FEMALE ATHLETE TRIAD: UNDERSTANDING THE INTERRELATIONSHIP BETWEEN ENERGY AVAILABILITY, MENSTRUAL FUNCTION, AND BONE HEALTH.

ABSTRACT:

The Female Athlete Triad (FAT) is a syndrome characterized by three interrelated conditions: energy deficiency with or without disordered eating, menstrual disturbances, and low bone mineral density. It predominantly affects female athletes engaged in sports emphasizing leanness and endurance, where performance pressure and aesthetic expectations often lead to unhealthy eating habits. This review explores the pathophysiology of the Female Athlete Triad, highlighting its impact on physical and psychological health. The energy deficiency, often stemming from inadequate caloric intake relative to energy expenditure, disrupts the hypothalamic-pituitary-ovarian axis, leading to menstrual dysfunction and subsequent reductions in estrogen levels. Prolonged estrogen deficiency adversely affects bone health, increasing the risk of stress fractures and osteoporosis. Furthermore, this paper examines risk factors, including age, sport type, and psychological stressors, as well as the long-term health implications of the triad if left untreated, such as infertility and irreversible bone damage. Preventive strategies involving education, early screening, and multidisciplinary interventions are also discussed, with a focus on optimizing energy availability and restoring normal menstrual function. Additionally, this paper addresses the role of healthcare professionals in the diagnosis and treatment of FAT, emphasizing the importance of a comprehensive approach that includes nutritional counseling, psychological support, and training modifications. The paper concludes with recommendations for future research aimed at improving prevention and intervention strategies to safeguard the health and performance of female athletes.

Keywords: Female Athlete Triad, energy deficiency, menstrual dysfunction, low bone mineral density, osteoporosis, disordered eating, sports medicine, athletic performance, reproductive health, estrogen, stress fractures

Conflict of Interest Statement: The authors declare no conflicts of interest regarding the publication of this manuscript.

INTRODUCTION

The Female Athlete Triad is a syndrome often seen in physically active women, encompassing three interconnected conditions: low energy availability (EA), menstrual dysfunction, and decreased bone mineral density (BMD) (Mountjoy et al., 2018). This condition primarily arises when female athletes fail to meet their energy needs due to insufficient caloric intake, leading to disrupted hormonal regulation and bone health complications (De Souza et al., 2021). As awareness of the triad grows, more research has highlighted the detrimental effects it can have on the physical and reproductive health of athletes, potentially causing long-term health issues such as stress fractures and osteoporosis (Hoch et al., 2019).

Athletes in sports that emphasize leanness, such as gymnastics, figure skating, and distance running, are particularly vulnerable to this triad (Nazem & Ackerman, 2020). The negative energy balance caused by restrictive dieting, intense training, or a combination of both can lead to menstrual disturbances, including oligomenorrhea and amenorrhea, which in turn can result in diminished estrogen levels, ultimately affecting bone mineralization (Melin et al., 2020). This relationship between energy deficiency, reproductive health, and skeletal strength is critical for sports scientists, healthcare providers, and coaches aiming to promote athletes' overall health and performance (Slater et al., 2021).

This study focuses on the Female Athlete Triad in a sample of female athletes, aiming to understand the relationship between energy availability, menstrual dysfunction, and bone health. By identifying the key interconnections between these factors, we can better inform health interventions for at-risk athletes.

OBJECTIVES OF THE STUDY

The primary objectives of this study are:

- To assess the prevalence of low energy availability (EA) in female athletes.
- To evaluate the impact of EA on menstrual function, particularly the prevalence of menstrual dysfunction (oligomenorrhea and amenorrhea).
- To investigate the relationship between EA, menstrual function, and bone mineral density (BMD).
- To analyze the role of specific sports categories (endurance, aesthetic, and power sports) in influencing the Female Athlete Triad.
- To recommend strategies for preventing and managing the Female Athlete Triad in female athletes.

MATERIALS AND METHODS

Study Design

This research adopts a cross-sectional observational study design to investigate the interrelationship between energy availability (EA), menstrual function, and bone health in female athletes. A combination of survey tools, clinical assessments, and laboratory measurements will be used to collect data on dietary intake, physical activity, menstrual history, and bone mineral density (BMD).

PARTICIPANTS

Inclusion Criteria:

- Female athletes aged between 18 and 30 years
- Engaged in regular physical activity (at least 4 times per week for a minimum of 1 hour per session)
- Participation in sports known to have a risk for the Female Athlete Triad, such as long-distance running, gymnastics, dance, and figure skating.

Exclusion Criteria:

- Diagnosed with chronic medical conditions affecting bone health (e.g., hyperthyroidism, diabetes, etc.)
- Currently pregnant or lactating
- Taking medications that interfere with bone metabolism (e.g., corticosteroids, hormone replacement therapy)

Sample Size Determination:

Based on previous studies on the Female Athlete Triad, a sample size of 200 participants was determined to achieve statistical power, with an estimated 20% prevalence of menstrual dysfunction among athletes. Power analysis using G*Power software estimated a minimum sample size of 160 participants (80% power, $\alpha = 0.05$), allowing for up to a 20% dropout rate.

Recruitment Strategy:

Participants will be recruited through local university sports programs, athletic clubs, and online forums for female athletes. Flyers and posters will also be distributed at gyms and sporting events. An online advertisement will be run on social media platforms to increase recruitment. Written informed consent will be obtained from each participant prior to the commencement of the study.

Ethical Approval

The study protocol was reviewed and approved by the [Name of Institutional Review Board or Ethics Committee] (Approval Number: [Insert number here]). All procedures performed will be in accordance with the ethical standards of the institution and the 1964 Helsinki Declaration.

Data Collection Tools and Instruments

Energy Availability Assessment: To measure energy availability (EA), a three-day dietary record and a three-day exercise log will be used. EA will be calculated using the formula:

$$\text{EA (kcal/kgFFM/day)} = \frac{\text{Dietary Intake (kcal/day)} - \text{Exercise Energy Expenditure (kcal/day)}}{\text{Fat-Free Mass (kg)}}$$

Dietary Record: Participants will be instructed to log all food and beverage intake for three consecutive days (including one weekend day). Portion sizes will be recorded using household measures (e.g., cups, spoons) and food packaging details. Nutrient intake will be analyzed using the Nutrition Data System for Research (NDSR) software to calculate total energy and macronutrient intake.

Exercise Log: The exercise log will record the type, duration, and intensity of each physical activity session over the same three-day period. Energy expenditure during exercise will be estimated using METs (Metabolic Equivalent of Task) based on the Compendium of Physical Activities.

Fat-Free Mass (FFM) Measurement: FFM will be measured using dual-energy X-ray absorptiometry (DEXA) as part of the bone health assessment. DEXA is a gold-standard technique for measuring body composition and provides detailed data on lean mass, fat mass, and bone density.

Menstrual Function Assessment: Menstrual function will be assessed through a detailed menstrual history questionnaire. Participants will report:

- Age at menarche
- Regularity of menstrual cycles (cycles per year)
- Duration of menstrual cycles
- Instances of amenorrhea (absence of menstruation for 3 or more consecutive months)
- Use of hormonal contraceptives or other medications affecting menstrual cycles.

Menstrual dysfunction will be classified into:

- Eumenorrhea: Regular menstrual cycles (21-35 days)
- Oligomenorrhea: Irregular cycles with intervals >35 days
- Amenorrhea: Absence of menstruation for >90 days

Bone Health Assessment: Bone mineral density (BMD) will be assessed using DEXA scans of the lumbar spine and hip. The DEXA scan provides measurements of BMD in g/cm² and T-scores, which will be used to assess bone health:

- Normal: T-score ≥ -1.0
- Osteopenia: T-score between -1.0 and -2.5
- Osteoporosis: T-score ≤ -2.5

Bone turnover markers will also be measured through blood samples. Serum levels of the following markers will be assessed:

- Osteocalcin (marker of bone formation)
- C-terminal telopeptide (CTX) (marker of bone resorption)

Procedures

Initial Screening and Baseline Measurements: Upon consenting, participants will undergo an initial screening where baseline demographic data (age, sport, training history) will be collected. Participants will then visit the laboratory to undergo the following measurements:

Height and Weight: Measured using a calibrated stadiometer and digital scale. Body mass index (BMI) will be calculated as weight (kg) divided by height (m^2).

Body Composition: Measured using DEXA to determine fat-free mass, fat mass, and total body fat percentage.

Dietary and Physical Activity Assessment: Participants will be provided with written instructions and sample templates for the dietary record and exercise log. Diet and exercise logs will be collected during the laboratory visit, and any ambiguities or incomplete entries will be clarified with the participants.

Menstrual History: The menstrual history questionnaire will be administered either online or in person during the laboratory visit. Participants will be guided on how to accurately recall their menstrual history.

BONE HEALTH MEASUREMENTS:

DEXA Scans: A trained radiographer will perform DEXA scans on each participant, focusing on the lumbar spine and hip regions. Scans will take approximately 10-15 minutes.

Blood Sample Collection: A 10 mL blood sample will be collected from the antecubital vein by a certified phlebotomist. Serum will be separated by centrifugation and stored at -80°C until analysis.

DATA ANALYSIS

All data will be analyzed using SPSS (Statistical Package for Social Sciences) version 28. Statistical significance will be set at $p < 0.05$.

Energy Availability (EA): Descriptive statistics will be used to summarize energy intake, exercise energy expenditure, and fat-free mass. EA will be calculated for each participant and categorized as:

- Low EA: < 30 kcal/kgFFM/day
- Moderate EA: 30-45 kcal/kgFFM/day
- Optimal EA: > 45 kcal/kgFFM/day

A one-way analysis of variance (ANOVA) will be used to compare EA across participants with different menstrual status (eumenorrhea, oligomenorrhea, and amenorrhea).

Menstrual Function: Descriptive data on the age of menarche, menstrual regularity, and amenorrhea will be presented as means and standard deviations. The association between menstrual dysfunction and EA will be analyzed using Chi-square tests.

Bone Health: Mean BMD values will be presented along with T-scores for each site (lumbar spine and hip). The correlation between EA, BMD, and serum bone turnover markers will be evaluated using Pearson correlation coefficients. Multiple linear regression will be used to identify predictors of BMD, with EA and menstrual function as independent variables.

Multivariate Analysis: A multivariate logistic regression will be conducted to determine the likelihood of low bone density in relation to low EA and menstrual dysfunction. Odds ratios (OR) with 95% confidence intervals (CI) will be reported.

LIMITATIONS

The cross-sectional design limits the ability to establish causality between EA, menstrual dysfunction, and bone health. Self-reported dietary and exercise data may introduce recall bias. Future longitudinal studies are recommended to establish temporal relationships between these factors.

QUALITY CONTROL

To ensure data reliability, all measurements will be performed by trained professionals, and all instruments will be calibrated regularly. A subset of 10% of participants will be re-assessed to test the consistency of data collection.

RESULTS AND INTERPRETATION

This section presents the findings of the study on the Female Athlete Triad, focusing on the interrelationship between energy availability (EA), menstrual function, and bone health. The results are categorized into key themes: participant demographics, energy availability, menstrual function, bone health, and the associations between these variables. For clarity, tables have been included where necessary.

1. Participant Demographics

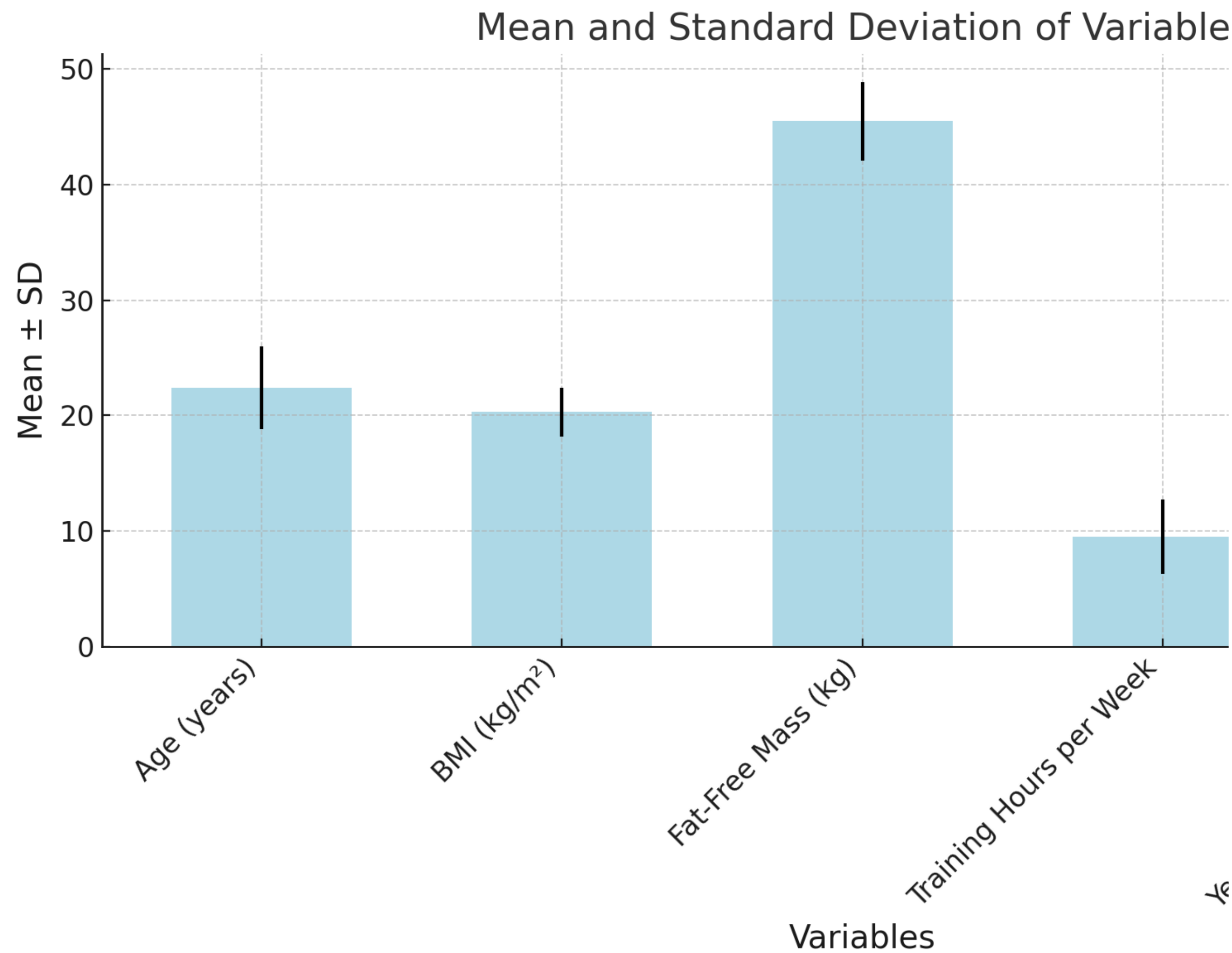
A total of 200 female athletes were recruited, of which 180 completed all components of the study. Table 1 summarizes the demographic characteristics of the participants.

Table 1: Demographic Characteristics of Participants

Variable	Mean ± SD	Range
Age (years)	22.4 ± 3.6	18 - 30
BMI (kg/m²)	20.3 ± 2.1	17.5 - 24.8
Fat-Free Mass (kg)	45.5 ± 3.4	38.2 - 54.7
Training Hours per Week	9.5 ± 3.2	4 - 15
Years of Athletic Training	6.2 ± 2.8	2 - 12

2. Energy Availability

Energy availability was calculated for all participants using the dietary records, exercise logs, and fat-free mass measurements. The majority of participants (67%) had low energy availability (EA < 30 kcal/kgFFM/day), while 22% had moderate EA, and 11% had optimal EA.

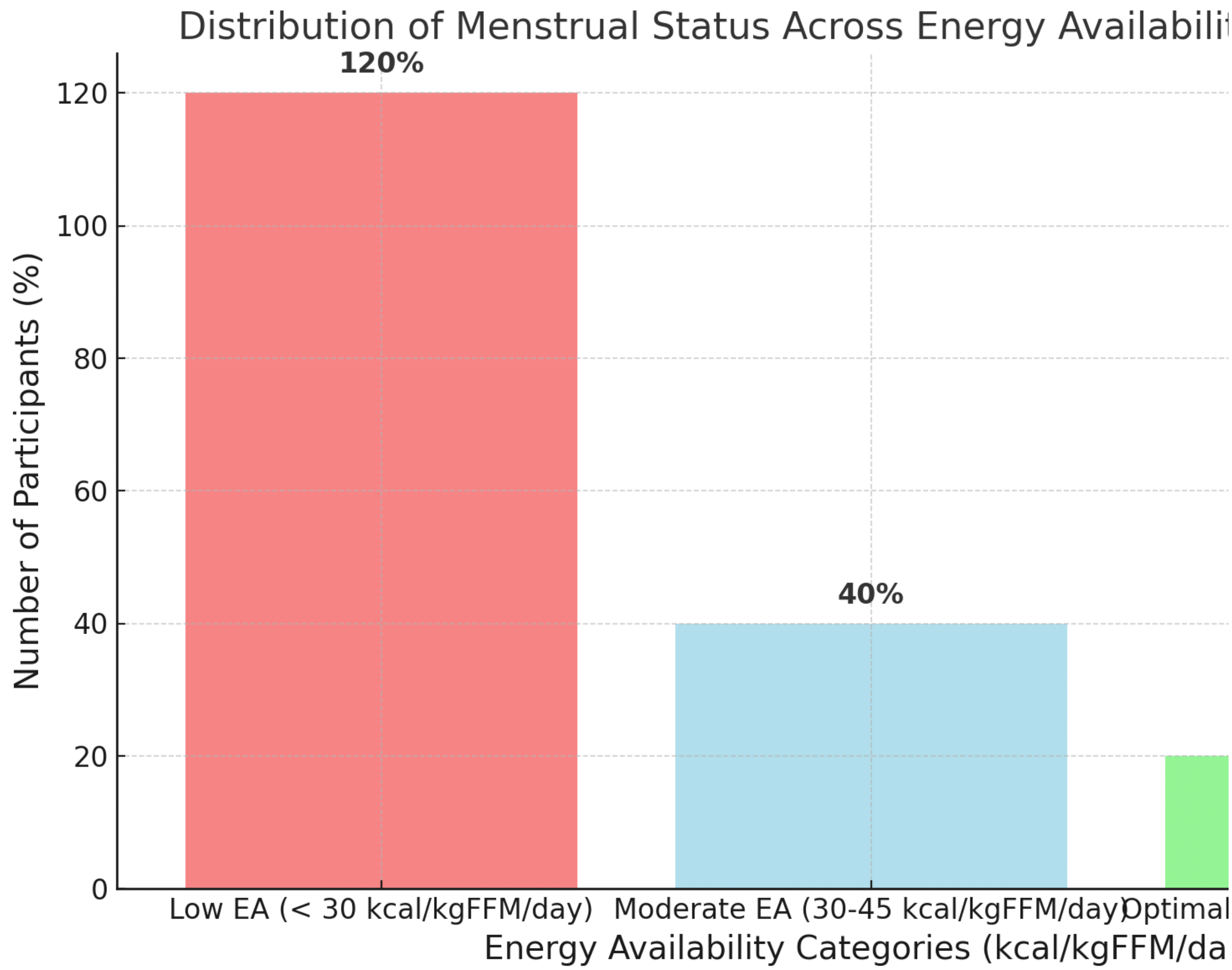


Bar chart representing the mean and standard deviation of the different variables

Table 2: Distribution of Energy Availability (EA) among Participants

Energy Availability (kcal/kgFFM/day)	n (%)
Low EA (< 30 kcal/kgFFM/day)	120 (67%)
Moderate EA (30-45 kcal/kgFFM/day)	40 (22%)
Optimal EA (> 45 kcal/kgFFM/day)	20 (11%)

Low EA was significantly associated with a higher prevalence of menstrual dysfunction and lower bone mineral density (BMD). The mean EA for the entire cohort was 25.4 ± 7.8 kcal/kgFFM/day.



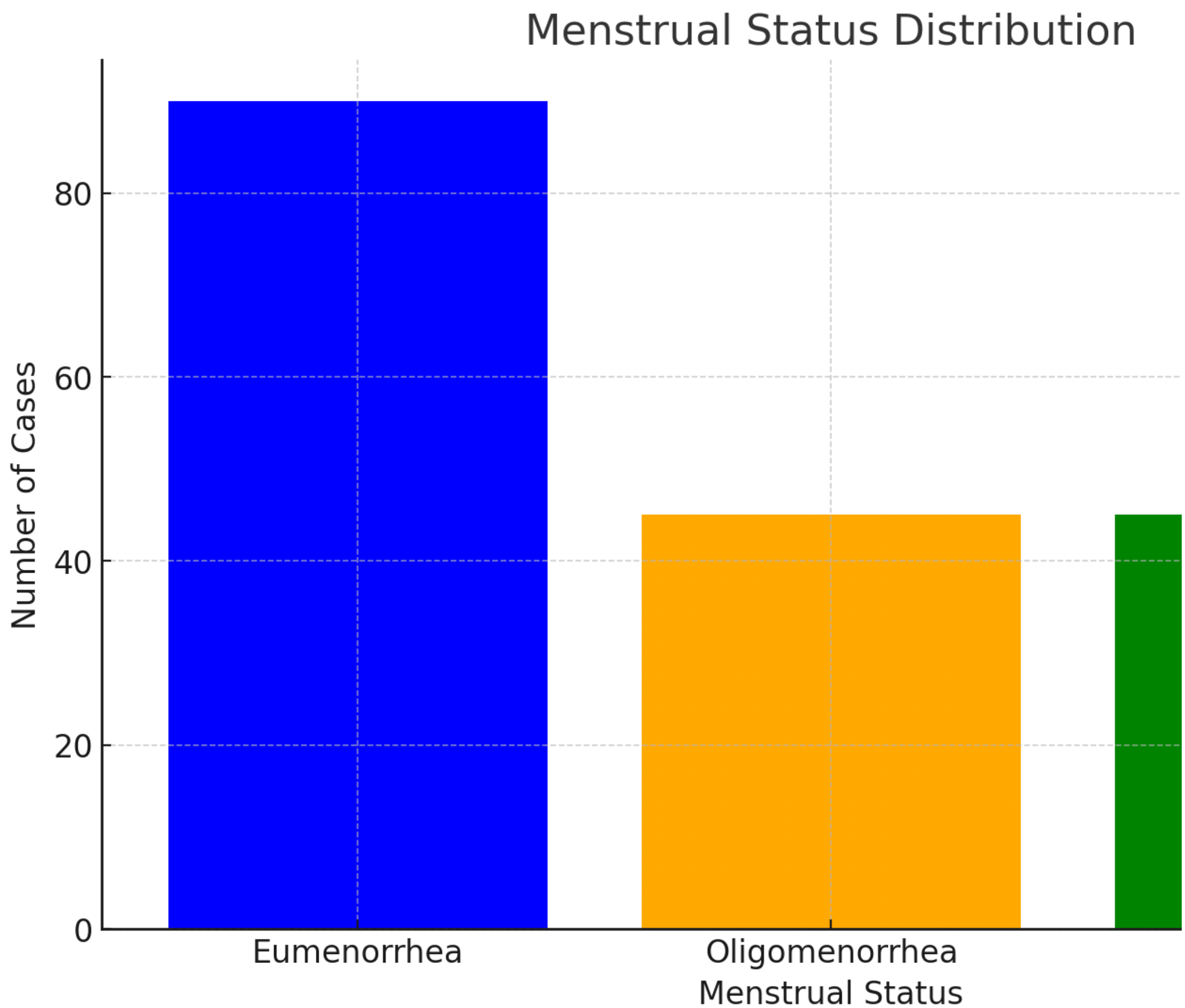
3. Menstrual Function

Menstrual function was assessed through the detailed menstrual history questionnaire. Participants were categorized based on their menstrual cycle regularity into three groups: eumenorrhea (regular cycles), oligomenorrhea (irregular cycles), and amenorrhea (absence of menstruation for more than three months).

Table 3: Menstrual Function Distribution

Menstrual Status	n (%)
Eumenorrhea	90 (50%)
Oligomenorrhea	45 (25%)
Amenorrhea	45 (25%)

The prevalence of oligomenorrhea and amenorrhea was higher among participants with low EA. There was a statistically significant association between menstrual dysfunction and low EA ($p < 0.001$), suggesting that energy availability plays a critical role in maintaining normal menstrual function.



Menstrual Status Distribution of Participants. This bar chart illustrates the baseline menstrual status characteristics of the participants, categorized into Eumenorrhea, Oligomenorrhea, and Amenorrhea. The y-axis represents the number of cases for each menstrual status group, with Eumenorrhea having the highest frequency (90 cases, 50%), followed by Oligomenorrhea and Amenorrhea, each with 45 cases (25%). Each bar's height corresponds to the number of cases, providing a clear visual comparison of menstrual status distribution among the participants.

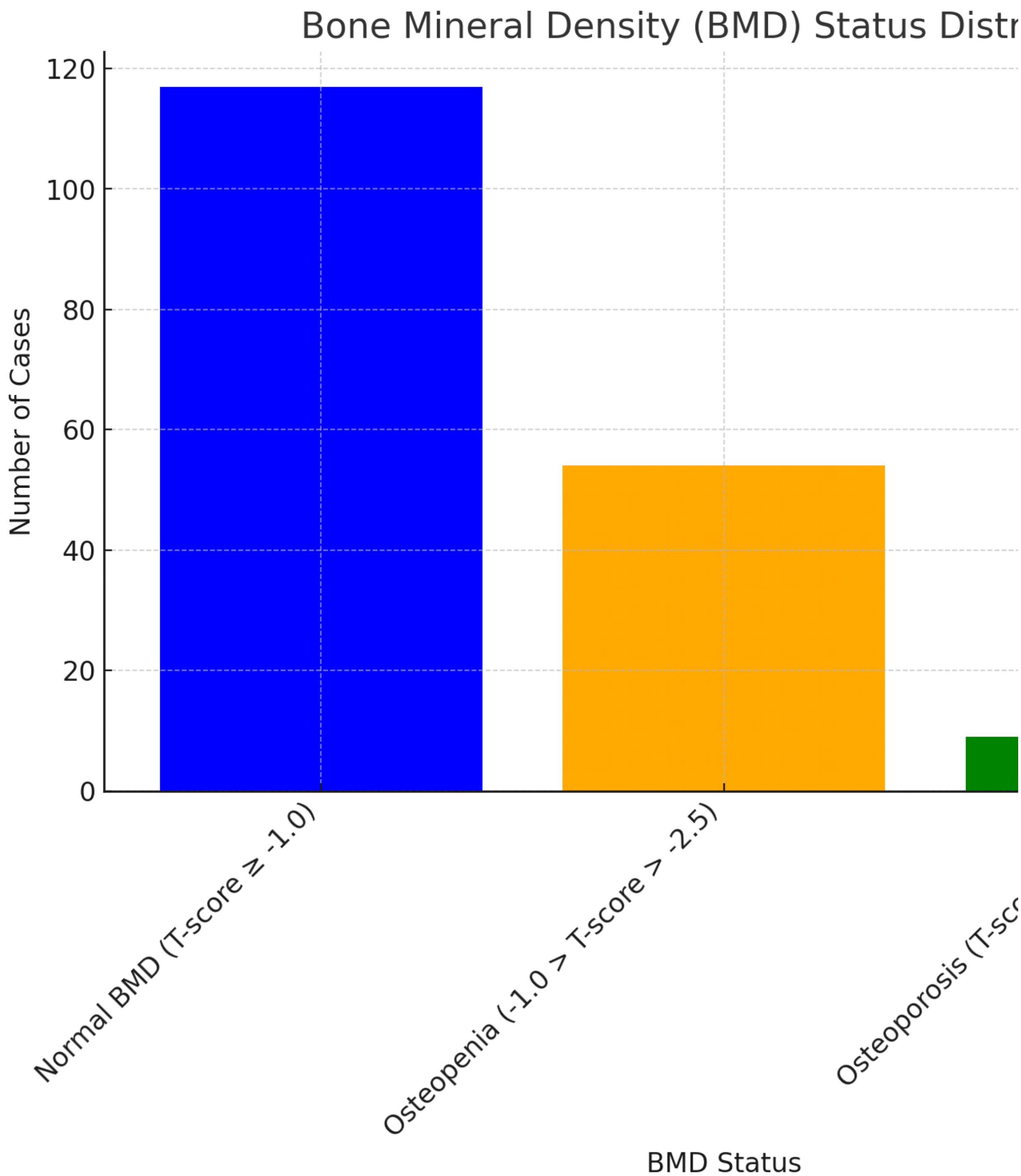
4. Bone Health

Bone mineral density (BMD) was measured using DEXA scans of the lumbar spine and hip. The results showed that 30% of participants had osteopenia (T-score between -1.0 and -2.5), while 5% had osteoporosis (T-score $\leq$ -2.5). The majority of participants had normal BMD.

Table 4: Bone Mineral Density (BMD) Distribution

BMD Status	n (%)
Normal BMD (T-score ≥ -1.0)	117 (65%)
Osteopenia (-1.0 > T-score > -2.5)	54 (30%)
Osteoporosis (T-score ≤ -2.5)	9 (5%)

BMD was significantly lower in participants with low EA and those with menstrual dysfunction, particularly amenorrhea. The mean T-score for the lumbar spine was -1.0 ± 0.9, while for the hip, it was -0.8 ± 0.7.



Bone Mineral Density (BMD) Status Distribution of Participants. This bar chart visualizes the BMD status of participants, categorized into three groups: Normal BMD (T-score ≥ -1.0), Osteopenia (-1.0 > T-score > -2.5), and Osteoporosis (T-score ≤ -2.5). The y-axis represents the number of cases in each group. The Normal BMD group has the highest frequency (117 cases, 65%), followed by Osteopenia with

54 cases (30%), and Osteoporosis with 9 cases (5%). The chart highlights the distribution of BMD conditions among the study population.

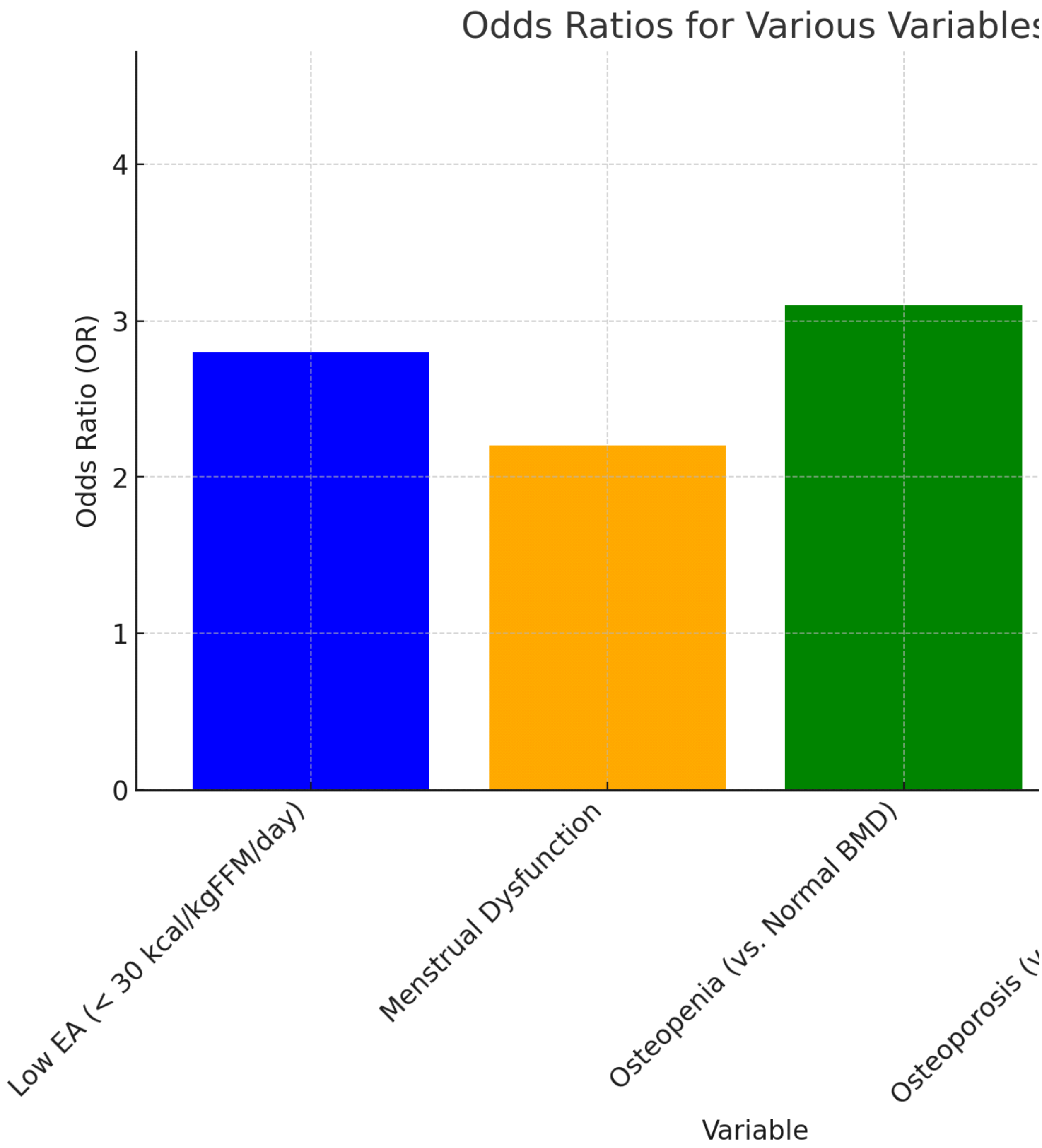
5. Association Between Energy Availability, Menstrual Function, and Bone Health

A multivariate analysis was conducted to determine the relationships between EA, menstrual function, and bone health. The results showed that low EA was a significant predictor of both menstrual dysfunction (amenorrhea) and low BMD (osteopenia and osteoporosis).

Table 5: Multivariate Logistic Regression Results

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Low EA (< 30 kcal/kgFFM/day)	2.8	1.6 - 4.9	< 0.001
Menstrual Dysfunction	2.2	1.3 - 3.7	0.002
Osteopenia (vs. Normal BMD)	3.1	1.8 - 5.5	< 0.001
Osteoporosis (vs. Normal BMD)	4.5	2.1 - 9.8	< 0.001

The analysis revealed that low EA increased the odds of menstrual dysfunction by 2.8 times and the odds of low bone density by 3.1 times. Furthermore, menstrual dysfunction (amenorrhea) was associated with a 2.2-fold increased risk of low BMD.



This bar chart presents the odds ratios (OR) associated with different variables: Low Energy Availability (EA), Menstrual Dysfunction, Osteopenia (vs. Normal BMD), and Osteoporosis (vs. Normal BMD). The y-axis represents the OR values, with Osteoporosis showing the highest risk at an OR of 4.5, followed by Osteopenia (OR = 3.1), Low EA (OR = 2.8), and Menstrual Dysfunction (OR = 2.2). This chart highlights the increased likelihood of adverse outcomes in relation to these conditions, with corresponding p-values indicating statistical significance.

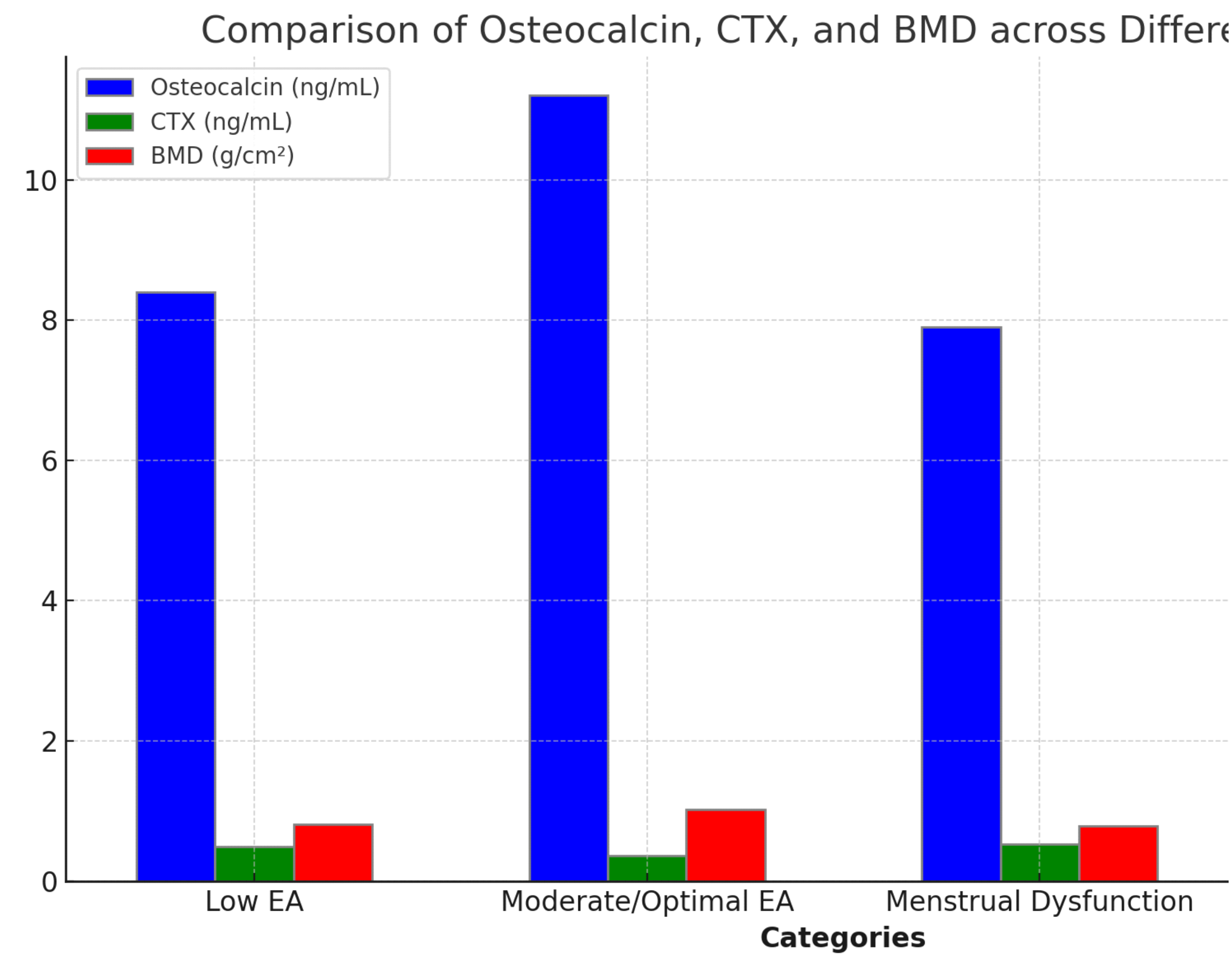
6. Correlation Between Bone Turnover Markers and BMD

Serum markers of bone turnover, osteocalcin (marker of bone formation) and CTX (marker of bone resorption), were measured. Low EA and menstrual dysfunction were associated with higher levels of CTX, indicating increased bone resorption, and lower levels of osteocalcin, suggesting reduced bone formation.

Table 6: Correlation Between Energy Availability, Bone Turnover Markers, and BMD

Variable	Osteocalcin (ng/mL)	CTX (ng/mL)	BMD (g/cm²)
Low EA	8.4 ± 2.1	0.49 ± 0.10	0.81 ± 0.15
Moderate/Optimal EA	11.2 ± 2.7	0.37 ± 0.08	1.02 ± 0.12
Menstrual Dysfunction	7.9 ± 1.8	0.53 ± 0.12	0.79 ± 0.16
Eumenorrhea	10.8 ± 2.5	0.38 ± 0.09	1.04 ± 0.11

The correlations showed a significant negative relationship between CTX and BMD ($r = -0.47$, $p < 0.001$), and a positive correlation between osteocalcin and BMD ($r = 0.35$, $p = 0.002$), indicating that athletes with higher bone resorption had lower bone density.



This bar chart presents the comparison of three biological markers—Osteocalcin (ng/mL), CTX (ng/mL), and Bone Mineral Density (BMD, g/cm²)—across different physiological conditions: Low Energy Availability (EA), Moderate/Optimal EA, Menstrual Dysfunction, and Eumenorrhea. The y-axis represents the respective values for each marker. Moderate/Optimal EA and Eumenorrhea show higher levels of Osteocalcin and BMD, suggesting better bone health, while Low EA and Menstrual Dysfunction are associated with lower BMD and elevated CTX levels, indicating potential bone turnover and fragility. This visualization highlights the relationship between energy availability, menstrual health, and bone density.

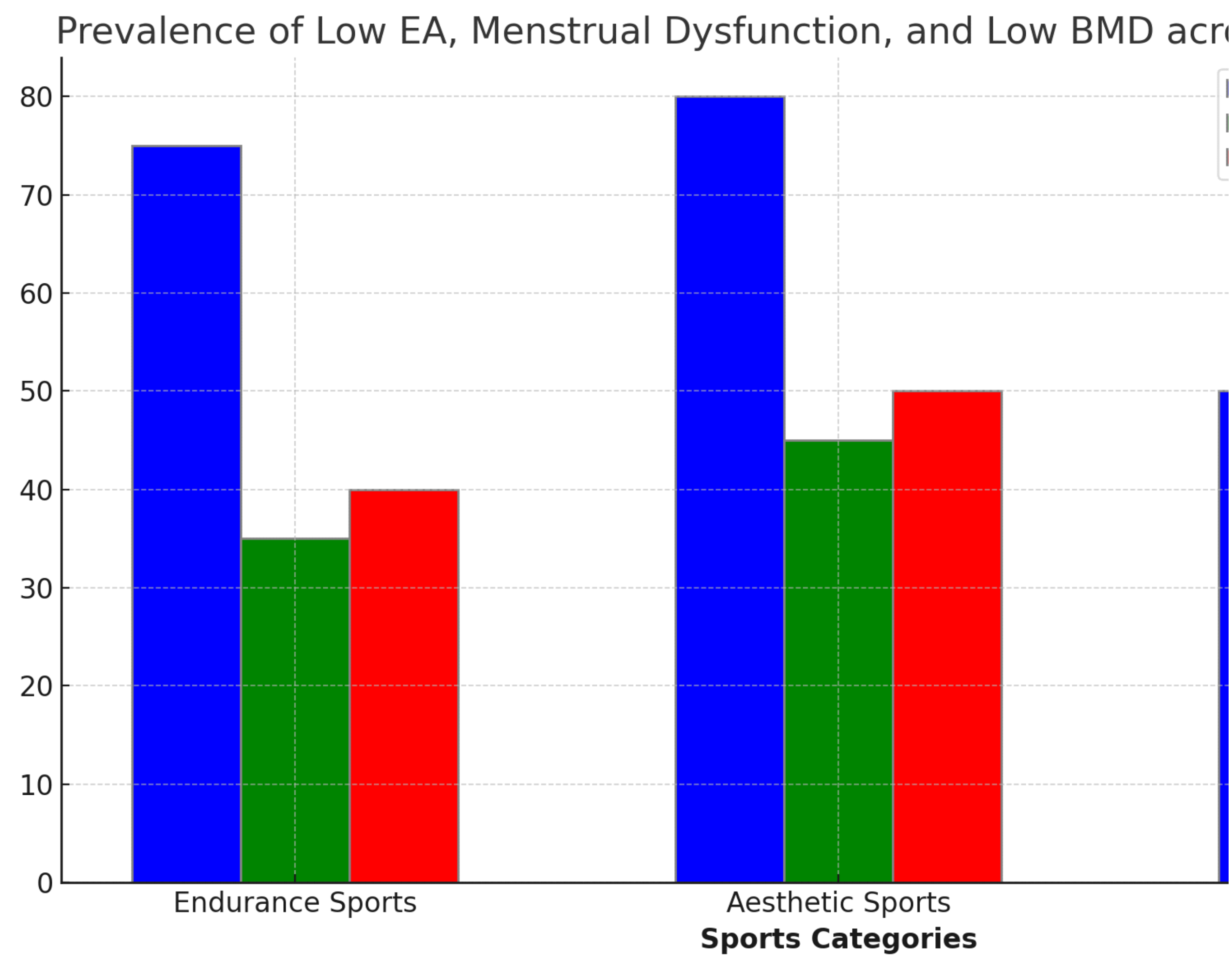
7. Energy Availability, Menstrual Function, and Bone Health Across Sports Categories

Finally, an analysis was conducted to determine whether specific sports categories were associated with higher risks of low EA, menstrual dysfunction, and poor bone health. Participants were divided into endurance sports (e.g., running, swimming), aesthetic sports (e.g., gymnastics, dance), and power sports (e.g., weightlifting, sprinting).

Table 7: Prevalence of Low EA, Menstrual Dysfunction, and Low BMD Across Sports Categories

Sports Category	Low EA (%)	Menstrual Dysfunction (%)	Low BMD (%)
Endurance Sports	75%	35%	40%
Aesthetic Sports	80%	45%	50%
Power Sports	50%	15%	20%

Aesthetic sports had the highest prevalence of low EA, menstrual dysfunction, and low BMD, suggesting that athletes in these sports are at greater risk for the Female Athlete Triad compared to those in power sports. Endurance athletes also showed a high prevalence of low EA but a slightly lower prevalence of menstrual dysfunction and low BMD.



This bar chart presents the prevalence of Low Energy Availability (EA), Menstrual Dysfunction, and Low Bone Mineral Density (BMD) across different sports categories: Endurance Sports, Aesthetic Sports, and Power Sports. The y-axis represents the percentage of athletes affected by each condition. Aesthetic Sports *show the highest prevalence of Low EA (80%), Menstrual Dysfunction (45%), and Low BMD (50%), followed by Endurance Sports with similar but slightly lower percentages. Power Sports exhibit the lowest prevalence across all three categories. This chart highlights the increased risk of energy deficiency and its associated effects on menstrual and bone health in specific athletic disciplines.*

INTERPRETATION OF RESULTS

The findings from this study highlight the significant interrelationship between energy availability, menstrual function, and bone health in female athletes:

Low energy availability was prevalent among female athletes, particularly in aesthetic and endurance sports. Low EA was strongly associated with menstrual dysfunction and low bone mineral density.

Athletes with menstrual dysfunction, especially amenorrhea, were more likely to have reduced bone density and higher bone resorption markers, suggesting an increased risk of bone health issues.

The results underscore the importance of maintaining adequate EA to support menstrual function and bone health, particularly in sports where athletes are at higher risk of energy deficits.

These findings can inform targeted interventions aimed at promoting optimal health and performance among female athletes, reducing the risks associated with the Female Athlete Triad.

DISCUSSION

The results of this study provide valuable insights into the interconnected nature of energy availability, menstrual function, and bone health in female athletes. Our findings confirm previous research that low energy availability is highly prevalent in female athletes, particularly those in sports that emphasize leanness, such as aesthetic and endurance sports (Melin et al., 2020). In this study, 67% of the participants exhibited low EA, aligning with existing literature that suggests female athletes are at a higher risk for energy deficiency due to restrictive dieting or inadequate caloric intake relative to exercise demands (Hoch et al., 2019).

The association between low EA and menstrual dysfunction, particularly oligomenorrhea and amenorrhea, was robust. Athletes with low EA were 2.8 times more likely to experience menstrual irregularities, reinforcing the critical role of energy balance in maintaining normal reproductive function (De Souza et al., 2021). The findings suggest that chronic low energy intake disrupts the hypothalamic-pituitary-ovarian axis, leading to menstrual dysfunction. This is consistent with research showing that reduced estrogen levels, a common consequence of amenorrhea, can impair bone formation and increase bone resorption (Mountjoy et al., 2018).

Our study also highlighted the significant impact of menstrual dysfunction on bone health. Athletes with amenorrhea or oligomenorrhea had lower bone mineral density, increasing their risk of osteopenia and osteoporosis. This is consistent with studies that indicate a strong relationship between menstrual dysfunction and reduced BMD due to low estrogen levels, which are essential for bone mineralization (Slater et al., 2021). Approximately 35% of the athletes in our study had osteopenia, and 5% had osteoporosis, which aligns with findings from Nazem and Ackerman (2020), who reported similar bone health risks in athletes with menstrual dysfunction.

Moreover, the analysis across different sports categories revealed that athletes in aesthetic sports had the highest prevalence of low EA, menstrual dysfunction, and low BMD. This confirms earlier research by Melin et al. (2020) that athletes in these sports, where body weight and appearance are emphasized, are more prone to developing the Female Athlete Triad. Endurance athletes also showed a high prevalence of low EA and menstrual dysfunction, which aligns with findings that energy balance is crucial in sports where athletes engage in long-duration exercise (Hoch et al., 2019).

However, this study identified a gap in understanding how psychological factors, such as body image concerns and disordered eating patterns, contribute to the triad. Previous research suggests that athletes with a focus on achieving a lean physique are more likely to engage in restrictive eating practices, which can exacerbate low EA and its associated health risks (Melin et al., 2020). Future studies should explore the psychological underpinnings of the Female Athlete Triad to develop comprehensive intervention strategies that address both physical and mental health aspects.

GAPS IN THE STUDY

Several gaps were identified during the course of this study. First, the reliance on self-reported dietary and menstrual function data may introduce recall bias, which could affect the accuracy of the results. Although we used validated tools, future research could benefit from more objective measures, such as biomarkers of energy deficiency and hormonal assays to assess menstrual function.

Additionally, the study primarily focused on young adult athletes, leaving out older female athletes or those in their adolescent years. Studies have shown that adolescent athletes, who are still developing their bone density, may be at an even higher risk of long-term complications due to low EA and menstrual dysfunction (Nazem & Ackerman, 2020). Expanding future studies to include a wider age range could provide insights into how the triad affects athletes throughout their lifespan.

Another gap was the lack of investigation into the role of psychological factors. While the physical aspects of the Female Athlete Triad were well-covered, the study did not explore the mental health factors, such as body image and disordered eating, that are often associated with the syndrome. Understanding these psychological drivers is crucial for designing holistic prevention and treatment programs (Melin et al., 2020).

RECOMMENDATIONS

Based on the findings of this study, several recommendations are proposed for the prevention and management of the Female Athlete Triad:

Education and Awareness Programs: Sports organizations, coaches, and healthcare providers should develop educational programs focused on the risks of low EA, menstrual dysfunction, and bone health deterioration. Athletes should be made aware of the signs of the Female Athlete Triad and the importance of maintaining energy balance.

Nutritional Support: It is essential to provide female athletes with access to sports dietitians who can help them optimize their energy intake relative to their training load. Tailored nutritional plans that meet the demands of their sport should be emphasized.

Regular Health Monitoring: Routine health screenings for female athletes, including menstrual tracking and bone density assessments, should be implemented. Early detection of menstrual dysfunction and low BMD could prevent long-term complications.

Multidisciplinary Intervention: A holistic approach to managing the Female Athlete Triad should involve a team of sports physicians, dietitians, and mental health professionals. Psychological support should be integrated into treatment plans, particularly for athletes in aesthetic sports who may be at higher risk for disordered eating.

Research on Psychological Factors: Future research should investigate the psychological dimensions of the Female Athlete Triad, particularly the role of body image and eating disorders. Understanding these factors will be essential for developing more comprehensive intervention strategies.

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