletes. These disturbances are not benign: they impair bone health, alter metabolism, and may have long-term consequences extending into adulthood.

Prevention through education, adequate nutrition, and careful training management is essential. A coordinated, multidisciplinary approach — encompassing medical, nutritional, and psychological guidance — is crucial to protect the health, performance, and long-term development of young athletes.

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References

1. ACOG Committee Opinion No. 651: Menstruation in Girls and Adolescents: Using the Menstrual Cycle as a Vital Sign. *Obstet Gynecol*. 2015;126(6):e143-e146. doi:10.1097/AOG.0000000000001215

2. Brown KA, Dewoolkar AV, Baker N, Dodich C. The female athlete triad: special considerations for adolescent female athletes. *Transl Pediatr*. 2017;6(3):144-149. doi:10.21037/tp.2017.04.04

3. Calcaterra V, Vandoni M, Bianchi A, et al. Menstrual Dysfunction in Adolescent Female Athletes. *Sports (Basel)*. 2024;12(9):245. Published 2024 Sep 4. doi:10.3390/sports12090245

4. Mountjoy M, Sundgot-Borgen JK, Burke LM, et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *Br J Sports Med*. 2018;52(11):687-697. doi:10.1136/bjsports-2018-099193

5. Gruber N, Modan-Moses D. Menstrual Cycle in Adolescents: Updating the Normal Pattern. *J Clin Endocrinol Metab*. 2021;106(1):e372-e374. doi:10.1210/clinem/dgaa688

6. Taim BC, Ó Catháin C, Renard M, Elliott-Sale KJ, Madigan S, Ní Chéilleachair N. The Prevalence of Menstrual Cycle Disorders and Menstrual Cycle-Related Symptoms in Female Athletes: A Systematic Literature Review. *Sports Med*. 2023;53(10):1963-1984. doi:10.1007/s40279-023-01871-8

7. Mörö S, Kosola S, Holopainen E. Girls referred for amenorrhea: analysis of a patient series from a specialist center. Front Public Health. 2024 Feb 16;12:1304277. doi: 10.3389/fpubh.2024.1304277. PMID: 38435281; PMCID: PMC10906086.

8. Seitz A, Raval AP. Menstruation: An Important Indicator for Assessing Stroke Risk and Its Outcomes. *Stroke*. 2025;56(2):533-542. doi:10.1161/STROKEAHA.124.048869

9. Roomruangwong C, Sirivichayakul S, Matsumoto AK, et al. Menstruation distress is strongly associated with hormone-immune-metabolic biomarkers. *J Psychosom Res*. 2021;142:110355. doi:10.1016/j.jpsychores.2020.110355

10. Wiksten-Almströmer M, Hirschberg AL, Hagenfeldt K. Reduced bone mineral density in adult women diagnosed with menstrual disorders during adolescence. *Acta Obstet Gynecol Scand*. 2009;88(5):543-549. doi:10.1080/00016340902846080

11. Slap GB. Menstrual disorders in adolescence. *Best Pract Res Clin Obstet Gynaecol*. 2003;17(1):75-92. doi:10.1053/ybeog.2002.0342

12. Passoni P, Inzoli A, De Ponti E, Polizzi S, Ceccherelli A, Fantauzzi M, Procaccianti C, Cattoni A, Villa S, Riva A, Righetti S, Landoni F, Fruscio R. Association between Physical Activity and Menstrual Cycle Disorders in Young Athletes. Int J Sports Med. 2024 Jun;45(7):543-548. doi: 10.1055/a-2278-3253. Epub 2024 Feb 28. PMID: 38417813; PMCID: PMC11216807.

13. Thein-Nissenbaum J, Hammer E. Treatment strategies for the female athlete triad in the adolescent athlete: current perspectives. *Open Access J Sports Med*. 2017;8:85-95. Published 2017 Apr 4. doi:10.2147/OAJSM.S100026

14. Łagowska K, Kapczuk K. Testosterone concentrations in female athletes and ballet dancers with menstrual disorders. *Eur J Sport Sci*. 2016;16(4):490-497. doi:10.1080/17461391.2015.1034786

15. Roberts TA, Glen J, Kreipe RE. Disordered Eating and Menstrual Dysfunction in Adolescent Female Athletes Participating in School-Sponsored Sports. *Clinical Pediatrics*. 2003;42(6):561-564. doi:10.1177/000992280304200613

16. Berz K, McCambridge T. Amenorrhea in the Female Athlete: What to Do and When to Worry. *Pediatr Ann*. 2016;45(3):e97-e102. doi:10.3928/00904481-20160210-03

17. Hulme A, Nielsen RO, Timpka T, Verhagen E, Finch C. Risk and Protective Factors for Middle- and Long-Distance Running-Related Injury. *Sports Med*. 2017;47(5):869-886. doi:10.1007/s40279-016-0636-4

18. Jayanthi N, Pinkham C, Dugas L, Patrick B, Labella C. Sports specialization in young athletes: evidence-based recommendations. *Sports Health*. 2013;5(3):251-257. doi:10.1177/1941738112464626

19. De Souza MJ, Koltun KJ, Williams NI. The Role of Energy Availability in Reproductive Function in the Female Athlete Triad and Extension of its Effects to Men: An Initial Working Model of a Similar Syndrome in Male Athletes. *Sports Med*. 2019;49(Suppl 2):125-137. doi:10.1007/s40279-019-01217-3

20. Sundgot-Borgen J, Torstveit MK. Prevalence of eating disorders in elite athletes is higher than in the general population. *Clin J Sport Med*. 2004;14(1):25-32. doi:10.1097/00042752-200401000-00005

21. Loucks AB, Kiens B, Wright HH. Energy availability in athletes. *J Sports Sci*. 2011;29 Suppl 1:S7-S15. doi:10.1080/02640414.2011.588958

22. Loucks AB, Thuma JR. Luteinizing hormone pulsatility is disrupted at a threshold of energy availability in regularly menstruating women. *J Clin Endocrinol Metab*. 2003;88(1):297-311. doi:10.1210/jc.2002-020369

23. Warren MP, Chua AT. Exercise-induced amenorrhea and bone health in the adolescent athlete. *Ann N Y Acad Sci*. 2008;1135:244-252. doi:10.1196/annals.1429.025

24. Williams NI, Helmreich DL, Parfitt DB, Caston-Balderrama A, Cameron JL. Evidence for a causal role of low energy availability in the induction of menstrual cycle disturbances during

strenuous exercise training. *J Clin Endocrinol Metab*. 2001;86(11):5184-5193. doi:10.1210/jcem.86.11.8024

25. Gordon CM, Ackerman KE, Berga SL, et al. Functional Hypothalamic Amenorrhea: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab*. 2017;102(5):1413-1439. doi:10.1210/jc.2017-00131

26. Cano Sokoloff N, Misra M, Ackerman KE. Exercise, Training, and the Hypothalamic-Pituitary-Gonadal Axis in Men and Women. Front Horm Res. 2016;47:27-43. doi: 10.1159/000445154. Epub 2016 Jun 27. PMID: 27348623; PMCID: PMC7043068.

27. Mountjoy M, Sundgot-Borgen JK, Burke LM, et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *Br J Sports Med*. 2018;52(11):687-697. doi:10.1136/bjsports-2018-099193

28. Misra M, Klibanski A. Endocrine consequences of anorexia nervosa. *Lancet Diabetes Endocrinol*. 2014;2(7):581-592. doi:10.1016/S2213-8587(13)70180-3

29. Welt CK, Chan JL, Bullen J, et al. Recombinant human leptin in women with hypothalamic amenorrhea. *N Engl J Med*. 2004;351(10):987-997. doi:10.1056/NEJMoa040388

30. Nattiv A, Loucks AB, Manore MM, et al. American College of Sports Medicine position stand. The female athlete triad. *Med Sci Sports Exerc*. 2007;39(10):1867-1882. doi:10.1249/mss.0b013e318149f111

31. Bachrach LK. Acquisition of optimal bone mass in childhood and adolescence. *Trends Endocrinol Metab*. 2001;12(1):22-28. doi:10.1016/s1043-2760(00)00336-2

32. De Souza MJ, Nattiv A, Joy E, et al. 2014 Female Athlete Triad Coalition Consensus Statement on Treatment and Return to Play of the Female Athlete Triad: 1st International Conference held in San Francisco, California, May 2012 and 2nd International Conference held in Indianapolis, Indiana, May 2013. *Br J Sports Med*. 2014;48(4):289. doi:10.1136/bjsports-2013-093218

33. Ackerman KE, Holtzman B, Cooper KM, et al. Low energy availability surrogates correlate with health and performance consequences of Relative Energy Deficiency in Sport. *Br J Sports Med*. 2019;53(10):628-633. doi:10.1136/bjsports-2017-098958

34. Loucks AB. Energy availability, not body fatness, regulates reproductive function in women. *Exerc Sport Sci Rev*. 2003;31(3):144-148. doi:10.1097/00003677-200307000-00008

35. Thomas DT, Erdman KA, Burke LM. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *J Acad Nutr Diet*. 2016;116(3):501-528. doi:10.1016/j.jand.2015.12.006

36. Joy E, De Souza MJ, Nattiv A, et al. 2014 female athlete triad coalition consensus statement on treatment and return to play of the female athlete triad. *Curr Sports Med Rep*. 2014;13(4):219-232. doi:10.1249/JSR.0000000000000077

37. Silva L, Gomes AR, Martins C. Psychological factors related to eating disordered behaviors: a study with Portuguese athletes. *Span J Psychol*. 2011;14(1):323-335. doi:10.5209/rev_sjop.2011.v14.n1.29

38. Mountjoy M, Ackerman KE, Bailey DM, et al. 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). *Br J Sports Med*. 2023;57(17):1073-1097. doi:10.1136/bjsports-2023-106994

39. Baxter-Jones ADG, Barbour-Tuck EN, Dale D, et al. The role of growth and maturation during adolescence on team-selection and short-term sports participation. *Ann Hum Biol*. 2020;47(4):316-323. doi:10.1080/03014460.2019.1707870

40. Daily JP, Stumbo JR. Female Athlete Triad. *Prim Care*. 2018;45(4):615-624. doi:10.1016/j.pop.2018.07.004

41. Kelly AW, Hecht S. The female athlete triad. *Ann Jt*. 2022;7:6. Published 2022 Jan 15. doi:10.21037/aoj-2020-03

42. Matzkin, Elizabeth et al. "Female Athlete Triad: Past, Present, and Future." *The Journal of the American Academy of Orthopaedic Surgeons* vol. 23,7 (2015): 424-32. doi:10.5435/JAAOS-D-14-00168

43. Mehta J, Thompson B, Kling JM. The female athlete triad: It takes a team. *Cleve Clin J Med*. 2018;85(4):313-320. doi:10.3949/ccjm.85a.16137

44. Grabia M, Perkowski J, Socha K, Markiewicz-Żukowska R. Female Athlete Triad and Relative Energy Deficiency in Sport (REDs): Nutritional Management. *Nutrients*. 2024;16(3):359. Published 2024 Jan 25. doi:10.3390/nu16030359

45. Elliott-Sale KJ, Tenforde AS, Parziale AL, Holtzman B, Ackerman KE. Endocrine Effects of Relative Energy Deficiency in Sport. *Int J Sport Nutr Exerc Metab*. 2018;28(4):335-349. doi:10.1123/ijsnem.2018-0127

46. Heikura IA, Uusitalo ALT, Stellingwerff T, Bergland D, Mero AA, Burke LM. Low Energy Availability Is Difficult to Assess but Outcomes Have Large Impact on Bone Injury Rates in Elite Distance Athletes. *Int J Sport Nutr Exerc Metab*. 2018;28(4):403-411. doi:10.1123/ijsnem.2017-0313

47. Gould RJ, Ridout AJ, Newton JL. Relative Energy Deficiency in Sport (RED-S) in Adolescents - A Practical Review. *Int J Sports Med*. 2023;44(4):236-246. doi:10.1055/a-1947-3174

48. Romano, M. E., & Sass, A. (2025). Reproductive Health Management of Female Adolescent Athletes With Relative-Energy Deficiency in Sport. *Journal of pediatric and adolescent gynecology*, *38*(2), 108–116. doi:10.1016/j.jpag.2024.11.008