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Research Paper

Exploring variations in sports motivation across menstrual cycle phases: Insights from a longitudinal within-subjects study with active females

Laura Reusch [a], Beate Zunner [b], Susanne Tittlbach [a], Melinda Herfet [a,*]

[a] BaySpo–Bayreuth Center of Sport Science, University of Bayreuth, Universitätsstraße 30, Bayreuth 95440, Germany
[b] Praxis am Main, Bayreuth 95444, Germany

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ABSTRACT

Background: Inactivity, as one of the leading risk factors for global mortality, highlights the need for a deeper understanding of how to foster sports motivation. Given the hormonal fluctuations during menstrual cycle phases, it has been suggested that sports motivation may vary as sex hormones impact other areas such as training, emotions, and perception. However, there are inconsistencies in previous studies attributed to varying methodologies in menstrual phase classification and verification. Hence, the main aim of this study was to explore variations in sports motivation across menstrual cycle phases using recommended methods.
Methods: This longitudinal within-subjects study investigated 17 healthy active females (mean age: 28.1 ± 5.3, body mass index: 22.5 ± 2.5 kg/m^2) across three menstrual cycles. Using the mPath App, participants completed daily questionnaires that assessed their sports motivation, menstrual cycle day, and sports program. To determine menses and ovulation during the participant's menstrual cycle, calendar-based counting and luteinizing hormone testing were employed.
Results: Motivation scores were highest during mid-follicular days and periovulatory days, although the overall differences between the menstrual cycle phases were insignificant. Positive correlations were found between periovulatory sports motivation and sport session frequency, and negative between periovulatory sport session intensity and frequency.
Conclusion: This study offers new insights for sports motivation and menstrual cycle research, suggesting that there are no significant differences in sports motivation across the hormonal events of the menstrual cycle. Additional factors like coaching, social support, and enjoyment of exercise may also exert influence and therefore warrant further investigation through mixed-method strategies to investigate these psychosocial factors alongside to the menstrual cycle. Future research should replicate these findings using more precise measurements of progesterone and estrogen to enhance methodological accuracy and reliability.

1. Introduction

Physical inactivity is a serious public health challenge, as it increases the risk of all-cause mortality and noncommunicable diseases such as cardiovascular disease, cancer, and type-2 diabetes (Haileamlak, 2019; Lee et al., 2012). Over 1.4 billion adults worldwide are insufficiently active, highlighting the prevalence of inadequate physical activity. One in every three women does not frequently achieve adequate physical activity according to the World Health Organization's recommendations of 150–300 min per week of moderate-intensity physical activity (World Health Organization, 2024). Given the established benefits of regular physical activity in preventing and managing noncommunicable diseases, promoting adherence to exercise regimens is a key focus of health management worldwide. Sports motivation is not only a key predictor of sports performance and athlete success (Gillet et al., 2009; Gould et al., 2002), but also crucial for maintaining regular exercise adherence (Williams et al., 2008), emphasizing the importance of further investigating the factors influencing sports motivation.

The complex construct of motivation gives an insight into why an individual initiates, regulates, directs, sustains, and discontinues behavior (Clancy et al., 2017). There are three main forms of motivation: intrinsic, extrinsic, and amotivation (Deci & Ryan, 1985). Intrinsic motivation occurs when individuals engage in an activity for its intrinsic value and the pleasurable sensations, whereas extrinsic motivation

* Corresponding author.
E-mail address: melinda.herfet@uni-bayreuth.de (M. Herfet).

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refers to the engagement in an activity solely to achieve a desired outcome. Lastly, amotivation describes a lack of motivation, resulting in an individual not engaging in an activity at all (Gillet et al., 2009; Vallerand, 2007). To further explore intrinsic and extrinsic motivation, Ryan and Deci (2000) developed the Self-Determination Theory, which offers a comprehensive framework for understanding this construct. According to this framework, the sports motivation of most athletes is influenced by a combination of factors, including their personal interests, curiosity, and desire for mastery, as well as external influences such as support or pressure from coaches, friends, and family (Deci & Ryan, 1985; Pelletier et al., 2013). When athletes exhibit high levels of self-determination, their motivation in sports is optimized, leading to increased adherence (Pelletier et al., 2001; Vallerand, 2007). While self-determination theory highlights key psychological drivers of motivation – such as autonomy, competence, and relatedness – it does not fully address the potential impact of biological or genetic factors. To bridge this gap, Spence and Lee (2003) proposed the ecological model of physical activity (EMPA), which conceptualizes physical activity as a behavior influenced by the dynamic interplay between psychological, genetic, and biological factors. Notably, biological processes such as the menstrual cycle may influence motivation, suggesting that fluctuations in hormones could interact with psychological determinants to affect athletes' engagement in physical activity.

There are multiple factors influencing sports motivation (Beer et al., 2020), and very recent findings emphasize that the menstrual cycle may also play an important role (Cook et al., 2018; Crewther & Cook, 2018; Prado et al., 2021). Naturally menstruating women experience the menstrual cycle as regular thickening and shedding of the uterine lining in a cyclical pattern that lasts 21 to 35 days (Elliott-Sale et al., 2021; Reed & Carr, 2000). The hormones follicle-stimulating hormone (FSH), luteinizing hormone (LH), estrogen, and progesterone fluctuate throughout the menstrual cycle and characterize different menstrual cycle phases (Patricio & Sergio, 2019). During the follicular phase, FSH stimulates follicle development in the ovary, leading to estrogen production and eventual ovulation triggered by a peak in LH. The luteal phase begins after ovulation. During this phase the corpus luteum produces progesterone and estrogen. If fertilization does not happen, the corpus luteum deteriorates, leading to a decrease in progesterone and estrogen levels. This hormonal shift causes the endometrium to detach, initiating menstrual blood flow which introduces a new menstrual cycle (Carmichael et al., 2021; Patricio & Sergio, 2019). Outside of the reproductive system, sex hormones have numerous additional effects since their receptors have been identified in other target tissues such as the brain Brinton et al. (2008); Gruber et al. (2002) and skeletal muscle (Kim et al., 2016). Thus, it has been suggested that sex hormones could also influence, for example, training, emotions, and perception (Kissow et al., 2022; Paludo et al., 2022; Sundström Poromaa & Gingnell, 2014). As the sex hormone levels induce diverse emotions (Albert et al., 2015; Klatzkin et al., 2006), and emotions are connected to motivation (Løvoll et al., 2017; MacIntyre & Vincze, 2017), it is reasonable to assume that sports motivation may fluctuate throughout the phases of the menstrual cycle.

Li et al. (2022) demonstrated that the menstrual cycle and sex hormones are associated with an individual's motivational system. According to their findings, hormone levels correlated significantly with the speed of approach-avoidance responses: higher estrogen levels were associated with positive emotions and engagement in motivational behavior, while increased secretion of progesterone seems to correlate with avoidance behavior for negative stimuli. While Li et al. (2022) conducted a study on motivation in a general and emotional setting, Prado et al. (2021) specifically investigated the impact of the menstrual cycle on sports motivation. Their findings demonstrated a significant effect of the menstrual cycle phases on exercise motivation, with lower motivation observed in the luteal phase prior to starting the exercise. During the exercise and post-exercise, the motivation did not differ between the follicular and luteal phase. Two other studies performed by Crewther and Cook (2018) as well as Cook et al. (2018) observed significantly better scores in sports motivation and competitiveness in the ovulation phase in comparison to the follicular and luteal phase. Although these studies provide initial insights into the link between menstrual cycle phases and sports motivation, they have certain methodological limitations. Primarily, the methods used to verify menstrual cycle phases, such as calendar-based counting or basal body temperature measurement, are classified as relatively weak (Janse De Jonge et al., 2019). While Prado et al. (2021) employed both calendar-based counting and basal body temperature measurement, Cook et al. (2018) and Crewther and Cook (2018) relied solely on calendar-based counting. Further, the two-phase (follicular phase and luteal phase, adopted by Prado et al. (2021)) and the three-phase (follicular phase, ovulation, and luteal phase, adopted by Crewther and Cook (2018) as well as Cook et al. (2018)) classification systems neglect the diverse hormonal events within those phases (Schmalenberger et al., 2021). These limitations result in vague estimations of hormonal events, which may contribute to the inconsistent outcomes in menstrual cycle research, as they focus on relative changes in hormone levels rather than the specific hormonal events that are crucial for understanding the proposed effects of these hormones (Janse De Jonge et al., 2019; Schmalenberger et al., 2021). Furthermore, these studies assessed sports motivation solely via daily questionnaires using a Likert scale, which did not capture general sports motivation as conceptualized within Self-Determination Theory (SDT).

Given the limited existing evidence, this study focused on regularly exercising active females, i.e. women exercising at least twice per week on an amateur level, who are naturally menstruating. This approach ensures our findings are grounded in the experiences of typical active females, contributing to a more foundational understanding of menstrual cycle influences on sports motivation and thereby adherence to physical activity. Recognizing these variations is crucial for tailoring effective strategies to promote physical activity aligned with hormonal fluctuations within the female population. This foundational research lays the groundwork for future studies with diverse populations, advancing our knowledge in this evolving field.

Thus, the objective of this study was to explore variations in sports motivation across the menstrual cycle in regularly exercising active females using recommended methods to determine sports motivation and the menstrual cycle.

2. Methods

2.1. Recruitment

The recruitment for the study was carried out through advertisement within an article written by the accompanying physician B. Zunner and published in the health magazine "Gesund Leben" (Zunner, 2023). In addition, participants were recruited through personal contact by the research team, social media posts as well as targeted inquiries at local sports clubs.

The study included active females who exercised regularly at least twice a week on an amateur level, aged between 18 and 45, with a body mass index (BMI) between 18 and 27 kg/m^2. Participants had to naturally menstruate (i.e. regular menstrual blood flow every 21 to 35 days), use non-hormonal contraception methods and be hormone-free for at least six months. Active females experiencing menopause or amenorrhea (absence of regular bleeding), consecutive menstrual cycle length variations of more than eight to ten days, pregnancy or intentions to become pregnant, breastfeeding, engaging in dieting or displaying signs of disordered eating, undergoing active cancer treatment including chemotherapy or receiving immunosuppressive therapy were not able to participate in this study. These exclusions were necessary due to the requirement for a regular menstrual cycle and the absence of preexisting health conditions. Inclusion and exclusion criteria determining menstrual cycle health followed the Reproductive Status Questionnaire (RSQ) (Schmalenberger et al., 2021) and the Federation of Gynecology and Obstetrics (FIGO) System 1 (Munro et al., 2018). Women using hormonal contraception, or those who had recently used hormonal contraception and had not been hormone-free for at least six months were also excluded. To avoid the inclusion of active females experiencing anovulatory menstrual cycles (Janse De Jonge et al., 2019; Schmalenberger et al., 2021), urinary LH surge testing was performed during a test menstrual cycle and two study cycles.

Prior to the study, a sample size of 15 participants was determined adopting Cohen's $f = 0.4$, a power of 95 % and an alpha of 5 % for one group with four measurements, calculated with the G*Power 3.1.9.6 software and based on the results from Prado et al. (2021). 25 active females were initially recruited. Two participants dropped out during the test menstrual cycle and three during the study menstrual cycles. Of the 20 participants who completed both study cycles, one did not obtain a positive ovulation test result within these menstrual cycles (despite having obtained a positive result in the test menstrual cycle) and two participants failed to complete at least 75 % of the daily questionnaires. Hence, the data of 17 participants was subjected to statistical analysis.

2.2. Study design and procedure

The study involved a longitudinal within-subjects design. Prior to initiating the study, it received review and approval from the ethics committee of the University of Bayreuth (Az. O 1305/1-GB). The research application "m-Path" from KU Leuven (Mestdagh et al., 2023; Verdonck & Mestdagh, 2024) was used as the data collection instrument. The individual study ID was emailed to participants, and the LH tests were sent to them by post.

At first, participants installed m-Path on their smart phone and registered using their individual study ID. The participants started the study with the test menstrual cycle using the "rolling research" approach, i.e., each participant started on their menstrual cycle day 1 (first day of menses), resulting in varied start and end dates for each participant. The purpose of the test menstrual cycle was to gather information via the two entry questionnaires, to familiarize the participants with the urinary LH tests, and to control for anovulatory menstrual cycles. In the test menstrual cycle, LH testing started on menstrual cycle day 8 for each participant (Janse De Jonge et al., 2019), as the timing of ovulation for the individual participant was unknown. Afterwards, the two study menstrual cycles took place, where participants submitted their answers to the daily questionnaires and LH testing results to m-Path. For the study menstrual cycles, the starting day of LH testing was adjusted based on the positive test days obtained during the test menstrual cycle. Throughout the study, participants continued their daily lives and were encouraged to maintain their usual sports program without specific instructions or guidelines from the research team.

Following the end of study menstrual cycle 2, a final questionnaire sought additional information from participants regarding their sports motivation, sports program, menstrual cycle, illness, or other relevant details during the study period to better understand participants and their outcomes. The study design is shown in Fig. 1.

2.3. Measurement tools

2.3.1. Demographic data

At the start of the study, participants were requested to complete a demographic questionnaire via m-Path gathering the following data: sex, age, height, weight, general sports motivation (using the Sport Motivation Scale II (Pelletier et al., 1995, 2013)), level of education, menstrual cycle status and gynecological disorders (using the FIGO System 1 and the RSQ) as well as cycle-related symptoms, menstrual cycle tracking, contraceptive methods, former contraception, pregnancy and breastfeeding, hormonal medication, and drug consumption. Additionally, the participant's physical activity, weekly sports program, and practiced sport were assessed (using the Global Physical Activity Questionnaire (World Health Organization, 2021)) in a second entry questionnaire. Collecting this initial data was essential as it provided fundamental details about the participants and controlled for the inclusion and exclusion criteria.

2.3.2. Sports motivation

To examine daily sports motivation, daily questionnaires were utilized. Research investigating motivation often claims the use of self-reported questionnaires as a valuable instrument (Clancy et al., 2017). Each day, every participant was asked to fill out two short questionnaires via m-Path, one in the morning and one in the evening. The questionnaire in the morning contained the question "How motivated are you to exercise today?", where participants could choose a score on a seven-point Likert scale (Clancy et al., 2017), ranging from 1 = not at all motivated to 7 = extraordinarily motivated. The morning questionnaire was open from 6 a.m. to 11 a.m. with a reminder at 9 a.m. The evening questionnaire included questions asking participants if they trained or competed that day. If they answered yes, they were asked to specify the type of training/competition from six given sports types, and its intensity using also a seven-point Likert scale, ranging from 1 = very low intensity to 7 = very high intensity. The evening questionnaire was open at 6 pm. with a reminder at 7 pm. and had no expiration time. Participants completed the daily questionnaires throughout two consecutive menstrual cycles. Only data with a response rate of 75 % were included.

To obtain a comprehensive understanding of participants' motivation, additional qualitative data on general sports motivation were gathered via the demographic questionnaire. The measurement of general motivation provided valuable insights into participants' enduring desire to pursue their sport, complementing the quantitative daily motivation scores, which tend to objectify the complex construct of sports motivation. To measure general sports motivation, the Sport Motivation Scale (SMS) II (Pelletier et al., 1995, 2013), which is based on Self-Determination Theory, was used. The SMS II is a validated questionnaire (Pelletier et al., 2013) and categorizes six different types of motivation from most self-determined to least self-determined: intrinsic motivation; followed by various forms of extrinsic motivation, including integrated, identified, introjected, and external regulation; and amotivation. Among these, intrinsic, integrated, and identified

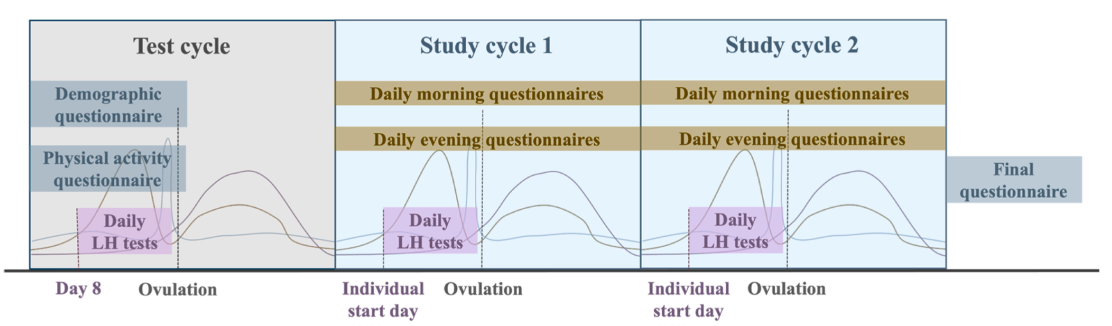

Fig. 1. Study design illustrating the test and study cycles with timing of the LH tests and questionnaires during three menstrual cycles of the participants.

motivations are considered more autonomous, i.e. higher need satisfaction for autonomy, and have been linked to several positive outcomes. For instance, autonomous motivation has been shown to predict long-term commitment (Pelletier et al., 2001). For each of the types, three statements from the SMS II were presented within a block. Participants selected the statement blocks of each type they felt most represented by, e.g. the block for integrated motivation: "Because practicing sports reflects the essence of whom I am. Because participating in sport is an integral part of my life. Because through sport, I am living in line with my deepest principles.". Participants could choose multiple motivation types if they felt represented by more than one.

2.3.3. Menstrual cycle phase classification and determination

To examine the research objective, methods to classify and determine menstrual cycle phases were necessary.

To classify the participant's menstrual cycles, this study adopted the recommended phasing procedure by Schmalenberger et al. (2021). Using this procedure, the menstrual cycle is characterized by four hormonal events: perimenstrual, mid-follicular, periovulatory, and mid-luteal, as depicted in Fig. 2. Following the procedure by Schmalenberger et al. (2021), the perimenstrual event is defined as day −3 before menstrual onset to day 2 after onset, and lasts 5 days in total. Mid-follicular days are defined as day −7 to −3 before a positive LH test result, lasting 5 days too. The periovulatory event is defined as day −2 before positive test to day of and day +1 following the positive LH test result, lasting 4 days. The mid-luteal days are defined as day +6 to +10 following the positive LH test result. The mid-luteal event can vary in total days in dependence on the total menstrual cycle length; in shorter menstrual cycles this event might last only of 2–3 days.

To determine these diverse hormonal events of the menstrual cycle, LH surge testing was combined with calendar-based counting, as recommended by Janse De Jonge et al. (2019). It is important to mention that measuring serum estrogen and progesterone levels is regarded as the gold standard for verifying the menstrual cycle phases (Janse De Jonge et al., 2019), but due to methodological limitations, it was not feasible to carry out this method. Adopting calendar-based counting and LH surge testing enabled the verification of menses and ovulation, and consequently the verification of the perimenstrual and periovulatory phase. However, since no measurements of estrogen and progesterone levels were conducted, only assumptions can be made regarding the occurrence of mid-follicular and mid-luteal hormonal events, without direct verification. Consequently, the mid-follicular and mid-luteal hormonal phases must be assumed in this context (Elliott-Sale et al., 2025).

Within calendar-based counting, the self-reported onset of menses is designated as day 1 and subsequent hormonal events are determined by counting days from this reference point (Janse De Jonge et al., 2019). Calendar-based counting was utilized via the question in the morning questionnaire "Which menstrual cycle day are you at today?". As the counting method does not allow for variation in menstrual cycle length and does not test for anovulatory menstrual cycles, LH testing was also implemented (Janse De Jonge et al., 2019; Schmalenberger et al., 2021). For LH testing, participants were instructed to dip an ovulation strip into a urine sample daily between 10 a.m. and 8 pm. (while timing should remain similar each day), starting five to seven days prior to their estimated ovulation for each menstrual cycle until a positive test result is obtained. A positive test result indicated that ovulation is likely to occur within the next 10–24 h (Reed & Carr, 2000). To increase reliability of LH testing, participants sent a picture of their test results to the research team for feedback on whether to submit a negative result and retest the next day, or to submit a positive result. The LH test results were submitted to m-Path within the evening questionnaire. "DAVID LH Ovulation Rapid Test Strips" with a sensitivity of 20 mIU/ml were used to determine the LH peak.

2.4. Data analysis

At first, one of the two consecutive study menstrual cycles per participant was selected for statistical analysis, as not all participants completed the daily questionnaires for at least 75 % in both menstrual cycles. Therefore, 17 menstrual cycles were subjected to statistical analysis. Only ovulatory study menstrual cycles with a positive LH test result per menstrual cycle were analyzed. Next, the days of each participant's study menstrual cycle were assigned to the respective hormonal event (perimenstrual, mid-follicular, periovulatory, and mid-luteal) based on their self-reported start of menses and positive LH test result. Afterwards, daily sports motivation and intensity scores were averaged for each hormonal event. As a result, one mean score value for sports motivation and intensity was obtained for each hormonal event. Next, repeated measures ANOVA was used to identify variations in sports motivation across the hormonal events. Effects were controlled for age, BMI, and contraceptive method using a repeated measures ANCOVA, to account for potential influences of these covariates on the association between sports motivation and the menstrual cycle. The non-parametric Friedman test was used to analyze the variations in sports intensity as well as sports frequency across the hormonal events. A Spearman's rho correlation examined the relationship between sports motivation, intensity, and frequency during the respective hormonal

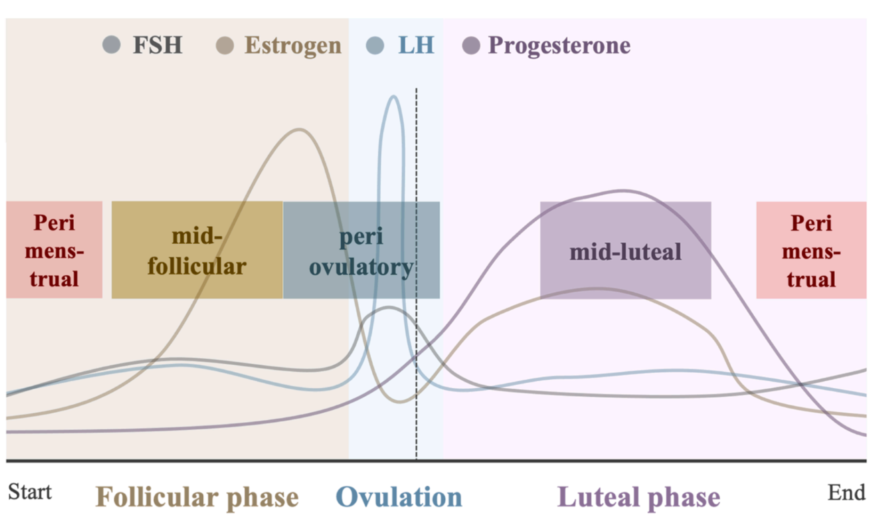

Fig. 2. The hormonal events derived from the phasing procedure by Schmalenberger et al. (2021).
The menstrual cycle with the respective fluctuations in sex hormones was created with inspiration from D'Souza et al. (2023).

event. Statistical significance was set at $p < .05$. The software SPSS® 29.0.2.0 (IBM®, Chicago, IL, USA) was used for analysis.

3. Results

3.1. Sample

Information on the $N = 17$ active females' demography, menstrual cycle status, and contraception is presented in Table 1.

The participants' general sports motivation leaned towards self-determined types, with a total of 38 mentions of higher self-determined motivation types: intrinsic (13 x), integrated (16 x), and identified (9 x). In contrast, less self-determined motivation types were mentioned only 10 times: introjected (10 x), external (0 x), and amotivation (0 x). As intrinsic, integrated and identified motivation are the more autonomous motivation types, this sample exhibits a generally high level of inherent sports motivation.

The results from the physical activity questionnaire revealed that all participants engaged in moderate to intense sports activities on a regular basis, with an average frequency of 4.41 ± 1.29 times per week. Two participants reported that their occupations involved strenuous or moderate physical activity. A wide range of sports activities was practiced by the participants, with the most frequently reported sports including running, cycling, resistance training, yoga, and high-intensity interval training (HIIT). All participants engaged in sports at an amateur level.

Within the demographic questionnaire, all participants retrospectively reported experiencing discomfort related to their menstrual cycle, such as dysmenorrhea (i.e. cramps), back pain, fatigue, headaches, and other symptoms.

The cumulated frequency of different sports types per hormonal event varied across the hormonal events. Walking/hiking (9 x) and intensive endurance training (15 x) were most frequent during periovulatory days. Light endurance training (16 x) and resistance training (11 x) reached their peaks during the mid-follicular days. HIIT/maximal power training had its highest frequencies during the perimenstrual days (7 x), while flexibility/mobility had highest frequencies during the perimenstrual and mid-follicular days (5 x). Most sport sessions were practiced during the mid-follicular days (56 x), followed by perimenstrual days (48 x), and finally periovulatory and mid-luteal days (41 x). Fig. 3 shows the distribution of sports types with highlighted proportions of the menstrual cycle phases for each type.

3.2. Variations in sports motivation across the hormonal events

For mid-follicular days participants reported the highest sports motivation scores (4.56 ± 0.91), followed by periovulatory days (4.51 ± 0.80), mid-luteal days (4.17 ± 0.74), and finally perimenstrual days (4.05 ± 1.02), as depicted in Fig. 4. Repeated measures ANOVA with a Greenhouse–Geisser correction determined that mean motivation scores showed no statistically significant difference between hormonal events of the menstrual cycle ($F = 2.865$, $p = .07$). There were no effects of the covariates age and BMI, or contraceptive method on sports motivation.

During periovulatory (4.85 ± 1.01) and mid-follicular days (4.42 ± 0.84), there were also the highest sports intensity scores, followed by mid-luteal days (4.24 ± 0.81), and perimenstrual days (4.15 ± 1.08). The mean intensity scores are as well depicted in Fig. 4. The participants were most engaged in sport sessions on mid-follicular days (3.29 ± 1.1). Perimenstrual days showed the second highest frequency of sport session (2.82 ± 1.55), followed by midluteal (2.41 ± 1.32) and periovulatory (2.41 ± 1.00). The Friedman test determined no statistically significant difference between menstrual cycle phases of the menstrual cycle, for neither sports intensity ($\chi 2 = 4.13$; $p = 0.25$) nor frequency ($\chi^2 = 6.23$; $p = .1$).

3.3. Relationship between sports motivation, intensity, and frequency during the hormonal events

Within the dataset, two significant correlations were identified: a positive relationship between periovulatory motivation and periovulatory frequency, Spearman's $\rho = .56$, $p = .02$, and a negative relationship between periovulatory intensity and periovulatory frequency, Spearman's $\rho = -.56$, $p = .02$. Following Cohen's standards for effect size (Cohen, 1988), both correlations show a strong effect, with Spearman's $\rho = .56 > 0.5$ and Spearman's $\rho = |-.56| > 0.5$. Other correlations within perimenstrual, mid-follicular, periovulatory, and mid-luteal variables were not significant.

4. Discussion

This study investigated the variations in sports motivation across the menstrual cycle in active females using recommended methods for classifying and determining menstrual cycle phases.

The key findings are as follows: There were no distinctive differences in sports motivation across the menstrual cycle phases of the menstrual cycle among the tested active females. The highest scores for sports motivation were observed during the mid-follicular and periovulatory days, while slightly lower scores were noted during the mid-luteal and perimenstrual days. However, these differences did not reach statistical significance.

Analyses revealed that the periovulatory and mid-follicular days obtained the highest values in other aspects too, e.g., the highest number of sport sessions was conducted during mid-follicular days, and the highest sports intensity was reported during both the periovulatory and mid-follicular days, while not reaching statistical significance. However, sports motivation and frequency correlated on periovulatory days significantly. These findings support the results from Li et al. (2022), as general motivation was heightened in the late follicular phase. Furthermore, Crewther and Cook (2018) as well as Cook et al. (2018) have emphasized the importance of higher-fertility days, particularly ovulation, in sports motivation. This peak in motivation may be partly explained by evolutionary mechanisms, where increased drive and competitiveness during ovulation serve to enhance success in intrasexual competition. In this context, Crewther and Cook (2018) suggested a possible link to intrasexual competition, indicating that more competitive and motivated females could prevail against competitors within courtship behavior.

Sports motivation and sports intensity scores were lowest on perimenstrual days, while showing no significant difference compared to other menstrual cycle phases. All participants reported that they generally experiene menstruation-related symptoms such as painful cramps, headaches, back pain, or affective symptoms. A systematic review performed by Taim et al. (2023) demonstrated that menstrual cycle-related symptoms are particularly prevalent during premenstrual and menstrual days for female athletes. Studies on patients with chronic pain have shown that pain-related symptoms were associated with decreased motivation for tasks (Schwartz et al., 2014). Therefore, it is

Table 1
Overview of study sample (mean ± SD).

Demographic details	Mean ± SD
Age (years)	28.1 ± 5.3
Body mass index (kg/m^2)	22.5 ± 2.5
Menstrual cycle status	Mean ± SD
Menstrual cycle length (days)	28.3 ± 2.7
Positive LH test result obtained (cycle day)	15.2 ± 2.3
Contraceptive methods (multiple answers possible)	Mentions
Condoms	14
Copper intrauterine device	4
Calendar method	2
Other	1

LH = luteinizing hormone.

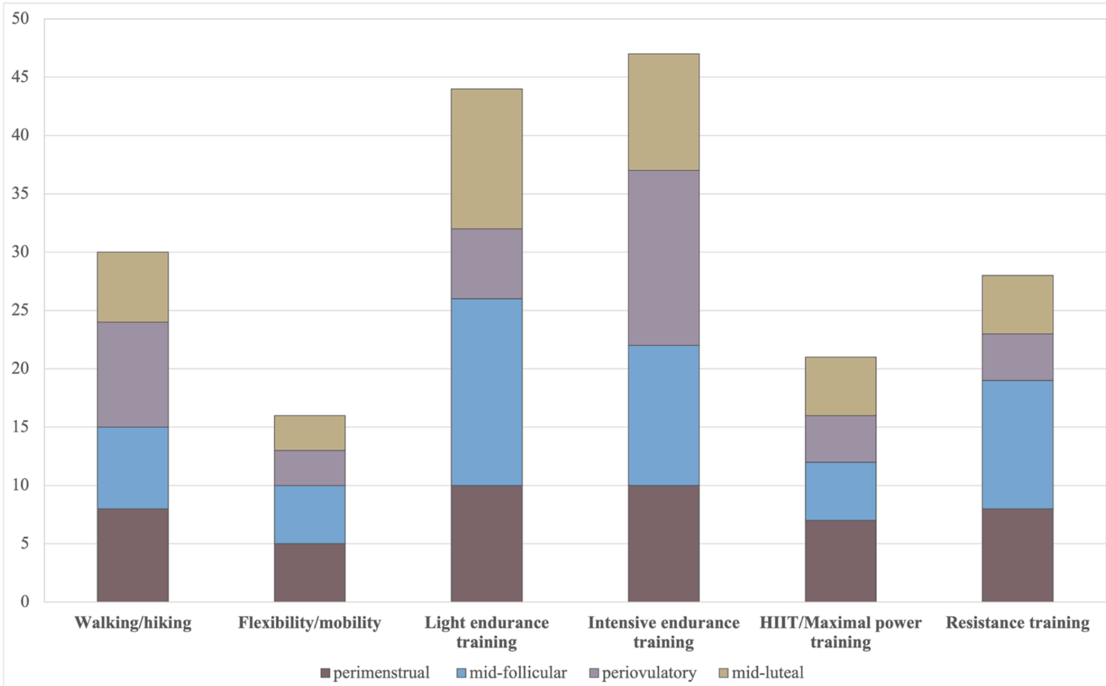

Fig. 3. Total amount of sport sessions per sports type with the respective proportion of each hormonal event.

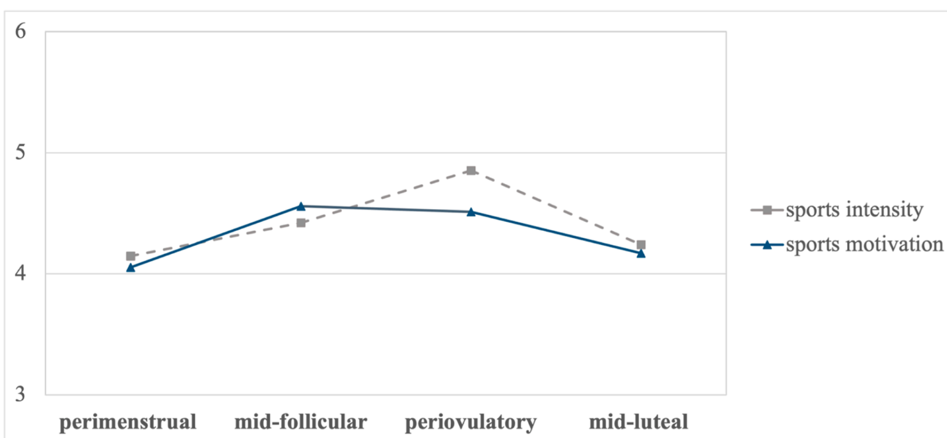

Fig. 4. Daily sports motivation scores and sport sessions intensity reported by participants on perimenstrual, mid-follicular, periovulatory, and mid-luteal days.

possible that the lowest scores in sports motivation and intensity were recorded during perimenstrual days in this study, as these days are characterized by dysmenorrhea (Taim et al., 2023). Despite this, the frequency of sport sessions was high during perimenstrual days, indicating that participants remained active even during days marked by painful or emotional symptoms. The sample's high general sports motivation may account for this sustained activity, even when daily motivation scores were at their lowest. Participants predominantly reported higher self-determined sports motivation types, indicating a high level of intrinsic motivation. Consequently, they may have continued their training despite experiencing discomfort or symptoms because they enjoy movement.

The positive correlation between periovulatory sports motivation and frequency suggests that the number of sports sessions increases with high motivation. This is consistent with research showing that sports motivation can enhance adherence to exercise. Considering the significance of regular physical activity for overall health (World Health Organization, 2024), it may be advantageous to encourage women to leverage the ovulation phase as a time for increased training volume. By utilizing peak sports motivation levels and their positive relationship with frequency, women could be motivated to engage in more training (but not necessarily higher intensity) sessions during this phase.

One of the limitations of our study relates to the scope of these training parameters. Specifically, this study focused primarily on session frequency and intensity, while omitting other important aspects such as training duration. This narrow focus may lead to potential misinterpretations of the data. For instance, a reduction in session frequency and intensity could be mistakenly interpreted as a decrease in overall training load. However, participants might have compensated for fewer or less intense sessions by engaging in longer training sessions during other days. Such compensatory behaviors could mitigate the perceived impact of menstrual cycle phases on total training volume and load, particularly on perimenstrual days that coincide with weekends. Future research should aim to incorporate comprehensive measures, including session duration, to capture total training load and provide a better understanding of how menstrual cycle phases influence training behaviors.

In contrast to former studies investigating variations in sports motivation across the menstrual cycle, only very few findings showed distinctive variations comparing the hormonal events. There might be multiple reasons for these diverse results. Firstly, the high general sports motivation of the sample could explain the missing effect of the menstrual cycle. The participants had reported highly self-determined sports motivation types (i.e., intrinsic, integrated, and identified) in their initial demographic questionnaire, indicating that their sports motivation is inherently high and more autonomous (Pelletier et al., 2013; Vallerand, 2007). Thus, the absent effect of the menstrual cycle might be a result of an inherently highly motivated sample, which generally exhibits low fluctuations within their sports motivation. An examination of the motivation scores for each menstrual cycle phase reflects that the standard deviations are, in fact, quite small. This assumption appears further reasonable, as former studies did not measure general sports motivation via the Sport Motivation Scale II. However, Crewther and Cook (2018) as well as Cook et al. (2018) studied sports motivation in elite athletes, where a high level of general sports motivation can be assumed (Gould et al., 2002). There were further differences in study design in contrast to recent studies which might contribute to the diversity of findings. In this study, daily motivation scores were collected throughout various menstrual cycle phases and averaged for each event. In contrast, recent studies only administered motivation questionnaires on a few days during the entire menstrual cycle (Cook et al., 2018; Crewther & Cook, 2018; Prado et al., 2021), leading to fewer measurement points and a less comprehensive picture of motivation throughout the different menstrual cycle phases. Prado et al. (2021) measured motivation before, during, and after the sport session, unlike this study where participants reported their scores in the morning, even though the sport session may not have occurred until the evening. This temporal gap could have both advantageous and disadvantageous implications for measuring sports motivation. On one hand, requiring participants to report their sports motivation consistently in the morning may enhance measurement reliability, as it establishes a standardized time frame for data collection each day. On the other hand, this approach may introduce bias, as participants' perceptions of their sports motivation could be influenced by the amount of time remaining until the upcoming session. For instance, some athletes might report higher motivation levels in the morning if they are aware that their session is imminent, whereas others might report lower motivation if they perceive a longer interval until their next activity. These potential influences should be considered when interpreting the results.

The factors that have already been established as influential to sports motivation should be considered, when interpreting the connection of sports motivation and the menstrual cycle. The self-determination of each athlete can be influenced by a variety of factors, including genetic and biological factors (Spence & Lee, 2003) as well as social factors such as the support from coaches, family, and friends (Pelletier et al., 2013). Additionally, the level of pleasure and enjoyment experienced during physical activity plays a significant role in shaping an athlete's motivation (Beer et al., 2020). While hormonal fluctuations associated with the menstrual cycle can affect the female athlete's physiology, perception, and emotions (Kissow et al., 2022; Paludo et al., 2022; Sundström Poromaa & Gingnell, 2014), it is likely that the broader social context and individual experiences during exercise show greater significance in determining an athlete's overall motivation. Thus, understanding sports motivation requires a comprehensive approach that considers physiological and psychosocial elements too.

This study was the first to measure sports motivation in active females by classifying the menstrual cycle with the four menstrual cycle phases and by verifying these phases using a combination of LH tests and calendar-based counting. It should be noted that, due to the absence of estrogen and progesterone measurements, the interpretation of these results is limited. Specifically, conclusions regarding all menstrual cycle phases and their associated motivational scores must be drawn with caution, as only the perimenstrual and periovulatory events were verified, while the mid-follicular and mid-luteal phases were assumed. Additionally, this partial verification of menstrual cycle phases increases the risk of including participants with menstrual disturbances. This represents a limitation of the current analysis and poses a general obstacle in menstrual cycle research.

5. Conclusion

In summary, this study provides new insights into sports motivation and menstrual cycle research for active females. There appear to be no distinctive differences in sports motivation across the hormonal events of the menstrual cycle. This suggests only a minor association between the menstrual cycle and sports motivation, with sports motivation likely influenced by multiple other factors, such as coaches, support from family and friends, or the level of pleasure and enjoyment during exercise. These psychosocial factors warrant further investigation using mixed-method approaches, which can provide a deeper understanding of how they interact with each other and with the menstrual cycle. Such comprehensive research may identify the underlying mechanisms affecting sports motivation in active females and facilitate the development of targeted interventions to improve adherence to physical activity, thereby promoting better health and overall well-being. Additionally, future research might consider examining whether measuring the types of motivation not only once, but across the menstrual cycle can yield deeper insights into these dynamics. While these results support previous research findings only partially, they underscore the wide variability in menstrual cycle research outcomes, emphasizing the necessity of conducting further research using recommended or even more specific methods for classifying and verifying menstrual cycle phases, i.e. using direct measurements of estrogen and progesterone.

Data availability

Data can be made available on request.

CRediT authorship contribution statement

Laura Reusch: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Beate Zunner:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Susanne Tittlbach:** Methodology, Conceptualization. **Melinda Herfet:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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