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SPORTS PERFORMANCE

An audit and quality assessment of the methods used to determine menstrual cycle phases in studies assessing athletic performance in elite female athletes

G. Sherwin[a*], T.R Flood[a,b*], R.J. Burden[a,c], L.M Burke[d], A. Field[a], M.A. Kuikman[d], A.K.A. McKay[d], E.S. Smith[d] and K. J. Elliott-Sale[a]

[a]Department of Sport and Exercise Sciences, Manchester Metropolitan University Institute of Sport, Manchester, UK; [b]Department of Psychological and Sport Sciences, University of West London, London, UK; [c]UK Sports Institute, Manchester, UK; [d]Mary Mackillop Institute for Health Research, Australian Catholic University, Melbourne, Victoria, Australia

ABSTRACT

Menstrual cycle (MC) phases may impact athletic performance due to the non-reproductive actions of 17-β-oestradiol and progesterone, which fluctuate across the MC. Research often includes recreational athletes, with findings generalised to elite athletes. To inform evidence-based practice and future research, the scope and quality of studies examining the relationship between athletic performance and MC phases in elite female athletes must be evaluated. This study audited these studies. Eleven studies, involving 218 athletes, were included. Of these studies, 91% (n = 198) of athletes were categorised as tier 4 (elite/international level) and 9% (n = 20) as tier 5 (world-class). The majority of studies (55%, n = 6) relied solely on calendar-based counting to delineate MC phases, while 45% (n = 5) incorporated calendar-based counting and biochemical methods. A methodological quality ranking system for MC phase determination revealed that one study achieved gold-tier status (9%); 18% achieved silver, 55% bronze, and 18% were ungraded. Research on the effects of MC phases on athletic performance in elite female athletes is of low methodological quality due to an overreliance on calendar-based counting without biochemical verification. Future research should verify MC phases to improve the research impact for elite female athletes.

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KEYWORDS
Ovarian hormones; methodological quality; best practice; biochemical methods; athlete calibre

Introduction

The menstrual cycle (MC) is a biological rhythm characterised by fluctuations in the endogenous ovarian hormones 17-β-oestradiol and progesterone. A eumenorrheic (*i.e*., normal and healthy) MC lasts 21—35 days, wherein there is evidence of ovulation and a correct ovarian hormone profile within defined ranges (*i.e*., low oestradiol and progesterone concentrations during menstruation), a peak in oestradiol prior to ovulation, and a peak in progesterone greater than 16 nmol.L^{-1} following ovulation) (Elliott-Sale et al., 2021). The MC can be divided into four distinct phases based on significant differences in ovarian hormone concentrations (Figure 1).

Oestradiol and progesterone exert non-reproductive effects (Chrousos et al., 1998; Davis & Hackney, 2017) that may influence exercise performance (de Jonge, 2003). As such, athletic performance could theoretically be affected by MC phases (*i.e*., the fluctuations in oestradiol and progesterone across the MC). To date there is no consensus on the effects of MC phases on exercise performance (Constantini et al., 2005; de Jonge, 2003; Lebrun, 1993; McNulty et al., 2020). This lack of consensus may be due to large between-study variation in previous research designs; specifically in the participants studied (*e.g*., training status), the method of MC phase determination used (*i.e*., assumed versus verified) and in the applied sampling techniques (*i.e*., unintentionally including subtle menstrual dysfunction profiles amid eumenorrheic profiles).

A 2021 narrative review (Carmichael et al., 2021a) showed that most studies (87%) related to MC and athletic performance were performed on Tier 2 (trained/developmental) to Tier 0 (sedentary) level female athletes, according to an athlete calibre classification framework (McKay et al., 2021), meaning that 13% of studies included national or international-level athletes. In elite sport, where performance variability is small and tiny margins separate winning and losing, changes that may be insignificant to recreational athletes may have a notable impact on event outcomes and have medal/title-winning consequences for elite

CONTACT K.J. Elliott-Sale k.elliott-sale@mmu.ac.uk Department of Sport and Exercise Sciences, Manchester Metropolitan University Institute of Sport, 99 Oxford Road, Manchester M1 7EL, UK
*contributed equally.

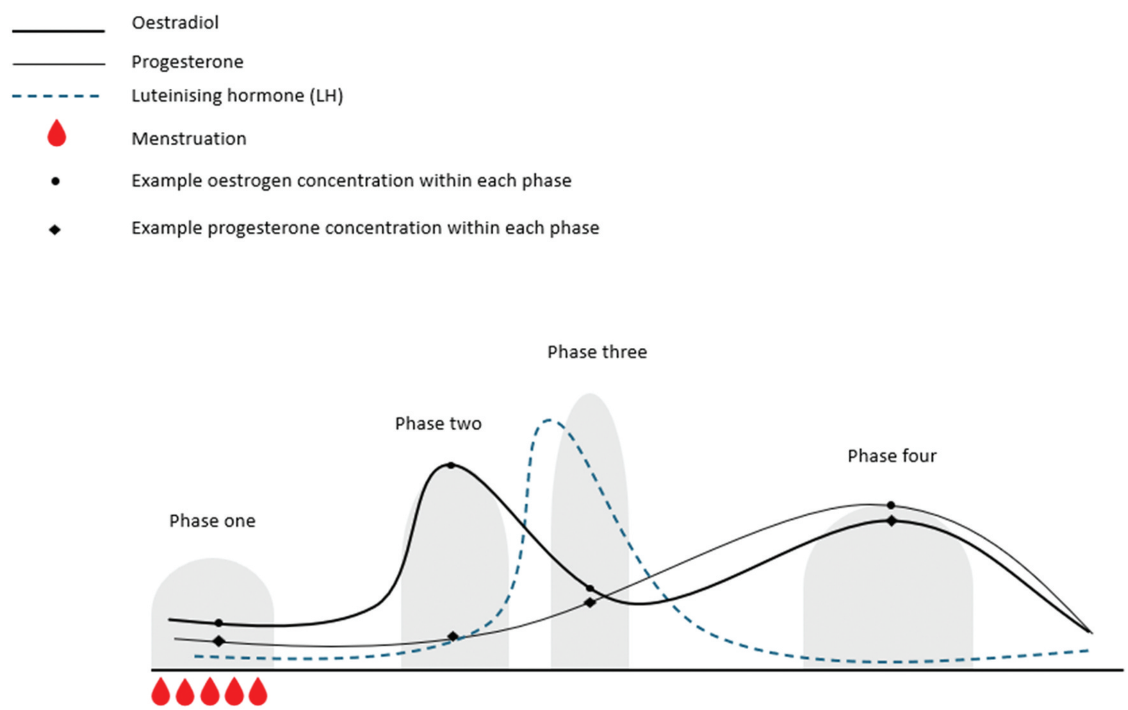

Figure 1. Figure 1. MC phases based on those defined by Elliott-Sale et al. (2021). Phase one can be defined as the onset of bleeding until day five; phase two can be defined as 14—26 hours prior to ovulation and the luteinising hormone surge; phase three is indicated by a positive urinary ovulation test and lasts for approximately 24—36 hours; phase four can be defined as seven days following confirmed ovulation, with progesterone concentration > 16 $nmol.L^{-1}$. In previous literature, phase one may be described as the 'early follicular phase'; phase two may be described as the 'late follicular phase'; phase three may be described as the 'ovulatory phase'; and phase four may be described as the 'mid-luteal phase'. Abbreviations: MC = menstrual cycle. LH = luteinising hormone.

athletes (Hopkins et al., 2001). In addition, given the greater training volumes observed in elite athletes (Osborne et al., 2023), any MC-related changes in athletic performance may have a significant impact on chronic training adaptations (Thompson et al., 2020) and training intensity distribution (de Jonge, 2003). Therefore, any training or competition-based recommendations for elite female athletes in relation to their MC should be based on research that specifically involves elite female athletes as the sample population.

To investigate the impact of MC phase on athletic performance in eumenorrheic female athletes, verifying the phase in which the outcome measurement is tested is vital (Burden et al., 2024; Elliott-Sale et al., 2021, 2024). Methods used to establish MC phases include calendar-based counting [based on regular menstruation], basal body temperature (BBT), urinary-luteinising hormone (LH) measurement, salivary analysis, serum hormone analysis, salivary ferning (salivary crystallisation producing a fern-like appearance under a microscope prior to ovulation; Su et al., 2017), and transvaginal ultrasonography (Thompson et al., 2019). *Best practice* for verifying MC phases combines self-reported and objective measurements; reporting menses to identify Phase one, using urinary ovulation kits to confirm a mid-cycle LH surge distinguishing Phase two and Phase three, and a blood sample for progesterone determination to categorise Phase four, with retrospective confirmation of oestradiol and progesterone within defined ranges for each phase (Elliott-Sale et al., 2021). Sole reliance on regular menstruation (*e.g.*, using so-called MC tracking apps or calendar-based counting) assumes the occurrence and timing of ovulation and the presence of sufficient Phase four progesterone concentration, leading to estimated rather than verified MC phases (Burden et al., 2024). Factors such as historical precedence, convenience, and minimal demand for resources or budget promote the persistence of these methodologies with considerable limitations, reflecting the limited funding of projects, the complexity of verifying MC phases using biochemical methods, and a lack of researcher knowledge to correctly implement biochemical methods. Consequentially, previous studies may have incorrectly labelled their MC phases [with the exception of Phase one], thus obfuscating the phase in which a measurement was made and the interpretation of such measurements. Indeed, McNulty et al. (2020) assessed the quality of evidence from 78 studies investigating exercise performance across the MC and most evidence was rated as very low (26%), low (42%) and moderate quality (24%). Only 8% of studies were classified as high quality, with MC phases verified using blood samples, urinary ovulation detection kits and calendar-based counting.

Verifying MC phases reduces the likelihood of including athletes with menstrual irregularities (*i.e.*, deviations in the normal MC timing, duration, and menstrual flow; Harlow et al., 2000) or menstrual dysfunction (*i.e.*, a range of conditions that disrupt the normal MC, often associated with altered hypothalamic-pituitary-ovarian axis function; De Souza et al., 2010) in eumenorrheic studies (Noordhof et al., 2024). Research has shown a greater prevalence of sub-clinical menstrual dysfunction (De Souza et al., 2010; Torstveit & Sundgot-Borgen, 2005), such as anovulation (*i.e.*, menstruation without the presence of ovulation) and luteal-phase deficiency (*i.e.*, menstruation with lower progesterone concentrations <16 nmol.L^{-1} in Phase four) in exercising women versus controls, which might be linked to differences in training volume (*i.e.*, higher in elites) and energy availability (*i.e.*, lower in elites). Failure to verify eumenorrhea may result in the unintended inclusion of women with menstrual irregularities or menstrual dysfunction, thus leading to a heterogeneous sample and inaccurate conclusions.

Before considering future research priorities assessing MC phases and athletic performance in elite female athletes, it is valuable to audit the quantity and quality of the current evidence base; thus identifying and evaluating the research designs employed to date. An audit framework was developed to assess female athlete representation within sports and exercise science research (Smith et al., 2022). This framework provides an understanding of a topic by systematically auditing the literature to provide guidance or recommendations for future research. Within this framework, a tiering system was created to assess the quality of methodological control relating to the determination of MC phases that reflects best practice guidance (Elliott-Sale et al., 2021).

The primary aim of this audit was to assess the methods used to determine MC phases in athletic performance research involving elite female athletes using an adapted version of an established framework (Smith et al., 2022). The secondary aim was to assess the methodological quality of these studies.

Methods

Study search and selection

Digital literature searches were conducted in March 2024 using SPORT discuss, PubMed and Web of Science and repeat searches were conducted in April 2024. Citation tracking was performed using Google Scholar to identify any studies missed in the initial searches. An updated search was conducted in February 2025 to identify any studies published since the last search in April 2024. Studies considered for inclusion were full text accessible, peer-reviewed research studies written in English only. No date restrictions were applied for inclusion. The pre-defined criteria for inclusion are described in Table 1.

Screening and selection

Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia, https://www.covidence.org) was used for the initial screening of titles and abstracts. Search results and citations were imported into the software and duplicates were removed. In the digital literature searches conducted in 2024 and 2025, initial screening and full-text reviews were completed independently by two reviewers (GS and TF), based on the *a priori* eligibility criteria. All conflicts were discussed and resolved between the two researchers.

Search terms

Searches were conducted using the following terms:

Athlete Population: ('elite' OR 'elite athlete' OR 'Olympic' OR 'world-class' OR 'international')

Hormonal Profile: ('menstrual cycle' OR 'menstrual cycle phase' OR 'ovarian hormones' OR 'reproductive hormones')

Performance Outcome: ('athletic performance' OR 'sport performance' OR 'exercise' OR 'muscle strength' OR 'power' OR 'anaerobic' OR 'anaerobic performance' OR 'anaerobic power' OR 'anaerobic capacity' OR 'aerobic' OR 'aerobic exercise' OR 'aerobic performance' OR 'endurance capacity' OR 'fatigue').

Audit outcomes

This audit follows the framework outlined by Smith et al. (2022), focusing on outcomes related to population, athletic calibre, sample size, menstrual status, journal or study impact and research theme. Notably, 'population' and 'journal or study impact' were excluded from the analysis, and 'methods used to determine MC phases' were included to focus on the methods employed to assess athletic performance across the MC in elite female athletes.

Table 1. Eligibility criteria based on population, intervention, and study outcomes.

Population	Athlete characteristics: Healthy cis-gender women aged 18—35 years old, naturally menstruating or eumenorrheic (definitions outlined in Table 2), or described as 'not using hormonal contraceptives/free from hormonal contraceptives' were accepted for inclusion in the audit. Athlete calibre classification: Athletes classified as Tier 4 or Tier 5 based on McKay et al. (2021) were considered for inclusion. • Tier 4: An athlete competing at international level, on a national team, or in international leagues or competitions, who completes maximal or near maximal training with intention to compete at top-level competition. • Tier 5: An Olympic or world medallist, in the top 3–20 in the world rankings, or within 2% of world-record/leading performance who complete maximal or near maximal training within given sporting norms. • Team sport athletes were considered for inclusion if they were described as performing in the highest league in the sport in their respective country (*e.g.*, female footballers playing in the women's super league in the United Kingdom (UK)). • Studies describing athletes as 'trained', 'highly trained', or equivalent, without sufficient qualification classifying them as Tier 4 or Tier 5, or athletes described as 'recreational' or 'untrained' were excluded. Studies of mixed athlete calibre: • Studies with mixed athlete calibres were classified based on the predominant calibre within most of the sample, excluding those with athletes < Tier 4 if no distinction was made between groups. In studies intentionally comparing athletes of different training status (e.g., < Tier 4 and > Tier 4 athletes), only the Tier 4/5 athlete group was included in the audit.
Intervention	Studies were required to compare the athletic performance outcomes across at least two phases of the MC.
Study outcomes	The primary outcome of each study was athletic performance (*"measuring a performance outcome following an intervention or in association with a topic of interest"*; Smith et al., 2022). Studies were included if they were within one of the following divisions: • Athletic performance variables from researcher-implemented performance tests or assessments, conducted outside of training or competition (structured assessments typically performed in controlled conditions *e.g.*, 1 RM to assess strength, agility, Time to exhaustion/VO_{2max} test to measure endurance, etc.) • Athletic performance variables assessed during regular training/competition, without additional structured assessments (*e.g.*, Global Positioning System variables (GPS), match performance outcomes, athlete monitoring) Studies were included if they were either of the following divisions: • Prospective – Athletic performance was assessed across MC phases in real-time (as they occurred) to investigate an effect. • Retrospective – Athletic performance data were collected and later mapped against estimated or verified MC phases to investigate an effect.

Abbreviations: MC = menstrual cycle; RM = repetition maximum; VO2max = maximal oxygen uptake.

Table 2. Criteria for each methodological quality tier, adapted from Smith et al. (2022).

Tier	MC studies
Gold	Athletes are eumenorrheic: (1) Have MC lengths ≥21 days and ≤35 days resulting in nine or more consecutive periods per year. (2) Evidence of LH surge (3) Correct hormonal profile from blood sample analysis or saliva sample analysis (*i.e.*, low oestradiol and progesterone concentrations during menstruation, a peak in oestradiol prior to ovulation, and a peak in serum progesterone greater than 16 nmol.L^{-1} following ovulation). In the case of salivary progesterone, there is currently no clinical threshold to establish sufficient progesterone concentration in Phase 4. The post-ovulation +7-day sample needs to be compared with samples obtained during the first half of the MC to assess the delta change. A Phase 4 salivary progesterone concentration >50 pg/mL and >1.5x the follicular baseline has been used to evidence sufficient progesterone concentration in Phase 4 to indicate ovulation (Ferrer et al., 2024). (4) No HC use 3 months prior to recruitment (5) MC characteristics are tracked for ≥2 months prior to testing. (6) Outcome measures are repeated in a second cycle.
Silver	Athletes are naturally menstruating with ovulatory cycles: (1) They experience menstruation, with MC lengths ≥ 21 days and ≤ 35 days. (2) Confirmed ovulation (LH) (3) Without correct hormonal profile. (4) Prior HC use not stated or less than 3 months prior to recruitment. (5) MC characteristics are tracked for 1 month prior to testing. (6) Outcome measures are not repeated in a second cycle.
Bronze	Athletes are naturally menstruating: (1) They experience menstruation, with MC lengths ≥21 days and ≤35 days. (2) No confirmed ovulation (3) Without correct hormonal profile. (4) Prior HC use not stated or less than 3 months prior to recruitment. (5) No tracking of MC characteristics prior to testing. (6) Outcome measures are not repeated in a second cycle
Ungraded	Insufficient detail to award a gold, silver, or bronze tier

Abbreviations: MC = menstrual cycle; LH = luteinising hormone; HC = hormonal contraceptive.

Outcome 1. Sample size, sport, and athlete calibre

Details on sample size, age, sport, and athlete calibre were extracted. Athlete samples were classified as Tier 4 or Tier 5 using a classification framework (McKay et al., 2021).

Outcome 2. Performance measure

Performance outcomes were categorised based on performance assessments conducted outside of training or competition and performance during training or competition. Studies were classified by research design as retrospective or prospective.

Outcome 3. MC phase determination methods

The methods used to determine MC phases were identified, including any combinations of techniques.

Outcome 4. Methodological quality

For the digital literature searches in 2024 and 2025, methodological quality was independently evaluated by two authors (GS, TF) to ensure agreement. Quality was assessed using a tiered ranking system (Smith et al., 2022). Studies were ranked into gold, silver, bronze, or ungraded tiers, based on the criteria presented in Table 2.

Data analysis

Frequency-based metrics were calculated and reported as counts and percentages. For sample size and age, ranges were provided, and where available, means ± standard deviations were reported.

Results

The results from the search strategy and study identification are presented in Figure 2. Eleven studies were included in the final audit. Table 3 summarises the studies included in the audit and the main outcomes.

Outcome 1. Sample size, sport, and athlete calibre

Table 3 summarises the study sample size, age of athlete sample, the sport athletes identified with, contextual details on athlete calibre, and the assigned athlete calibre tier. The 11 studies included in the audit contained 218 athletes in their analyses. Sample size ranged from 5 to 22 women per study, and the age of athletes ranged from 18 to 35 years old. Eight of the eleven studies (Abbott et al., 2024; Campa et al., 2021; Carmichael et al., 2021b; Gasperi et al., 2023; Juillard et al., 2024; Julian et al., 2021; Romero-Moraleda et al., 2025; Scott et al., 2024) included only naturally menstruating athletes. Two studies (Bouvier et al., 2025; Carlin et al., 2024) included naturally menstruating athletes and hormonal contraceptive users. In these studies, only the naturally menstruating athletes were included in this audit. One study (Schoene et al., 1981) included three participant groups: regularly menstruating women with no history of competitive athletic

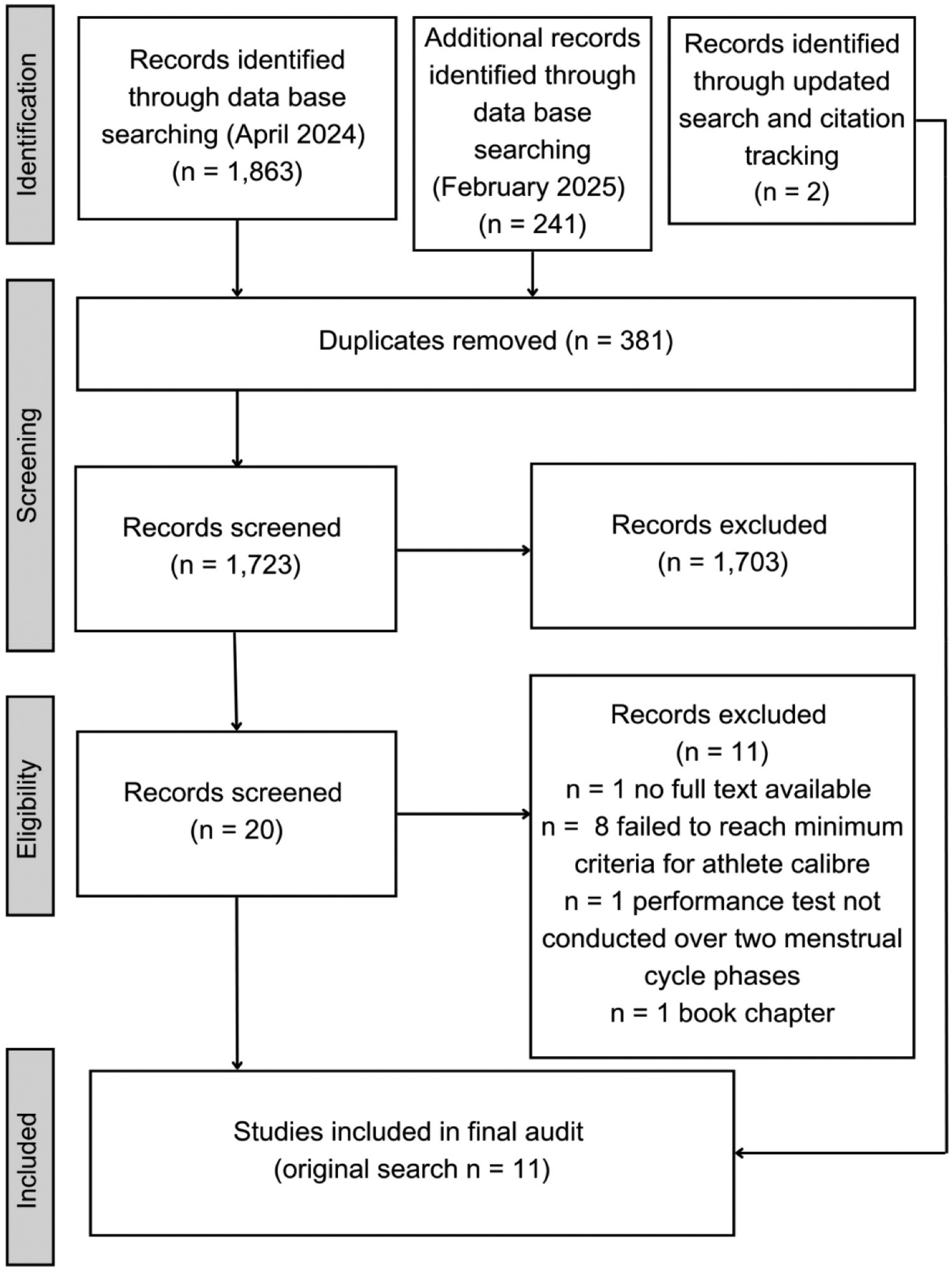

Figure 2. Flow diagram of studies from audit search strategy. Primary searches were conducted in March 2024 and April 2024 and a repeat search was conducted in February 2025.

participation; regularly menstruating highly trained, middle or long-distance female runners of varsity, national, or international ranking; and amenorrhoeic highly trained, middle or long-distance runners of varsity, national, or international ranking. From the Schoene et al. (1981) study, only the regularly menstruating female runners were included in this audit. Of the 218 athletes, 198 athletes (91%) were classified as elite/international (*i.e.*, tier 4; McKay et al., 2021), and the remaining 20 athletes (9%) were classified as world-class (*i.e.*, tier 5; McKay et al., 2021).

Outcome 2. Performance measure

Five studies investigated a MC phase effect in researcher-implemented performance tests or assessments outside of regular training, competition, or athlete monitoring, using the Illinois agility test (Juillard et al., 2024); countermovement jump (Campa et al., 2021; Romero-Moraleda et al., 2025); squat jump (Bouvier et al., 2025); 20-metre sprint (Campa et al., 2021); 40-metre sprint (Bouvier et al., 2025) sit and reach flexibility (Campa et al., 2021); half-squat,

Table 3. All audit studies and outcomes. Key. **1** = have MC lengths ≥21 days and ≤35 days. **2 =** evidence of lh surge. **3 =** correct hormone profile from blood sample or saliva sample analysis. **4 =** hc users excluded, and no hc use 3 months prior to recruitment. **5 =** MC characteristics were tracked prior to testing. **6 =** outcome measures are repeated in a second cycle. ✓ = criteria met ✗ = criteria not met. Age of athlete sample reported as 'mean ± standard deviation'. Additional information regarding menstrual status is provided when the extracted data does not fully align with the methodological quality criteria.

	Outcome 1				Outcome 2		Outcome 3	Outcome 4	
Reference	Sample size	Sport	Additional participant information	Athlete calibre	Outcome of the study	Research design	MC tracking methods used	Methodological quality tier & Classification	Information provided relating to menstrual status
Abbott et al. (2024)	22 (25 ± 5 years)	Football	Professional women's soccer players in the Women's Super League (Brighton and Hove Albion Football Club)	Tier 4	Training, competition, or athlete monitoring variables	Retrospective	Calendar-based counting only	Ungraded Naturally menstruating	(1) ✗ (2) ✗ (3) ✗ (4) ✗HC-users excluded but no time frame (5) ✗ (6) ✗Outcomes tested over 26 matches in a soccer season
Bouvier et al., (2025)	11 (26 ± 4 years) (21 total sample size – 10 HC-users)	Football	Elite female footballers from the French national league	Tier 4	Researcher-implemented performance test/ assessment outside of training and competition	Prospective	Calendar-based counting and serum blood sampling	Silver Naturally menstruating with verified hormonal profiles	(1) ✓ 24–35 days in length (2) ✗ (3) ✓ Minimum mid-luteal serum progesterone concentration of 16 nmol. L^{-1} (4) ✓ (5) ✓ (6) ✗
Carlin et al. (2024)	7 (age not reported for non-HC users only) (13 total sample – 6 HC-users)	Cycling	Elite French cyclists	Tier 4	Training, competition, or athlete monitoring variables	Prospective	Calendar-based counting only (via linear regression model based on cycle length)	Bronze Naturally menstruating	(1) ✓ 22–35 days in length (2) ✗ (3) ✗ (4) ✗HC-users excluded but no time frame (5) ✗ (6) ✗Outcomes collated over 30 months

(*Continued*)

Table 3. (Continued).

	Outcome 1				Outcome 2		Outcome 3	Outcome 4	
Reference	Sample size	Sport	Additional participant information	Athlete calibre	Outcome of the study	Research design	MC tracking methods used	Methodological quality tier & Classification	Information provided relating to menstrual status
Carmichael et al. (2021b)	5 (18–35 years)	Australian rules football	Australian rules football players from one team in the Women's Australian Football League	Tier 4	Training, competition, or athlete monitoring variables	Retrospective	Calendar-based counting, urine samples for urinary pregnanediol glucuronide levels	Bronze Naturally menstruating	(1) ✓ (2) ✗ (3) ✗ (4) ✗HC-users excluded but no time frame (5) ✗ (6) ✗Outcomes collated across a competitive season
Campa et al. (2021)	20 (24 ± 3 years)	Football	Female soccer players within an Italian first division soccer team	Tier 4	Researcher-implemented performance test/ assessment outside of training and competition	Prospective	Calendar-based counting only	Bronze Naturally menstruating	(1) ✓ 29 days average length (2) ✗ (3) ✗ (4) ✓ No HC-use 6 months before recruitment (5) ✗ (6) ✓ Outcomes tested over two cycles
Gasperi et al. (2023)	11 (21 ± 3 years)	Basketball	Female professional basketball players in the first division Lithuanian women's basketball league (Lietuvos Moteru)	Tier 4	Training, competition, or athlete monitoring variables	Retrospective	Calendar-based counting only	Bronze Naturally menstruating	(1) ✓ 27–29 days in length (2) ✗ (3) ✗ (4) ✗HC-users excluded but no time frame (5) ✗ (6) ✗
Juillard et al. (2024)	18 (10 In final analysis) (19 ± 1 years)	Football	Elite academy women's soccer players, playing for U23 team of Dijon Football Côte d'Or (DFCO) in France	Tier 4	Researcher-implemented performance test/ assessment outside of training and competition	Prospective	Calendar-based counting only	Ungraded Naturally menstruating	(1) ✗ (2) ✗ (3) ✗ (4) ✗HC-users excluded but no time frame (5) ✗ (6) ✗

(*Continued*)

Table 3. (Continued).

	Outcome 1			Outcome 2			Outcome 3	Outcome 4	
Reference	Sample size	Sport	Additional participant information	Athlete calibre	Outcome of the study	Research design	MC tracking methods used	Methodological quality tier & Classification	Information provided relating to menstrual status
Julian et al. (2021)	83 (15 in final analysis) (19 ± 4 years)	Football	Female soccer players from the first and second German league	Tier 4	Training, competition, or athlete monitoring variables	Retrospective	Calendar-based counting, urinary ovulation kits and serum blood sampling	Bronze Eumenorrhea confirmed prior to testing Tracking not continued during testing months	(1) ✓ 24–35 days in length (2) ✓ Prior to testing only (3) ✓ Prior to testing only (4) ✗HC-users excluded but no time frame (5) ✓ MC characteristics tracked for one month prior to testing (6) ✗Outcomes collected over four months
Romero-Moraleda et al. (2025)	15 (23 ± 6 years)	Football	Elite female soccer players belonging to the same team. The team competed in the Spanish first division during the 2021/2022 season.	Tier 4	Researcher-implemented performance test/ assessment outside of training and competition	Prospective	Calendar-based counting, urinary ovulation kits and saliva sampling	Gold Eumenorrheic	(1) ✓ 30 ± 4 days in length (2) ✓ (3) ✓ Saliva samples confirmed hormonal profile (4) ✓ (5) ✓ (6) ✗
Schoene et al. (1981)	6 (28 ± 8 years)	Running	Mixture of Olympic and world championship athletes [PBs: marathon 2:45:00, 1500m 04:21, 800m 2:10.5, 10k 35:40, marathon 2:43:20, 800m 2:15]	Tier 4	Researcher-implemented performance test/ assessment outside of training and competition	Prospective	Calendar-based counting, BBT, and serum blood sampling	Silver Naturally menstruating with BBT and verified hormone profile	(1) ✗ (2) ✗ (3) ✓ (4) ✗ (5) ✗ (6) ✗ BBT used to estimate ovulation
Scott et al. (2024)	20 (28 ± 4 years)	Football	Outfield players representing the United States of America (USA) women's national team	Tier 5	Training, competition, or athlete monitoring variables	Retrospective	Calendar-based counting only via FitrWomen algorithm	Bronze Naturally menstruating	(1) ✓ 29 ± 3 days in length (2) ✗ (3) ✗ (4) ✓ No HC-use 6 months before recruitment (5) ✓ MC characteristics tracked for nine months prior to testing (6) ✗

Abbreviations: MC = menstrual cycle. LH = luteinising hormone. HC = hormonal contraceptive. BBT = basal body temperature. PBs = personal best.

deadlift, and hip thrust (Romero-Moraleda et al., 2025); and $V.O_{2max}$ test (Schoene et al., 1981). Five studies investigated a MC phase effect during regular training, competition, or athlete monitoring, without additional structured assessments, through countermovement jump (Carmichael et al., 2021b); adductor strength test (Carmichael et al., 2021b); total distance covered during soccer match play and/or training sessions (Abbott et al., 2024; Julian et al., 2021; Scott et al., 2024); number of high-intensity bouts and sprints in soccer match play (Julian et al., 2021); and number of shots, rebounds, turnovers, and effective field goal percentage in basketball match play (Gasperi et al., 2023). Carlin et al. (2024) aggregated averaged external load variables in cyclist training sessions, including training time, total distance, speed, power, cadence, torque, intensity factor, and training stress score (Carlin et al., 2024).

Six studies (Bouvier et al., 2025; Carlin et al., 2024; Campa et al., 2021; Juillard et al., 2024, Romero-Moraleda et al., 2025; Schoene et al., 1981) were categorised as prospective in their research design (*i.e.*, athletic performance was assessed across MC phases in real-time as they occurred) and five studies (Abbott et al., 2024; Carmichael et al., 2021b; Gasperi et al., 2023; Julian et al., 2021; Scott et al., 2024) were categorised as retrospective (athletic performance data were mapped against estimated or verified MC phases after the fact).

Outcome 3. MC phase determination methods

Six different protocols (Figure 3) for MC phase determination were reported across the eleven studies. Calendar-based counting was the most popular protocol employed and was used in 55% (n = 6) of studies. Five studies (45%) employed a combination of tracking methods. One study measured oestradiol concentrations, though referred to these measurements as 'oestrogen'. For consistency and accuracy, the term oestradiol has been used throughout this audit to reflect the specific hormone measured.

Outcome 4. Methodological quality

Methodological quality was assessed using the tier ranking system by Smith et al. (2022) for MC studies (Figure 4). When assessed against these criteria, one study was awarded a gold tier (9%), two studies were awarded silver tier (18%), six studies were awarded bronze tier (55%), and two studies were ungraded (18%). Cohen's Kappa was calculated to quantify inter-rater reliability (k = 1.0). There was complete agreement between both reviewers on the methodological quality tiers awarded, and the third reviewer was not required. Table 3 outlines the information for MC phase determination extracted from each study, and the methodological quality rating awarded to each study.

Discussion

The aim of this audit was to assess the methods used to determine MC phases in athletic performance research involving elite female athletes, using an adapted version of an established framework (Smith et al., 2022), and to assess the methodological quality of these studies. This audit identified 11 studies assessing MC phase and athletic performance in elite female athletes. Of these, 55% (n = 6) relied solely on calendar-based counting, while 45% (n = 5) used biochemical methods to verify MC phases. One study (9%) achieved a gold tier for methodological quality, two studies achieved silver tier (18%) and 73% of studies were categorised as bronze tier (55%; n = 6) or ungraded (18%; n = 2) due to the lack of biochemical verification (see Table 3).

Athlete calibre and performance measure

Eleven studies assessed the effect of MC phase on athletic performance in elite female athletes; ten studies included Tier 4 elite/international) (Abbott et al., 2024; Bouvier et al., 2025; Carlin et al., 2024; Carmichael et al., 2021b; Campa et al., 2021; Gasperi et al., 2023; Juillard et al., 2024; Julian et al., 2021; Romero-Moraleda et al., 2025; Schoene et al., 1981) and one included Tier 5 (world class) athletes (Scott et al., 2024). Poor descriptors made it difficult to ascertain if nationally competing athletes (Tier 3 – highly trained/national level) also met Tier 4 criteria. To address this, the framework was adapted to include and classify team sport athletes in top domestic leagues as Tier 4 (*e.g.*, Women's Super League footballers in the UK), unless Tier 5 criteria were clearly met. Vague terms like 'highly trained' and 'high level' complicated classification, and six studies were excluded due to providing insufficient qualification on athlete calibre to classify their athletes as Tier 4 or Tier 5 (Dokumacı & Hazır, 2019; Ekberg et al., 2024; García-Pinillos et al., 2021; Gordon et al., 2013; Phillips et al., 1996; Tounsi et al., 2017). A 2021 systematic review (Meignié et al., 2021) assessed studies on the impact of MC phase on elite female athletes. Differences in study inclusion (prior to 2021) between our audit and this review, stem from varying 'elite' definitions and inclusion criteria. This audit applied stricter eligibility criteria from an established framework (McKay et al., 2021), excluding studies from

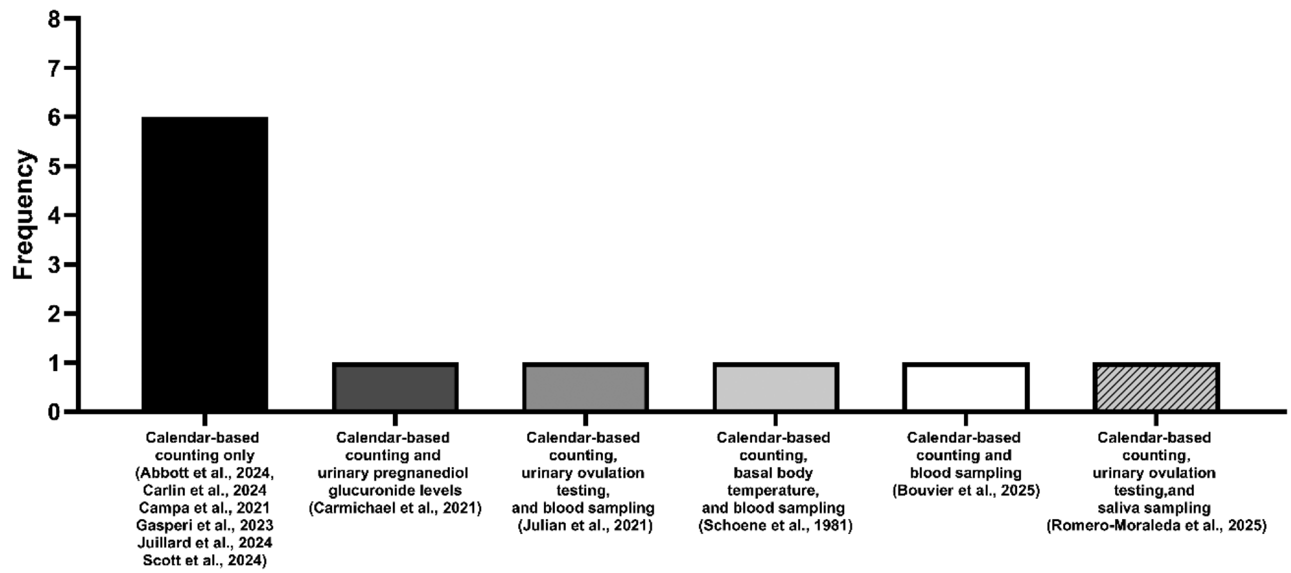

Figure 3. Frequency of the combination of protocols used for MC phase determination in all audit studies. Abbreviations: MC = menstrual cycle.

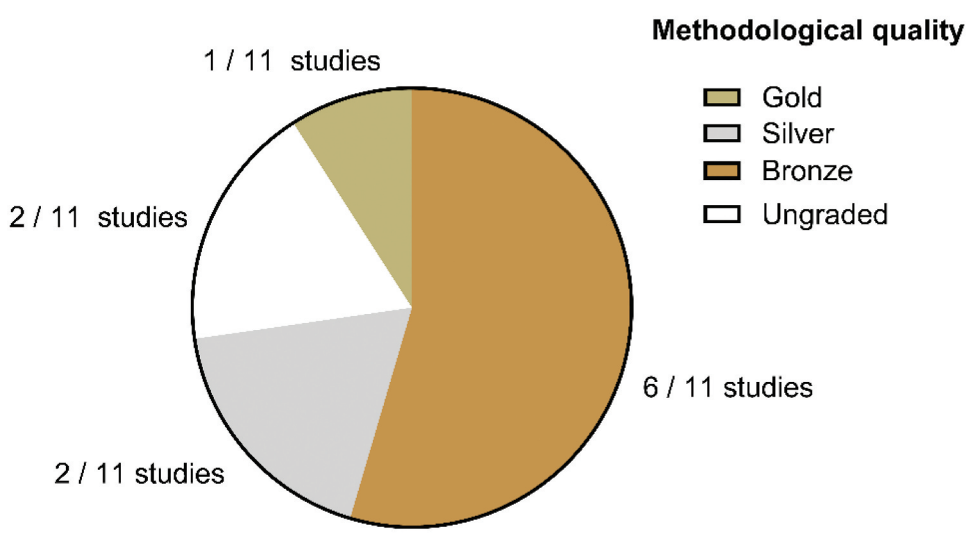

Figure 4. Methodological quality of studies included in the audit, as assessed by MC studies tier system by Smith et al. (2022).

Meignié et al. (2021) that involved below Tier 4 athletes. By focusing on the highest calibre athletes, this audit ensures that MC phase-based research is relevant to elite performers. Future studies in this area should adopt established frameworks (McKay et al., 2021) and incorporate contextual sporting information to improve interpretation and between-study comparisons.

Studies in this audit used two data acquisition methods; five studies used researcher-led performance tests/assessments conducted outside of training or competition (Bouvier et al., 2025; Campa et al., 2021; Juillard et al., 2024; Romero-Moraleda et al., 2025; Schoene et al., 1981), while six studies used data collected during regular training, competition or athlete monitoring, without additional structured assessments (Abbott et al., 2024; Carlin et al., 2024; Carmichael et al., 2021b; Gasperi et al., 2023; Julian et al., 2021; Scott et al., 2024). Fixed training programmes often make the latter approach (*e.g*., GPS, match performance outcomes) the most feasible option for assessing athletic performance in elite athletes. This approach is cost-effective, reduces the logistical burden of coordinating testing with stakeholders, and avoids disruptions to intense training schedules.

Two research designs were employed to assess athletic performance and MC phase in elite athletes; six studies were prospective and five studies were retrospective. To produce meaningful data, both approaches must use verified phases. Three of the prospective studies (Bouvier et al., 2025; Romero-Moraleda et al., 2025; Schoene et al., 1981) verified MC phases used biochemical methods, while the others estimated MC phases through calendar-based counting (Campa et al., 2021; Carlin et al., 2024; Juillard et al., 2024). None of the five retrospective studies (Abbott et al., 2024; Carmichael et al., 2021b; Gasperi et al., 2023; Julian et al., 2021; Scott et al., 2024) used biochemical methods, meaning all phases were estimated.

MC Phase determination methods and methodological quality

The majority (55%; n = 6) of studies relied solely on calendar-based counting to determine MC phases. This method estimates phases based on the regular occurrence of menstruation and cycle length, counting forward or backwards from menses (Grieger & Norman, 2020) or arbitrarily dividing MC length in half (Wideman et al., 2013). Calendar-based counting makes two assumptions; first, that an event has occurred (*e.g.*, ovulation), and second, that it occurred at a specific time (*e.g.*, ovulation at the halfway point of the cycle). Furthermore, it cannot detect subtle menstrual dysfunctions, such as anovulation or luteal-phase deficiency, which are believed to occur more frequently in elite athletes (Taim et al., 2023). Therefore, calendar-based counting significantly undermines the validity and integrity of the associated data (Burden et al., 2024; Elliott-Sale et al., 2021).

The historical reliance on calendar-based counting may stem from a limited understanding of its impact on research validity, lack of resources, desire to expedite research, and oversimplification of the MC in the media. Achieving gold tier methodological quality requires subject specific knowledge, time, and resources. The practical limitations in elite sport surrounding the implementation of gold-standard methods for MC phase determination are recognised. Notably, rigid training programmes, frequent travel, and practitioner and athlete burden, such as time demands, disruption to routine and invasiveness, present challenges (Taim et al., 2024). Moreover, urinary ovulation testing and blood sampling can be costly and time-sensitive blood sampling may be hindered by athlete and practitioner availability (Taim et al., 2024). These constraints may have contributed to the reliance on less accurate and sometimes inaccurate methods to estimate MC phases, such as calendar-based counting. Whilst these logistical challenges are acknowledged, researchers and practitioners must adhere to their research question (*i.e.*, in studies) or intention (*i.e.*, in practice). If the purpose of MC tracking is to truly establish menstrual health, then the determination of ovulation and sufficient progesterone concentration during Phase 4 are key indicators of this. If the intention is to robustly interrogate performance under different ovarian hormone conditions, then verification of these phases is needed. When resources are limited, as in the case of calendar-based counting, the research question or application might align with this; menstrual health is solely limited to the regularity of bleeding and performance can only be compared during bleeding and non-bleeding days. While the importance of methodological guidance for implementing MC tracking in applied elite sport is recognised, this falls outside the scope of the present audit.

In the absence of a best practice approach (Elliott-Sale et al., 2021), researchers should use language that actually reflects the methods employed. For example, studies using calendar-based counting should refer to 'bleeding' and 'non-bleeding' days, not specific MC phases (*e.g.*, Phase two, Phase three, and Phase four) for observations made during non-bleeding days. All six studies relying solely on calendar-based counting in this audit used inappropriate terminology in relation to their MC phase determination methods. Four studies (Abbott et al., 2024; Campa et al., 2021; Gasperi et al., 2023; Juillard et al., 2024) used 'follicular' and 'luteal' phases, separated by an assumed ovulation mid-point at day 14, one study divided the MC into 'menstrual phase'(bleeding days), 'mid-cycle'(last day of menstrual bleed to day of estimated ovulation), and 'late-cycle' (day after estimated ovulation to the day prior to subsequent menstruation) (Carlin et al., 2024), and one study used 'Phase one, Phase two, Phase three, and Phase four (Scott et al., 2024), despite failing to verify MC phases or the presence of ovulation with biochemical methods.

Forty-five percent (n = 5) of studies used biochemical methods alongside calendar-based counting: one study used serum blood samples (Bouvier et al., 2025); two studies combined serum blood samples with urinary ovulation tests (Julian et al., 2021) and BBT (Schoene et al., 1981); and one study assessed post-ovulatory progesterone metabolite secretion via urinary pregnanediol glucuronide levels (Carmichael et al., 2021b); only one study (Romero-Moraleda et al., 2025) combined calendar-based counting with best practice methods of urinary ovulation testing and salivary hormone analysis (Figure 3). Schoene et al. (1981) were awarded a silver tier rating (Table 3). Although the methodological quality criteria in this audit were based on current best practice recommendations for

MC phase determination published by Elliott-Sale et al. (2021), an exception was made for Schoene et al. (1981), where historical context was considered. Admittedly, their methodology relied on BBT measurement rather than urinary ovulation testing to establish ovulation. Despite this, the first one-step ovulation test was not introduced until 1989, making the use of BBT measurement to establish ovulation considered as best practice at that time. While BBT has now been largely replaced by urinary ovulation testing in best practice MC phase tracking recommendations (Elliott-Sale et al., 2021) due to its susceptibility to external factors such as illness and sleep disturbances (Su et al., 2017), its use aligned with the methodological standards the time of publication (1981) and the study was classified as a silver tier to reflect its relative methodological rigour.

Several of the studies included here were published after best practice guidelines (Elliott-Sale et al., 2021) were established (Abbott et al., 2024; Carlin et al., 2024; Gasperi et al., 2023; Juillard et al., 2024; Scott et al., 2024) yet only achieved bronze or no grade (Table 3). It is encouraging to note that the two most recent studies (2025) achieved gold (Romero-Moraleda et al., 2025) and silver tier (Bouvier et al., 2025) for methodological quality. Future studies should continue to uphold and build upon the best practice recommendations in research on athletic performance across the MC in elite female athletes.

One bronze-tier study (Julian et al., 2021) verified eumenorrhea upon athlete recruitment using best practice MC phase tracking methods (see Table 3) but later relied on calendar-based counting to estimate MC phases for testing. Extrapolating eumenorrhea to subsequent cycles is problematic due to large variability in MC length (Chiazze, 1968; Smith et al., 2024) and sporadic anovulatory cycles in regularly menstruating women (Hambridge et al., 2013). Calendar-based counting was used as the researchers assumed athletes and coaches would refuse to provide the blood samples required for continued best practice tracking (Julian et al., 2021).

Two studies were ungraded (Abbott et al., 2024; Juillard et al., 2024) due to insufficient detail for methodological quality classification. Both studies failed to report the average MC lengths of athletes during data collection, a key criterion to achieve a bronze tier classification (Table 2). This omission makes it unclear whether athletes met the definition of 'naturally menstruating' (*i.e.*, menstruation and MC lengths of 21–35 days) and raises concerns regarding the potential inclusion of athletes with menstrual irregularities. Whilst both studies reported excluding HC-users, Abbott et al. (2024) failed to specify a minimum exclusion period prior to data collection, and Juillard et al. (2024) excluded oral contraceptive users within 6 months of data collection but did not clarify whether other forms of HC were also excluded. Although neither study verified MC phases with biochemical methods, clearly reporting MC lengths of the sample and explicitly defining HC exclusion criteria would represent small but important improvements in reporting standards and contribute to improving methodological quality and study comparability.

Reporting standards and recommendations

The methodological quality criterion for MC research (Smith et al., 2022) recommends an absence of HC use for at least 3 months prior to data collection to ensure eumenorrheic cycles are re-established, increasing the resulting validity (Elliott-Sale et al., 2021; Smith et al., 2022). Six studies (four bronze, two ungraded) excluded HC users but did not specify the absence period, and one study (silver) did not report HC-user exclusion. An additional gold-tier criteria is repeating outcomes across two MCs to assess cycle variation. Five studies assessed outcomes across multiple cycles, but four did not repeat outcomes over a second independent cycle. For example, one study collated data from 30 months (81 cycles across 7 non-HC using athletes; Carlin et al., 2024), while three summed data from 26 matches over a season (Abbott et al., 2024), a full competitive season (Carmichael et al., 2021b), or 4 months (76 match observations, 36 from follicular and 40 from luteal phases Julian et al., 2021). Summing cycles does not reduce variability, especially with using calendar-based tracking, as ovarian hormone concentrations cannot be compared for consistency across cycles.

In this audit, the MC-specific framework by Smith et al. (2022) was deliberately selected to evaluate methodological quality over alternative tools, such as the modified Downs and Black (D&B) checklist used by McNulty et al. (2020). The D&B framework included some MC-specific criteria, such as requiring a clear description of MC phases and confirmation of participants as non-HC users for at least 3 months prior to testing. Despite this, their overall quality rating primarily assessed general methodological factors and was adjusted based solely on the presence of biochemical verification (*e.g.*, blood samples and urinary ovulation tests), which may oversimplify the assessment of methods used to determine MC phases. In contrast, our audit employed the Smith et al. (2022) protocol which was developed to explicitly evaluate the methods employed for MC phase determination, allowing for a more nuanced assessment of previous studies. This framework contains criteria not captured in the modified D&B checklist, such as tracking MC characteristics of participants for at least 1 month prior to testing, and repeating outcomes measures in a second independent MC. McNulty et al. (2020) also restricted inclusion to studies reporting average MC lengths of 21–35 days, a marker of methodological rigour that separated bronze tier and ungraded classifications in the protocol by Smith et al. (2022). The limitations of generalised checklists are further illustrated in the review by Meignié et al. (2021), using an unmodified D&B checklist that did not account for methods used to determine the MC phase. As a result, studies that used solely calendar-based counting to determine MC phase were rated as having 'good methodological quality', despite failing to accurately verify MC phases and thus instil confidence in their findings.

These findings highlight the lack of high-quality research on MC phases and athletic performance in elite female athletes. The knowledge gap in this area, driven by conflicting datasets, will persist unless the determination of MC phases and methodological quality is significantly improved, particularly through the verification of these phases in lieu of assumed phases. Currently, research quality and quantity are insufficient to confirm or refute MC phase-based effects on athletic performance, making universal recommendations unfeasible. Future research should follow best practices to verify MC phases in elite female athlete studies.

Conclusion

There is a paucity of evidence on the effects of oestradiol and progesterone fluctuations across the MC on athletic performance in elite female athletes. Among the studies in this area, only one achieved a gold tier for methodological quality in determining MC phases, and the majority of studies (n = 6, 55%) relied solely on calendar-based counting to estimate MC phases. Improving the quality of MC phase determination is crucial for assessing cyclical variations in athletic performance. Future research should avoid estimating MC phases by using calendar-based counting only, rather it should verify MC phases using best practice methodologies to enhance validity and integrity of research findings (Elliott-Sale et al., 2021). Encouragingly, the most recently published studies in this audit (Bouvier et al., 2025; Romero-Moraleda et al., 2025) achieved a comparatively higher methodological quality tier (*i.e.*, silver and gold, respectively), which may demonstrate a promising step towards more rigorous research practices. Whilst achieving a gold tier for methodological quality may increase costs and study durations, adhering to best practice recommendations will generate findings that are both valid and translational.

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ORCID

K.J. Elliott-Sale http://orcid.org/0000-0003-1122-5099

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