women

MDPI

Opinion

Menstrual-Cycle Phase-Based Periodization of Resistance Training and Chronic Gains in Strength and Body Composition: A Discordant Evidence Base in Need of an Uncertainty-Aware Synthesis

Arnulfo Ramos-Jiménez [1,2,*], Mariazel Rubio-Valles [1], Jaime Güereca-Arvizuo [1], María Guadalupe Delgadillo-Ramos [2,3] and Marco Antonio Hernández-Lepe [2,3]

[1] Biomedical Sciences Institute, Autonomous University of Ciudad Juarez, Ciudad Juarez 32401, Mexico; mariazel.rubio@uacj.mx (M.R.-V.); jaime.guereca@uacj.mx (J.G.-A.)
[2] Conahcyt National Laboratory of Body Composition and Energetic Metabolism (LaNCoCoME), Tijuana 22390, Mexico; lupitadelgadillo@uabc.edu.mx (M.G.D.-R.); marco.antonio.hernandez.lepe@uabc.edu.mx (M.A.H.-L.)
[3] Faculty of Medicine and Psychology, Autonomous University of Baja California, Tijuana 22390, Mexico
* Correspondence: aramos@uacj.mx; Tel.: +52-656-1679303

Abstract

Periodizing resistance training around the menstrual cycle, typically by concentrating load in the follicular phase, has become popular through commercial cycle-tracking applications. This opinion argues that the recommendation rests on a small, heterogeneous, and conflicting evidence base and that much of the conflict stems from conflating two questions: acute, within-cycle variation in muscular performance and chronic adaptation to phase-periodized training. Acute studies in eumenorrheic women report small or absent between-phase differences in maximal strength and power, weakening the premise of a privileged follicular anabolic window. Among the few chronic studies, follicular advantage appears mainly where phase verification was limited or when training dose was concentrated in the favored phase; it was not reproduced in the most rigorous trial to date, in which volume–load, not cycle phase, was associated with adaptation. Phase-verification rigor and volume–load equating, alongside heterogeneity in outcome measurement, are plausible, testable candidate explanations; none is yet an established cause. Existing quantitative syntheses address hormonal contraceptive use, not phase-based periodization in naturally cycling women. A registered systematic review with co-primary frequentist and Bayesian meta-analyses that model these factors as effect modifiers and test any pooled effect against a pre-specified smallest effect size of interest is warranted and introduced (INPLASY202660145).

Keywords: menstrual cycle; resistance training; periodization; muscle strength; muscle hypertrophy; eumenorrheic women; meta-analysis

Check for updates

Academic Editors: Maria Grazia Tarsitano, Edoardo Mocini and Francesca Greco

Received: 3 August 2026
Revised: 9 September 2026
Accepted: 18 September 2026
Published: 23 September 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Interest in tailoring resistance training to the menstrual cycle has grown rapidly, and the specific proposition that training should be concentrated in the follicular phase, when estrogen levels rise, has been advanced to enhance strength and muscle mass in women [1]. The proposition is widely disseminated, including through commercial cycle-tracking and training applications, and menstrual-cycle tracking is increasingly embedded in support for female athletes, although its application remains inconsistent and its evidentiary basis

for performance decisions is explicitly regarded as inconclusive [2]. The scale of adoption is illustrated by the fact that a continental football governing body has now issued a consensus statement specifically on menstrual cycle tracking in women's football in response to its widespread yet inconsistent use in elite environments [2]. The clinical and practical appeal is understandable; female participants remain underrepresented in resistance-training research, and practitioners are asked to make recommendations from a thin evidence base [3].

The premise, however, quietly conflates two questions that are neither interchangeable nor tightly coupled. The conflation has gone largely unexamined because both questions share a single mechanistic premise, that the follicular rise in estrogen is anabolic and because narrative recommendations and commercial applications have moved from that premise to chronic prescription without a body of chronic-use trials to bridge the gap [1]. The first is acute: does maximal strength or power differ across cycle phases when a woman is tested repeatedly within a single cycle? The second is chronic: does a resistance-training program whose load is deliberately periodized to the cycle phase produce greater gains in strength and hypertrophy over weeks to months than a comparator periodized to the opposite phase or cycle-agnostic? An acute follicular advantage would not, by itself, establish a chronic adaptive advantage; conversely, a phase could, in principle, modulate adaptation without altering acute performance. The chronic question is the one that justifies periodizing a training program and must be tested directly. This opinion evaluates the current state of the evidence on chronic conditions, examines why the primary studies may disagree, and introduces a registered systematic review designed to quantify the answer with explicit uncertainty (INPLASY202660145).

2. Two Different Questions: Acute Performance Versus Chronic Adaptation

At the acute level, the mechanistic premise of a privileged follicular window is weakly supported in eumenorrheic women. Across a single cycle, force, velocity, and power output during the loaded half-squat were very similar in the early-follicular, late-follicular, and mid-luteal phases, with unclear differences in most pairwise comparisons [4]. Strength performance, neuromuscular fatigue, and perceived exertion did not differ across menstrual-cycle phases, although high intra-individual fluctuations in estrogen were associated with lower movement velocity in some women [5]. Maximal dynamic strength in the upper and lower body did not vary across six subphases of the cycle in strength-trained women [6], and peak torque and fatigue during isokinetic testing were likewise unaffected by phase [7]. These four primary studies [4–7] are small, each enrolling tens rather than hundreds of women, and each tested the same participants repeatedly within a cycle, a design that controls between-subject variance but does not compensate for the limited total sample; it is the consistency of their null findings, rather than their size, that weakens the premise. A multimethod, systems physiology review concluded that between-phase differences in exercise-relevant outcomes are relatively subtle, difficult to attribute to specific hormones, and unlikely to influence muscular hypertrophy in response to resistance-exercise training [8]; a subsequent consensus statement judged the evidence linking cycle phase to performance to remain inconclusive [2].

This does not mean that ovarian hormones are irrelevant to skeletal muscle. Estrogen influences muscle protein turnover, satellite cell behavior, and the growth hormone/insulin-like growth factor axis, providing biological plausibility for hormonal modulation of training adaptations [9,10]. On its face, the direction of these effects would predict a follicular advantage: estrogen promotes satellite cell proliferation and attenuates muscle protein breakdown, so the late-follicular estrogen peak could favor net protein accretion and repair.

Two facts blunt this prediction: estrogen is also elevated in the mid-luteal phase, alongside progesterone, and the acute performance data reviewed above show no corresponding follicular superiority [3,9]. However, this plausibility is limited; an integrative appraisal of eumenorrheic females concluded that menstrual-cycle phase may affect strength but not skeletal muscle protein metabolism [3], and current recommendations emphasize that establishing any such effect requires methodological rigor that most studies have not achieved [9]. Biological plausibility, in other words, is real but does not, on its own, justify chronic recommendations, precisely because the acute performance signal it would predict is largely absent; the chronic adaptation question must be answered with chronic intervention data rather than inferred from mechanisms.

3. The Chronic-Adaptation Evidence Is Small and Discordant

Only a small number of studies have delivered a phase-periodized resistance-training program and tracked chronic adaptations in strength or hypertrophy over at least one full menstrual cycle (Table 1). Studies were identified through citation chaining from the reviews and consensus statements cited above [1–3,8,9], complemented by targeted PubMed searches; this mapping is explicitly non-systematic, and a formal, reproducible search will be conducted in the registered review (INPLASY202660145). For inclusion in Table 1, a study had to deliver a resistance-training program deliberately organized around the menstrual-cycle phase—either follicular-emphasized versus luteal-emphasized training or phase-based versus cycle-agnostic periodization—and follow strength or hypertrophy outcomes for at least one full cycle. Studies in which a conventional program was delivered, and outcomes were assessed only at different cycle phases, address the phase of measurement rather than phase-periodized training and were therefore not treated as equivalent. Their results do not converge; the apparent direction of effect varies with study characteristics.

Table 1. Evidence map of chronic intervention studies delivering menstrual-cycle phase-based periodized resistance training and following adaptations in muscular strength and/or hypertrophy in women.

Study [Ref]	Population/ Country	Design	Comparison	Adaptation Outcome(s) Reported	Principal Finding (Direction)
Reis 1995 [11]	Eumenorrheic women (n = 7)/Germany	Within-participant, contralateral-leg (one leg cycle-triggered vs. one leg regular)	Follicular-emphasis frequency ("cycle-triggered": every 2nd day in follicular, ~weekly in luteal) vs. regular training (every 3rd day throughout)	Maximal strength; strength-to-cross-sectional-area ratio	Larger maximal-strength gain with follicular-emphasis (32.6% vs. 13.1%); serum-hormone-verified phase; favors follicular, but cycle phase is confounded with the concentration of training and n = 7
Wikström-Frisén 2017 [12]	Trained women, natural cycle and oral-contraceptive users/Sweden	Controlled (parallel), 4 months	High-frequency 2-week block timed to follicular vs. luteal phase; separate control	Squat, countermovement jump, hamstring peak torque, leg lean mass	Gains in the follicular-timed group only; favors follicular timing; calendar-based phase verification; mixed natural-cycle/oral-contraceptive population
Sakamaki-Sunaga 2016 [13]	Eumenorrheic women/Japan	Within-participant (arm-to-arm), 12 weeks	Follicular- vs. luteal-phase training frequency	Cross-sectional area, one-repetition maximum, maximal voluntary contraction	Increases in both arms; the study did not detect a clear between-arm difference; positive between-arm correlation

Table 1. *Cont.*

Study [Ref]	Population/ Country	Design	Comparison	Adaptation Outcome(s) Reported	Principal Finding (Direction)
Sung 2014 [14]	Eumenorrheic women without oral contraception (n = 20)/Germany	Within-participant (leg-to-leg), 3 menstrual cycles (~12 weeks)	Follicular-phase-based (8 of 10 sessions per cycle in the follicular phase) vs. luteal-phase-based (converse) leg-press training; equal total sessions per leg	Maximal isometric force; muscle diameter; muscle fiber composition	Greater increases in maximal isometric force and muscle diameter with follicular-phase-based training; favors follicular; serum hormones sampled once per phase; equal total dose with phase-concentrated distribution
Vargas-Molina 2022 [15]	Resistance-trained eumenorrheic women (n = 10)/Spain	Randomized pilot (parallel), 8 weeks	Menstrual-cycle-based undulating periodization vs. traditional undulating periodization	Fat-free mass; one-repetition-maximum strength	Fat-free mass increased in both arms (~+1.4 kg, statistically significant, traditional; ~+1.7 kg, non-significant, cycle-based, consistent with larger variance in a very small sample); no clear between-arm difference detected; pilot
D'Souza 2026 [16]	Eumenorrheic women (n = 24)/Canada	Within-participant, unilateral RCT, 3 menstrual cycles (~12 weeks)	High volume in follicular vs. high volume in luteal vs. balanced continuous vs. non-exercising control	Thigh lean mass, vastus lateralis cross-sectional area, fat-free mass, one-repetition maximum, maximal voluntary isometric contraction	All training conditions > control (all $p < 0.001$); no clear differences detected among training conditions (all $p \geq 0.17$); volume–load, not phase, associated with adaptation

Directions denote the group favored within each study. Figures are those reported in the cited primary reports; where a study reported no exact between-condition effect size for an outcome, the direction is summarized qualitatively. RCT, randomized controlled trial. The findings column intentionally retains the metrics reported by each primary study (percentages, *p*-values, or qualitative direction) because the published data do not permit a common standardized effect size for all studies (some reports lack standard deviations or exact between-condition estimates); standardized effect sizes (Hedges' g), with author contact for missing data, will be calculated in the registered review (INPLASY202660145). Volume–load equating between conditions: not equated in Reis et al. [11] (higher training frequency in the cycle-triggered condition); the two phase-timed groups completed the same number of high-frequency sessions in Wikström-Frisén et al. [12], but total volume–load was not reported as matched; equal total sessions per condition in Sakamaki-Sunaga et al. [13] and Sung et al. [14]; not reported as formally matched in Vargas-Molina et al. [15]; total volume–load matched by design in D'Souza et al. [16].

Three reports favored the follicular phase. In a comparison of "menstrual-cycle-triggered training" (higher training frequency in the follicular phase and reduced frequency in the luteal phase) with regular training, the follicular-emphasis model produced a larger increase in maximal strength (32.6% vs. 13.1%) and in the ratio of maximal strength to muscle cross-sectional area [11]. Over four months, women who performed a two-week block of high-frequency leg resistance training during the first (follicular) two weeks of each cycle increased squat and countermovement jump performance, hamstring peak torque, and leg lean mass, whereas those who performed the same high-frequency block during the last (luteal) two weeks did not [12]. Similarly, in a within-participant leg-to-leg comparison across three cycles, leg press training concentrated in the follicular phase (eight of ten sessions per cycle) produced greater gains in maximal isometric force and muscle diameter than the luteal-based condition, with an equal total number of sessions per leg [14].

More recent, better-controlled studies did not replicate a phase advantage. In a within-participant design, each arm was trained at a higher frequency during either the follicular or the luteal phase for 12 weeks. Cross-sectional area, one-repetition maximum, and maximal voluntary contraction increased in both arms, with no clear between-arm difference detected and a positive correlation between the two arms' hypertrophic responses [13]. A related study delivered a conventional 12-week program and assessed maximal isometric force during the follicular and luteal phases before and after training; because it addresses the phase at which gains are measured rather than deliberately phase-periodized training, it is noted here but excluded from Table 1 [17]. An eight-week pilot comparing menstrual-cycle-based undulating periodization with traditional undulating periodization in trained women reported fat-free-mass gains in both arms (approximately +1.4 kg, statistically significant, in the traditional arm; approximately +1.7 kg, non-significant, in the cycle-based arm, a pattern consistent with larger variance in a very small sample); the study did not detect a clear between-arm difference, and a significant within-group change in one arm alongside a non-significant change in the other does not itself demonstrate one [15].

The most rigorous test to date is a within-participant, unilateral randomized controlled trial in 24 eumenorrheic women across three consecutive menstrual cycles [16]. Each participant's legs were randomly assigned to a non-exercising control, balanced continuous training, high volume in the follicular phase with low volume in the luteal phase, or the reverse. All training conditions produced greater gains than the control in thigh lean mass, vastus lateralis cross-sectional area, fat-free mass, and one-repetition-maximum strength (all $p < 0.001$), with no clear differences detected among the training conditions (all $p \geq 0.17$). The authors concluded that phase-based training confers neither a hypertrophy nor a strength advantage over continuous training and that training volume–load—not cycle phase—was associated with the observed adaptations [16]. A non-significant comparison in a single trial with 24 participants does not, however, rule out a smaller yet practically meaningful phase effect; quantifying that possibility relative to a pre-specified smallest effect size of interest is one aim of the registered review.

A pattern is nonetheless discernible, although it should be read as hypothesis-generating rather than explanatory. The follicular-favoring signals [11,12,14] each carry at least one design feature that complicates attribution to cycle phase. The earliest study is also the oldest and least controlled in the set. It verified cycle phase with serum hormones but, in only seven participants, compared a follicular-concentrated training schedule with an even-distribution schedule, so cycle phase was confounded with the timing and amount of training [11]; another relied on calendar-based phase verification in a mixed natural-cycle and oral-contraceptive sample [12]; and the third sampled serum hormones only once per phase and, by design, concentrated the training dose in the target phase [14]. The null signals, by contrast, come from designs that reduce between-subject noise [13,16] and, in the most rigorous trial to date, explicitly separate cycle phase from volume–load [16]. Because verification rigor, dose distribution, study era, design, population, and outcome measurement co-vary across this handful of studies, no qualitative reading can isolate the contribution of any single factor; the pattern identifies candidate effect modifiers to be tested formally, not established causes.

4. Why the Studies May Disagree: Candidate Methodological Moderators

Two candidate moderators are developed below because they are the most consistently implicated across the studies in Table 1 and the most readily testable in a synthesis. They are not the only plausible contributors to heterogeneity; training status, exercise selection, the precision of outcome measurement, study era, and sample size also vary across these studies and are considered in Section 4.3.

4.1. Menstrual-Phase-Verification Rigor

The reference standard for classifying cycle phase is serum measurement of estrogen and progesterone, ideally combined with calendar-based counting and urinary luteinizing hormone testing, with a strict luteal-phase criterion (progesterone >16 nmol·L^{-1}) [18]. Serum measurement is the reference standard because calendar counting assumes that ovulation occurred and that the luteal phase was of normal length; anovulatory and luteal-phase-deficient cycles occur in regularly menstruating women and are indistinguishable from ovulatory cycles by calendar alone, so calendar-based classification can assign a luteal label to a woman whose progesterone never rose [18]. In a review of menstrual-cycle research in sport and exercise, only 44% of studies measured serum hormone concentrations, and the likely inclusion of participants with anovulatory or luteal-phase-deficient cycles, compounded by small samples, was identified as a source of the field's conflicting results [18]. Recommendations to apply this rigor specifically to resistance-exercise-training research have since been reiterated [9]. Verification standards vary even among the follicular-favoring chronic studies: the earliest classified phase using serum estrogen and progesterone alongside luteinizing hormone and temperature monitoring [11], whereas the four-month follicular-timing study relied on calendar-based verification in a mixed natural-cycle and oral-contraceptive sample [12], in which some participants classified as being in a given phase may not have been. Poor verification, therefore, cannot, by itself, explain the positive findings, but across the broader literature, where most studies did not confirm phase with serum hormone levels, it remains a plausible modifier of the direction of effect that can bias an already small evidence base. Verification rigor is thus not a peripheral quality item but a candidate moderator to be handled explicitly, as a signaling item, a subgroup factor, and a sensitivity criterion, in any synthesis.

4.2. Training Volume–Load Equating

The second candidate moderator is whether the training conditions delivered the same total volume–load, defined here as the product of external load, repetitions, and sets, with session frequency determining how it accrues. Total training dose and its temporal distribution are distinct quantities; a phase-based program can deliver the same total dose while deliberately concentrating it in different phases, as in the contralateral-limb comparisons of Table 1 [13,14]. Three related but non-identical estimates must therefore be separated: whether the total dose differs between comparison groups, whether the same total dose is distributed differently across cycle phases, and whether cycle phase modifies the response to a given dose. Strength adaptations in trained women are dose-dependent on repetitions and weekly frequency [19], so any comparison in which the "follicular" arm accumulates more training, or more concentrated training, than its comparator confounds cycle phase with training dose. The earliest positive study is illustrative; its follicular-emphasis model delivered a higher training frequency during the follicular phase (training every second day) than its comparator (every third day throughout the cycle), concentrating training in the follicular window. Therefore, a superior outcome cannot be attributed to the phase in isolation from the timing and amount of training [11]. The most rigorous randomized controlled trial to date addressed exactly this confound and reported that adaptation tracked accumulated volume–load rather than phase [16]; within a single trial, this supports volume–load as a determinant of adaptation, but it does not by itself establish that volume–load differences explain the disagreement among earlier studies, nor does a non-significant phase comparison establish that cycle phase has no effect. In that trial, the volume–load contrast was prescribed prospectively, with high- and low-volume blocks assigned to phases in advance and a balanced condition matched in total, and session volume–load was recorded throughout rather than reconstructed post hoc, thereby

strengthening the inference within the trial [16]. Volume–load equating, therefore, belongs in any synthesis as a pre-specified sensitivity restriction, retaining only comparisons in which total volume–load was matched between arms.

4.3. Design, Training Status, Statistical Power, and Outcome Measurement

Within-participant and unilateral designs, which assign a participant's two limbs to different conditions, substantially reduce between-subject variability; the largest and most recent designs, one comparing phase-emphasis conditions head-to-head and another additionally equating volume–load, returned null phase effects [13,16]. The earliest within-participant study was positive [11], but it enrolled only seven participants and did not isolate cycle phase from training volume, so the critical contrast is not the within-participant design itself but sample size and volume–load control. Small parallel-group designs are more vulnerable to imbalance and low power. Training status also varies across studies, from untrained to trained, and most samples are small, ranging from single digits to the low tens of participants. These features are legitimate subgroup and sensitivity factors, and the small number of eligible studies means that any quantitative synthesis must foreground uncertainty rather than a single point estimate. Populations also range from strictly eumenorrheic samples to mixed samples that include oral-contraceptive users [12], which should not be treated as equivalent. A further candidate source of disagreement is heterogeneity in outcome measurement: Table 1 spans direct imaging of muscle size (cross-sectional area and muscle diameter), regional lean mass, and whole-body fat-free mass, which differ in their sensitivity to localized hypertrophy; the registered review will therefore prioritize direct imaging measures. Because these features co-vary with verification rigor and volume–load, and because so few studies equate them, none of these factors can currently be isolated as the explanation for the discordance. In the registered review, training status and study design are pre-specified as exploratory subgroups; study precision, which is partly determined by sample size, is reflected in the study weights, whereas the prediction interval characterizes the expected dispersion and uncertainty of true effects across settings; and outcome-measurement type is handled by the outcome hierarchy, which prioritizes direct imaging (Section 6).

5. What Existing Syntheses Do and Do Not Answer

Prior quantitative syntheses do not address the chronic question of deliberately phase-periodized training in naturally cycling women. Systematic reviews and meta-analyses of the acute, within-cycle effect assess performance across phases rather than adaptation to phase-based training. A multilevel meta-analysis of hormonal contraceptive use found that oral contraceptive use had no significant effect on resistance-training adaptations in hypertrophy, power, or strength (for strength, standardized mean difference 0.10, 95% confidence interval −0.08 to 0.28; p = 0.20; 8 studies, 325 participants) and explicitly concerns exogenous-hormone users rather than phase-based periodization in naturally cycling women [20]. The most directly relevant synthesis of chronic adaptations is a narrative review arguing that follicular-phase-based training may be superior to luteal-phase-based training [1], a position that predates and now runs counter to the volume–load-controlled randomized trial [16]. Because practitioners and commercial applications may still rely on that earlier narrative conclusion, the newer evidence creates a need for updated coaching and clinical guidance, not merely for further research. A scoping review mapped the use of phase-based resistance training in women after anterior cruciate ligament reconstruction but did not pool the effects [21]. Mechanistic and methodological reviews converge on a cautious reading; effects are subtle, and rigorous phase verification is required before firm conclusions can be drawn [3,8,9]. The closest prior systematic

review qualitatively appraised menstrual-cycle and oral-contraceptive effects on both acute responses and chronic adaptations to resistance training and reported conflicting, methodologically limited evidence. At that time, three of four training studies favored follicular-phase-based training while explicitly calling for further experimental work; it did not statistically pool effects, was not confined to phase-based periodization, and predates the volume–load-controlled trial that has since reframed the question [22]. The picture has since changed. Among the six chronic studies now available (Table 1), follicular-favoring estimates coexist with uncertain or null estimates, and these studies differ so markedly in precision, design, and methodological quality that a simple tally would misrepresent their evidential weight; the null estimates are concentrated in the most recent and best-controlled designs [13,15,16]. No registered systematic review has yet provided a quantitative, uncertainty-aware synthesis of chronic adaptations in strength and hypertrophy to deliberately phase-periodized resistance training in eumenorrheic women. That is the gap.

6. Toward a Registered, Uncertainty-Aware Synthesis

The appraisal in Sections 3–5 stands on its own; this section sets out, prospectively, how the hypotheses that appraisal generates will be tested formally. We have registered a systematic review and meta-analysis to address this gap (INPLASY202660145) [23]. Its design follows directly from the analysis above. Only the design choices necessary to follow the argument are summarized here; full methodological details are available in the registered protocol [23]. Two comparisons are analyzed separately—follicular-emphasis versus luteal-emphasis phase-based training and any phase-based periodization versus cycle-agnostic (non-periodized or evenly distributed) training, with a sensitivity analysis restricted to volume–load-equated comparisons. Two outcomes are assessed separately: maximal muscular strength (dynamic or isometric/isokinetic maximal voluntary contraction, selected according to a pre-specified hierarchy) and muscle hypertrophy (direct imaging measures preferred over regional and whole-body lean-mass measures). Effects are expressed as standardized mean differences (Hedges' g), with explicit handling of dependent effect sizes: within-participant and contralateral-limb comparisons will be analyzed as paired effects that retain their pairing correlation (imputed and varied in sensitivity analyses where unreported); in multi-arm studies, dependency on a shared control will be addressed primarily by combining the intervention arms into a single comparison, with adjustment of the shared-control variance as a sensitivity analysis; and multiple eligible strength or hypertrophy outcomes from the same study will be reduced to one effect per study by the pre-specified outcome hierarchy in the primary analysis, with multilevel or robust-variance modeling as a sensitivity analysis; the decision rules governing each of these choices are prespecified in the registered protocol [23].

Because the number of eligible studies is small, the synthesis is deliberately uncertainty-aware and reports two co-primary analyses. The primary frequentist random-effects model uses the restricted maximum likelihood (REML) estimator of between-study variance with the Hartung–Knapp–Sidik–Jonkman adjustment and reports a pooled estimate with a prediction interval; the Paule–Mandel estimator is applied as a sensitivity analysis. A Bayesian hierarchical model with a weakly informative prior on the between-study standard deviation reports the posterior median with a 95% credible interval, the posterior probability of benefit, and the posterior probability of exceeding a pre-specified smallest effect size of interest, so that a small or uncertain pooled effect is presented as such rather than being dichotomized into "significant" or "not." The smallest effect size of interest will itself be justified substantively rather than generically; candidate thresholds on the standardized scale will be translated into outcome-specific units, such as kilograms

of one-repetition-maximum strength or square centimeters of muscle cross-sectional area, using pooled baseline standard deviations, and judged against the magnitude of change that would plausibly alter training prescription. A single generic numerical threshold has therefore not been fixed in advance; the registered protocol prespecifies this derivation procedure, and the resulting outcome-specific thresholds will be fixed and documented before data extraction and before any pooled estimate is inspected [23]. Because the eligible studies are expected to be few and heterogeneous, conditions under which frequentist estimation of between-study heterogeneity and confidence-interval coverage performs poorly, the Bayesian analysis is arguably the more directly informative of the two for decision-making under this degree of heterogeneity. It propagates the considerable uncertainty in the heterogeneity parameter into the pooled estimate instead of conditioning on a single point value, and it replaces a binary significance verdict with direct, decision-relevant probability statements about the direction and magnitude of any effect. For this reason, the Bayesian model is treated as co-primary rather than as a secondary sensitivity analysis, and any pooled effect is interpreted using the posterior probability of a practically meaningful benefit rather than relying on statistical significance alone. In practical terms, the Bayesian analysis answers the question a coach actually asks: how probable it is that phase-based training produces a gain large enough to matter, rather than whether a difference of any size can be declared statistically significant. Menstrual-phase-verification rigor (serum-confirmed versus not) and volume–load equating are pre-specified primarily as sensitivity, stratification, and explanatory analyses rather than as definitive tests of what drives heterogeneity. With very few studies, subgroup and meta-regression estimates are unstable, an apparently null moderator effect is weak evidence against effect modification, and an apparently large one can be dominated by a single study; training status and study design are additional exploratory subgroups; and the certainty of evidence is rated with the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. A pre-specified, broadened secondary analysis considers phase-based periodization of other modalities, motivated by proteomic evidence that menstrual-cycle phase-based sprint-interval training induces distinct skeletal muscle adaptations in endurance-trained women [24]; modality is modeled as a moderator.

Ongoing trials will refine the estimate as they report. The MENSES trial (ClinicalTrials.gov NCT06679491), for example, is a randomized comparison of resistance training with load increased in the follicular phase, increased in the luteal phase, or applied continuously across phases in naturally cycling athletes, alongside an oral-contraception comparison group, with serum-verified phase classification and neuromuscular outcomes; at the time of writing, it is listed as recruiting, with estimated completion in 2027. Prospectively incorporating such trials and contacting authors for eumenorrheic-subgroup data from mixed-population studies will allow the review to quantify the best current estimate, characterize the methodological factors driving disagreement, and identify the trials still needed to resolve it.

7. Conclusions

The recommendation to periodize resistance training to the menstrual cycle is more popular than the current evidence warrants. The chronic-adaptation literature is small and discordant, and two methodological factors, phase-verification rigor and volume–load equating, are plausible candidate explanations for much of that discordance, alongside heterogeneity in outcome measurement; because these features co-vary across a handful of small studies, none can yet be identified as the established cause. At the acute level, between-phase differences in maximal strength and power in eumenorrheic women are generally small or absent, further weakening the mechanistic rationale. Whether and for

whom phase-based periodization meaningfully alters chronic strength and hypertrophy cannot yet be answered with confidence; equally, the recent null results should not be read as proof of ineffectiveness, because no adequately powered body of evidence yet excludes a small but practically meaningful effect in either direction. For the practitioner reading this today, the defensible position is threefold. First, prioritize the factors with established dose–response support in resistance-training research: progressive volume–load, training frequency, and adherence, a position consistent with established resistance-training principles and with the finding of the best current trial that adaptation tracked volume–load rather than cycle phase [16,19]. Second, phase-based adjustments may reasonably be offered on the basis of individual preference, symptom management, and athlete autonomy [2,16]; this is an autonomy-based rationale, not a claim of superior adaptation. Third, treat commercial claims that concentrating training in the follicular phase accelerates strength or hypertrophy gains as not supported by current controlled evidence; in particular, phase-based periodization should not be marketed by applications or practitioners as an evidence-based performance-enhancement strategy. A registered systematic review with co-primary frequentist and Bayesian meta-analyses that separates the acute from the chronic question and formally tests phase-verification rigor and volume–load equating as candidate effect modifiers is warranted and underway (INPLASY202660145).

Author Contributions: Conceptualization, A.R.-J. and M.A.H.-L.; writing—original draft preparation, M.R.-V. and J.G.-A.; writing—review and editing, A.R.-J. and M.G.D.-R.; supervision, M.A.H.-L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI), Grant ApoyosLNC-2023-69, which was awarded to M.A.H.-L.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All sources are cited. The systematic-review dataset and analysis code will be shared in an open repository upon completion of the review registered as INPLASY202660145.

Acknowledgments: The LaNCoCoME acknowledges the support received from SECIHTI in the years 2025 and 2026, for the Doctoral Degree Scholarship provided for the second author, M.R.-V.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. 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] [PubMed]
2. Verhagen, E.; Ferrer, E.; Antero, J.D.S.; Bahtijarevic, Z.; Barlow, A.; Bolling, C.; Gabarro, M.; Harrison, M.; Jarrin, P.; Janse de Jonge, X.; et al. UEFA consensus statement on menstrual cycle tracking in women's football. *BMJ Open Sport Exerc. Med.* **2025**, *11*, e002769. [CrossRef] [PubMed]
3. Knowles, O.E.; Aisbett, B.; Main, L.C.; Drinkwater, E.J.; Orellana, L.; Lamon, S. Resistance training and skeletal muscle protein metabolism in eumenorrheic females: Implications for researchers and practitioners. *Sports Med.* **2019**, *49*, 1637–1650. [CrossRef] [PubMed]
4. 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*, 123–133. [CrossRef] [PubMed]
5. Dragutinovic, B.; Moser, F.; Notbohm, H.L.; Ihalainen, J.K.; Bloch, W.; Schumann, M. Influence of menstrual cycle and oral contraceptive phases on strength performance, neuromuscular fatigue, and perceived exertion. *J. Appl. Physiol.* **2024**, *137*, 919–933. [CrossRef] [PubMed]
6. Zinner, C.; Wirges, P.; Geisler, S.; Isenmann, E. No effect of menstrual cycle on maximum dynamic strength in upper and lower body in strength-trained females: A six-arm cross-over study. *J. Sports Med. Phys. Fit.* **2025**, *65*, 883–890. [CrossRef] [PubMed]
7. Velten, L.; Prado, R.C.R.; Conforti, A.L.P.; Andreatta, M.V.; Ferreira Reis, C.B.; Leite, R.D. Menstrual cycle does not affect peak torque or fatigue in resistance-trained women. *Int. J. Sports Med.* **2026**, *47*, 198–205. [CrossRef] [PubMed]

8. D'Souza, A.C.; Wageh, M.; Williams, J.S.; Colenso-Semple, L.M.; McCarthy, D.G.; McKay, A.K.A.; Elliott-Sale, K.J.; Burke, L.M.; Parise, G.; MacDonald, M.J.; et al. Menstrual cycle hormones and oral contraceptives: A multimethod systems physiology-based review of their impact on key aspects of female physiology. *J. Appl. Physiol.* **2023**, *135*, 1284–1299. [CrossRef] [PubMed]
9. Van Every, D.W.; D'Souza, A.C.; Phillips, S.M. Hormones, hypertrophy, and hype: An evidence-guided primer on endogenous endocrine influences on exercise-induced muscle hypertrophy. *Exerc. Sport Sci. Rev.* **2024**, *52*, 117–125. [CrossRef] [PubMed]
10. Gharahdaghi, N.; Phillips, B.E.; Szewczyk, N.J.; Smith, K.; Wilkinson, D.J.; Atherton, P.J. Links between testosterone, oestrogen, and the growth hormone/insulin-like growth factor axis and resistance exercise muscle adaptations. *Front. Physiol.* **2020**, *11*, 621226. [CrossRef] [PubMed]
11. Reis, E.; Frick, U.; Schmidtbleicher, D. Frequency variations of strength training sessions triggered by the phases of the menstrual cycle. *Int. J. Sports Med.* **1995**, *16*, 545–550. [CrossRef] [PubMed]
12. Wikström-Frisén, L.; Boraxbekk, C.J.; Henriksson-Larsén, K. Effects on power, strength and lean body mass of menstrual/oral contraceptive cycle based resistance training. *J. Sports Med. Phys. Fit.* **2017**, *57*, 43–52. [CrossRef] [PubMed]
13. Sakamaki-Sunaga, M.; Min, S.; Kamemoto, K.; Okamoto, T. Effects of menstrual phase-dependent resistance training frequency on muscular hypertrophy and strength. *J. Strength Cond. Res.* **2016**, *30*, 1727–1734. [CrossRef] [PubMed]
14. Sung, E.; Han, A.; Hinrichs, T.; Vorgerd, M.; Manchado, C.; Platen, P. Effects of follicular versus luteal phase-based strength training in young women. *SpringerPlus* **2014**, *3*, 668. [CrossRef] [PubMed]
15. Vargas-Molina, S.; Petro, J.L.; Romance, R.; Bonilla, D.A.; Schoenfeld, B.J.; Kreider, R.B.; Benítez-Porres, J. Menstrual cycle-based undulating periodized program effects on body composition and strength in trained women: A pilot study. *Sci. Sports* **2022**, *37*, 753–761. [CrossRef]
16. D'Souza, A.C.; Van Every, D.W.; Bhinder, A.; Elango, S.; Lamont, G.A.C.; Lees, M.J.; Lim, C.; McKendry, J.; Newbold, J.P.; Naphin, C.; et al. Menstrual cycle phase does not influence training-induced muscle hypertrophy or strength: A randomized controlled trial. *Med. Sci. Sports Exerc.* **2026**, *58*, 2255–2273. [CrossRef] [PubMed]
17. Sung, E.S.; Kim, J.H. The resistance training effects of different weight level during menstrual cycle in female. *J. Exerc. Rehabil.* **2019**, *15*, 249–253. [CrossRef] [PubMed]
18. Janse de Jonge, X.; Thompson, B.; Han, A. Methodological recommendations for menstrual cycle research in sports and exercise. *Med. Sci. Sports Exerc.* **2019**, *51*, 2610–2617. [CrossRef] [PubMed]
19. 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] [PubMed]
20. Nolan, D.; McNulty, K.L.; Manninen, M.; Egan, B. The effect of hormonal contraceptive use on skeletal muscle hypertrophy, power and strength adaptations to resistance exercise training: A systematic review and multilevel meta-analysis. *Sports Med.* **2024**, *54*, 105–125. [CrossRef] [PubMed]
21. O'Loughlin, E.; Reid, D.; Sims, S. The role of menstrual cycle phase-based resistance training for women post anterior cruciate ligament reconstruction: A scoping review. *Phys. Ther. Rev.* **2023**, *28*, 211–222. [CrossRef]
22. 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]
23. Ramos-Jiménez, A.; Amaro-Gahete, F.J.; Rubio-Valles, M.; Hernández-Torres, R.P.; Guereca-Arvizuo, J.; Hernández-Lepe, M.A. *Menstrual-Cycle Phase-Based Periodization of Resistance Training Versus Cycle-Agnostic Resistance Training for Muscular Strength and Hypertrophy in Eumenorrheic Women: A Protocol for a Systematic Review and Meta-Analysis*; INPLASY Protocol 202660145; INPLASY: Middletown, DE, USA, 2026. [CrossRef]
24. Kissow, J.; Jacobsen, K.J.; Jessen, S.; Thomsen, L.B.; Quesada, J.P.; Bangsbo, J.; Deshmukh, A.S.; Hostrup, M. Global proteomics reveals distinct muscle adaptations to menstrual cycle phase-based sprint interval training in endurance-trained females. *Mol. Cell Proteom.* **2025**, *24*, 101053. [CrossRef] [PubMed]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.