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# Can Women Maintain Their Strength Performance Along the Menstrual Cycle?

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**Abstract:** This study aimed to explore the effect of the menstrual cycle (MC) phases (i.e., early follicular phase [EFP], late follicular phase [LFP], and mid-luteal phase [MLP]) on the repetitions performed to momentary failure in back squat and bench press exercises, as well as to determine subsequent fatigue (i.e., change in countermovement jump [CMJ], perceived effort, and muscle soreness). Twelve physically active eumenorrheic women performed a back squat and bench press set to momentary failure at 80% of the one-repetition maximum during the EFP, LFP, and MLP. The results revealed that subjects were able to perform 2.2 [0.2 to 4.2] more repetitions in the LFP with respect to the EFP for the back squat exercise ($p$ = 0.009), but no significant differences were observed for the bench press ($p$ = 0.354). The EFP displayed a larger CMJ height drop (−0.86 [−1.71 to −0.01] cm) with respect to the LFP (0.01 [−0.57 to 0.58] cm) and the MLP (−0.36 [−1.15 to 0.43] cm). Neither the perceived effort of each set to failure nor the resulting muscle soreness differed between MC phases. Therefore, practitioners should be aware that the MC could condition the repetitions available to momentary failure and the resulting allostatic load.

**Keywords:** resistance training; follicular phase; repetitions in reserve; fatigue; menstruation

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## 1. Introduction

The rise of women in sports does not seem to match their presence in sport and exercise research [1]. When considered, they are asked to take part during the early follicular phase (EFP) of their menstrual cycle (MC), when estrogen and progesterone hormone levels remain low, minimizing their potential impact on study outcomes [1]. Therefore, there is a need to explore women's performance response to the rest of the MC phases, which is remarkable from their perceptive standpoint [2].

Of the three hormonal environments that women experience along the MC (low levels of estrogen and progesterone at the menstrual or EFP, high and low levels of estrogen and progesterone at the pre-ovulatory or late follicular phase (LFP), and high levels of estrogen and progesterone at the post-ovulatory or mid-luteal phase (MLP) [3]), the LFP and MLP phases seems to represent two relevant moments for training planning given the inotropic effect of estrogen [4]. The formation of stronger cross-bridge cycles [5] and the increase in neuronal excitability [6] could enhance women´s strength performance, which could lead practitioners to prioritize certain training sessions during this period, with the understanding that estrogen is an anabolic hormone, with a neuroexcitatory function and with a possible positive effect on strength enhancement, while progesterone is a catabolic hormone, which has a cortical inhibitory function and could have a negative effect on strength production [7].

Regarding sports performance in the different phases of the menstrual cycle, no clear evidence has been found: McNulty et al. [8] indicate that performance is trivially reduced in the early follicular phase compared to the other phases of the menstrual cycle, while in the CMJ jumping height variable, worse results were observed in the early follicular and late luteal phases [9]. With respect to the isokinetic and isometric strength of knee flexors and extensors, better results were found in the ovulatory phase [10]. Although this differs due to the different manifestations and capacities analyzed, generally, worse results can be found in the early follicular phase and better results in the late follicular phase for isometric or dynamic strength [7].

To date, different strength-related measures have been compared along the MC in eumenorrheic women. On the one hand, Blagrove et al. [11] summarized those studies exploring the effect of the MC in different tasks eliciting large force outputs (i.e., maximal voluntary contraction, isokinetic peak torques) or rate of force development (i.e., jumping, cycling ergometry peak power output), observing that these were minimally affected by the MC [11]. On the other hand, Pereira et al. [12] summarized those studies exploring the effect of the MC on different time to failure tasks (i.e., isometric sustained, isometric intermittent, isokinetic, cycling, and running) reporting an equivalent performance enhancement distribution for the luteal and follicular phases, with the inconsistencies across studies potentially being explained by the different muscle groups involved (upper vs. lower body) or the type of contraction performed (isometric vs. dynamic). Colenso-Semple et al. [13] found, in their review of the effect of strength performance on the phase of the menstrual cycle, that the answer was unclear, and studies with good methodological quality, such as measurement of hormones through blood or urine analysis with detection of luteinizing hormone, should be carried out.

Given the task dependency effects of the MC, it would be valuable for practitioners to explore its effects on basic strength exercises (e.g., back squat, bench press) and on those relevant variables for strength training programming (e.g., one-repetition maximum [1-RM], repetitions in reserve). In this regard, the 1-RM seems to remain unchanged for the different MC phases either for the bench press [14] or the back squat exercises [15]. With respect to the range of repetitions available to momentary failure, Santana et al. [16] reported that women executed one to three more repetitions during the MLP with respect to the EFP at the half-squat exercise at 80% of the 1-RM. However, it should be noted that progesterone may inhibit the effects of estrogen, with the performance enhancements being conditioned to the E/P ratio during this phase [17]. Therefore, the pre-ovulatory surge in estrogen and suppressed progesterone concentrations at the LFP might induce further improvements and its analysis should also be contemplated. Finally, estrogen may have a positive effect on lower body performance in strength training, whereas no clear response is found for the upper body. These differences may be due to greater estrogen production when training larger muscle groups, such as the quadriceps after squat training versus the pectoral muscle group in bench press training [18,19].

Likewise, a growing interest is emerging with regard to the effect of the MC in the external and internal load management given that estrogen may help attenuate indices of post-exercise muscle damage [20]. Romero-Parra et al. [21] have recently summarized those studies evaluating the effect of the MC on different fatigue measures (i.e., muscle soreness, strength loss), revealing that the slightest muscle soreness increase and lower strength loss occurred in the MLP followed by the LFP and the EFP. However, it should be noted that the five studies included in the meta-analysis that evaluated the muscle soreness induced light to moderate muscle damage; how subjects would respond to a more strenuous fatiguing protocol remains unknown [21]. Likewise, the three studies evaluating the strength loss response did not compare all the MC phases [21].

Therefore, to overcome the above limitations and knowledge gaps, the present study aimed to explore the effect of the MC phases (i.e., EFP, LFP, and MLP) on the repetitions performed to momentary failure in the back squat and bench press exercises, as well as to determine the subsequent fatigue (i.e., change in countermovement jump [CMJ], perceived effort, and muscle soreness).

## 2. Materials and Methods

### *2.1. Experimental Approach to the Problem*

A repeated-measures design was used to explore the effect of the MC on the repetitions performed to momentary failure in back squat and bench press exercises on the Smith machine and the subsequent fatigue (i.e., change in CMJ, perceived effort, and muscle soreness) (Figure 1). The MC phases were determined using a combination of the calendar-based method and a urine luteinizing hormone (LH) urine kit [3]. Participants were tested during the menstrual or EFP, the pre-ovulatory or LFP, and the post-ovulatory or MLP. Prior to each testing session, participants were instructed to abstain from alcohol, caffeine, and strenuous physical activity, and to replicate their dietary intake, all of which were confirmed through verbal questioning.

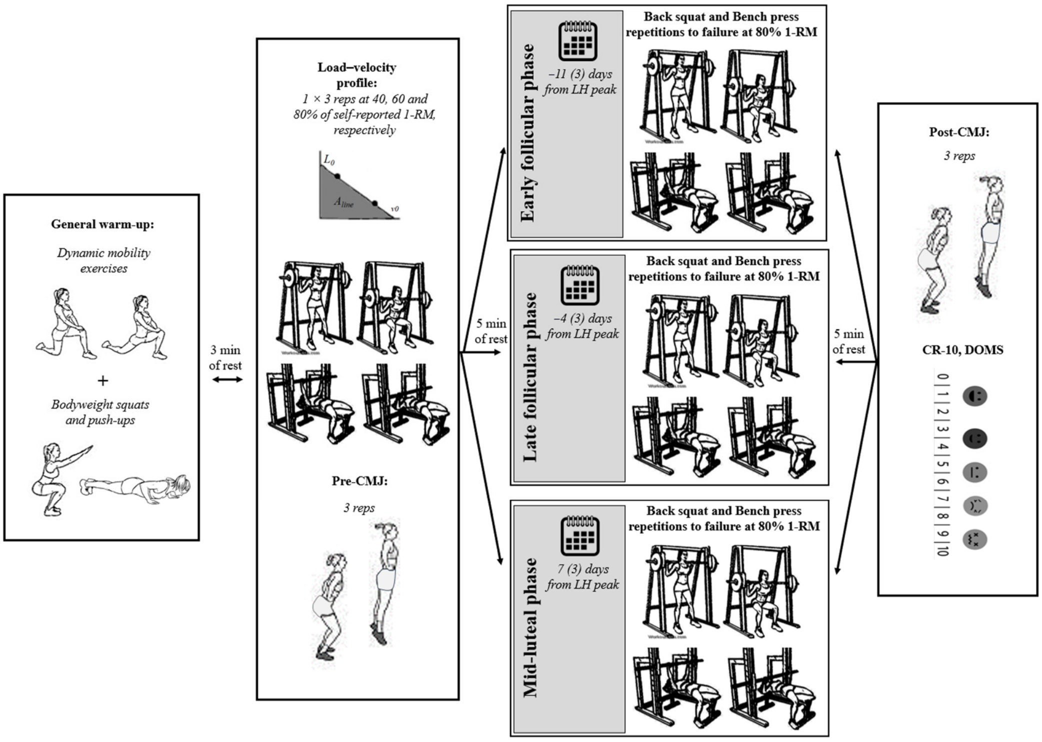


**Figure 1.** Experimental design.

### *2.2. Subjects*

Twelve physically active eumenorrheic women volunteered to participate in this study (mean ± standard deviation [SD]: age = 23.0 ± 3.2 years [range: 19–31]; body height = 1.63 ± 0.05 m; body mass = 59.8 ± 8.0 kg; back squat 1-RM: 1.21 ± 0.21 kg/kg of body mass; bench press 1-RM: 0.62 ± 0.07 kg/kg of body mass). They were familiar with strength training, exercise technique, and had been using self-perceived scales for at least 6 months. All participants were required to meet the following inclusion criteria: (i) be between 18 and 30 years old, (ii) be physically active but non-athletes, according to the guidelines of the American College of Sports Medicine [22], (iii) have a regular menstrual cycle (MC) lasting 21 to 35 days for the past six months, and (iv) not taking any hormonal contraceptives. All subjects were informed about the study procedures and provided written informed consent prior to the study. The study protocol adhered to the principles of the Declaration of Helsinki and received approval from the institutional review board (CEI-08/2022). The sample size was selected based on convenience, and a post hoc power analysis was conducted using G*Power software (version 3.1) with $\alpha = 0.05$, power $(1 - \beta) = 0.8$, and an effect size of 0.25, and the statistical test ANOVA: repeated measures within factors, yielding a moderate power of 0.41.

*2.3. Determination of the MC Phases*

Subjects monitored their MC phases through the mobile application (Mycalendar® Period-tracker, SimpleInnovation, Redmond, WA, USA) and a self-detected ovulation kit (Ovulation LH Test Strip, Cuckool, Nantong, China). They were tested at the onset of the MC (−11 [3] days from LH peak) for the menstrual or EFP. Once the menses had ended, they were instructed to assess the urine LH surge at midmorning until a positive test result had occurred. They were cited on days 6–12 for the pre-ovulatory or LFP evaluation (−4 [3] days from LH peak), and later confirmed an LH-positive result. Then, they were tested at the post-ovulatory or MLP on day 20–24 (7 [3] days from LH peak).

*2.4. Bench Press and Back Squat Smith Machine 1-RM*

Bench press and back squat exercises were selected to be used with the Smith machine. Subjects performed a standardized warm-up that consisted of five minutes of dynamic mobility exercises focused on shoulder, spine, hip, and ankle mobility and self-selected bodyweight half-squats and normal or kneeling push-ups, depending on the subjects' skill level. After a brief rest of 1 min, they performed one set of three repetitions at 40, 60, and 80% of self-reported 1-RM. Inter-set rest was fixed at three minutes. The fastest mean propulsive velocity collected at the heaviest load was used to estimate the 1-RM value through generic equations for the bench press [23] and back squat exercises [24]. A validated linear position transducer (Smartcoach Europe, Stockholm, Sweden) was used to record the mean propulsive velocity of all repetitions throughout the study [25]. Subjects received verbal velocity performance feedback immediately after completing each repetition to encourage maximal effort.

*2.5. Back Squat and Bench Press Repetitions to Momentary Failure at 80% 1-RM*

Subjects started each testing session with the previously described warm-up procedure. For the back squat, they were instructed to stand in a fully extended position with feet approximately shoulder-width apart, holding the barbell across the back at the level of the acromion. From this position, they were required to descend at a controlled velocity until the tops of their thighs were parallel to the floor, then immediately return to the initial position as quickly as possible [26]. For the bench press, participants used the five-point body contact technique (head, upper back, and buttocks in firm contact with the bench, and both feet flat on the floor) with a self-selected grip width that was maintained throughout all lifts. They performed a downward phase until the barbell touched their chest at the lower sternum, held this position for approximately two seconds, and executed an upward phase as quickly as possible, without bouncing. Verbal encouragement was provided throughout the tests, and momentary failure was defined as the point at which participants could no longer complete the concentric portion of a repetition with full range of motion and proper form [27]. The total repetitions performed, along with the maximum, mean, and minimum propulsive velocities for each set, were recorded for subsequent analysis.

*2.6. Acute Fatigue Measures: CMJ, Effort and Muscle Soreness Perception*

Prior to and after completing the back squat set to momentary failure, subjects were asked to perform three maximal CMJs. Participants were instructed to descend quickly until their thighs were parallel to the floor, then immediately jump as high as possible. For both exercises, participants were required to keep their hands on their hips to prevent any arm swing. Floor-level, high-density photoelectric cells (OptoGait; Microgate, Bolzano, Italy) were used to estimate vertical jump height via the flight time method, which has demonstrated a high level of agreement with force plate measurements [28]. The maximum height achieved by each participant was recorded for pre- and post-test comparisons.

After completing the back squat and bench press sets to momentary failure, subjects were immediately asked about their perceived effort using Borg's category-ratio 10 scale (CR-10) [29]. The day after, subjects were also asked to rate their muscle soreness, sleep quality, and stress using a seven-point scale where one indicates "very sore" and seven indicates "feeling great" [30]. In order to avoid non-valid values, all subjects were previously familiarized with both scales.

### 2.7. Statistical Analyses

Data are presented as the mean and SD. The normal distribution of the data was confirmed by the Shapiro–Wilke test ($p > 0.05$), except for the CR-10 and muscle soreness perception. A one-way repeated-measures analysis of variance (ANOVA) was conducted on the repetitions performed to momentary failure in the back squat and bench press exercises. Pairwise comparisons were identified using Bonferroni post hoc corrections. A two-way repeated-measures ANOVA (MC phases [EFP vs. LFP vs. MLP] $\times$ time [pre and post]) was applied to determine the evolution of the CMJ height after the back squat set. The Friedman ANOVA test was used to compare the CR-10 and muscle soreness perception between MC phases. Statistical analyses were performed using the software package SPSS (IBM SPSS version 25.0, Chicago, IL, USA). Alpha was set at a $p \leq 0.05$.

## 3. Results

### 3.1. Back Squat Repetitions to Momentary Failure at 80% 1-RM

No significant effects of the MC were reported for the absolute load associated with the 80% 1-RM ($F_{(2,22)} = 1.0$; $p = 0.384$). There was a significant difference in the repetitions performed to momentary failure between the MC phases ($F_{(2,22)} = 5.91$; $p = 0.009$) (Table 1). Subjects performed 2.2 [0.2 to 4.2] more repetitions in the LFP with respect to the EFP ($p = 0.037$) (Figure 2).

**Table 1.** Comparison of the sets performed to momentary failure in the back squat and bench press exercises in the different menstrual cycle (MC) phases.

| | EFP | LFP | MLP | ANOVA |
|---|---|---|---|---|
| Back squat | | | | |
| Maximum velocity (m/s) | 0.57 (0.08) | 0.57 (0.08) | 0.56 (0.09) | $F_{(2,22)} = 0.38$; $p = 0.691$ |
| Repetitions | 12.3 (3.2) | 14.5 (4.0) | 13.7 (4.3) | $F_{(2,22)} = 5.91$; $p = 0.009$ |
| CR-10 | 6.9 (1.3) | 6.9 (2.0) | 6.6 (2.0) | $\chi^2_{(2, N = 12)} = 1.06$; $p = 0.590$ |
| Bench press | | | | |
| Maximum velocity (m/s) | 0.47 (0.05) | 0.49 (0.08) | 0.48 (0.06) | $F_{(2,22)} = 0.86$; $p = 0.437$ |
| Repetitions | 9.3 (2.4) | 9.9 (2.3) | 9.2 (3.1) | $F_{(2,22)} = 1.09$; $p = 0.354$ |
| CR-10 | 5.8 (1.6) | 5.7 (2.0) | 6.2 (1.6) | $\chi^2_{(2, N = 12)} = 2.4$; $p = 0.293$ |
| Muscle soreness | 2.3 (1.4) | 2.7 (1.5) | 2.7 (1.0) | $\chi^2_{(2, N = 12)} = 2.88$; $p = 0.237$ |

Data are presented as mean or standard deviation. ANOVA: analysis of variance; F: Snedecor's F; $\chi^2$ = Chi-Square $p$: $p$-value.

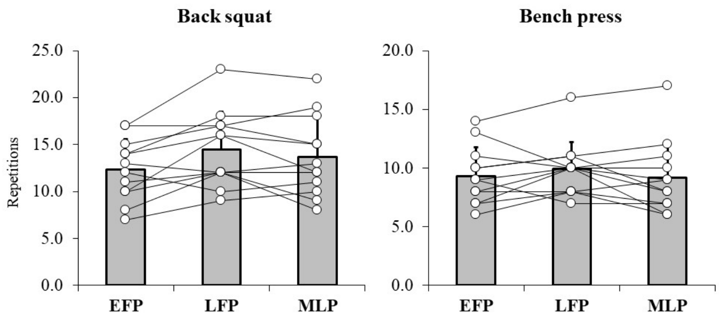


**Figure 2.** Group and individual response to the different MC phases for the repetitions performed to momentary failure in the Smith machine back squat and bench press exercises. EFP: early follicular phase, LFP: late follicular phase; MLP: mid-luteal phase.

*3.2. Bench Press Repetitions to Momentary Failure at 80% 1-RM*

No significant effects of the MC were reported for the absolute load associated with the 80% 1-RM ($F_{(2,22)}$ = 1.3; $p$ = 0.287). No significant differences were reported for the repetitions performed to momentary failure between the MC phases ($F_{(2,22)}$ = 1.09; $p$ = 0.354).

*3.3. Acute Fatigue: CMJ*

The MC phase × time interaction did not reach statistical significance for the CMJ ($F_{(2,30)}$ = 1.4; $p$ = 0.271). There was no significant main effect of the MC phase ($F_{(2,22)}$ = 0.3; $p$ = 0.743). A significant time effect was observed ($F_{(1,15)}$ = 6.8; $p$ = 0.024) (Table 2). Specifically, the CMJ height changed −0.86 [−1.71 to −0.01] cm at the EFP, 0.01 [−0.57 to 0.58] cm at the LFP, and −0.36 [−1.15 to 0.43] cm at the MFP (Figure 3).

**Table 2.** Comparison of the countermovement jump (CMJ) heights performed previously and after the back squat set to momentary failure in different menstrual cycle (MC) phases.

| Variable | MC Phase | Pre | Post | Δ (95% CI) | ANOVA | | |
|---|---|---|---|---|---|---|---|
| | | | | | MC Phase | Time | Interaction |
| CMJ (cm) | EFP<br>LFP<br>MLP | 24.1 (4.7)<br>23.9 (4.6)<br>24.0 (5.2) | 23.2 (4.9)<br>23.9 (4.7)<br>23.6 (5.1) | −0.86 (−1.71 to −0.01)<br>0.01 (−0.57 to 0.58)<br>−0.36 (−1.15 to 0.43) | $F_{(2,22)}$ = 0.30; $p$ = 0.743 | $F_{(1,15)}$ = 6.8; $p$ = 0.024 | $F_{(2,30)}$ = 1.4; $p$ = 0.271 |

Data are presented as mean ± standard deviation. EFP: early follicular phase; LFP: late follicular phase; MLP: mid-luteal phase; 95% CI: 95% confidence interval; ANOVA: analysis of variance; F: Snedecor's F; and $p$: $p$-value.

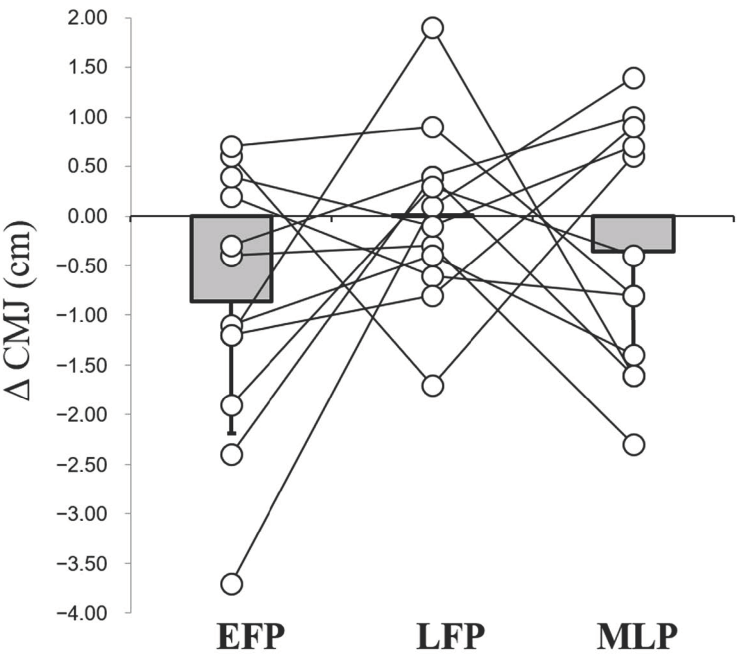


**Figure 3.** Group and individual response for the countermovement jump (CMJ) height changes performed previously and after the back squat set performed to momentary failure in different menstrual cycle phases. EFP: early follicular phase, LFP: late follicular phase, and MLP: mid-luteal phase.

*3.4. CR-10 and Muscle Soreness*

There were no significant differences between MC phases for the CR-10 ($\chi^2_{(2,\ N = 12)}$ = 4.47; $p$ = 0.107) and muscle soreness ($\chi^2_{(2,\ N = 12)}$ = 2.88; $p$ = 0.237) perception.

### *3.5. Sleep Quality and Stress*

There were no significant differences between MC phases and sleep quality ($p = 0.626$) and between MC and stress ($p = 0.264$). The best sleep quality was observed for LPF (2.417) versus EFP (2.917).

## 4. Discussion

The results revealed that subjects were able to perform 2.2 [0.2 to 4.2] more repetitions in the LFP with respect to the EFP for the back squat exercise, but no significant differences were observed for the bench press. Although no significant interactions were observed for the CMJ performed prior to and after the back squat set, the EFP displayed a larger CMJ height drop (−0.86 [−1.71 to −0.01] cm) with respect to the LFP (0.01 [−0.57 to 0.58] cm) and the MLP (−0.36 [−1.15 to 0.43] cm). From a perceptive standpoint, neither the perceived effort of each set to failure nor the resulting muscle soreness differed between MC phases.

The inotropic effect of estrogen [4] was not evident in the maximal strength performance (i.e., 1-RM) of the back squat and bench press exercises. Different studies support the notion that 1-RM values remain stable throughout the MC in eumenorrheic women [14,15]. Similarly, the different hormonal phases of the MC do not appear to influence the parameters of the force–velocity relationship, such as the load–axis intercept (L0), velocity–axis intercept (v0), and the area under the L-V relationship curve (Aline) [31,32]. Therefore, it seems that trainers should not be aware of adjusting training loads along the MC.

Significant effects were observed for the range of repetitions available for the different phases of the MC for the back squat, but not for the bench press exercise. These measures have scarcely been analyzed, although similar results have been reported [16,33]. Arazi et al. [33] observed non-significant differences in the repetitions performed at 60% 1-RM of the bench press exercise between the EFP, LFP, and MLP of the recreationally trained eumenorrheic women recruited. On the other hand, Santana et al. [16] compared the repetitions performed to concentric failure at 80% 1-RM of the half-squat Smith machine exercise at the EFP and MLP, observing a performance decrement during the former phase of one to three repetitions for the trained eumenorrheic women recruited. Differences of a similar magnitude were reported between the EFP and LFP (2.2 [0.2 to 4.2] repetitions), which reveal a plausible role of estrogen in increasing the women's work capacity. These results are of paramount importance for women's strength training planning according to the latest evidence reported in the velocity-based resistance training field, which supports the assertion that a higher velocity loss threshold in the set (20 vs. 40%) induces superior gains in 1-RM and in low- and high-velocity lifts [34]. Therefore, complementing these recommendations, it seems that these increased workloads should be performed at the high-estrogen-levels period of the MC, and it could be that in the real-world context it is more efficient to perform strength training at or near muscle failure in the late follicular phase, both in terms of performance and neuromuscular fatigue.

Phase-based training has been proposed as a potential method for inducing superior adaptations with respect a regular strength training throughout the menstrual cycle [35]. In addition to the aforementioned superior work capacity, it seems that estrogen and progesterone could determine how women cope with training given their respective anabolic and catabolic roles [35]. The different allostatic loads were reflected in the larger CMJ height drop observed at the EFP (−0.86 [−1.71 to −0.01] cm) with respect to the maintenance at the LFP (0.01 [−0.57 to 0.58] cm) and the MLP (−0.36 [−1.15 to 0.43] cm). Thompson et al. [36] also reported a larger CMJ height drop at the EFP (~9%) with respect to the LFP (~3%) of the eumenorrheic women recruited after a leg resistance training session. Likewise, Morenas-Aguilar et al. [31] determined that the lower limbs' L-V relationship variables were slightly more reduced during EFP (L0: −4.0%; v0: −0.2%, Aline: −4.3%) with respect to the LFP (L0: −2.9%; v0: +0.2%; Aline: −2.7%) and MLP (L0: −2.9%; v0: +2.3%; Aline: −0.8%) after a maximal incremental graded exercise test. Therefore, these results suggest that a given workload will have different impacts depending on the MC phase in which it is applied.

From a perceptive standpoint, neither the perceived effort of each set to failure, nor the resulting muscle soreness, nor sleep quality, nor the stress differed between MC phases. In this regard, it is notable that women may have a higher or lower predisposition to increased muscle pain or effort perception due to experiencing primary dysmenorrhea [37]. It has been suggested that the proportion of women experiencing this is about 25%, increasing to up to 90% in adolescents [37]. Thus, there is a high prevalence of avoiding the EFP in the training or competing schedule [2], whereby practitioners are encouraged to monitor their athletes' individual response through perceptual and objective measures as a well-being scale to monitor muscle soreness, stress, or sleep quality or a Borg scale, respectively. Also, these tools should be used in the real context due to the large inter- and intra-individual variability in these variables, which can interfere with sporting performance.

Despite the previously mentioned results, readers should be mindful of a couple of limitations. First, there was not an MC register during the previous months of the study, though subjects were asked if they had a regular MC and no use of HC. Nonetheless, self-detected ovulation kits and the self-registration of MC phases through mobile application were used to determine the MC phases for the test duration, which is a tool that is recommended for determining MC phases in a more objective way [38]. Second, there was a limited number of participants ($n$ = 13), but with moderate statistical power for this sample size. Third, a generic equation was used for RM estimation. While this was not the most correct way to achieve this, it was more operational to use it to analyze repetitions to failure with a relative load.

## 5. Conclusions

Practitioners should be aware that the MC could condition the repetitions available to momentary failure. Specifically, the LFP seems to be an appropriate time for increasing the training volume in the back squat exercise. The current results also revealed that the MC influences the resulting allostatic load, with eumenorrheic women being more susceptible to a higher degree of fatigue during the EFP. However, this was not plausible from the perceptive standpoint, whereby practitioners are encouraged to monitor their athletes' individual responses through perceptual and objective measures.

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## References

1. Bruinvels, G.; Burden, R.J.; McGregor, A.J.; Ackerman, K.E.; Dooley, M.; Richards, T.; Pedlar, C. Sport, exercise and the menstrual cycle: Where is the research? *Br. J. Sports Med.* **2017**, *51*, 487–488. [CrossRef] [PubMed]
2. McNamara, A.; Harris, R.; Minahan, C. That time of the month'... for the biggest event of your career! Perception of menstrual cycle on performance of Australian athletes training for the 2020 Olympic and Paralympic Games. *BMJ Open Sport Exerc. Med.* **2022**, *8*, e001300. [CrossRef] [PubMed]
3. de Jonge, X.J.; Thompson, B.; Ahreum, H.A.N. Methodological Recommendations for Menstrual Cycle Research in Sports and Exercise. *Med. Sci. Sports Exerc.* **2019**, *51*, 2610–2617. [CrossRef] [PubMed]

4. Collins, B.C.; Laakkonen, E.K.; Lowe, D.A. Aging of the musculoskeletal system: How the loss of estrogen impacts muscle strength. *Bone* **2019**, *123*, 137–144. [CrossRef] [PubMed]
5. Lowe, D.A.; Baltgalvis, K.A.; Greising, S.M. Mechanisms behind Estrogens' Beneficial Effect on Muscle Strength in Females. *Exerc Sport Sci. Rev.* **2010**, *38*, 61. [CrossRef]
6. Smith, M.J.; Keel, J.C.; Greenberg, B.D.; Adams, L.F.; Schmidt, P.J.; Rubinow, D.A.; Wassermann, E.M. Menstrual cycle effects on cortical excitability. *Neurology* **1999**, *53*, 2069. [CrossRef]
7. Niering, M.; Wolf-Belala, N.; Seifert, J.; Tovar, O.; Coldewey, J.; Kuranda, J.; Muehlbauer, T. The Influence of Menstrual Cycle Phases on Maximal Strength Performance in Healthy Female Adults: A Systematic Review with Meta-Analysis. *Sports* **2024**, *12*, 31. [CrossRef]
8. McNulty, K.L.; Elliott-Sale, K.J.; Dolan, E.; Swinton, P.A.; Ansdell, P.; Goodall, S.; Thomas, K.; Hicks, K.M. The Effects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis. *Sports Med.* **2020**, *50*, 1813–1827. [CrossRef]
9. Dam, T.V.; Dalgaard, L.B.; Sevdalis, V.; Bibby, B.M.; Janse de Jonge, X.; Gravholt, C.H.; Hansen, M. Muscle Performance during the Menstrual Cycle Correlates with Psychological Well-Being, but Not Fluctuations in Sex Hormones. *Med. Sci. Sports Exercise* **2022**, *54*, 1678–1689. [CrossRef]
10. Pournasiri, F.; Zarei, M.; Mainer-Pardos, E.; Nobari, H. Isometric and isokinetic strength of lower-limb muscles in female athletes during different phases of menstrual cycle: A causal-comparative study. *BMC Women's Health* **2023**, *23*, 657. [CrossRef]
11. Blagrove, R.C.; Bruinvels, G.; Pedlar, C.R. Variations in strength-related measures during the menstrual cycle in eumenorrheic women: A systematic review and meta-analysis. *J. Sci. Med. Sport* **2020**, *23*, 1220–1227. [CrossRef] [PubMed]
12. Pereira, H.M.; Larson, R.D.; Bemben, D.A. Menstrual Cycle Effects on Exercise-Induced Fatigability. *Front. Physiol.* **2020**, *11*, 517. [CrossRef] [PubMed]
13. Colenso-Semple, L.M.; D'Souza, A.C.; Elliott-Sale, K.J.; Phillips, S.M. Current evidence shows no influence of women's menstrual cycle phase on acute strength performance or adaptations to resistance exercise training. *Front. Sports Act. Living* **2023**, *5*, 1054542. [CrossRef] [PubMed]
14. García-Pinillos, F.; Lago-Fuentes, C.; Bujalance-Moreno, P.; Pérez-Castilla, A. Effect of the menstrual cycle when estimating 1 repetition maximum from the load-velocity relationship during the bench press exercise. *J. Strength Cond. Res.* **2022**, *36*, e55–e58. [CrossRef] [PubMed]
15. Romero-Moraleda, B.; Del Coso, J.; Gutiérrez-Hellín, J.; Ruiz-Moreno, C.; Grgic, J.; Lara, B. The influence of the menstrual cycle on muscle strength and power performance. *J. Hum. Kinet.* **2019**, *68*, 123. [CrossRef]
16. Santana, O.; Vieira-Cavalcante, V.; Caetano Paulo, A.; Rodacki, C.; Bertuzzi, R.; Lima-Silva, A.E.; Cristina-Souza, G. Caffeine reverts loss of muscular performance during the early-follicular phase in resistance-trained naturally menstruating women. *J. Sports Sci.* **2022**, *40*, 1592–1601. [CrossRef]
17. Oosthuyse, T.; Bosch, A.N. The effect of the menstrual cycle on exercise metabolism: Implications for exercise performance in eumenorrhoeic women. *Sports Med.* **2010**, *40*, 207–227. [CrossRef]
18. Jung, R.; Gehlert, S.; Geisler, S.; Isenmann, E.; Eyre, J.; Zinner, C. Muscle strength gains per week are higher in the lower-body than the upper-body in resistance training experienced healthy young women-A systematic review with meta-analysis. *PLoS ONE* **2023**, *18*, e0284216. [CrossRef]
19. Kissow, J.; Jacobsen, K.J.; Gunnarsson, T.P.; Jessen, S.; Hostrup, M. Effects of Follicular and Luteal Phase-Based Menstrual Cycle Resistance Training on Muscle Strength and Mass. *Sports Med.* **2022**, *52*, 2813–2819. [CrossRef]
20. Enns, D.L.; Tiidus, P.M. The influence of estrogen on skeletal muscle: Sex matters. *Sports Med.* **2010**, *40*, 41–58. [CrossRef]
21. Romero-Parra, N.; Cupeiro, R.; Alfaro-Magallanes, V.M.; Rael, B.; Rubio-Arias, J.Á.; Peinado, A.B.; Benito, P.J. Exercise-induced muscle damage during the menstrual cycle: A systematic review and meta-analysis. *J. Strength Cond. Res.* **2021**, *35*, 549–561. [CrossRef] [PubMed]
22. Pescatello, L.S.; Riebe, D.; Thompson, P.D. *ACSM's Guidelines for Exercise Testing and Prescription*; Lippincott Williams & Wilkins: Philadelphia, PA, USA, 2014.
23. González-Badillo, J.J.; Sánchez-Medina, L. Movement velocity as a measure of loading intensity in resistance training. *Int. J. Sports Med.* **2010**, *31*, 347–352. [CrossRef] [PubMed]
24. Sánchez-Medina, L.; Pallarés, J.G.; Pérez, C.E.; Morán-Navarro, R.; González-Badillo, J.J. Estimation of relative load from bar velocity in the full back squat exercise. *Sports Med. Int. Open* **2017**, *1*, 80–88. [CrossRef]
25. Weakley, J.; Morrison, M.; García-Ramos, A.; Johnston, R.; James, L.; Cole, M.H. The Validity and Reliability of Commercially Available Resistance Training Monitoring Devices: A Systematic Review. *Sports Med.* **2021**, *51*, 443–502. [CrossRef]
26. Jiménez-Alonso, A.; García-Ramos, A.; Cepero, M.; Miras-Moreno, S.; Rojas, F.J.; Pérez-Castilla, A. Effect of Augmented Feedback on Velocity Performance During Strength-Oriented and Power-Oriented Resistance Training Sessions. *J. Strength Cond. Res.* **2020**, *36*, 1511–1517. [CrossRef]
27. Steele, J.; Fisher, J.; Giessing, J.; Gentil, P. Clarity in reporting terminology and definitions of set endpoints in resistance training. *Muscle Nerve* **2017**, *56*, 368–374. [CrossRef]
28. Glatthorn, J.F.; Gouge, S.; Nussbaumer, S.; Stauffacher, S.; Impellizzeri, F.M.; Maffiuletti, N.A. Validity and reliability of Optojump photoelectric cells for estimating vertical jump height. *J. Strength Cond. Res.* **2011**, *25*, 556–560. [CrossRef]
29. Borg, G. *Borg's Perceived Exertion and Pain Scales*; Human Kinetics: Champaign, IL, USA, 1998.

30. Hooper, S.L.; Mackinnon, L.T. Monitoring overtraining in athletes: Recommendations. *Sports Med.* **1995**, *20*, 321–327. [CrossRef]
31. Morenas-Aguilar, M.D.; Ruiz-Alias, S.A.; Blanco, A.M.; Lago-Fuentes, C.; García-Pinillos, F.; Pérez-Castilla, A. Does the Menstrual Cycle Impact the Maximal Neuromuscular Capacities of Women? An Analysis Before and After a Graded Treadmill Test to Exhaustion. *J. Strength Cond. Res.* **2023**, *37*, 2185–2191. [CrossRef]
32. García-Pinillos, F.; Bujalance-Moreno, P.; Lago-Fuentes, C.; Ruiz-Alias, S.A.; Domínguez-Azpíroz, I.; Mecías-Calvo, M.; Ramirez-Campillo, R. Effects of the menstrual cycle on jumping, sprinting and force-velocity profiling in resistance-trained women: A preliminary study. *Int. J. Environ. Res. Public Health* **2021**, *18*, 4830. [CrossRef]
33. Arazi, H.; Nasiri, S.; Eghbali, E. Is there a difference toward strength, muscular endurance, anaerobic power and hormonal changes between the three phase of the menstrual cycle of active girls? *Apunt. Med. L'esport* **2019**, *54*, 65–72. [CrossRef]
34. Rissanen, J.; Walker, S.; Pareja-Blanco, F.; Häkkinen, K. Velocity-based resistance training: Do women need greater velocity loss to maximize adaptations? *Eur. J. Appl. Physiol.* **2022**, *122*, 1269–1280. [CrossRef] [PubMed]
35. Thompson, B.; Almarjawi, A.; Sculley, D.; Janse de Jonge, X. The effect of the menstrual cycle and oral contraceptives on acute responses and chronic adaptations to resistance training: A systematic review of the literature. *Sports Med.* **2020**, *50*, 171–185. [CrossRef] [PubMed]
36. Thompson, B.; Sculley, D.; Hands, D.; de Jonge, X.J. The acute effect of the menstrual cycle and oral contraceptive cycle on responses to a resistance training session. *J. Sci. Med. Sport* **2019**, *22*, 31–32. [CrossRef]
37. Daley, A.J. Exercise and Primary Dysmenorrhoea. *Sports Med.* **2008**, *38*, 659–670. [CrossRef]
38. McNulty, K.L.; Taim, B.C.; Freemas, J.A.; Hassan, A.; Lupton Brantner, C.; Oleka, C.T.; Scott, D.; Howatson, G.; Moore, I.S.; Yung, K.K.; et al. Research across the female life cycle: Reframing the narrative for health and performance in athletic females and showcasing solutions to drive advancements in research and translation. *Women Sport Phys. Act. J.* **2024**, *32*, wspaj.2024-0064. [CrossRef]