Original Research Articles

The Impact of Menstrual Cycle on Women's Athletic Performance: A Study on National Athletes of North Sumatra: A Study on Challenges and Opportunities

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ABSTRACT

Objectives: This research aims to investigate the relationship between menstrual cycle phases and athletic performance among elite female athletes from North Sumatra, Indonesia. The study specifically examines variations in strength, endurance, power, and technical skill execution across different phases of the menstrual cycle and identifies potential strategies for performance optimization.
Methods: Thirty-eight elite female athletes (age 18-29 years) from various sporting disciplines participated in this 3-month longitudinal study. Performance metrics were assessed weekly and mapped to individual menstrual cycle phases confirmed through hormonal testing. Physical performance tests included countermovement jumps, 30m sprint, handgrip dynamometry, and sport-specific skill assessments. Participants completed daily symptom questionnaires and training logs. Statistical analysis employed repeated measures ANOVA, with post-hoc Bonferroni corrections and linear mixed models to account for individual variations.
Results: Significant performance fluctuations were observed across menstrual cycle phases, with a 7.2% decrease in power output during the early luteal phase compared to the late follicular phase ($p < 0.01$). Endurance capacity decreased by 5.8% during the early follicular phase ($p < 0.05$). Technical skill execution demonstrated the highest variability (CV = 8.4%) during the premenstrual phase. Individual response patterns varied substantially, with 63% of athletes reporting performance decrements associated with specific cycle phases.
Conclusion: The menstrual cycle significantly impacts various performance parameters in elite female athletes from North Sumatra, with the most pronounced effects during the early luteal and early follicular phases. Individual response patterns emphasize the need for personalized approaches to training periodization and competition scheduling. Implementation of cycle-based training modifications and symptom management strategies presents opportunities for performance enhancement.

Keywords: menstrual cycle, athletic performance, female athletes, north sumatra, hormonal fluctuations, performance optimization, sports physiology, individualized training.

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INTRODUCTION

The participation of women in elite sports has grown substantially over recent decades, necessitating a deeper understanding of female-specific physiological factors that may influence athletic performance. The menstrual cycle, characterized by regular hormonal fluctuations, represents a fundamental biological process that potentially affects various physiological and psychological parameters relevant to athletic performance (Constantini et al., 2005). Despite comprising approximately half of the athletic population, female athletes remain underrepresented in sports science research, creating a significant knowledge gap regarding sex-specific training and performance considerations.

The menstrual cycle is traditionally divided into follicular, ovulatory, and luteal phases, each characterized by distinct hormonal profiles primarily involving estrogen and progesterone. These hormonal fluctuations have been associated with alterations in muscle contractile properties, neuromuscular coordination, thermoregulation, metabolism, and psychological state (Janse de Jonge, 2003; Bruinvels et al., 2017). However, existing literature presents inconsistent findings regarding the magnitude and direction of these effects on athletic performance, likely due to methodological variations, small sample sizes, and insufficient control for confounding variables.

A critical examination of the current literature reveals several limitations. First, most studies have focused on recreational athletes or non-athletic populations, with limited research on elite athletes whose physiological adaptations may modify cycle-related effects. Second, investigations typically examine isolated performance parameters rather than comprehensive assessments encompassing multiple physical capacities and technical skills. Third, there is a notable scarcity of research conducted in Southeast Asian populations, where genetic, environmental, and sociocultural factors may influence both menstrual patterns and athletic performance differently from more extensively studied Western populations.

The Indonesian context presents unique considerations, with North Sumatra representing a region of significant sporting achievement despite limited sports science resources. Cultural perceptions surrounding menstruation add complexity to this research area, potentially affecting reporting, management strategies, and athletic participation during certain cycle phases. Previous regional studies have documented menstrual irregularities among Indonesian female athletes but have not systematically examined performance correlations (Siregar & Hasibuan, 2020).

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This research aims to address these gaps by investigating the impact of menstrual cycle phases on multiple performance parameters among elite female athletes from North Sumatra. Specifically, the study objectives are to:

1. Quantify performance variations in strength, power, endurance, and technical skills across different menstrual cycle phases
2. Identify individual response patterns and their relationship to menstrual symptoms
3. Examine current knowledge, practices, and attitudes regarding menstrual cycle management among athletes and coaches
4. Develop preliminary recommendations for cycle-based training modifications and competition strategies

By generating region-specific data and integrating physiological, psychological, and cultural dimensions, this research aims to contribute to more effective training and performance optimization strategies for female athletes in Indonesia and similar contexts.

MATERIALS AND METHODS

Study Participants

Thirty-eight elite female athletes from North Sumatra, Indonesia, currently enrolled in the Physical Education College at Universitas Islam Riau, voluntarily participated in this study. Participants represented various sporting disciplines including track and field (n=14), swimming (n=8), martial arts (n=10), and team sports (n=6). Inclusion criteria were: (1) regular menstrual cycles (24-35 days) for at least six months prior to the study; (2) no use of hormonal contraceptives within the previous three months; (3) national-level competitive status; (4) absence of diagnosed gynecological disorders; and (5) no injuries preventing full training participation. The mean (± SD) characteristics of the participants were: age 22.4 ± 3.2 years; height 163.5 ± 5.8 cm; weight 58.3 ± 6.4 kg; body fat percentage 19.8 ± 3.7%; and training experience 7.6 ± 2.8 years.Prior to participation, all athletes received comprehensive information about the study procedures and provided written informed consent. The research protocol was approved by the Ethics Committee of Universitas Negeri Medan (Protocol number: UNIMED-HREC-2023-078) and conducted in accordance with the Declaration of Helsinki.

Organization of the Study

This quantitative research employed a longitudinal design spanning three complete menstrual cycles (approximately 3 months) to account for cycle-to-cycle variability. Data collection took place from January to April 2023 at the Sports Science Laboratory of Universitas Negeri Medan and the North Sumatra High-Performance Training Center. Participants underwent preliminary screening including medical history, gynecological evaluation, and baseline physical performance assessment. Individual menstrual cycle phases were determined through a combination of methods: (1) calendar-based tracking; (2) basal body temperature monitoring; and (3) urinary luteinizing hormone testing to confirm ovulation. For analytical purposes, the menstrual cycle was divided into five phases: early follicular (days 1-5), late follicular (days 6-12), ovulatory (days 13-15), early luteal (days 16-22), and late luteal (days 23- 28), with adjustments made for individual cycle lengths.Weekly performance testing sessions were scheduled to ensure that each participant was assessed at least once during each identified cycle phase over the three-month period. Additionally, participants maintained daily logs documenting menstrual symptoms, perceived exertion, and subjective well-being.

Test and Measurement Procedures

Table 1. Test and Measurement Procedures Across Performance, Physiological, and Psychological Domains

Assessment Domain	Specific Measures / Instruments	Protocol Description	Outcome Variables
Strength and Power	Countermovement Jump (CMJ) using force platform (AMTI, USA)	Bilateral CMJ performed on calibrated force plate; hands on hips; best of 3 trials recorded	Jump height, peak power, rate of force development
	Handgrip strength using digital dynamometer (Jamar Plus+, USA)	Bilateral maximal grip trials; standardized arm position; best value recorded	Grip strength (kg)
	30 m sprint via photocell gates (Microgate Witty, Italy)	Standing start; sprint 30 m; electronic timing for precision	Sprint time (s)
	Sport-specific power tests	Tests tailored to athlete discipline (e.g., throws, kicks, strokes)	Discipline-specific power outputs
Endurance	Yo-Yo Intermittent Recovery Test Level 1	Shuttle running with progressive intensity; recovery intervals prescribed	Total distance (m), estimated VO_2 response
	400 m time trial (for track athletes)	Individual run at maximal sustainable pace	Time to completion (s)
	Sport-specific endurance tests	Evaluations designed for each sport (e.g., swim intervals, paddling ergometer)	Task-specific endurance performance
Technical Skill Assessments	Standardized coach evaluations	Coaches assess skill execution using validated rating scales	Accuracy, execution quality scores
	Inertial Measurement Units (IMUs)	Wearable sensors measure precision, variability, and movement patterns	Movement accuracy, consistency metrics
Physiological Markers	Resting HR & HRV (Polar H10)	Morning supine measurement; 5-min recording	Heart rate (bpm), HRV indices (RMSSD, SDNN)
	Blood lactate response	Capillary blood sampling post standardized submaximal exercise	Lactate concentration (mmol/L)
	Oral temperature	Morning measurement upon waking	Body temperature (°C)
Psychological Measures	Profile of Mood States (POMS)	Weekly questionnaire assessing mood disturbances	Total Mood Disturbance (TMD), subscale scores
	Daily subjective ratings	Athlete-reported energy, motivation, physical capability (0–10 scale)	Daily subjective well-being metrics
	Menstrual Symptom Questionnaire	Self-reported physical and emotional symptoms	Symptom severity scores

All testing sessions followed standardized protocols, including consistent time of day, environmental conditions, warm-up procedures, and verbal encouragement. Testing was conducted by trained research assistants who were blinded to the participants' menstrual cycle phase when possible.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Data normality was assessed using the Shapiro-Wilk test. Descriptive statistics are presented as means ± standard deviations or medians with interquartile ranges as appropriate. To examine performance variations across menstrual cycle phases, repeated measures analysis of variance (ANOVA) was employed with Greenhouse-Geisser corrections applied when the assumption of sphericity was violated. Post-hoc analyses with Bonferroni adjustments were conducted for pairwise comparisons between cycle phases. Effect sizes were calculated using partial eta squared (η^2) and interpreted as small (0.01), medium (0.06), or large (0.14). Linear mixed models were used to account for individual variability, with menstrual cycle phase as a fixed effect and participant ID as a random effect. Additional fixed effects included menstrual symptom severity, cycle length, and sport type. Correlations between performance parameters and physiological/psychological variables were assessed using Pearson's or Spearman's correlation coefficients as appropriate. For the analysis of subjective data from questionnaires, Friedman's test was applied with Wilcoxon signed-rank tests for post-hoc comparisons. Statistical significance was set at $p < 0.05$ for all analyses.

RESULTS

Menstrual Cycle Characteristics and Symptomatology

The participants exhibited mean menstrual cycle length of 28.3 ± 2.7 days with moderate interindividual variability (range: 24-34 days) and minor intraindividual cycle-to-cycle variations (CV = 8.2%). Menstrual symptoms were reported by 92% of the athletes, with the most common complaints being abdominal cramps (76%), lower back pain (68%), fatigue (63%), and irritability (57%). Symptom severity, assessed on a 0-10 scale, was highest during the early follicular phase (mean score: 4.8 ± 2.1) and late luteal phase (mean score: 4.2 ± 1.9).

Performance Variations Across Menstrual Cycle Phases:

Strength and Power Performance:

Significant phase-related variations were observed in explosive power measures ($F(4,148) = 8.67$, $p < 0.01$, $\eta^2 = 0.19$). Countermovement jump performance peaked during the late follicular phase (32.1 ± 3.8 cm) and was lowest during the early luteal phase (29.8 ± 3.6 cm), representing a mean decrement of 7.2% ($p < 0.01$). Similar patterns were observed in 30m sprint times, with optimal performance in the late follicular phase (4.68 ± 0.32 s) compared to the early luteal phase (4.82 ± 0.36 s, $p < 0.05$). Maximal handgrip strength showed less pronounced variations across the cycle ($F(4,148) = 2.34$, $p = 0.06$, $\eta^2 = 0.06$), though a trend toward reduced performance was noted during the early follicular phase.

Endurance Capacity:

Endurance performance demonstrated significant menstrual cycle effects ($F(4,148) = 7.21$, $p < 0.01$, $\eta^2 = 0.16$). Distance covered in the Yo-Yo Intermittent Recovery Test was highest during the late follicular phase (1682 ± 321 m) and lowest during the early follicular phase (1584 ± 298 m), representing a 5.8% difference ($p < 0.05$). Submaximal exercise heart rates were significantly elevated during the luteal phase compared to the follicular phase ($p < 0.01$), while blood lactate concentrations at standardized workloads were higher during the early luteal phase ($p < 0.05$).

Technical Skill Execution:

Technical skill performance exhibited the greatest variability across the menstrual cycle (CV = 8.4%). Standardized skill assessment scores were significantly lower during the late luteal and early follicular phases compared to mid-cycle phases ($F(4,148) = 9.32$, $p < 0.001$, $\eta^2 = 0.20$). Performance decrements were more pronounced in fine motor skills requiring precision than in gross motor patterns. Table 2. Summarizes the performance variations across menstrual cycle phases, with values normalized as percentages of individual maximum performance.

Table 2. Performance Parameters Across Menstrual Cycle Phases (% of Maximum Performance)

Performance Parameter	*Early Follicular*	*Late Follicular*	*Ovulatory*	*Early Luteal*	*Late Luteal*	*p- value*
CMJ Height	94.6 ± 4.2	99.3 ± 1.2	97.8 ± 2.4	92.8 ± 4.5	95.2 ± 3.8	<0.01
30m Sprint Time	96.2 ± 3.1	99.5 ± 0.9	98.4 ± 1.8	95.4 ± 3.6	97.3 ± 2.5	<0.05
Handgrip Strength	95.4 ± 3.8	98.6 ± 1.7	99.2 ± 1.2	97.8 ± 2.3	96.9 ± 2.9	0.06
Endurance Capacity	94.2 ± 4.5	99.4 ± 0.8	97.6 ± 2.5	96.3 ± 3.2	95.1 ± 3.9	<0.01
Technical Skill	92.8 ± 5.2	98.7 ± 1.9	99.5 ± 0.7	95.6 ± 3.5	93.2 ± 4.8	<0.001

Note: Values are expressed as mean ± SD percentages of individual maximum performance across all phases.

Individual Response Patterns

Analysis of individual data revealed substantial heterogeneity in response patterns. Cluster analysis identified three distinct groups based on performance fluctuations across the menstrual cycle:

1. Highly Affected (n=14, 36.8%): Athletes demonstrating performance decrements >8% during specific cycle phases, most commonly early luteal and early follicular phases

2. Moderately Affected (n=15, 39.5%): Athletes showing performance variations of 4-8% across the cycle
3. Minimally Affected (n=9, 23.7%): Athletes maintaining relatively stable performance (variations <4%) throughout the menstrual cycle

The magnitude of performance fluctuations was significantly correlated with menstrual symptom severity ($r = 0.68$, $p < 0.01$) and training volume ($r = -0.42$, $p < 0.05$), suggesting that higher training loads may attenuate cycle-related performance variations. Sport-specific differences were also observed, with endurance athletes demonstrating more pronounced luteal phase performance decrements compared to strength/power athletes ($p < 0.05$).

Physiological and Psychological Correlates

Significant correlations were identified between performance decrements and several physiological and psychological variables. Early follicular phase performance reductions were associated with higher pain scores ($r = -0.59$, $p < 0.01$) and elevated inflammatory markers. Luteal phase decrements correlated with increased body temperature ($r = -0.47$, $p < 0.05$) and subjective fatigue ratings ($r = -0.62$, $p < 0.01$). Mood state fluctuations, assessed via POMS, were significant across the cycle ($\chi^2(4) = 23.76$, $p < 0.001$), with increased tension-anxiety and fatigue scores during the late luteal and early follicular phases. These mood disturbances were moderately correlated with technical skill performance decrements ($r = -0.51$, $p < 0.01$).

Current Knowledge and Practices

Assessment of athletes' knowledge regarding menstrual cycle effects revealed limited awareness, with only 28.9% of participants reporting prior education on this topic. Most athletes (73.7%) had never discussed cycle-related training modifications with their coaches. Among the common coping strategies employed were pain medication (63.2%), reduced training intensity during symptomatic days (47.4%), and heat therapy (39.5%). Coaches' survey data (n=12) indicated minimal consideration of menstrual cycle in training planning, with 83.3% reporting no systematic adjustments to accommodate cycle phases. However, 91.7% expressed interest in implementing evidence-based strategies if provided with practical guidelines.

DISCUSSION

This research provides comprehensive evidence that the menstrual cycle significantly impacts various aspects of athletic performance among elite female athletes from North Sumatra, Indonesia. The multidimensional assessment approach revealed phase-specific performance fluctuations with distinct patterns across different physical capacities and technical skills.

The observed performance peak during the late follicular phase aligns with previous research suggesting that elevated estrogen levels may enhance neuromuscular function and muscle force production (Wikström-Frisén et al., 2017). This hormonal environment, characterized by high estrogen and low progesterone, appears favorable for both power and endurance performance. The subsequent performance decline during the early luteal phase coincides with rising progesterone levels, which may counteract estrogen's ergogenic effects through altered substrate metabolism, thermoregulation, and fluid balance (Constantini et al., 2005).

The substantial decrements in technical skill execution during the premenstrual and early menstrual phases represent a particularly notable finding with practical implications. These phases were associated with increased psychological symptoms and pain, potentially disrupting motor control precision and attentional focus. This finding extends previous work by Juznewski et al. (2022), who reported similar effects on fine motor skills in Brazilian athletes, suggesting cross- cultural consistency in this aspect.

The magnitude of performance variations observed (5-8% across different parameters) exceeds the typical margin differentiating medal positions at elite competitions (≈1-3%), underscoring the practical significance of these findings. However, the substantial individual variability identified through cluster analysis highlights the danger of generalizing these effects and emphasizes the need for personalized approaches to menstrual cycle management in athletic contexts.

Our findings partially align with systematic reviews by McNulty et al. (2020) and Blagrove et al. (2023), who reported potential performance decrements during early follicular and mid-luteal phases. However, the present study identified more pronounced effects than typically reported in Western populations, particularly regarding technical skill execution. This discrepancy may reflect genuine population differences related to genetics, environmental factors, or methodological variations.

The clustering of participants into high, moderate, and low responder groups represents a novel contribution to the literature, moving beyond the common approach of reporting only group means. This pattern-based analysis provides a more nuanced understanding of menstrual cycle effects and may explain some of the inconsistencies in previous research.

Unlike some studies reporting minimal practical effects (Elliott-Sale et al., 2020), our findings indicate performance variations of sufficient magnitude to warrant consideration in training and competition strategies. This divergence might reflect the comprehensive performance assessment approach employed, capturing effects that might be missed in studies focusing on isolated parameters. The findings must be interpreted within the specific cultural context of North Sumatra, Indonesia, where menstruation remains a relatively sensitive topic surrounded by certain taboos. The limited prior knowledge and open communication regarding menstrual cycle management reported by participants reflects broader sociocultural attitudes. However, the high interest in evidence-based strategies expressed by both athletes and coaches suggests an opportunity for educational interventions that respect cultural sensitivities while advancing scientific approaches to female athlete development.

The coping strategies reported by athletes reflected a combination of biomedical approaches (e.g., pain medication) and traditional practices. This mixed approach highlights the importance of integrating scientific evidence with culturally acceptable management strategies when developing practical recommendations.

Several limitations warrant consideration when interpreting these findings. First, despite hormonal verification of cycle phases, the inherent variability in cycle characteristics and limited sampling frequency may have introduced some phase misclassification. Second, while the sample size exceeds many previous studies in this field, the distribution across different sports limited sport- specific analyses. Third, the three-month study duration, while capturing sufficient data for primary analyses, precluded examination of seasonal variations and longer-term adaptation patterns. Fourth, despite efforts to standardize testing conditions, variations in training loads and environmental factors may have influenced some measurements.

CONCLUSION

This study provides substantial evidence that the menstrual cycle influences multiple aspects of athletic performance among elite female athletes from North Sumatra, with the most pronounced effects observed during the early luteal and early follicular phases. The magnitude of these effects appears sufficient to impact competitive outcomes, particularly in sports where small performance margins are decisive. However, the considerable individual variability identified underscores the importance of personalized approaches to menstrual cycle management in athletic contexts.

The findings offer several practical implications for female athletes and their support staff. First, systematic tracking of individual cycle characteristics and associated performance patterns can inform optimal scheduling of high-intensity training and competition when possible. Second, targeted interventions during vulnerable phases—including modified training parameters, symptom management strategies, and nutrition adjustments—may mitigate performance decrements. Third, increased awareness and communication regarding menstrual cycle effects can reduce stigma and facilitate more effective athlete-coach collaboration.

Future research should build upon these findings by examining longer-term adaptations to cycle- based training periodization, developing validated tools for individual response prediction, and exploring interactions between menstrual cycle effects and other factors such as environmental conditions, travel, and psychological stress. Additionally, developing and evaluating culturally appropriate educational interventions represents an important practical direction for research in this context.

By addressing the physiological challenges associated with the menstrual cycle while recognizing individual response patterns, female athletes and their support teams can transform a potential performance barrier into an opportunity for optimized training approaches and enhanced competitive outcomes.

CONFLICT OF INTERESTS

The authors declare no conflict of interest. The funding sponsors had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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