Effects of menstrual cycle phases on muscle strength and hypertrophy in eumenorrheic women practicing resistance training: a systematic review

Efectos de las fases del ciclo menstrual sobre la fuerza muscular y la hipertrofia en mujeres eumenorréicas que realizan entrenamiento de fuerza: una revisión sistemática

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Abstract

Objective. This study aimed to compare the effects of menstrual cycle phases on strength and hypertrophy in eumenorrheic women who practice resistance training (RT).
Methods. The methodology followed the PRISMA-ScR guidelines, with searches conducted in the Cochrane Library, PubMed, and the CAPES Journal Portal using the descriptors “Muscle Strength,” “Menstrual Cycle,” “Fertile Period,” “Follicular Phase,” “Luteal Phase,” and “Resistance Training.” Studies were included if they involved healthy adult eumenorrheic women practicing RT and whose protocols investigated MC, strength, and hypertrophy. After applying the eligibility criteria, 12 articles were included. Methodological analysis used the TESTEX tool.
Results. It was found that the luteal and follicular phases have the potential to promote greater strength and hypertrophy gains, possibly due to the predominant hormonal combination. In addition, training periodization strategies based on MC phases were shown to optimize strength and performance outcomes, as evidenced in studies that adapted RT frequency and intensity according to the MC. Furthermore, some studies did not find statistically significant differences between phases, which may be related to methodological limitations such as small samples, variations in intervention protocols, and lack of rigorous cycle monitoring.
Conclusion. It is concluded that the luteal and follicular phases demonstrate greater potential for muscle hypertrophy gains due to the predominant hormonal combination in these periods, and that further investigations are needed regarding muscle strength gains.

Keywords

Eumenorrheic; hypertrophy; menstrual cycle; muscle strength; resistance training; women.

Resumen

Objetivo. Este estudio tuvo como objetivo comparar los efectos de las fases del ciclo menstrual sobre la fuerza y la hipertrofia en mujeres eumenorréicas que practican entrenamiento de fuerza (EF).
Métodos. La metodología siguió las directrices PRISMA-ScR, realizándose búsquedas en Cochrane Library, PubMed y el Portal de Revistas CAPES utilizando los descriptores "Fuerza muscular", "Ciclo menstrual", "Periodo fértil", "Fase folicular", "Fase lútea" y "Entrenamiento de fuerza". Se incluyeron estudios que involucraban a mujeres adultas eumenorréicas sanas que practicaban EF y cuyos protocolos investigaban el CM, la fuerza y la hipertrofia. Tras aplicar los criterios de elegibilidad, se incluyeron 12 artículos. El análisis metodológico se realizó utilizando la herramienta TESTEX.
Resultados. Se encontró que las fases lútea y folicular tienen el potencial de promover mayores ganancias de fuerza e hipertrofia, posiblemente debido a la combinación hormonal predominante. Además, se demostró que las estrategias de periodización del entrenamiento basadas en las fases del CM optimizan los resultados de fuerza y rendimiento, tal como se evidenció en estudios que adaptaron la frecuencia y la intensidad del EF según el CM. Por otra parte, algunos estudios no encontraron diferencias estadísticamente significativas entre las fases, lo que podría atribuirse a limitaciones metodológicas como muestras pequeñas, variaciones en los protocolos de intervención y falta de un seguimiento riguroso del ciclo. Conclusión. Se concluye que las fases lútea y folicular muestran un mayor potencial para las ganancias de hipertrofia muscular debido a la combinación hormonal predominante en estos periodos, y que se requieren más investigaciones sobre las ganancias de fuerza muscular.

Palabras clave

Ciclo menstrual; eumenorréica; entrenamiento de fuerza; fuerza muscular; hipertrofia; mujeres.

Introduction

Resistance training (RT) is an exercise modality broadly recommended for diverse populations, providing benefits that encompass psychological, physical, social, and aesthetic aspects (Cavalcante et al., 2023). It is characterized by movements performed by the skeletal muscles against an external resistance or by attempts to generate such movements. RT can be performed using dumbbells, specialized machines, body weight, elastic bands, as well as through plyometric exercises (Altheyab et al., 2024).

Among the physiological adaptations promoted by RT, increases in muscle strength and hypertrophy are particularly noteworthy. Strength gains are defined as an enhanced capacity to produce tension against an external resistance, primarily mediated by neuromuscular adaptations such as increased motor unit recruitment and improved intramuscular coordination (Ahn et al., 2022). Muscle hypertrophy, in turn, refers to an enlargement of muscle fibers, mainly resulting from elevated protein synthesis and an increase in muscle cross-sectional area (Seo et al., 2020). However, in women, adaptations to RT may be influenced by specific physiological factors, particularly the hormonal fluctuations associated with the menstrual cycle (MC). The MC is a natural and cyclical process occurring in women of reproductive age and is regulated by the complex interaction of the hypothalamic–pituitary–ovarian axis. With an average duration of approximately 28 days (ranging from 21 to 35 days), its primary function is to prepare the body for a possible pregnancy (McNulty et al., 2020).

The menstrual cycle (MC) is traditionally divided into four phases—menstrual, follicular, ovulatory, and lutea, each characterized by specific and dynamic changes in the concentrations of hormones such as estrogen, progesterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH). The menstrual phase (days 1–5) marks the beginning of the cycle and is characterized by the shedding of the endometrium (Kissow et al., 2022). During this period, estrogen and progesterone levels remain at baseline due to the regression of the corpus luteum. Following this, the follicular phase (days 6–14) is characterized by a progressive increase in FSH and, most notably, in estrogen levels, which promotes endometrial proliferation and creates a favorable environment for ovulation. This increase in estrogen has been associated with beneficial effects on neuromuscular function and metabolism (Chidi-Ogbolu & Baar, 2019; Pereira et al., 2024).

Ovulation (around day 14) is triggered by an acute surge in LH, resulting in the release of the ovum. During this short period, estrogen levels reach their peak, while progesterone begins to rise slightly (McNulty et al., 2020). Finally, the luteal phase (days 15–28) is dominated by progesterone, secreted by the corpus luteum, along with a concurrent second rise in estrogen. Progesterone prepares the endometrium for implantation and modulates parameters such as basal body temperature and fluid retention. In the absence of fertilization, the levels of both hormones decline abruptly, restarting the cycle (Carmichael et al., 2021).

Evidence suggests that these hormonal fluctuations may significantly influence adaptive responses to exercise (Cano Sokoloff et al., 2016). While estrogen, which predominates during the follicular phase, has been associated with potential anabolic and neuroexcitatory effects, progesterone, which reaches its peak in the luteal phase, may counteract some of these effects and influence physical performance (Chidi-Ogbolu & Baar, 2019). The mechanisms proposed to explain these responses involve the action of estrogen in reducing neuronal inhibition mediated by GABA and stimulating glutamatergic receptors, thereby increasing the excitability of the central nervous system. In contrast, progesterone tends to exert an inhibitory effect, mainly by potentiating the action of GABA (Blagrove et al., 2020). Furthermore, progesterone also produces a thermogenic effect, increasing body temperature during the luteal phase (Morris et al., 1976), which, theoretically, may contribute to greater nerve conduction velocity and improved muscle contractility.

Given this complex interaction, it is important to investigate how the different phases of the menstrual cycle (MC) may influence gains in muscle strength and hypertrophy. Furthermore, this review aims to provide theoretical and practical support for optimizing exercise prescription based on evidence specific to the female population. Therefore, the objective of this systematic review was to examine the effects of the phases of the MC on muscle strength and hypertrophy in eumenorrheic women engaged in resistance training.

Method

Protocol and Registration

This systematic review has an investigative character regarding the effects of the different phases of the menstrual cycle on strength and hypertrophy in eumenorrheic women who practice resistance training. The guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were adopted (Page et al., 2021). This review was registered in the Open Science Framework (OSF) under the registration link https://osf.io/ube8c/ (DOI: 10.17605/OSF.IO/UBE8C).

Eligibility Criteria

The inclusion criteria for the studies were: a) scientific articles published in Portuguese or English; b) participants had to be healthy adult eumenorrheic women engaged in resistance training; c) studies that investigated menstrual cycle phases, strength, and hypertrophy; d) resistance training protocols as the intervention, with at least two groups (control or another intervention); e) studies classified as randomized controlled trials (RCTs) or experimental studies. The exclusion criteria were: a) participants who were amenorrheic, postmenopausal, or not healthy; b) intervention protocols not related to resistance training; c) studies without comparisons between menstrual cycle phases; d) studies whose specific outcomes were not directly related to muscle strength, muscle mass, menstrual cycle, and resistance training; e) book chapters, books, theses, dissertations, monographs, conference abstracts, and systematic reviews.

Search Strategy

The searches were conducted between october and november 2025 in the Cochrane Library, PubMed, and the CAPES Journal Portal databases. These databases were selected because they contain more robust RCT studies and offer free access to various journals through the Federal University of Juiz de Fora. Different search strategies were applied in each database.

To determine the search strategies, a preliminary literature review was conducted to identify common terms related to this research. These searches resulted in the inclusion of the following keywords: Muscle Strength; Menstrual Cycle; Fertile Period; Follicular Phase; Luteal Phase; Resistance Training. The search terms were combined using two Boolean operators (AND/OR) according to the descriptors found in DeCS (Health Sciences Descriptors) and MeSH (Medical Subject Headings), as well as their synonyms. The search strategy for each database consulted is presented in Appendix 1.

The studies were imported into the EndNote reference manager for subsequent analysis. Duplicate records were removed automatically and manually by two reviewers. Disagreements that arose during any stage of the independently conducted screening process were resolved by a third reviewer. The data were then collected and analyzed using Excel spreadsheets.

Risk of bias

Two authors independently assessed the risk of bias for each included study. If the score was inconsistent, a third author was consulted to decide the final score. We used the Risk of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool to verify the risk of bias in the quasi-experimental studies. This instrument contains seven elements for classification and is carried out in three stages, pre-intervention, intervention, and post-intervention. The risk of bias score is assigned to each domain according to the classification "high risk of bias", "severe risk of bias", "moderate risk of bias", "low risk of bias", and "no information" (Sterne et al., 2016).

Assessment of Methodological Quality

The methodological quality assessment of the included studies was conducted using the TESTEX tool (Tool for the Assessment of Study Quality and Reporting in Exercise). This tool allows for the analysis of methodological consistency in studies included in reviews within the field of exercise science. It was developed with a focus on the specific characteristics of exercise intervention studies, such as intensity control, adherence to the protocol, and monitoring of the control group. The application of this tool enables a more accurate evaluation of the reliability and validity of the findings, considering the particularities of research in physical training.

TESTEX consists of 12 items, and each article can receive a maximum score of 15 points. The item "Outcome measure in 85% of participants" can receive up to 3 points: 0 points if sample attrition is greater than 15%; 1 point if adherence is >85%; 1 point if adverse events are reported; and 1 point if training frequency is reported. The item "Between-group statistical comparisons" can receive up to 2 points: 1 point if between-group comparisons are reported for the primary outcome and 1 point if they are reported for at least one secondary outcome. The remaining items can receive only 0 or 1 point. Thus, each article may receive a maximum total of 15 points (Smart et al., 2015).

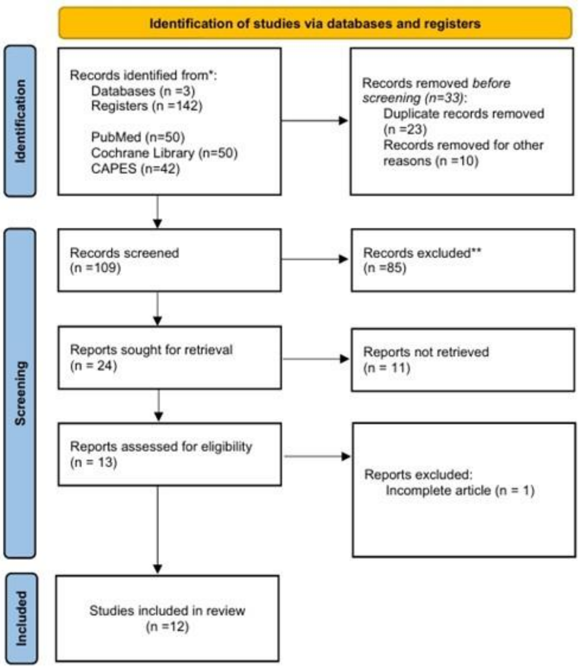
Data Extraction

The following data were extracted from the included studies: authors' names, year of publication, objectives, study design, sample characteristics, interventions and protocol duration, menstrual cycle phases assessed, and main results.

Results

A total of 142 records were identified through database searches (PubMed = 50, Cochrane Library = 50, and CAPES = 42). After removing 23 duplicate records and 10 records for other reasons, 109 studies remained for title and abstract screening. Of these, 85 were excluded, leaving 24 reports for full-text retrieval. Eleven reports could not be retrieved, resulting in 13 full-text articles assessed for eligibility. One study was excluded because it was an incomplete article, and 12 studies met the eligibility criteria and were included in the final review. Figure 1 presents the study selection flowchart, according to the PRISMA methodology.

Figure 1. Flowchart of the Article Selection Process



Risk of Bias Analysis (Robins-I)

Table 1. Risk of bias analysis for randomized studies

Studies	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
(Reis et al., 1995)	Low	Low	Low	Low	Low	Low	Low	Low
(Sakamaki et al., 2012)	Low	Low	Low	Low	Low	Low	Low	Low
(Sung et al., 2014)	Low	Low	Low	Low	Low	Low	Moderate	Moderate
(Sakamaki-Sunaga et al., 2016)	Low	Low	Low	Low	Low	Low	Low	Low
(Gil et al., 2017)	Low	Low	Low	Low	Low	Low	Low	Low
(Wikström-Frisén et al., 2017)	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
(Romero-García et al., 2021)	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
(Sung & Kim, 2019)	Low	Low	Low	Low	Low	Low	Low	Low
(García-Pinillos et al., 2022)	Low	Low	Low	Low	Low	Low	Low	Low
(Vargas-Molina et al., 2020)	Low	Low	Low	Low	Low	Low	Moderate	Moderate
(Dias et al., 2024)	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
(Dragutinovic et al., 2024)	Low	Low	Low	Low	Low	Low	Low	Low

Methodological Quality Assessment of the Studies

The methodological quality analysis of the interventions resulted in an average score of 8.6 out of a possible 15 points, indicating a moderate quality among the studies. The variables "Clearly specified eligibility criteria," "Statistical comparisons between groups," "Baseline similarity between groups," and "Point measures with variability" were reported in all studies. The variable "Outcome measures in 85% of participants" was described in 10 of the included articles. The variable "Characteristics of exercise volume and energy expenditure" was presented in 11 studies. The variables "Maintenance of relative exercise intensity" and "Monitoring of physical activity in the control group" were reported in 7 studies. Randomization occurred in 6 articles, assessor blinding was documented in 2 studies, and allocation concealment in 1. Intention-to-treat analysis was absent from all studies (Table II).

Despite demonstrating good practices regarding eligibility criteria, adherence, and adequate use of statistical procedures, the analyzed articles showed limitations in methodological controls such as blinding, rigorous randomization, intention-to-treat analysis, and control of external variables. These shortcomings partially compromise the reliability of the evidence produced and may introduce a degree of bias.

Table 2. Results of the methodological quality of the included studies.

Study	1	2	3	4	5	6	7	8	9	10	11	12	Total
(Reis et al., 1995)	1	1	0	1	0	1	0	2	1	1	0	1	9
(Sakamaki et al., 2012)	1	0	0	1	0	0	0	2	1	1	1	1	8
(Sung et al., 2014)	1	1	0	1	0	1	0	2	1	1	1	1	10
(Sakamaki-Sunaga et al., 2016)	1	0	0	1	0	1	0	2	1	0	1	1	8
(Gil et al., 2017)	1	1	0	1	0	0	0	2	1	0	0	1	7
(Wikström-Frisén et al., 2017)	1	0	0	1	0	1	0	2	1	1	0	1	8
(Romero-García et al., 2021)	1	1	0	1	0	1	0	2	1	1	0	1	9
(Sung & Kim, 2019)	1	0	0	1	0	2	0	2	1	0	1	1	9
(García-Pinillos et al., 2022)	1	0	0	1	0	0	0	2	1	0	0	0	5
(Vargas-Molina et al., 2020)	1	1	0	1	0	2	0	2	1	0	1	1	10
(Dias et al., 2024)	1	1	1	1	1	2	0	2	1	1	1	1	13
(Dragutinovic et al., 2024)	1	0	0	1	1	2	0	1	1	1	1	1	10

Legend: Low Quality – total score below 6; Moderate Quality – total score between 6 and 11; High Quality – total score from 12 onward. 1 – Specification of inclusion criteria; 2 – Randomization specified; 3 – Allocation concealment; 4 – Similarity of groups at baseline; 5 – Assessor blinding; 6 – Outcome measures in 85% of participants; 7 – Intention-to-treat analysis; 8 – Statistical comparisons between groups; 9 – Point measures and measures of variability for all reported outcome measures; 10 – Monitoring of activities in control groups; 11 – Relative exercise intensity maintained; 12 – Characteristics of exercise volume and energy expenditure.

Data Extracted from the Intervention and Variable Analysis

Table III presents a synthesis of the included studies, considering their objectives, study designs, sample characteristics, interventions and protocol duration, menstrual cycle phases assessed, and main findings. The 12 included articles were published between 1995 and 2024, with 75% (9 articles) published in the last decade (2015–2025), indicating that this topic has been the focus of continuous scientific production. In addition, regarding study design, 58% (7 studies) were classified as randomized controlled trials (RCTs), and 41% (5 studies) as experimental studies.

The total sample across the included studies comprised 290 women, with ages ranging from 20.9 (±4) to 31.1 (±5.5) years. Although the included studies implemented different interventions, all resistance-training protocols involved upper-limb exercises performed for 3 to 4 sets, with 8 to 15 repetition maximums (RM), and rest intervals ranging from 90 seconds to 5 minutes. Furthermore, some studies prescribed exercise loads based on percentages of one-repetition maximum (1RM), ranging from 20% to 90%, with rest intervals between 30 seconds and 3 minutes, and repetitions varying from 3 to 20.

The duration of the intervention periods ranged from 1 to 5 months, with a total number of training sessions varying between 6 and 40. Among the included studies, 7 studies (58%) assessed the menstrual cycle during the follicular and luteal phases; 2 studies (16%) assessed the ovulatory, follicular, and luteal phases; 1 study (8%) evaluated the menstrual, follicular, and luteal phases; 1 study (8%) evaluated the menstrual, ovulatory, and luteal phases; and only one study (8%) assessed all four menstrual cycle phases (menstrual, follicular, ovulatory, and luteal).

Table 3. Characteristics of the included studies]

Author (year)	Sample n/ year (mean ± sd)	Training Volume	Results
(Reis et al., 1995)	7 women/ 24,4 ± 3,5	3 × 12 RM knee extensions; 2 months of training. Regular training: once every 3 days; Menstrual cycle–adapted training: once every 2 days in the follicular phase (FP) and once per week in the luteal phase (LP).	↑ muscle strength in cycle-adapted training compared to regular training
(Sakamaki et al., 2012)	8 women/ 29,1 ± 6,1	1 × 30 + 3 × 15 unilateral dumbbell curls, 30-second rest intervals, load at 30% of 1RM combined with RFS, 6 sessions over 6 days, with 3 days in the follicular phase (FP) and 3 days in the luteal phase (LP).	↑ muscle strength and hypertrophy in the LP and FP
(Sung et al., 2014)	36 women/ EG1: 26.25±6.16 EG2: 25.45±4.13 EG3: 26.50±7.37	3 sessions per week of unilateral leg press at 80% of 1RM, 3 × 8–10 repetitions, 3–5 min rest; 1 session per week of unilateral bodyweight squats, 3 × 15–20 repetitions, 3–5 min rest, over 5 months.	↑ muscle strength in the LP after training compared to the FP ↑ muscle diameter in the LP
(Sakamaki-Sunaga et al., 2016)	14 women/ 21,2 ±1,9	3 × 8–15 to failure of unilateral dumbbell bicep curls at 80% 1RM, 2-minute rest, 12 weeks.	↑ Muscle strength and hypertrophy in the FP and LP
(Gil et al., 2017)	40 women/ EG1: HI: 21,6±2,2; EG2: LI+BRF: 22,7±3,7 EG3: LI: 20,9±4 CG: 25,1±5,7	4 sets of dumbbell bicep curls and knee extensions on the machine: GE1: 4 × 8 at 80% of 1RM, 2-minute rest GE2: 1 × 30 + 3 × 15 at 20% of 1RM, 30-second rest GE3: 1 × 30 + 3 × 15 at 20% of 1RM, 30-second rest, total of 8 sessions	↑ Muscle strength in GE2 compared to the control group in the LP
(Wikström-Frisén et al., 2017)	59 women/ EG1: 25±4 EG2: 24,5±2,6 CG: 24,5±3,9	Periodized training: 3 × 8–12 RM of leg press and leg curl machine, 1–2 min rest GE1: 5 times per week during the first two weeks of the menstrual cycle (MC) GE2: 5 times per week during the last two weeks of the MC GC: 3 times per week throughout the entire protocol (4 months)	↔ Muscle strength, ↔ muscle hypertrophy in all groups
(Romero-García et al., 2021)	13 women/ 31,1 ± 5,5	2 attempts/repetitions of half squats on the Smith machine, with loads corresponding to 20%, 40%, 60%, and 80% of their respective 1RM, 2–3 min rest, in 1 session per menstrual cycle phase, performed 3 times in a single month.	↔ Muscle strength and performance
(Sung & Kim, 2019)	36 women/ EG1: 26,25 ±6,16 EG2: 25,45 ±4,13 EG3: 26,50 ±7,37	3 × 8–12 knee extensions, load at 85% of 1RM, 2-minute rest, 3 sessions per week, for 12 weeks.	↑ Muscle strength in all groups in the intragroup assessment
(García-Pinillos et al., 2022)	9 women/ 28,7 anos ± 3,6	2 repetitions of the bench press for each load, at 50%, 70%, 80%, and 90% of 1RM, with 4 load-testing sessions conducted across the 3 phases of the menstrual cycle.	No differences among the 3 phases of the menstrual cycle for any of the analyzed load–velocity parameters

(Vargas-Molina et al., 2020)	14 women/ 26,6 anos ± 3	Traditional: Week 1 and 5 – 3–5 RM (Strength); Week 2 and 6 – 8–10 RM to failure (Hypertrophy); Week 3 and 7 – 20–25 RM to failure (Endurance); Week 4 and 8 – 12–15 RM (Recovery). Menstrual cycle–based (MC): Week 1 and 5 (Ovulatory) – 8–10 RM to failure; Week 2 and 6 (Luteal) – 20–25 RM to failure; Week 3 and 7 (Menstrual) – 12–15 RM; Week 4 and 8 (Follicular) – 3–5 RM. Duration: 8 weeks, 4 sessions per week.	↑ Maximum strength in both groups ↑ Jump height in both groups
(Dias et al., 2024)	20 women/ 27,6 ± 5,5	4 sets of unilateral knee extensions + 4 sets of unilateral leg press, 8–12 RM performed to concentric failure, 90-second rest intervals, 16 sessions over 2 months (8 sessions per month, 2 times per week).	↑ Muscle hypertrophy in phases O2, L2, and M3 compared to baseline
(Dragutinovic et al., 2024)	34 women EG1:23 ±3 EG2: 24±3 EG3:23 ±3	3 × 8 repetitions of squats at 60% of 1RM, 2-minute rest; after a 5-minute rest, 3 × repetitions to failure at 70% of 1RM, with 2-minute rest between sets, over 1 month.	↔ Between the MC and CC

GE = Experimental Group; GC = Control Group; BMI = Body Mass Index; OC = Oral Contraceptive; HI = High Intensity; LI = Low Intensity; BFR or RFS = Blood Flow Restriction; LI+BFR = Low Intensity with Blood Flow Restriction; SS = Submaximal Strength; RT = Resistance Training; TT = Traditional Training; MC = Menstrual Cycle; MP = Menstrual Phase; FP = Follicular Phase; OP = Ovulatory Phase; LP = Luteal Phase; RM = Repetition Maximum.

Discussion

The present study aimed to investigate the potential effects of different menstrual cycle (MC) phases on muscle strength and hypertrophy in eumenorrheic women engaged in resistance training (RT). The main findings are related to: a) muscle strength during the follicular (FP) and luteal (LP) phases, b) muscle hypertrophy during the follicular (FP) and luteal (LP) phases, and c) training periodization applied based on the menstrual cycle.

Muscle strength in the follicular and luteal phases

Regarding muscle strength, the evidence was characterized by substantial heterogeneity across the included studies, representing an important limitation of this review. Differences in study design, participant characteristics, resistance training protocols, outcome measures, and methods used to determine menstrual cycle phases reduced the comparability of findings and precluded definitive conclusions. Nevertheless, the available evidence suggests that the menstrual cycle (MC) may influence muscle strength adaptations in eumenorrheic women undergoing resistance training (RT). Six of the included studies specifically investigated muscle strength outcomes (Dragutinovic et al., 2024; García-Pinillos et al., 2022; Reis et al., 1995; Romero-Moraleda et al., 2019; Sakamaki-Sunaga et al., 2016; Sung et al., 2014). The primary assessment methods used were one-repetition maximum (1RM) tests, isometric dynamometry, and functional lower-limb tests.

Reis et al. (1995) They reported that the group whose training program incorporated periodization aligned with the circadian rhythm demonstrated substantially greater strength gains (32.6%), compared with the traditional training group, which showed a more modest 13.1% increase in strength.

Sung et al. (2014) they observed differences in muscle strength during the luteal phase (LL) compared with the high-hormone phase (HL). Furthermore, Sakamaki-Sunaga et al. (2016) reported substantial increases in muscle cross-sectional area (CSA) and improvements in maximal voluntary contraction when comparing pre- and post-intervention assessments. However, it is important to note that no significant differences were identified between the phases of the menstrual cycle (MC). Similarly, Romero-Moraleda et al. (2019) found that the development of strength, power, and speed was generally similar across all phases of the cycle. Nevertheless, slightly greater improvements were observed during the early follicular, late follicular, and mid-luteal phases.

The findings of this study are consistent with the comprehensive systematic review conducted by Blagrove et al. (2020), which presents evidence suggesting a potential advantage of the follicular phase (FP) for maximal strength performance. In addition, research by Shahid et al. (2024), based on a meta-analysis including 584 female participants, reported that the late FP produced the most pronounced effects on isometric strength performance, whereas the luteal phase (LP) was associated with less favorable outcomes. However, it is important to emphasize that the magnitude of these effects was relatively small and showed considerable variability depending on the type of muscle contraction evaluated. Therefore, the effects of training performed during the FP or LP on muscular strength performance still require further investigation to better clarify the mechanisms underlying these responses.

In contrast, studies by Dragutinovic et al. (2024), García-Pinillos et al. (2022) did not identify significant differences in strength or performance across the phases of the menstrual cycle. Dragutinovic et al. (2024) reported no differences in the testing protocol outcomes between women with a natural menstrual cycle and those using oral contraceptives. Similarly, the study by García-Pinillos et al. (2022) found no significant differences among the three menstrual cycle phases analyzed. These findings are consistent with a large body of literature reporting no meaningful variations across menstrual cycle phases, as highlighted by the comprehensive meta-analysis conducted by McNulty et al. (2020), which reviewed 73 studies on the topic. The authors concluded that, although some trends can be observed, most studies have not demonstrated consistently significant differences between menstrual cycle phases.

The factors that may explain these divergent findings are related to several methodological limitations. One important aspect is the heterogeneity of training protocols, which differ in terms of volume, intensity, frequency, and exercise selection, making direct comparisons across studies difficult. Additionally, the lack of rigorous methods to confirm menstrual cycle phases, often relying only on calendar-based tracking rather than more precise measures such as hormonal markers or basal body temperature, represents another relevant limitation. Other issues include the absence of participant and assessor blinding and differences in sample characteristics, such as training status and familiarity with menstrual cycle monitoring, all of which may substantially contribute to the variability observed among studies.

The findings of this literature review are consistent with recent evidence suggesting that female physical performance may vary across different phases of the menstrual cycle. The review conducted by Kissow et al. (2022) analyzed resistance training interventions performed during the follicular and luteal phases. The authors reported that both phases can lead to positive outcomes, provided that the training program is appropriately periodized. They highlighted that the follicular phase, characterized by higher estrogen levels and low progesterone, may favor performance enhancement and muscle anabolism. However, they also emphasized that the luteal phase, in which both hormones are present at moderate levels, may contribute to the maintenance of performance and support recovery processes.

In the study by Gil et al. (2017), the only one to employ blood flow restriction (BFR), different training intensities and protocols were applied. The results did not show significant differences between groups in terms of power or submaximal strength. However, an advantage was observed in localized muscular endurance during the knee extension exercise in the BFR group during the luteal phase. Therefore, the analysis of this and the other included studies highlights a lack of methodological standardization, which limits the ability to clearly determine the true effects of the menstrual cycle on different manifestations of muscular strength performance.

Muscle hypertrophy in the follicular and luteal phases

Regarding muscle hypertrophy, the findings from the studies included in this review consistently suggest that the menstrual cycle (MC) may influence hypertrophic adaptations in eumenorrheic women undergoing resistance training (RT). Five studies reported variations specifically related to hypertrophy. Sakamaki et al. (2012) observed a greater increase in muscle cross-sectional area (CSA) during the luteal phase (LP) compared to the follicular phase (FP). Similarly, Dias et al. (2024) reported significant increases in muscle mass during the O2, L2, and M3 phases of the cycle, based on bioelectrical impedance and perimetric assessments. In addition, Vargas-Molina et al. (2020) found significant improvements in maximal strength and jump height only in the group that followed a menstrual cycle–based periodized RT program, suggesting indirect effects on hypertrophy. Wikström-Frisén et al. (2017) identified increases in muscle mass and jump squat performance in women who trained at a higher frequency during the FP. Furthermore, Sakamaki-Sunaga et al. (2016) also reported increases in CSA, although no differences were observed between the training protocols applied across the different phases of the menstrual cycle.

These findings suggest that the hormonal variation between the FP and LP characterized by a greater predominance of estrogen in the former and progesterone in the latter may create distinct physiological environments that favor muscle anabolism when training stimuli are strategically aligned with these fluctuations.

This perspective is reinforced by the literature review conducted by Meignié et al. (2021), suggesting that both the follicular phase (FP) and the luteal phase (LP) can offer favorable conditions for hypertrophy and muscle anabolism, provided that training loads are tailored to the hormonal characteristics of each phase. During the FP, the gradual rise in estrogen alongside low progesterone levels creates an anabolic environment that enhances insulin sensitivity, stimulates protein synthesis, and supports post-exercise recovery. In contrast, during the LP, despite a reduction in estrogen and an increase in progesterone, the body reaches a more hormonally stable state, which may facilitate tissue repair and help maintain performance, as long as training volume and intensity are properly adjusted.

On the other hand, five studies did not identify significant differences specifically in hypertrophic gains across the phases of the menstrual cycle (Dragutinovic et al., 2024; García-Pinillos et al., 2022; Gil et al., 2017; Romero-Moraleda et al., 2019; Sung & Kim, 2019). For example, Romero-Moraleda et al. (2019) used a short-duration protocol and indirect body composition assessment via bioelectrical impedance, which may have limited the detection of small muscular changes. Sung & Kim (2019) also relied on less sensitive methods, such as perimetric measurements, and implemented relatively brief interventions, making it difficult to generate the cumulative training stimulus required to produce detectable hypertrophy.

García-Pinillos et al. (2022) focused primarily on functional performance outcomes and did not employ specific instruments for precise assessment of muscle mass, which limits the ability to detect subtle variations between menstrual cycle phases. Dragutinovic et al. (2024), although using a more structured training protocol, did not implement rigorous hormonal monitoring, relying only on calendar-based methods to classify cycle phases. This approach increases the risk of phase misclassification and may attenuate potential effects. Lastly, Gil et al. (2017) applied blood flow restriction (BFR) training periodized according to menstrual cycle phases; however, the short duration of the intervention reduced statistical power and hindered the detection of significant differences.

Thus, this inconsistency in findings is also emphasized in the review by Van Every et al. (2024), which highlights the need for more rigorous methodological control in studies involving women, particularly regarding hormonal monitoring. According to the authors, when menstrual cycle phases are accurately determined through hormonal assays, basal temperature, or other physiological markers, the rate of muscle protein synthesis does not appear to vary significantly across the different phases of the cycle. This suggests that, rather than the hormonal phase alone, the primary determinant of hypertrophic adaptations may be the total training load and the quality of the stimulus applied to the body.

In other words, variables such as intensity, volume, frequency, and training individualization appear to exert greater influence on outcomes than the simple hormonal variation between phases. However, an important caveat must be noted: the absence of strong direct effects of hormonal fluctuations on protein synthesis does not imply that the menstrual cycle is irrelevant (Van Every et al., 2024). Subtle changes in subjective and physiological factors such as fatigue, mood, inflammation, water retention, and recovery time may indirectly affect the capacity for training adaptation. Thus, although the hormonal milieu does not solely determine hypertrophic outcomes, it may act as a modulator of the training response, particularly in contexts of high physical demand.

Training periodization based on the menstrual cycle may optimize outcomes

A key finding of this research is that training periodization based on the menstrual cycle (MC) may be a more effective strategy than traditional linear or undulating models, particularly for eumenorrheic women. Protocols that adjust training volume, intensity, and frequency in accordance with hormonal fluctuations throughout the MC appear to optimize gains in strength, hypertrophy, and overall performance. Studies by Vargas-Molina et al. (2020), Wikström-Frisén et al. (2017) showed that emphasizing higher training loads during the follicular phase and reducing them during the luteal phase leads to greater improvements in maximal strength, anaerobic power, and body composition.

Vargas-Molina et al. (2022) employed an undulating periodization model with a body-segment training split (upper and lower limbs) and compared a traditional training protocol with one in which training stimuli were adjusted according to menstrual cycle phases. The group following hormonal-based periodization showed greater strength gains and significant improvements in body composition. Wikström-Frisén et al. (2017) also implemented menstrual cycle–based periodization, concentrating more intense training sessions during the first two weeks (follicular and ovulatory phases), which led to positive outcomes in both strength and muscle mass—particularly in the group with higher training frequency during the follicular phase.

These findings are strongly aligned with the systematic review by Thompson et al. (2020), which reinforces that the follicular phase (FP) represents a favorable anabolic hormonal environment. The FP is particularly suitable for the application of higher-load and higher-volume training stimuli, whereas the luteal phase (LP) may be better utilized for active recovery, maintenance work, or technical training. Moreover, the study by Reis et al. (1995) demonstrated that simply adjusting the frequency of resistance training sessions according to menstrual cycle phases yields significantly superior results compared with a traditional model. This strategy is based on the rationale of concentrating a greater volume of sessions during the FP when estrogen enhances protein synthesis and effort tolerance and reducing volume during the LP to minimize the risk of overload during a potentially more catabolic period.

This approach is further supported by Kissow et al. (2022), whose review proposes that periodic and cyclical modulation of training loads based on hormonal biomarkers and subjective symptoms may serve as a powerful tool to increase training efficiency and reduce injury incidence, particularly among trained female populations.

Given this, individualizing training based on the menstrual cycle (MC) appears to be a valuable strategy in exercise prescription for women, particularly in settings that require high performance and long-term physical sustainability. Identifying individual patterns of response across different MC phases, through monitoring symptoms, performance, and even hormonal markers, may allow for the development of programs that are better aligned with female physiological characteristics.

A meta-analysis was not performed because of the substantial methodological and clinical heterogeneity among the included studies. Considerable differences were observed in participant characteristics, resistance training protocols (training volume, intensity, exercise selection, and intervention duration), methods used to determine menstrual cycle phases, outcome measures for muscle strength, and timing of assessments. These sources of heterogeneity limited the comparability of the studies and violated the assumptions required for meaningful quantitative synthesis.

Conclusions

The luteal and follicular phases seem to present greater potential for muscle hypertrophy, likely due to the hormonal profiles that characterize these periods. In terms of muscle strength, although the evidence remains inconsistent, there are indications that both phases of the menstrual cycle (MC) may play a role in strength development. However, additional research is required to determine whether one phase is more favorable than the other for enhancing this capacity. Concerning training periodization based on MC phases, the studies analyzed suggest that this approach can be effective, indicating that aligning training strategies with hormonal fluctuations may enhance physiological responses to exercise.

Nevertheless, while there is evidence that the menstrual cycle can influence performance and training adaptations, it should not be viewed as an isolated or decisive factor. Future research should adopt stricter methodological controls, larger sample sizes, and well-defined intervention protocols to provide more reliable practical recommendations. Understanding hormonal variations and their impact on training should be used as a complementary strategy in individualized exercise prescription, taking into account the complexity of the female body and its multifactorial responses to training.

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References

Ahn, B., Ranjit, R., Kneis, P., Xu, H., Piekarz, K. M., Freeman, W. M., Kinter, M., Richardson, A., Ran, Q., Brooks, S. V., & Van Remmen, H. (2022). Scavenging mitochondrial hydrogen peroxide by peroxiredoxin 3 overexpression attenuates contractile dysfunction and muscle atrophy in a murine model of accelerated sarcopenia. *Aging Cell*, *21*(3), e13569. https://doi.org/10.1111/acel.13569

Altheyab, A., Alqurashi, H., England, T., Phillips, B., & Piasecki, M. (2024). Cross-education of lower limb muscle strength following resistance exercise training in males and females: A systematic review and meta-analysis. *EXPERIMENTAL PHYSIOLOGY*. (WOS:001306780800001). https://doi.org/10.1113/EP091881

Blagrove, R. C., Bruinvels, G., & Pedlar, C. R. (2020). Variations in strength-related measures during the menstrual cycle in eumenorrheic women: A systematic review and meta-analysis. *Journal of Science and Medicine in Sport*, *23*(12), 1220–1227. https://doi.org/10.1016/j.jsams.2020.04.022

Cano Sokoloff, N., Misra, M., & Ackerman, K. E. (2016). Exercise, Training, and the Hypothalamic-Pituitary-Gonadal Axis in Men and Women. Em F. Lanfranco & C. J. Strasburger (Org.), *Frontiers of Hormone Research* (V. 47, p. 27–43). S. Karger AG. https://doi.org/10.1159/000445154

Carmichael, M. A., Thomson, R. L., Moran, L. J., & Wycherley, T. P. (2021). The Impact of Menstrual Cycle Phase on Athletes' Performance: A Narrative Review. *International Journal of Environmental Research and Public Health*, *18*(4), 1667. https://doi.org/10.3390/ijerph18041667

Cavalcante, E. F., Kassiano, W., Ribeiro, A. S., Costa, B., Cyrino, L. T., Cunha, P. M., Antunes, M., Santos, L. D., Tomeleri, C. M., Nabuco, H. C. G., Sugihara-Júnior, P., Fernandes, R. R., Rodrigues, R. J., Carneiro, M. A. S., Pina, F. L. C., Dib, M. M., Teixeira, D. C., Orsatti, F. L., Venturini, D., … Cyrino, E. S. (2023). Resistance Training for Older Women: Do Adaptive Responses Support the ACSM and NSCA Position Stands? *Medicine & Science in Sports & Exercise*, *55*(9), 1651–1659. https://doi.org/10.1249/MSS.0000000000003179

Chidi-Ogbolu, N., & Baar, K. (2019). Effect of Estrogen on Musculoskeletal Performance and Injury Risk. *Frontiers in Physiology*, *9*, 1834. https://doi.org/10.3389/fphys.2018.01834

Dias, N. F., Bergamasco, J. G. A., Scarpelli, M. C., Silva, D. G., Chaves, T. S., Bittencourt, D., Medalha, R. A., Carello Filho, P. C., De Souza, E. O., Ugrinowitsch, C., & Libardi, C. A. (2024). Changes in muscle cross-sectional area during two menstrual cycles may not be exclusively attributed to resistance training. *Applied Physiology, Nutrition, and Metabolism*, *49*(12), 1729–1739. https://doi.org/10.1139/apnm-2024-0004

Dragutinovic, B., Moser, F., Notbohm, H. L., Ihalainen, J. K., Bloch, W., & Schumann, M. (2024). Influence of menstrual cycle and oral contraceptive phases on strength performance, neuromuscular fatigue, and perceived exertion. *Journal of Applied Physiology*, *137*(4), 919–933. https://doi.org/10.1152/japplphysiol.00198.2024

García-Pinillos, F., Lago-Fuentes, C., Bujalance-Moreno, P., & Pérez-Castilla, A. (2022). Effect of the Menstrual Cycle When Estimating 1 Repetition Maximum From the Load-Velocity Relationship During the Bench Press Exercise. *Journal of Strength & Conditioning Research*, *36*(3), e55–e58. https://doi.org/10.1519/JSC.0000000000003712

Gil, A. L. S., Neto, G. R., Sousa, M. S. C., Dias, I., Vianna, J., Nunes, R. A. M., & Novaes, J. S. (2017). Effect of strength training with blood flow restriction on muscle power and submaximal strength in eumenorrheic women. *Clinical Physiology and Functional Imaging*, *37*(2), 221–228. https://doi.org/10.1111/cpf.12291

Kissow, J., Jacobsen, K. J., Gunnarsson, T. P., Jessen, S., & Hostrup, M. (2022). Effects of Follicular and Luteal Phase-Based Menstrual Cycle Resistance Training on Muscle Strength and Mass. *Sports Medicine*, *52*(12), 2813–2819. https://doi.org/10.1007/s40279-022-01679-y

McNulty, K. L., Elliott-Sale, K. J., Dolan, E., Swinton, P. A., Ansdell, P., Goodall, S., Thomas, K., & Hicks, K. M. (2020). The Effects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis. *Sports Medicine*, *50*(10), 1813–1827. https://doi.org/10.1007/s40279-020-01319-3

Meignié, A., Duclos, M., Carling, C., Orhant, E., Provost, P., Toussaint, J.-F., & Antero, J. (2021). The Effects of Menstrual Cycle Phase on Elite Athlete Performance: A Critical and Systematic Review. *Frontiers in Physiology*, *12*, 654585. https://doi.org/10.3389/fphys.2021.654585

Morris, N. M., Underwood, L. E., & Easterling, W. (1976). Temporal Relationship Between Basal Body Temperature Nadir and Luteinizing Hormone Surge in Normal Women. *Fertility and Sterility*, *27*(7), 780–783. https://doi.org/10.1016/S0015-0282(16)41952-7

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71

Pereira, M. V. D. N., Paes, P. P., Costa, M. S. F., Freitas, I. L. T., Feitosa, R. C., Morena, J. M. D. D. L., Santos, W. R., & Santos, W. R. (2024). Cross sectional analysis of muscular strength and flexibility during the menstrual cycle in women engaged in strength training. *Retos*, *55*, 704–709. https://doi.org/10.47197/retos.v55.104259

Reis, E., Frick, U., & Schmidtbleicher, D. (1995). Frequency Variations of Strength Training Sessions Triggered by the Phases of the Menstrual Cycle. *International Journal of Sports Medicine*, *16*(08), 545–550. https://doi.org/10.1055/s-2007-973052

Romero-García, M., López-Rodríguez, G., Henao-Morán, S., González-Unzaga, M., & Galván, M. (2021). Effect of a Multicomponent Exercise Program (VIVIFRAIL) on Functional Capacity in Elderly Ambulatory: A Non-Randomized Clinical Trial in Mexican Women with Dynapenia. *J Nutr Health Aging*, *25*(2), 148–154. https://doi.org/10.1007/s12603-020-1548-4

Romero-Moraleda, B., Coso, J. D., Gutiérrez-Hellín, J., Ruiz-Moreno, C., Grgic, J., & Lara, B. (2019). The Influence of the Menstrual Cycle on Muscle Strength and Power Performance. *Journal of Human Kinetics*, *68*(1), 123–133. https://doi.org/10.2478/hukin-2019-0061

Sakamaki, M., Yasuda, T., & Abe, T. (2012). Comparison of low-intensity blood flow-restricted training-induced muscular hypertrophy in eumenorrheic women in the follicular phase and luteal phase and age-matched men. *Clinical Physiology and Functional Imaging*, *32*(3), 185–191. https://doi.org/10.1111/j.1475-097X.2011.01075.x

Sakamaki-Sunaga, M., Min, S., Kamemoto, K., & Okamoto, T. (2016). Effects of Menstrual Phase–Dependent Resistance Training Frequency on Muscular Hypertrophy and Strength. *Journal of Strength and Conditioning Research*, *30*(6), 1727–1734. https://doi.org/10.1519/JSC.0000000000001250

Seo, M. W., Jung, S. W., Kim, S. W., Jung, H. C., Kim, D. Y., & Song, J. K. (2020). Comparisons of Muscle Quality and Muscle Growth Factor Between Sarcopenic and Non-Sarcopenic Older Women. *Int J Environ Res Public Health*, *17*(18). https://doi.org/10.3390/ijerph17186581

Shahid, W., Noor, R., & Bashir, M. S. (2024). Effects of exercise on sex steroid hormones (estrogen, progesterone, testosterone) in eumenorrheic females: A systematic to review and meta-analysis. *BMC Women's Health*, *24*(1), 354. https://doi.org/10.1186/s12905-024-03203-y

Smart, N. A., Waldron, M., Ismail, H., Giallauria, F., Vigorito, C., Cornelissen, V., & Dieberg, G. (2015). Validation of a new tool for the assessment of study quality and reporting in exercise training studies: TESTEX. *International Journal of Evidence-Based Healthcare*, *13*(1), 9–18. https://doi.org/10.1097/XEB.0000000000000020

Sterne, J. A., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A.-W., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., … Higgins, J. P. (2016). ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*, i4919. https://doi.org/10.1136/bmj.i4919

Sung, E., Han, A., Hinrichs, T., Vorgerd, M., Manchado, C., & Platen, P. (2014). Effects of follicular versus luteal phase-based strength training in young women. *SpringerPlus*, *3*(1), 668. https://doi.org/10.1186/2193-1801-3-668

Sung, E.-S., & Kim, J.-H. (2019). The resistance training effects of different weight level during menstrual cycle in female. *Journal of Exercise Rehabilitation*, *15*(2), 249–253. https://doi.org/10.12965/jer.193808.024

Thompson, B., Almarjawi, A., Sculley, D., & Janse De Jonge, X. (2020). 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 Medicine*, *50*(1), 171–185. https://doi.org/10.1007/s40279-019-01219-1

Van Every, D. W., D'Souza, A. C., & Phillips, S. M. (2024). Hormones, Hypertrophy, and Hype: An Evidence-Guided Primer on Endogenous Endocrine Influences on Exercise-Induced Muscle Hypertrophy. *Exercise and Sport Sciences Reviews*, *52*(4), 117–125. https://doi.org/10.1249/JES.0000000000000346

Vargas-Molina, S., Petro, J. L., Romance, R., Bonilla, D. A., Schoenfeld, B. J., Kreider, R. B., & Benítez-Porres, J. (2022). Menstrual cycle-based undulating periodized program effects on body composition and strength in trained women: A pilot study. *Science & Sports*, *37*(8), 753–761. https://doi.org/10.1016/j.scispo.2021.11.003

Vargas-Molina, S., Petro, J. L., Romance, R., Kreider, R. B., Schoenfeld, B. J., Bonilla, D. A., & Benítez-Porres, J. (2020). Effects of a ketogenic diet on body composition and strength in trained women. *Journal of the International Society of Sports Nutrition*, *17*(1), 19. https://doi.org/10.1186/s12970-020-00348-7

Wikström-Frisén, L., Boraxbekk, C. J., & Henriksson-Larsén, K. (2017). Effects on power, strength and lean body mass of menstrual/oral contraceptive cycle based resistance training. *The Journal of Sports Medicine and Physical Fitness*, *57*(1–2). https://doi.org/10.23736/S0022-4707.16.05848-5

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