INDONESIAN HEALTH JOURNAL

**Volume 5 Number 3, October 2026**
pp. 853-867
E-ISSN: 2963-3036
DOI: 10.58344/ihj.v5i3.970

# Training Load and Menstrual Cycle Disorders in Female Athletes: A Narrative Review

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**Keywords:**

female athletes; training load; relative energy deficiency; menstrual cycle disorders; narrative review

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***Abstract***

Menstrual cycle disorders are frequently reported in female athletes, but the association with training load remains inconsistent across studies. This review aimed to examine associations between training load dimensions—volume, frequency, duration, and intensity—and menstrual cycle disorders, together with plausible mechanisms and moderator factors. A narrative review with explicit eligibility criteria searched PubMed, ScienceDirect, SpringerLink, Google Scholar, Garuda, and DOAJ for studies published from January 2015 to December 2025, supplemented by reference-list and update searches. Of 28 full-text articles assessed, 10 observational studies involving 2,182 female athletes were synthesized. Five studies reported positive associations, but four relied on unadjusted bivariate analyses; five studies found no significant association. Evidence was concentrated on training volume, which was associated with menstrual disorders in four of seven studies that measured it. Frequency and session duration were not significantly associated in the studies that tested them, while intensity was rarely examined separately. Two studies showed a dose-response trend. Sport-specific patterns were inconsistent and based on few studies. Gynecological age, body image, energy intake, and low energy availability may modify the association, although energy availability was directly estimated in only one synthesized study. Overall, higher training load, particularly greater volume, was associated with menstrual cycle disorders in half of the studies, but the evidence is heterogeneous and does not establish causality. Monitoring menstrual cycles, training load, and energy intake remains appropriate for early detection.

## INTRODUCTION

Women's participation in competitive sports continues to increase, accompanied by increasingly demanding exercises. Training load is a combination of the volume, frequency, duration, and intensity of training. High training load in female athletes is associated with impaired reproductive function, especially menstrual cycle disorders such as oligomenorrhea, amenorrhea, polymenorrhea, and cycle irregularities (Calcaterra et al., 2024; Mountjoy et al., 2023).

This problem is quite common. In elite German athletes who do not use hormonal contraceptives, oligomenorrhea is reported by 13% and secondary amenorrhea by 8% of athletes (Kirschbaum et al., 2025) , while in Swiss elite athletes 32.1% report secondary

amenorrhea, current or previous (Baumgartner et al., 2023). Cycle disorders are also reported in Indonesian athletes (C. N. Fadila & Kumaat, 2024; Fernanda et al., 2021) . This disorder is important because it relates to injury (Baumgartner et al., 2023), while the understanding of menstrual health in the sports environment is still low: 81% of the 1,086 female athletes at least partially agree that the health of female athletes is considered taboo in the sports environment, and only 3% have access to an obstetrician (von Rosen et al., 2022).

Cyclical disorders in athletes are generally associated with Relative Energy Deficiency in Sport (RED-S), which is a condition when energy intake is insufficient for the body's needs after being reduced from energy for exercise (Mountjoy et al., 2023). This condition can suppress the secretion of gonadotropin-releasing hormone (GnRH) so that reproductive hormone levels decrease (Calcaterra et al., 2024; Mountjoy et al., 2023). However, RED-S is not the only cause; reproductive axis immaturity in young athletes (Calcaterra et al., 2024) as well as endocrine disorders such as polycystic ovary syndrome and thyroid disorders (Mountjoy et al., 2023) can also play a role.

Findings on training load and menstrual cycle disorders were not uniform. Some studies reported positive associations (Abbas & Losi, 2025; Passoni et al., 2024; Ravi et al., 2021), whereas others did not and instead highlighted factors such as sport type, body image, nutritional intake, or gynecological age (Amoruso et al., 2024; Fernanda et al., 2021; Kirschbaum et al., 2025). Previous reviews mainly summarized the prevalence and broader determinants of menstrual dysfunction (Calcaterra et al., 2024; Gimunová et al., 2022), with limited comparison of specific training-load dimensions, adjustment for confounding, moderators, sport-specific differences, and the consistency of associations. This review therefore compares evidence by training-load dimension and sport context, interprets estimates with attention to adjustment and precision rather than statistical significance alone, and presents a conceptual framework linking training load, energy availability, and menstrual cycle disorders. Because no formal quality or risk-of-bias instrument was applied, the synthesis should be interpreted as a structured narrative review rather than formal evidence grading.

This review aims to examine the association between physical exercise load and menstrual cycle disorders in female athletes, including epidemiological evidence, physiological mechanisms, moderator factors, and implications for prevention and early detection.

## METHOD

### Design and Review Questions

This article is a narrative review, which is a review that synthesizes the evidence in a narrative-thematic manner without meta-analysis. This approach was chosen because the design, population, and study instruments are so diverse that the results cannot be quantitatively combined. Transparency is maintained with explicit review questions, criteria, and tracing strategies. The review questions were structured with a PEO framework: in female athletes of reproductive age (Population), is higher training load (Exposure) related to menstrual cycle disruption (Outcome)? The derivative question is the underlying mechanism of the relationship and the factors that moderate it.

Inclusion and Exclusion Criteria

Inclusion criteria include:

- Population: female athletes of reproductive age, i.e. individuals who undergo structured sports training and are members of clubs, teams, or federations, or participate in official competitions. Mixed samples are included when data on female athletes are analyzed separately.
- Exposure: the training load (volume, frequency, duration, and/or intensity) statistically tested against cyclic disruption, either as a primary variable or as one of the determinants. The general physical activity instrument (IPAQ/IPAQ-SF) is accepted as a proxy for exercise load only when the population is athletes who train regularly, since most of the physical activity comes from exercise.
- Outcome: oligomenorrhea, primary or secondary amenorrhea, polymenorrhea, or cycle irregularities.
- Design and publication: observational studies in peer-reviewed journals, published January 2015–December 2025, in Indonesian or English; national journal articles must be published in SINTA-accredited journals during the accreditation period.

Exclusion criteria include: (1) non-athlete population; (2) primary exposure is not a training burden, e.g. hormonal contraceptives or injury; (3) the primary outcome is not a cyclic disorder, e.g. premenstrual syndrome (PMS); (4) there is no statistical test of the relationship between training load and cycle disorders, or exposure is not measured separately from outcomes, e.g. only in the form of an athlete's perception that their menstruation changes as training increases; and (5) it is not an original research article published in a national journal that is not SINTA accredited. The use of hormonal contraceptives is not used as an eligibility criterion because not all studies report it; this aspect is discussed as a limitation.

Study Search and Selection Strategy

Searches were conducted on PubMed, ScienceDirect, SpringerLink, Google Scholar, Garuda, and DOAJ with keywords: ("training load" OR "training volume" OR "training intensity" OR "exercise intensity" OR "physical activity") AND ("menstrual cycle disorder" OR "menstrual dysfunction" OR amenorrhea OR oligomenorrhea OR "menstrual irregularity") AND ("female athlete" OR "women athletes"), as well as their equivalents in Indonesian ("training intensity" OR "physical activity" OR "training volume") AND ("menstrual cycle disorders" OR "menstrual cycle") AND ("female athletes" OR "female athletes"). The search was supplemented by a bibliography check of relevant articles and a search for updates until December 2025. After checking the titles and abstracts, 31 candidate records were obtained (database 16, bibliography 13, update 2). After the three duplicates were removed, 28 articles were rated full-text and 18 were excluded: eight because their main exposure was not training load, three because they were review articles, and seven articles whose topics were the closest, each because: they were descriptive studies without a relationship test (Joubert et al., 2022); the exposure was only in the form of athlete perception (Witkoś et al., 2023); the main focus was on PMS and premenstrual dysphoric disorder (PMDD) and only compared gymnasts with non-athletes without testing training load (Czajkowska et al., 2019); the population did not meet the definition of an athlete (Baranauskas et al., 2023; Salwi et al., 2025; Witkoś & Wróbel,

2019); and published in non-SINTA accredited journals (Sangi et al., 2025). A total of 10 studies were synthesized (Figure 1).

Three studies were excluded because the athlete status of the participants could not be ascertained. Baranauskas et al. (2023) recruited active women Strava app users from recreational to elite level without verification of club membership or participation in competitions; Witkoś & Wróbel (2019) examined amateur ballroom dancers without reporting club or competition membership; and Salwi et al. (2025) examined female students who could not be ascertained to practice regularly. Because Baranauskas et al. (2023) and Witkoś & Wróbel (2019) measured the volume and frequency of exercise specifically, the findings were not synthesized but discussed as supporting evidence. Two national journal articles that were included were published in the SINTA accreditation period, namely (C. N. Fadila & Kumaat, 2024) in the SINTA 4 journal and (Fernanda et al., 2021) in the SINTA 5 journal.

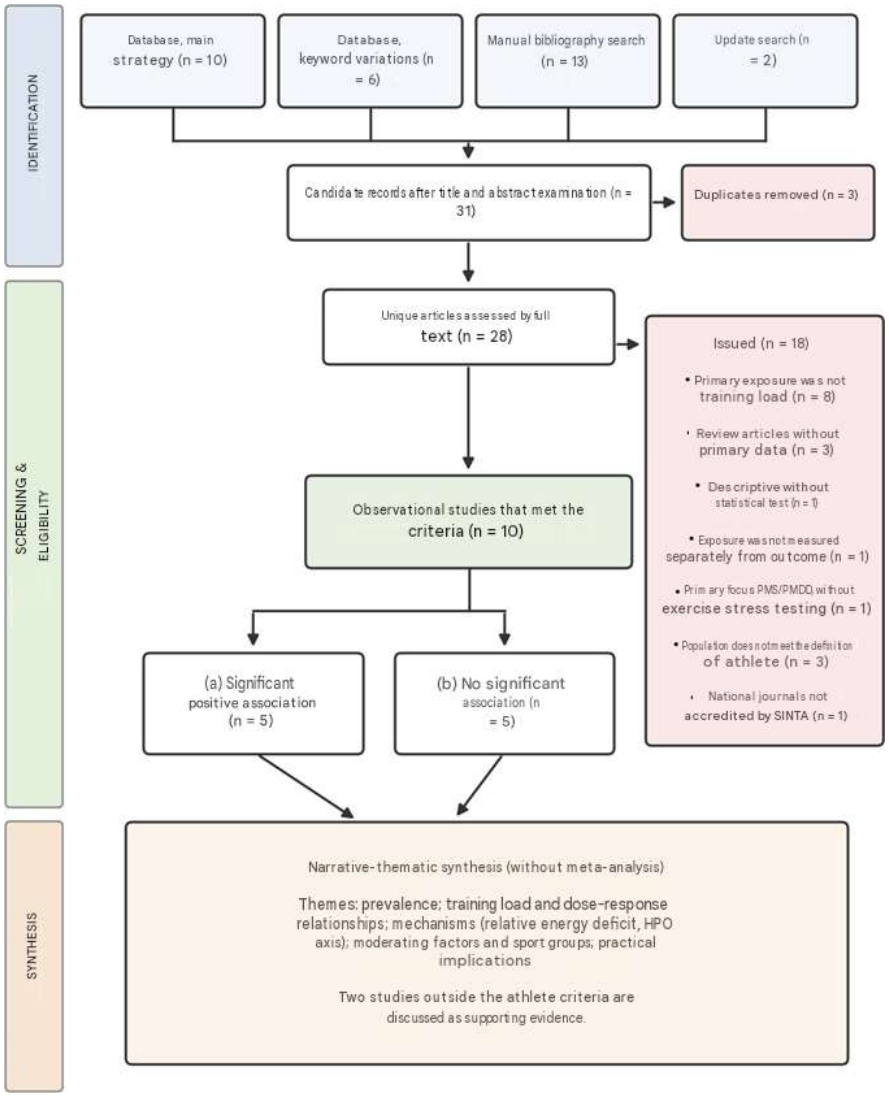



**Figure 1.** Study search and selection flow chart

*Source: Authors' analysis of the study-selection process, 2026.*

**Data Extraction and Synthesis**

Data extracted included authors, countries, samples, study design, instruments, exposure measures, outcome definitions, and key statistical estimates. A formal quality or risk-of-bias assessment was not performed. To avoid treating statistical significance as a direct measure of evidence strength, the synthesis considered the direction and magnitude of associations when reported, confidence-interval precision, adjustment for confounders, sample size, exposure and outcome measurement, and study-specific limitations. Labels indicating significant or non-significant associations were retained only as descriptive summaries. Studies were then grouped by sport category (aesthetic, endurance, martial arts, games, and multi-sport), and the synthesis addressed prevalence, training-load dimensions and dose-response patterns, plausible mechanisms, moderator factors, sport context, and practical implications.

## RESULTS AND DISCUSSION

### Study Characteristics

Ten studies were published in 2018–2025 and involved 2,182 female athletes (1,666 in training load analysis, after deducting hormonal contraceptive users in two studies (Ravi et al., 2021; Kirschbaum et al., 2025) and incomplete data on two studies (Passoni et al., 2024; Witkoś et al., 2024). The studies came from Poland, Italy, Germany, Finland, Pakistan, Indonesia, and one multinational sample. Six studies examined one sport and four studies of multiple branches. Nine studies were cross-sectional in design and one was reported as prospective (Passoni et al., 2024), but the data were collected through a single questionnaire. Five studies only analyzed athletes who did not use hormonal contraceptives, one study reported their use without controlling for them (Passoni et al., 2024), and four studies did not make them exclusion criteria or did not report them (Amoruso et al., 2024; N. Fadila et al., 2024; Fernanda et al., 2021; Heikura et al., 2018). Five studies showed significant positive associations and five did not (Table 2).

**Table 2.** Characteristics and statistical results of the synthesised study (n=10)

| Yes | Author (Year), Country | Sample [Group] | Design | Instruments | Exposure | Outcome | Key Results | Interpretive note |
|---|---|---|---|---|---|---|---|---|
| 1 | Witkoś et al. (2024), Poland | Physical athlete, non-HK; n=104 [Aesthetics] | CS | LEAF-Q | Hours/mgg | Current cycle disorders; history of amenorrhea ≥3 months (58.7%) | 9.96 vs 8.14 hours/mgg (p=0.002); not age-adjusted (younger disorder group) | Significant positive (bivariate) |
| 2 | Passoni et al. (2024), Italy | Runners; n=53 (47 analysed) [Endurance] | Observational prospective * | Questionnaire | km/mgg | Irregular cycles (<25/>35 days); 39,6% | OR 1.35 per 10 km/mgg (95%CI 1.05–1.73; p=0.02), adjusted for age, BMI, level, calorie intake; cut-off 65 | Positive significant, dose-response |

| Yes | Author (Year), Country | Sample [Group] | Design | Instruments | Exposure | Outcome | Key Results | Interpretive note |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | km/mgg; history HK 54.7% uncontrolled | |
| 3 | Fadila & Kumaat (2024), Indonesia | Women's Karateka; n=37 [Martial arts] | CS | IPAQ-SF, PSS | Physical activity | Poly-/oligomenorrhea | $\chi^2$ p=0.021; C=0.415; stress p=0.007; no confounding control; many E<5 cells | Significant positive (bivariate) |
| 4 | Abbas et al. (2025), Pakistan | 5 branches, non-HK; n=151 [Multi-branch] | CS | MSQ, IPAQ-SF, LEAF-Q | Hours/mgg + IPAQ-SF | Menstrual disorders (definition not detailed) | Amenorrhea 6.3% / 12.7% / 60.4% (low/moderate/high; p=0.001); high vs low OR 37.00 (10.87–125.96), no adjustment | Positive significant (bivariate), dose-response; OR imprecise |
| 5 | Ravi et al. (2021), Finland | 67 branches; n=846 (506 non-HK) [Multi-branch] | CS | LEAF-Q | Hours/year | Trace / amenorrhea | Median 627 vs 550 hours (p=0.041; no adjustment); lean sport OR 1.70 (p=0.010) | Significant positive (bivariate) |
| 6 | Heikura et al. (2018), multinational | Elite runners & sprints; n=35 [Endurance] | CS | LEAF-Q, estradiol, 7-day record | km/mgg | Amenorrhea | 101 vs 90 km/mgg (NS; d=0.40); LEAF-Q 12.8 vs 8.3 (p<0.01) | Insignificant (small sample) |
| 7 | Kirschbaum et al. (2025), Germany | Elite 64 branches; n=584 (415 non-HK) [Multi-branch] | CS | Online questionnaire | Hours/mgg | Primary/secondary amenorrhea, oligomenorrhea | OR 1.029 per hour/mgg (0.992–1.068; p=0.126), multivariate | Insignificant |
| 8 | Amoruso et al. (2024), Italy | Lean vs non-lean, 15–40 yrs; n=288; HK not reported [Multi-branch] | CS | Original questionnaire | Frequency & duration of sessions | Irregular cycles | frequency AOR 1.53–1.62 (p≥0.288); duration ≥2 hours AOR 1.13 (p=0.724); lean sport AOR 2.02 (p=0.018); body | Insignificant |

| Yes | Author (Year), Country | Sample [Group] | Design | Instruments | Exposure | Outcome | Key Results | Interpretive note |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | image AOR 3.83 (p=0.001) | |
| 9 | Fernanda et al. (2021), Indonesia | Youth badminton; n=20 [Games] | CS | IPAQ, HARS, food record | Physical activity | Normal vs abnormal cycles | Physical activity p=0.074; carbohydrates r=0.535 (p=0.015); protein/fat r=−0.513 (p=0.021) | Insignificant (small sample) |
| 10 | Witkoś et al. (2022), Poland | Club swimmers, non-HK; n=64 [Endurance] | CS | Questionnaire (partial LEAF-Q) | Session, hours, km, Borg scale | Cyclical disorders; amenorrhea 31.3% | All correlations NS (\|rho\| ≤0.16); BMI rho=−0.32 (p<0.01); logistical regression of risk of overfitting (10 cases/10 predictors) | Insignificant |

*Source: Authors' synthesis of the 10 included studies, 2026.*

Remarks: studies 1–5 = significant positive association; studies 6–10 = no significant association. (bivariate) = association tested only without adjustment for other variables. OR amounts cannot be directly compared between studies because the units of exposure are different. AOR = adjusted odds ratio; d = Cohen's d; FFM = fat-free mass ; HARS = Hamilton Anxiety Rating Scale; HK = hormonal contraception; IPAQ(-SF) = International Physical Activity Questionnaire (short form); BMI = body mass index; LEAF-Q = Low Energy Availability in Females Questionnaire; MSQ = Menstrual Symptom Questionnaire; OR = odds ratio; PSS = perceived stress scale.

Prevalence of Menstrual Cycle Disorders

The prevalence varies widely by sport and the definition of outcomes. The highest prevalence was found in physique athletes (58.65% had amenorrhea ≥3 months; Witkoś et al., 2024) and Pakistani multi-sport athletes (58.3%; Abbas et al., 2025). A prevalence of about one-third was found in running athletes (37.1–39.6%; Heikura et al., 2018; Passoni et al., 2024), Italian athletes (33.0%; Amoruso et al., 2024), Finnish athletes (31.6%; Ravi et al., 2021), and swimmers (31.26%; Witkoś et al., 2022), while lower rates were found in elite German athletes (oligomenorrhea 13%, secondary amenorrhea 8%; Kirschbaum et al., 2025). In Indonesian karate athletes, only 35.1% had normal cycles (Fadila & Kumaat, 2024). This range is in line with previous reviews, which reported reproductive disorders in 6–79% of women who exercised (Calcaterra et al., 2024) and a prevalence of menstrual disorders of 0–61% in 48 studies of athletes (Gimunová et al., 2022).

The Relationship of Exercise Load with Menstrual Cycle Disorders

Evidence for a positive association came primarily from unadjusted analyses: four of the five studies reporting statistically significant associations were bivariate, and only one used an adjusted model. In runners, every additional 10 km/week was associated with 35% higher odds of cycle irregularity after adjustment for age, BMI, exercise level, and calorie intake (OR 1.35; Passoni et al., 2024), whereas training days/week was not significant (p=0.30). Current or previous hormonal therapy use was common (54.7% of participants, mostly contraceptive pills) and was not controlled. Passoni et al. (2024) was therefore the only study with a statistically significant training-load association that adjusted for other measured variables.

In Finnish athletes, athletes with cycle disorders trained more in a year (median 627 vs 550 hours; Ravi et al., 2021), and in physique athletes longer per week (9.96 vs 8.14 hours; Witkoś et al., 2024), although physique athletes with cycle disorders were also younger (23.8 vs 27.7 years) and these two comparisons were bivariate without adjustment. In karate athletes, physical activity levels were associated with the menstrual cycle (p=0.021; Fadila & Kumaat, 2024), but the analysis was also bivariate, even though stress was significantly related in the same sample. In Pakistani athletes, the proportion of amenorrhea increased from low, medium, to high load groups (6.3%, 12.7%, and 60.4%). For a broader outcome, i.e. menstrual disorders (amenorrhea or irregular cycles compared to regular cycles), the odds of high load being 37 times greater than low load (OR 37.00; Abbas et al., 2025); odds also increased from medium to high load (OR 7.33) and from low to medium (OR 5.05). However, this OR was calculated from table 2×2 without adjusting for other variables, the burden category limits and operational definitions of outcomes were not explained, and the confidence interval was so wide that the estimates were not precise.

Dimensions of training load. The most frequently measured dimension was volume (seven studies), and significant associations were found in four of them (Abbas et al., 2025; Passoni et al., 2024; Ravi et al., 2021; Witkoś et al., 2024). The frequency was not significant in the three studies that tested it, namely the number of training days in runners (Passoni et al., 2024), the frequency in Italian athletes (Amoruso et al., 2024), and the number of sessions in swimmers (Witkoś et al., 2022). The duration of sessions was also insignificant in the two studies that tested it (Amoruso et al., 2024; Witkoś et al., 2022). Intensity was almost unassessable: only the Borg scale in swimmers was tested, and it did not correlate with cycle disruption (Witkoś et al., 2022), whereas the IPAQ combined intensity with duration. Thus, the evidence in this review mainly concerns the volume of exercise.

The dose-response tendency was seen in two studies. Passoni et al. (2024) showed an increase in odds per 10 km/week assuming a linear relationship, while Abbas et al. (2025) showed a gradient in three load categories. None of the studies showed a significant negative association. The magnitude of the effects between studies (OR 1.35 to 37.00) could not be directly compared because the units of exposure were different.

Supporting evidence beyond synthesis. Two studies excluded because their athlete status could not be ascertained pointed in the same direction. In 233 amateur ballroom dancers who did not use hormonal contraception, each additional one training session/week was associated with a 15% higher odds of menstrual disorders after adjusting for length of training and body weight (OR 1.15; Witkoś & Wróbel, 2019). In 3,705 active women Strava users, the highest

weekly volume was associated with amenorrhea/oligomenorrhea in all three intensity categories (AOR 1.41–1.46), while the intermediate volume category was insignificant so it more closely resembled the threshold effect (Baranauskas et al., 2023). These findings support the direction of conclusions, but cannot be generalized directly to athletes.

Physiological Mechanisms

According to the International Olympic Committee (IOC) consensus, RED-S is caused by prolonged or heavy low energy availability, and studies of exposure to low energy availability show that less energy intake is slightly more prominent than excessive exercise energy expenditure (Mountjoy et al., 2023). This means that cycle disruption is more likely to occur when an increase in exercise load is not offset by an increase in energy intake. Low energy availability suppresses the hypothalamic-pituitary-ovarian (HPO) axis so that GnRH, luteinizing hormone (LH), follicle-stimulating hormone (FSH), and estrogen decrease, and the cycle becomes disrupted (Figure 2).

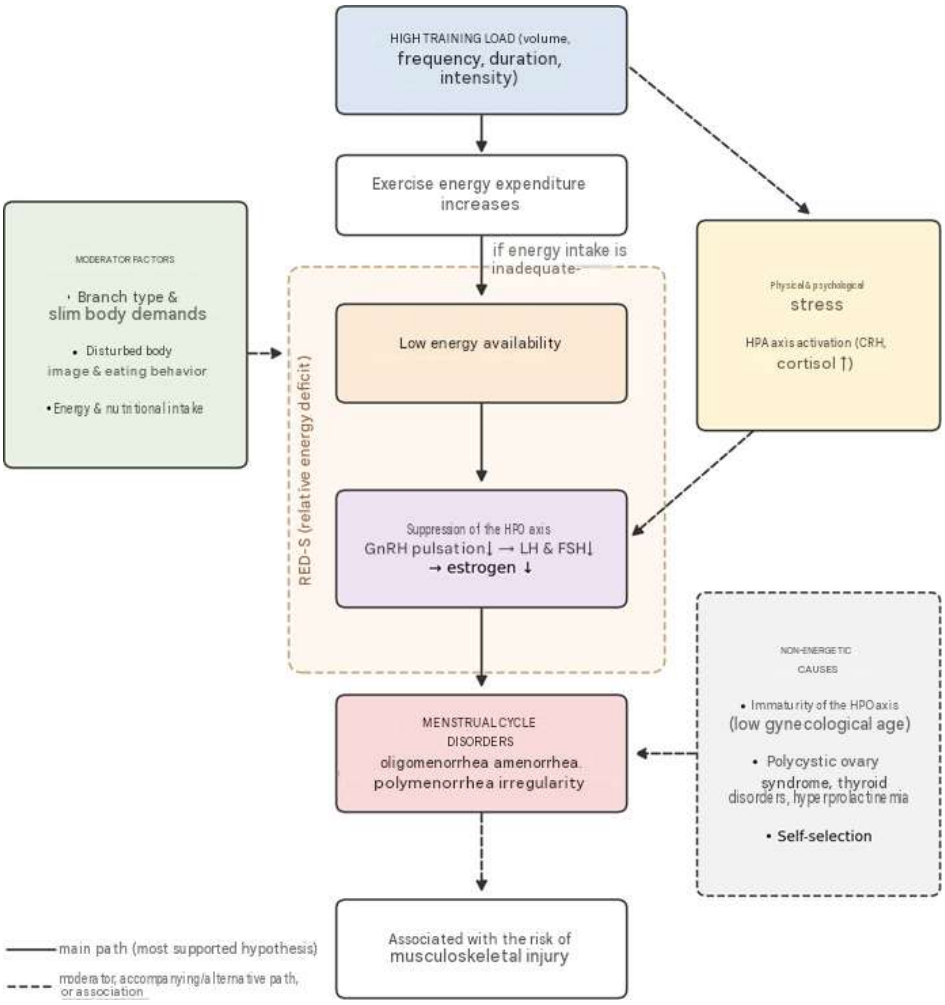



**Figure 2.** Conceptual framework of the association of training load with menstrual cycle disorders in female athletes

*Source: Authors' synthesis of the reviewed literature, 2026.*

Experimental evidence comes from Williams et al. (2015): in untrained women who were given exercise and a controlled diet, the frequency of menstrual disorders (luteal phase defects,

anovulation, and oligomenorrhea) increased with the magnitude of the energy deficit (−8% to −42%), and the disorder was evident at a deficit of about 22–42% or 470–810 kcal/day. The study was not synthesized because the participants were non-athletes. Among the synthesized studies, the LEAF-Q score was higher in athletes with amenorrhea (Heikura et al., 2018; Witkoś et al., 2024), but the LEAF-Q contained questions about menstruation so this relationship partially overlapped. Only Heikura et al. (2018) estimated energy availability, and the values did not differ significantly between amenorrhea athletes and athletes with normal cycles (32 vs 35 kcal/kg of lean free mass/day), as well as their running volume (101 vs 90 km/week); the authors concluded that energy availability was difficult to measure accurately. However, in the same study, athletes with low energy availability ran farther than athletes with moderate energy availability (115 vs 84 km/week), so the training volume remained seemingly related to energy availability. Other indirect evidence was lower BMI in athletes with cycle impairment (21.6 vs 22.7 kg/m²; Ravi et al., 2021) and a negative correlation of BMI with cycle impairment in swimmers (rho=−0.32; Witkoś et al., 2022). In addition, the association in Passoni et al. (2024) remained significant after calorie intake was controlled, but calorie intake was only measured dichotomously (≥ or <2,000 kcal/day). Since self-reported calorie intake did not yet reflect energy availability, these findings did not negate energy pathways, but suggested other pathways may play a role.

Another plausible pathway is physical and psychological stress through activation of the hypothalamic-pituitary-adrenal (HPA) axis; increased cortisol may inhibit GnRH (Calcaterra et al., 2024). Non-energetic causes such as reproductive-axis immaturity, polycystic ovary syndrome, thyroid disorders, and hyperprolactinemia should also be considered (Mountjoy et al., 2023), as should self-selection into particular sports. These mechanisms are biologically plausible, but the present synthesis does not demonstrate mediation: energy availability was directly estimated in only one included study and almost all studies were cross-sectional. Low energy availability/RED-S and stress should therefore be interpreted as plausible explanatory pathways supported mainly by external mechanistic evidence, not as mechanisms proven by the synthesized studies.

**Moderator Factors and Causes of Difference in Results**

Sport-specific patterns should be interpreted cautiously because several categories contained only one study. In the aesthetic category, the only included study (physique athletes; Witkoś et al., 2024) reported a positive association. In endurance sports, a positive association was found in runners (Passoni et al., 2024), but not in elite runners (Heikura et al., 2018) or swimmers (Witkoś et al., 2022). Multi-sport studies were also mixed (Table 3). In Italian athletes, training frequency and duration were not significant, whereas participation in lean sports was associated with menstrual irregularity (AOR 2.02; Amoruso et al., 2024); a similar association was reported in Finnish athletes (OR 1.70; Ravi et al., 2021). In elite German athletes, however, lean-sport participation was not significant after adjustment (OR 1.252; p=0.417; Kirschbaum et al., 2025). These findings suggest that body-composition demands and related eating behavior may be relevant, but the small number of studies and inconsistent estimates do not support firm sport-specific conclusions.

**Table 3.** Summary of findings by sports group

| Branch Group | (a) Significant Positive Associations | (b) No Significant Association | Pattern of Findings |
|---|---|---|---|
| Aesthetics | Witkoś et al. (2024), physics | – | Single study; positive association |
| Endurance | Passoni et al. (2024), running | Heikura et al. (2018), elite medium-long distance running; Witkoś et al. (2022), swimming | Mixed findings (1/3) |
| Martial arts | Fadila & Kumaat (2024), karate | – | Single study; positive association |
| Games | – | Fernanda et al. (2021), badminton | Single small study; no significant association |
| Multi-branch | Abbas et al. (2025); Ravi et al. (2021) | Amoruso et al. (2024); Kirschbaum et al. (2025) | Mixed findings (2/4) |

*Source: Authors' synthesis of the included studies, 2026.*

Remarks: the number of studies per branch group is small so the pattern per branch is indicative. Two studies outside of synthesis in ballroom dancers (Witkoś & Wróbel, 2019) and active women Strava users (Baranauskas et al., 2023) also showed a positive association.

Age and reproductive maturity. In 415 elite German athletes, exercise volume was not significantly associated with cycle disruption (OR 1.029 per hour/week; p=0.126), while gynecological age (length of time since menstruation) was the strongest predictor, with lower odds of cycle disruption at older gynecological age (OR 0.817; Kirschbaum et al., 2025). The apparent power of the model was low (Nagelkerke $R^2$=0.26), and in the decision tree model the exercise volume was only fifth below gynecological age, BMI, and the gender composition of coaches and support teams. Athletes aged 15–24 years were also more likely to experience cycle disruption than athletes aged 25–45 years (35.0% vs 25.9%; Ravi et al., 2021), and athletes with cycle disorders tended to be younger (Heikura et al., 2018; Witkoś et al., 2024). In badminton athletes aged 10–18 years, the authors also note that the cycle is generally only regularized 3–5 years after menarke (Fernanda et al., 2021). This is in line with the role of reproductive axis immaturity in young athletes.

Energy intake, body image, and stress. In badminton athletes, physical activity was not associated with the menstrual cycle, while more adequate carbohydrate intake was associated with a more normal cycle, and excess protein and fat intake was associated with cycle disruption (Fernanda et al., 2021). Only carbohydrate findings were in line with the energy deficit framework. Athletes who rated their bodies heavier than they were in reality had almost four times higher odds of cycle irregularities (AOR 3.83; Amoruso et al., 2024), leading to impaired eating behaviors as a possible intermediate, although dietary status in the study was not significantly associated (AOR 0.76). Stress was associated with cyclical disruption in karate athletes (Fadila & Kumaat, 2024), but not in badminton athletes (Fernanda et al., 2021), so its role has not been consistent.

Sample size and exposure variations. The study without associations was partially small (Fernanda et al., 2021, n=20; Heikura et al., 2018, n=35; Witkoś et al., 2022, n=64) so it may

not be strong enough to detect effects. The variation in exposure in some studies was also narrow: swimmers generally trained about six sessions/week (Witkoś et al., 2022), and only about one-fifth of Italian athletes trained more than two sessions/week with a duration of more than two hours (Amoruso et al., 2024). Larger studies (Amoruso et al., 2024; Kirschbaum et al., 2025) are also insignificant, but the point estimates in Amoruso et al. (AOR 1.53–1.62) and the upper bound of the confidence interval in Kirschbaum et al. (1.068 per hour/week) do not rule out weak to moderate associations. Thus, insignificant results are more appropriately read as "no significant association found", rather than evidence that an association is absent.

Practical Implications

Cycle disruption is related to injury: in swimmers, cycle disruption correlates with the number of injuries (Witkoś et al., 2022), and in Swiss athletes with secondary amenorrhea, injuries are more frequent at the volume of training ≥21 hours/week (70.7% vs 42.5%), while in athletes without secondary amenorrhea there is no difference (39.6% vs 38.8%; Baumgartner et al., 2023). The practical implications for coaches, healthcare workers, and athletes are:

- monitor the menstrual cycle regularly, not only when there are complaints; elite athletes who record their cycles are less likely to experience cycle disruptions (17% vs 33%; Kirschbaum et al., 2025);
- monitor the training load, especially the training volume in the endurance and aesthetic branches, and ensure that the increase in training is balanced by sufficient energy intake;
- pay special attention to young athletes and conduct risk screening of low energy availability, for example with LEAF-Q;
- pay attention to athletes' body image and stress, as well as engage doctors, nutritionists, and sports psychologists to rule out other causes.

**Limitations and Further Research**

This review includes studies with both statistically significant and non-significant findings, reports reasons for excluding closely related studies, compares findings by sport, and integrates international and Indonesian literature. Important limitations remain. Only 10 studies met the criteria; selection and extraction were performed by a single reviewer, no protocol was preregistered, and a formal quality or risk-of-bias assessment was not conducted. Fifteen of 31 candidate records came from manual reference searching or update searches, and the number excluded at title/abstract screening was not recorded. Evidence quality was heterogeneous: four of the five statistically significant associations were based on unadjusted bivariate analyses, several studies had small samples, exposure definitions varied, and hormonal contraceptive use was not handled consistently. Nearly all studies were cross-sectional and relied on self-report. Energy availability was estimated in only one study, training intensity was rarely assessed separately, and the number of studies within each sport group was small. Future studies should use prospective designs, objective training-load measures including intensity, direct assessment of energy availability, and appropriate control for gynecological age, hormonal contraception, and other confounders, with broader representation of Indonesian athletes and sports.

## CONCLUSION

Among the 10 synthesized studies, five reported a positive association between higher training load and menstrual cycle disorders, particularly for training volume, but four of these findings came from unadjusted bivariate analyses. The remaining five studies found no statistically significant association, and results differed across populations and sports. The evidence therefore supports a possible association rather than a causal conclusion. Low energy availability/RED-S is a plausible explanatory pathway supported mainly by external mechanistic literature; within the synthesis, energy availability was directly estimated in only one small study. Gynecological age, body image, energy intake, and sport-related body-composition demands may also influence the observed associations. Regular monitoring of menstrual cycles, training load, and energy intake is recommended as an early-detection strategy while stronger prospective evidence is developed.

## FUNDING

The research and preparation of this article was carried out independently without funding support from external parties.

## CONFLICT OF INTEREST

The author states that there are no conflicts of interest, whether personal, commercial, or financial, that can affect the implementation and results of this study.

## AUTHOR'S CONTRIBUTION

Afriza Kia Dela and Nur Ilahi Anjani contributed to research design, data collection and processing, system development, result analysis, and article manuscript preparation.

## GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

In the process of compiling this article, the author uses generative artificial intelligence (AI) as a tool in language refinement, writing structure, and grammar improvement. The use of AI is carried out on a limited basis and remains under the supervision of the author. All data, analysis, interpretation, and scientific substance in this article have been checked and verified by the author. The author is solely responsible for the accuracy, authenticity, and final content of the manuscript.

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