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Cross sectional analysis of muscular strength and flexibility during the menstrual cycle in women engaged in strength training

Análisis transversal de la fuerza muscular y la flexibilidad durante el ciclo menstrual en mujeres que realizan entrenamiento de fuerza

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Abstract. Hormonal variations during the menstrual cycle (MC) impact muscular strength and flexibility in women practicing strength training, potentially leading to performance reductions and increased injury susceptibility. Understanding these variations across MC phases is crucial for precise training program guidance. This cross-sectional, exploratory study assessed muscular strength and flexibility levels during the MC in 20 women (aged 20-35) engaged in strength training for at least 6 months. The Sit and Reach Test (SRT) measured flexibility, and the 1-Maximum Repetition Test (1RM) leg extension evaluated muscular strength during menstrual, post-menstrual, and pre-menstrual phases. While the post-menstrual period showed the highest strength values (50.65 ± 17.70 kg), no significant differences were observed compared to other phases. However, flexibility was significantly higher in the post-menstrual period (29.43 ± 8.69 cm) compared to menstrual (p=0.002) and pre-menstrual phases (p=0.001). Statistically, no significant differences were found in strength performance. Nevertheless, flexibility appeared influenced by MC phases, with superior outcomes in the post-menstrual period. This research enhances our understanding of how MC phases may impact strength and flexibility in women engaged in strength training, providing valuable insights for tailoring training programs to individual needs.
Keywords: Hormonal fluctuations, Women's fitness, Exercise performance, Strength Training, Flexibility

Resumen. Variaciones hormonales durante el ciclo menstrual (CM) afectan la fuerza muscular y la flexibilidad en mujeres que practican entrenamiento de fuerza, lo que podría llevar a reducciones en el rendimiento y aumentar la susceptibilidad a lesiones. Comprender estas variaciones a lo largo de las fases del CM es crucial para una orientación precisa de los programas de entrenamiento. Este estudio transversal y exploratorio evaluó los niveles de fuerza muscular y flexibilidad durante el CM en 20 mujeres (de 20 a 35 años) comprometidas con el entrenamiento de fuerza durante al menos 6 meses. El Test de Sentarse y Alcanzar (SRT) midió la flexibilidad, y el Test de Repetición Máxima de una repetición (1RM) de extensión de piernas evaluó la fuerza muscular durante las fases menstrual, post-menstrual y pre-menstrual. Mientras que el período post-menstrual mostró los valores de fuerza más altos (50.65 ± 17.70 kg), no se observaron diferencias significativas en comparación con otras fases. Sin embargo, la flexibilidad fue significativamente mayor en el período post-menstrual (29.43 ± 8.69 cm) en comparación con las fases menstrual (p=0.002) y pre-menstrual (p=0.001). Estadísticamente, no se encontraron diferencias significativas en el rendimiento de la fuerza. No obstante, la flexibilidad pareció estar influenciada por las fases del CM, con resultados superiores en el período post-menstrual. Esta investigación mejora nuestra comprensión de cómo las fases del CM pueden afectar la fuerza y la flexibilidad en mujeres comprometidas con el entrenamiento de fuerza, proporcionando ideas valiosas para adaptar programas de entrenamiento a necesidades individuales.
Palabras clave: Fluctuaciones hormonales, Fitness femenino, Rendimiento del ejercicio, Entrenamiento de fuerza, Flexibilidad.

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Introduction

In fitness facilities, it is common to encounter complaints from female participants during their menstrual period. Many women express a reluctance to engage in training during this time, citing feelings of weakness, diminished strength, and a lack of motivation. Beyond these training-related concerns, the menstrual cycle (MC) contributes to other issues that impact the overall quality of life for women. These challenges can be attributed to metabolic and hormonal changes inherent to this phase of the female reproductive cycle (Schoenfeld et al., 2023; Muñoz et al., 2024).

Among the main hormones that fluctuate throughout the MC, estrogen and progesterone stand out. These fluctuations in these and other hormones result in several physiological changes, contributing to an understanding of variations in physical performance during the MC (Blagrove et al., 2020). The female metabolism undergoes significant changes during the MC. These alterations are primarily due to the actions of estrogen, a hormone with anabolic function, and progesterone, which acts on catabolic pathways. These hormones directly influence ATP production, thus affecting muscular system responses both during exercise (catabolic phase) and in adaptive processes (anabolic phase). This directly impacts muscle strength production capacity and the responses that training can induce (Kissow et al., 2022). However, to minimize fluctuations during the MC, hormonal replacement therapy, especially in cases of severe fluctuations such as those observed during menopause, can play a crucial role in restoring hormonal balance and relieving symptoms associated with hormonal fluctuations. Therefore, it can minimize variations in physical performance that women may experience during different phases of the cycle (Blagrove et al., 2020).

Considering these hormonal fluctuations, training methods involving the muscular strength component, such as those employed in strength training, may be influenced throughout the MC, resulting in performance fluctuations that could compromise the anticipated response.

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Consequently, the intensity and volume of strength training should be adjusted based on the potential responses of the muscular system, which must be tailored to the performance characteristics present in each phase of the MC (Blagrove et al., 2020; Kissow et al., 2022; Muñoz et al., 2024).

Another performance component that varies throughout the MC is flexibility. During this period, there is a variation in the concentration of relaxin, a hormone that regulates the reproductive system and induces the relaxation of connective tissues, affecting joints and ligaments, which can result in variations in flexibility performance. These variations can either enhance or diminish the range of joint movement, depending on the phase of the menstrual cycle, exerting a direct influence on overall performance (Miyazaki & Maeda, 2022).

Consequently, these changes may lead to limitations or instability in the joints, affecting joint stability and increasing susceptibility to injuries. Moreover, alterations in joint stability will compromise the torque generated for executing movements, thereby accentuating the force impact during the cycle (Blagrove et al., 2020; Miyazaki & Maeda, 2022).

In this context, analyzing the changes induced in this phase and understanding their recurring transformations becomes essential for healthcare professionals to act assertively in exercise intervention and planning. It is crucial to elucidate the effects, reactions, and transformations that the female body undergoes monthly, which will result in variations in physical responses (Ansdell et al., 2020; Blagrove et al., 2020). Therefore, training for women should have its volume and intensity conditions adjusted depending on the phase of the menstrual cycle (MC), which can lead to better exercise outcomes and, consequently, better adherence to regular exercise.

Based on these considerations, the present study aimed to analyze muscular strength and flexibility during the MC in women engaged in strength training, aiming to contribute to an appropriate direction of physical conditions during the MC and thus guide training loads more assertively for the female audience.

Methodology

Type of study and ethical criteria

This is a descriptive, cross-sectional research with an exploratory design (Thomas & Silverman, 2009), conducted at a gym in the city of Campina Grande, State of Paraíba, Brazil. The procedures employed in this research align with ethical criteria for studies involving human subjects, following Resolution (466/12) of the National Health Council. The research protocol was approved by the Research Ethics Committee of the State University of Paraíba (opinion: 4,974,177).

Study design

The sample comprised 20 women individually and personally invited over a two-week period during morning, afternoon, and night shifts. Recruitment was based on a group of 163 women enrolled in the gym where the research was conducted. Out of these, 58 were eligible for invitation (fitting within the inclusion criteria described below), and 32 expressed availability and/or interest in participating. However, only 20 participants met the inclusion criteria, which required them to have been performing strength training continuously for at least six months, with a weekly frequency of at least three times per week; to report having a regular MC (28 days); to be able to use or not use contraception (regardless of the method); and not to present any clinical condition that would limit the execution of the proposed tests.

After the selection process and signing of the informed consent form (ICF), participants completed a sociodemographic questionnaire to gather information on age, weight, height, MC pattern, and training history, aiming to characterize the sample.

Subsequently, the sit and reach test (SRT) for assessing flexibility and the 1-Maximum Repetition Test (1RM) for evaluating strength were administered on the first two days of the sociodemographic questionnaire, postmenstrual and premenstrual periods, following this order. To characterize the MC and perform tests during different periods, participants filled out a table indicating the possible dates of their MC, following the classification suggested by Weineck (2000), as follows: (1) menstrual period (days 1 to 3); (2) post-menstrual period (4th to 11th day); (3) intermenstrual period (12th to 22nd day); and pre-menstrual period (23rd to 28th day). The first test session began during the menstrual phase, with the onset date of the flow serving as a reference for subsequent dates. When the flow started, the already recruited participant would notify the main researcher, who would then individually perform the collection within 48 hours (2 days) of the flow's onset. Subsequently, following the MC table, tests were conducted between the first two days of the post-menstrual phase (4 or 5 days after the onset of the flow), and finally, between the first two days of the pre-menstrual phase (23 or 24 days after the flow). The results were recorded in a data collection spreadsheet by the researcher himself, and the participants only had access to the result values after the collection was completed (after tests in the pre-menstrual phase), reducing the risk of result bias (Figure 1).

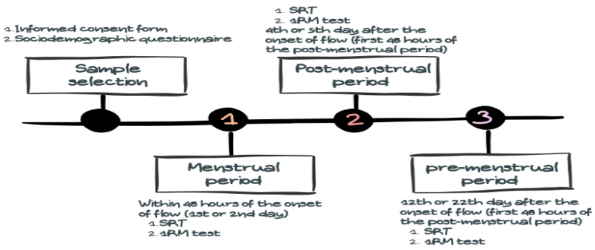

Figure 1. Study design.

Furthermore, to minimize errors, all participants were instructed to refrain from exercising for at least 24 hours before the collections to avoid influencing the results. The evaluation always began with STR, as flexibility capacity is more susceptible to performance variations due to previous effort than muscular strength (Fleck & Kraemer, 2017; Irawan et al., 2023), with the 1RM test being conducted afterwards. To reduce mechanical error in execution, test instructions were provided in advance, and before executing the data collection, participants performed a preliminary test, which was not recorded and aimed to familiarize them with the execution.

Collection procedures

The SRT was employed to assess flexibility capacities (Wells & Dillon, 1952; Irawan et al., 2023), focusing on the hamstring muscles and the lumbar region. For this test, the participant is seated with knees extended, lower limbs slightly separated, feet firmly supported on the wall of the wooden box (dimensions: 30.5cm x 30.5cm x 30.5cm), elbows extended, and upper limbs anteriorly flexed. From this initial position, the participant executes a forward movement with the torso, aiming to achieve the maximum possible displacement with the hands on a graduated scale in centimeters located at the top of the box. The zero point of the scale aligns with the footrest and advances ± 28 cm toward the participant.

Muscle strength was evaluated using the 1RM test (Fleck & Kraemer, 2017; Grgic et al., 2020) on the leg extension chair to identify potential differences in strength levels. The 1RM test involves a warm-up of 5 to 10 repetitions with a load ranging from 40% to 60% of the estimated by the evaluator 1RM, followed by a 1-minute rest. Subsequently, 3 to 5 repetitions are performed with a load ranging from 60% to 80% of the estimated by the evaluator 1RM, followed by a 2-minute rest. In an estimated manner, the load is then increased, and the participant attempts the 1RM. If performed successfully, there is another 3 to 5 minutes of rest, and the procedure is repeated for up to three attempts. When the participant is unable to complete the full movement correctly, the test is terminated, and the load obtained in the last successful execution is validated as the maximum load (Grgic et al., 2020). The initial position of the leg extension chair has the knees positioned at 110° of flexion, moving the leg to a position of 0° degrees of flexion. The knees are aligned with the axis of the equipment, and the contact with the pad provides external resistance between the feet and the shin. The hip remains flexed at approximately 90° (Vidmar et al., 2020).

Data analysis

Descriptive analysis was employed to characterize the sample, with mean and standard deviation values presented. Initially, an exploratory test confirmed the absence of outliers. The normality test (Shapiro-Wilk) indicated data normality across all comparisons. For evaluating differences between MC phases, the paired t-test was utilized. All analyses were conducted using SPSS 17.0, the full version in English, with a predetermined significance level ($p < 0.05$).

Results

The study comprised 20 women who had engaged in strength training for a minimum of 6 months, exercising at least three times a week. The participants had a mean age of 26.65 ± 5.51 years, a body mass of 64.1 ± 8.39 kg, and a height of 1.623 ± 0.05 cm.

Similar values were observed in the pre-menstrual and menstrual periods (48.35 ± 16.52 kg), showing no variations between these periods, which were lower than the values recorded in the post-menstrual period (50.65 ± 17.70 kg). In terms of flexibility, the lowest measurements were observed during the menstrual period (26.62 ± 8.86 cm) and premenstrual period (29.10 ± 8.81 cm), with the highest values noted in the postmenstrual period (29.43 ± 8.69 cm) (Table 1).

Table 1.
Muscle strength (1RM test) and flexibility found in the CM phases.

Periods	Strength (kg) Mean ± SD Median (Minimum - Maximum)	Flexibility (cm) Mean ± SD Median (Minimum - Maximum)
Pre-menstrual	48.35 ± 16.52 45.00 (25.00 - 76.00)	29.10 ± 8.81 28.10 (15.20 - 47.00)
Menstrual	48.35 ± 16.52 45.00 (25.00 - 76.00)	28.62 ± 8.86 27.83 (14.65 - 46.55)
Post-menstrual	50.65 ± 17.70 46.50 (25.00 - 78.00)	29.43 ± 8.69 28.00 (15.25 - 46.90)

Kg: kilograms; cm: centimeters; SD: standard deviation.

When compared pairwise between periods and across the main variables, a significant difference was observed in flexibility. Specifically, differences were noted between the pre-menstrual and menstrual period (1.64%; p=0.002), pre-menstrual and post-menstrual (-1.13%; p=0.002), and menstrual and post-menstrual (-2.82%; p=0.001). However, no significant difference was observed in the muscle strength variable between periods (Table 2).

Table 2.
Difference in strength (1RM test) and flexibility (TSA) between periods: pre-menstrual, menstrual and post-menstrual.

Comparison between periods	Strength Δ kg (%) ±SD (p)	Flexibility Δcm(%)±SD (p)
Pre-menstrual – menstrual	0.00 (0.00%) ± 16.30 (p=1.00)	0.48 (1.64%) ± 8.72 (p=0.002) *
Pre-menstrual – post-menstrual	2.3 (4.76%) ± 16.78 p=0.671)	0.33 (1.13%) ± 8.63 (p=0.002)*
Menstrual – post-menstrual	2.3 (4.76%) ± 16.78 (p=0.670)	0.81 (2.82%) ± 8.67 (p=0.001)*

Note: * p<0.005; Kg: kilograms; cm: centimeters; SD: standard deviation.

Discussion

The hormonal condition undergoes changes during the MC, leading to fluctuations in physical performance (Schoenfeld et al., 2023). In the follicular phase, which lasts from 1 to 14 days, the menstrual and post-menstrual periods occur. During menstruation, estrogen production begins (for ovulation control), a phase that typically exhibits a reduction in physical performance due to the low concentration of estrogen present, as it has not yet reached its optimal levels. Additionally, there are biological consequences associated with menstrual flow, such as flow intensity, pain, discomfort, and loss, which can increase the sensation of fatigue (Blagrove et al., 2020; Kissow et al., 2022; Muñoz et al., 2024).

In the post-menstrual phase, estrogen levels are already elevated, contributing to anabolic responses. Moreover, they are accompanied by an increase in noradrenaline production, which directly affects physical capacity, possibly reaching peak performance during this phase of the cycle (Kissow et al., 2022). This performance begins to decline but still remains satisfactory when reaching the ovulation phase, which typically occurs between 11 and 16 days before the subsequent menstruation. This is due to a sharp drop in estrogen, reducing anabolic capacity, and an increase in progesterone, which enhances catabolism, resulting in a hormonal concentration reversal and preparing the body for the luteal phase (Blagrove et al., 2020; Kissow et al., 2022; Muñoz et al., 2024).

In this study, no significant differences were observed in muscular strength between the periods, although the greatest strength was reported in the post-menstrual period, being 4.76% higher than in the pre-menstrual and menstrual periods. Although no significant differences in muscle strength were demonstrated between the periods, greater strength was found in the post-menstrual period, being 4.76% higher than in the menstrual period. This fact is justified by hormonal fluctuations leading to peak performance precisely during this period. This result was observed by Rodrigues, Correia & Wharton (2019), who found that in the mid-follicular phase (post-menstrual period), strength was greater than in the early follicular phase (menstrual period), assessing muscle strength through the 1-RM test in 15 women engaged in strength training for at least three years.

The discrepancies in results compared to the present study may have arisen due to the training time of the evaluated participants, as in this study, they had been training for a minimum of 6 months. This fact can be justified by the similar results found in the study by Michalski and colleagues (2020), who also did not observe significant differences in strength between the MC periods in women who had been strength training for at least 6 months.

Regarding the pre-menstrual period, muscular strength was identical to that of the menstrual period, equally showing lower values than the post-menstrual period (4.76%). These results are justified by the biological conditions of the luteal phase, where the pre-menstrual period occurs. At this moment, estrogen levels rise again but do not reach the same level as the post-menstrual period. There is also a higher concentration of progesterone and a reduction in noradrenaline concentrations (Blagrove et al., 2020; Kissow et al., 2022).

In addition to the aforementioned biological conditions, estrogen and progesterone concentrations affecting energy performance (anabolism and catabolism), the reduction of noradrenaline that occurs in this phase directly influences mood, leading to the situation known as premenstrual tension. Besides affecting mood, it causes feelings of fatigue, pain, and fluid retention, thus resulting in the worst physical performances during the pre-menstrual period (Pournasiri et al., 2023).

These results were also highlighted by Rodrigues, Correia & Wharton (2019) in the previously mentioned study, where they found the lowest strength outcomes in the luteal phase (pre-menstrual period) when compared to menstrual and post-menstrual periods, which yielded the best results. Similar findings were also observed by Pournasiri and colleagues (2023), who assessed the muscular strength of 37 athletes engaged in various sports for a minimum of three years. This was done through an isokinetic analysis of knee extensors and flexors, revealing that athletes exhibited higher strength indices in the post-menstrual period compared to the menstrual and pre-menstrual periods.

Concerning the flexibility variable, the present study observed a greater range of motion in the post-menstrual period (29.43 ± 8.69 cm), followed by the pre-menstrual period (29.10 ± 8.81 cm) and menstrual period (26.62 ± 8.86 cm), with significant differences noted between menstrual and pre-menstrual ($p=0.002$), menstrual and post-menstrual ($p=0.001$), and pre-menstrual and post-menstrual ($p=0.002$).

According to Miyazaki & Maeda (2022), joint stiffness is lower in the post-menstrual phase. These results were obtained by assessing stiffness in different phases of the MC in the knee's extension and flexion movements in eight women. This justifies the physiological hypothesis that increased estrogen in this phase not only contributes to strength aspects but also reduces joint stiffness, favoring the stretching of the quadriceps femoris and hamstring muscles, thereby promoting joint flexibility.

Examining joint instability, a factor that could directly influence flexibility, Ghangrekar and colleagues (2020) did not observe variations in instability during the three phases of the cycle, evaluating 90 women exercising for at least 3 months. Such findings, like those of the present study, do not confirm the hypothesis that relaxin favors ligament laxity, given that the highest concentrations of this hormone occur in the luteal phase (pre-menstrual period). In this phase, the degree of flexibility was lower than in the post-menstrual period ($p=0.002$).

Similar results were also found by Szajnowska and colleagues (2022), who assessed mobility through the toe-to-floor distance test, examining the mobility of the posterior chain of the lower limbs and trunk in 10 women. They exhibited more significant values in the late follicular phase (post-menstrual) when compared to the luteal phase (pre-menstrual).

Another relevant factor that can vary due to fluctuations in the MC is sports performance because changes in strength and flexibility, determinative capacities for numerous sports, can either enhance or impair performance. When assessing the perception of 130 volleyball athletes regarding the sensation of improved performance, Ergin & Kartal (2020) reported that athletes experience changes in performance according to menstruation, especially during the menstrual period (58.5%). After the menstrual period, they report feeling better regarding performance in training and competitions.

These factors can influence athletes' injuries, as observed by Barlow and colleagues (2023), who followed 26 football athletes and identified that the highest incidence of injuries occurs in the luteal phase (pre-menstrual period), especially those of muscular origin. Results that may arise from lower performance in this MC period due to the aforementioned biological responses.

Conclusions

Thus, it is concluded that women with a regular MC and engaged in strength training for at least 6 months exhibit slightly greater strength in the post-menstrual period, albeit without statistically significant results. On the other hand, flexibility appears to be influenced by the MC, showing better results in the post-menstrual phase.

However, the present study was conducted in a cross-sectional manner, with factors and personal conditions that could directly influence the obtained results. Additionally, the athletes had a low training history, which may make them less sensitive to performance variations during the MC.

Therefore, we suggest further research on the topic, adopting a longitudinal approach with women who have a more extensive training history, to identify possible variations in strength and flexibility during the MC. This perspective aims to provide accurate guidance regarding the period in which women demonstrate optimal physical performance.

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