

# From Menstrual Cycle Tracking to Menstrual Cycle Syncing: A Scoping Review of Cycle Phase Effects on Lifestyle Behaviors

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**Keywords:** Menstrual Cycle Syncing, Digital Health Technologies, Menstrual Cycle Tracking Applications, Lifestyle Behavior, Menstrual Cycle Phases, Women's Health, Scoping Review.


**Abstract:** **Introduction:** The concept of menstrual cycle syncing (MCS), first popularized in 2014, proposes that individuals adapt lifestyle behaviors such as nutrition, exercise, and sleep according to cyclical hormonal fluctuations. Despite its widespread dissemination through social media, scientific evidence and a scientific definition of MCS remains lacking. **Objective:** This scoping review aims to conceptualize MCS by examining scientific evidence on the effects of menstrual cycle (MC) phases on lifestyle behaviors and outcomes in eumenorrheic, non-athletic menstruating individuals and by assessing how and to what extent digital health technologies (DHTs) are used to support MCS research. **Methods:** A structured search was conducted across nine databases following PRISMA-ScR guidelines. Eligible studies were analyzed for methodology, sample characteristics, reliability of menstrual phase determination, and use of DHTs. **Results:** Of the 52 included studies, 71.2% reported phase-related behavioral or physiological variations, though methodologies were inconsistent and samples small. Only 7.7% of studies integrated DHTs. **Conclusion:** Current evidence does not support a universal model of MCS. This review proposes a refined definition of MCS as an individualized process, discusses the essential yet underused role of DHTs in enabling such personalization, and distills future research directions for digitally supported approaches to MCS research.


## 1 INTRODUCTION


Under the influence of (cyclical) hormonal changes, the female body undergoes physiological changes affecting multiple systems beyond reproduction that further change across the life course (Reed & Carr, 2000; Rugvedh et al., 2023; Thiyagarajan et al., 2024). The American College of Obstetricians and Gynecologists described the menstrual cycle (MC) as a fifth vital sign, recognizing its diagnostic value in assessing health status (American College of Obstetricians and Gynecologists, 2015). However, menstrual disorders such as premenstrual syndrome (PMS), premenstrual dysphoric disorder (PMDD),


polycystic ovarian syndrome (PCOS) or endometriosis remain highly prevalent, together affecting over 90% of young menstruating individuals and leading to both personal and economic burdens through absenteeism, reduced productivity, and healthcare costs (Odongo et al., 2023; O'Shea et al., 2024).

Across a typical, healthy (so called eumenorrheic) cycle that lasts between 21 and 35 days, four hormonally distinct phases can be differentiated (Schmalenberger et al., 2021): the menstrual phase (low estradiol and progesterone), the follicular phase (gradual rise in estradiol), the ovulatory phase (estradiol peak and luteinizing hormone surge), and the luteal phase (progesterone-dominant phase). In recent years, the concept of menstrual cycle syncing (MCS), the adaptation of lifestyle behaviors to the different phases of

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the MC, has gained growing public attention (Pfender et al., 2025). Originally introduced in 2014, the approach claims that aligning nutrition, exercise, sleep, and work activities with hormonal rhythms may optimize well-being and prevent hormonal imbalances (Vitti, 2014). The idea has spread widely through social media platforms, where it is promoted as an evidence-based wellness and hormone-balancing method, often promoted with claims about improving symptoms of conditions such as PCOS – reflecting, in part, Vitti’s own narrative of alleviating her PCOS-related complaints through cycle-based lifestyle adjustments. However, the scientific validation of these claims remains limited (Bruinvels et al., 2022) and despite increasing public interest, there is currently no academic consensus or operational definition of MCS – a gap we want to close with this research. Without a clear and shared definition, systematic empirical investigation is hindered, conceptual consistency across studies is compromised, and the responsible development, evaluation, and regulation of cycle-aware therapies and digital therapeutics will remain challenging.

To bridge the gap between anecdotal discourse and scientific evidence, this paper conducts a systematic scoping review of the existing literature on the effects of MC phases on lifestyle behaviors. It examines how lifestyle-related outcomes across physical activity, nutrition, sleep, stress, cognition, and social behavior vary across cycle phases and explores the extent to which these variations have been methodologically and digitally assessed. Through this synthesis, the study aims to conceptualize a research-based understanding of MCS. Accordingly, this paper addresses the following three research questions:

- RQ1:** What is the current state of research on the impact of menstrual cycle phases on lifestyle behaviors?
- RQ2:** How does this evidence inform the concept of menstrual cycle syncing?
- RQ3:** What potential do digital tools hold for advancing menstrual cycle research?

By systematically mapping current evidence, this paper contributes to a scientific foundation for MCS and identifies opportunities for leveraging digital health technologies (DHTs) to improve the accuracy and scalability of MCS research.

## 2 METHOD

Scoping reviews are particularly suited to mapping the breadth, characteristics, and methodological approaches of heterogeneous and emerging bodies of

literature, especially where concepts are inconsistently defined and evidence has not yet been comprehensively synthesized. This scoping review was carried out in accordance with the latest version of the PRISMA extension for scoping reviews by Tricco et al. (2018) to ensure transparency and comprehensiveness in reporting. The objective was to systematically identify and map the existing literature examining associations between MC phases and lifestyle-related behaviors or outcomes in healthy individuals assigned female at birth (AFAB). Publications were included if they fulfilled the criteria listed in Table 1.

In May 2024, a structured electronic literature search was conducted across Scopus, PubMed, Web of Science, EBSCOhost, Embase, and Cochrane. To ensure a comprehensive search within EBSCOhost, the following databases were considered: MEDLINE, CINAHL, APA PsycINFO, APA PsycARTICLES, and AMED. The final search strings for each database are presented in Appendix A.

Table 1: Inclusion criteria for the relevant studies.

Inclusion Criteria	Reason for Inclusion
Language	English
Year	2014-2024
Study type	Peer-reviewed articles
Concept	Impact of MC phases on lifestyle behavior outcomes (nutrition, physical activity, stress management, restorative sleep, social connection)
Population	Eumenorrheic naturally menstruating individuals AFAB, non-athletes
Context	Open

All retrieved records were imported to Rayyan.ai<sup>1</sup> for de-duplication and systematic screening. Two authors independently conducted a two-step selection process: (1) title and abstract screening, followed by (2) full-text review.

Data from the included studies were extracted using a customized Excel sheet capturing publication year and country, study design and sample size, method for menstrual phase determination, investigated lifestyle domain(s), key findings and direction of phase effects, and use of digital tools (e.g., apps, wearables). To adequately answer the research questions, the extracted data per item was summarized into categories based on a codebook which was developed iteratively (cf. Appendix B, Table A2).

<sup>1</sup> Rayyan.ai, <https://www.rayyan.ai/>

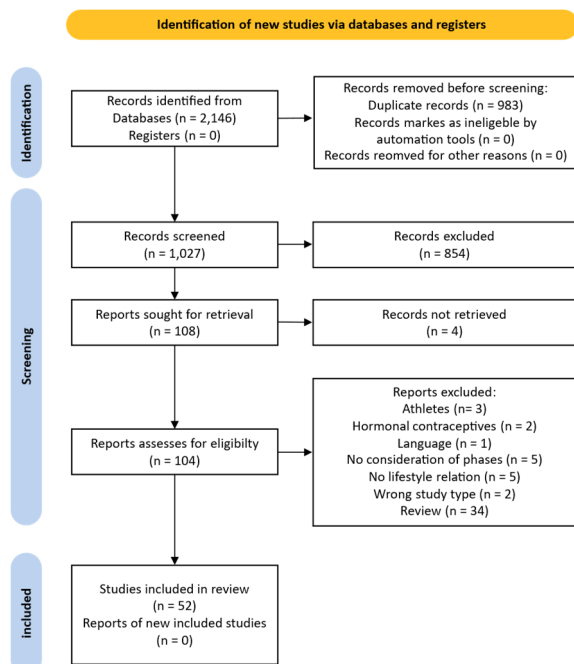


Figure 1: PRISMA Flowchart illustrating the study selection process created with Rayyan.ai.

The PRISMA flow diagram, shown in Figure 1, illustrates the paper selection process. The database search identified a total of 2,146 records. 52 articles met the full inclusion criteria and were included in this review (cf. Table A3 in Appendix C for a overview). The final sample comprised studies published between 2014 and 2024, collectively representing 3,255 participants.

### 3 RESULTS

#### 3.1 Sample Characteristics

**Lifestyle Domains:** Studies were distributed across lifestyle domains as follows (cf. Figure 2): physical activity (n=20, 38.5%), cognitive functions (n=13, 25.0%), sleep (n=7, 13.3%), nutrition (n=4, 7.7%), stress (n=4, 7.7%), or relationship behavior (n=4, 7.7%).

**Impact of MC on Lifestyle Behaviors:** 37 out of the 52 (71.2%) studies included in this scoping review reported some influence of the MC phases on the lifestyle behavior or outcome examined in the respective study. Of the 37 studies reporting an impact of MC phases on one or several lifestyle behavior outcomes (cf. Figure 2), n=14 studies focused on physical activity (14/20, 70%), n=10 studies on cognitive functions (10/13, 77.0%), n=4 studies on stress (4/4,

100%), n=4 on sleep (4/7, 57.1%), n=3 on nutrition (3/4, 75%), and n=2 on relationships (2/4, 50%).

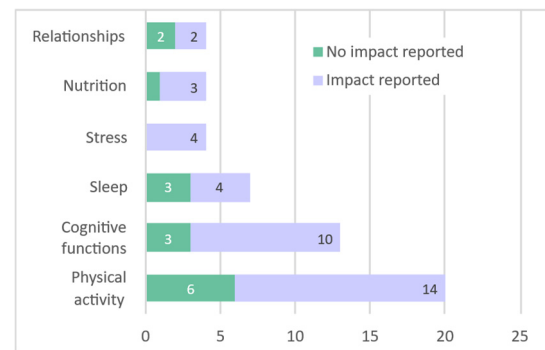


Figure 2: Number of studies reporting an impact of the MC on lifestyle behaviors based on lifestyle domain.

**Study Type:** Randomized controlled trials (RCTs) were the most common study type. Of around 24 studies of this type, 16 (67%) found an effect of the MC phases on corresponding lifestyle behavior outcomes. Cross-sectional studies accounted for 19 articles, where 16 (84%) found an impact of the MC on the respective lifestyle areas. Finally, 8 cohort studies and one mechanistic study were included. Of the cohort studies, 63% (n=5) indicated an effect of the MC.

**Sample Size:** Sample sizes ranged from a minimum of eight to a maximum of 622 participants, with a median of 20. Small (n=22, 42%) and medium (n=21, 40%) sample sizes comprised the majority of all studies. The large sample size category included only n=9 (18%) studies (cf. Figure 3).

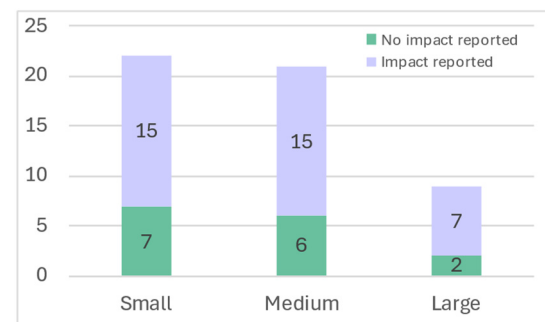


Figure 3: Number of studies reporting an impact of the MC on lifestyle behaviors based on simple size. Note: Small (1-20 participants), Medium (21-100 participants), Large (>100 participants).

**Participant Age:** Participant age was reported in 51 of the 52 studies. When grouped by mean age, half of all articles (n=26, 50%) included individuals AFAB with a mean age of 20-24, and 15 studies (29%) had participants aged 25-29. Participants aged 30-34, accounted for eight studies (15%). Participants

younger than 19 years, included only two studies (4%). Finally, one study did not disclose the age of its participants and was categorized under "Not Assigned". Overall, the studies reporting an impact of MC phases on outcomes were prevalent across all age groups. The percentage of studies reporting an impact per cluster was as follows: 100% for <19 years (n=2), 65% for 20-24 (n=17), 80% of 25-29 (n=12) and 75% of 30-34 (n=6).

**Number of Menstrual Cycle Phase:** The majority of studies (n=31) differentiated only between two MC phases (i.e., (early/mid) follicular vs. (mid/late) luteal (n=27), early follicular vs. preovulatory (n=1), menses vs. non-menses (n=1), fertility vs. non-fertility (n=1), low hormone vs. high hormone (n=1), followed by 14 studies considering three phases (i.e., early) follicular vs. late follicular/ovulatory vs. (late/mid) luteal (n=1), menstrual vs. premenstrual vs. midcycle (n=2). Only a smaller proportion of almost 10% (n=5) differentiated between four phases (i.e., menstrual, follicular, ovulatory, and luteal), while two studies examined the MC continuously. An impact of MC phases on outcomes was reported by at least 50% of studies in every category (two phases n=22, three phases n=11, four phases n=3). Of those investigating three phases, even 80% (n=11) found an influence.

**Outcomes Measurement Instruments:** Looking at the outcomes, 75% (n=39) of included articles exclusively used objective measures to investigate the impact of the MC on a particular lifestyle factor. Of those 39 studies, 74% reported an impact of the MC phases. Seven studies focused strictly on subjective outcomes, and of those six studies found an influence of the MC (86%). Only 12% of studies (n=6) used a combination approach, of which two found an effect of the MC phases (cf. Figure 4).

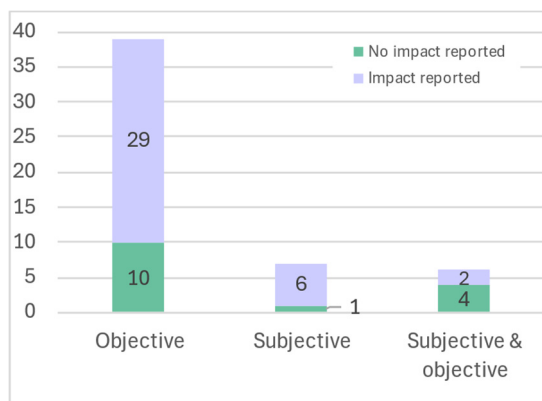


Figure 4: Number of studies reporting an impact of the MC on lifestyle behaviors based on measurement type.

### 3.2 Impact of Menstrual Cycle Phases on Lifestyle Behaviors per Lifestyle Domain

In this subsection, we will review all studies per lifestyle domain:

#### 3.2.1 Physical Activity

This review included 20 studies on physical activity, which were grouped by focus: strength performance (n=10), endurance (n=4), muscle adaptation (n=2), recovery (n=4), and training willingness/enjoyment (n=2).

**Strength Performance.** Six of ten strength studies (Arazi et al., 2019; Oğul et al., 2021; Peltonen et al., 2022; Recacha-Ponce et al., 2023; Romero-Moraleda et al., 2019b; Wiecek et al., 2016) found no significant cycle-related differences among participants (n=13–20; mean age 21–31). Oğul et al. (2021, n=20, mean age 22.4) noted one exception: minimum strength was higher in the mid-luteal phase, but not practically relevant. In contrast, Santana et al. (2022, n=10, mean age 25.5) reported reduced performance in the menstrual phase, which caffeine intake reversed. Two additional studies based on the same sample (n=13 each, mean age 31) confirmed caffeine's ergogenic effect (Lara et al., 2020; Romero-Moraleda et al., 2019a). Peltonen et al. (2022, n=16, mean age 26) found menstrual and luteal phases associated with more fatigue, while ovulation was linked to better neuromuscular efficiency and central excitability, suggesting power training may be optimized during ovulation, and hypertrophy/endurance during luteal/menstrual phases.

**Muscle Adaptation.** Sakamaki-Sunaga et al. (2016, n=14, mean age 21) found no difference in gains from follicular vs. luteal training. In contrast, Sung et al. (2014, n=20, mean age 26) reported superior muscle growth and strength when training was concentrated in the follicular phase.

**Endurance Performance.** Delp et al. (2023) found no objective differences. However, Greenhall et al. (2021) noted that more runners performed best in the luteal than follicular phase. Recacha-Ponce et al. (2023, n=20, mean age 27) found lower VO<sub>2</sub>max in the menstrual phase, recommending phase-aligned training for elite athletes. Matsuda et al., n=15, mean age 22 (2020, n=8, mean age 25) found larger drops in carnitine levels post-exercise during the luteal phase, suggesting a higher reliance on carbohydrates and reduced endurance, but made no training or dietary recommendations. For background, carnitine supports fat oxidation and delays fatigue (Borum, 1994).

**Recovery.** Hackney et al. (2019, n=8, mean age 25) reported slower recovery in the mid-follicular phase. Benito et al. (2023, n=13, mean age 31) suggested delayed recovery in the mid-luteal phase. Matsuda et al. (2022, n=12, mean age not reported) observed no cycle effect if carbs were consumed post-exercise; milk accelerated recovery. Olean-Oliveira et al. (2022, n=17, mean age 28) found that acute high-intensity intermittent exercise elicited different adipokine and lipoprotein responses across menstrual phases, with more pronounced anti-inflammatory and lipid-modulating effects in the follicular phase.

**Subjective Training, Willingness and Enjoyment.** Delp et al. (2023) reported higher perceived exertion and lower recovery during the menstrual phase. Righi and Barroso (2022, n=310) found most participants preferred exercising during the late follicular/ovulatory phase and avoided training during the menstrual and late luteal phases. Yet, training was adapted accordingly by only 37% (18–25 years), 50% (25–36), and 40.2% (36–45). Poli et al. (2021, n=14, mean age 24) found no cycle-phase differences in exercise enjoyment.

### 3.2.2 Cognitive Functions

Thirteen studies explored cognitive function across menstrual phases, focusing on economic decision-making and risk behavior (n=6), reward sensitivity (n=2), memory & attention scope (n=3), and spatial cognition and motor learning (n=2).

**Economic Decision Making & Risk Behavior.** Lewis et al. (2022, n=40, mean age 23) found no difference in value-based risk-taking between menstrual and ovulatory phases. However, Diekhof (2015, n=28, mean age 26) found greater impulsivity in the early follicular phase, reducing the ability to delay gratification. Lazzaro et al. (2016, n=36, mean age 25) observed that during ovulation women showed lower loss aversion and thus were less risk-averse than men, indicating that the ovulatory phase may enhance economic “rationality” in decision-making tasks. Ranehill et al. (2018, n=340, mean age 24.1) reported that neither initiation of hormonal contraceptives nor natural cycle phase significantly affected altruism, financial risk taking or willingness to compete, suggesting that cycle-linked changes may be smaller or more context-dependent than often assumed. Derntl et al. (2014, n =71 women & 45 men, female mean age 23.8) found that although no sex differences emerged in decision-making overall, higher progesterone in the luteal phase of women was negatively correlated with performance in risk-averse conditions, suggesting subtle cycle-phase influences on economic decision making. Wozniak et al. (2014) used a within-subjects experiment (math and word tasks) and found that women in the high-hormone

phase (n=75, mean age approx. 20) of the cycle were significantly more willing to enter tournaments than women in the low-hormone phase (n=34, mean age approx. 20), though still somewhat less willing than men; after receiving relative performance feedback, these phase and gender differences in competitive choice disappeared

**Reward Sensitivity.** Diekhof et al. (2020, n=75, mean age 25) found that avoidance learning from negative feedback declined from the luteal to the follicular phase. Diekhof and Ratnayake (2016, n=15, mean age 24.9) observed that during the late follicular vs. mid-luteal phase, women exhibited altered reward sensitivity and performance-monitoring brain activity, indicating menstrual-phase modulation of cognitive control and feedback processing.

**Memory & Attention Scope.** Peragine et al. (2020, n=140, mean age 24) reported no cycle-phase effects in verbal memory tasks. Similarly, Kerschbaum et al. (2017, n=96, mean age 26) found no differences in verbal recall across phases. Only Álvarez-San Millán et al. (2022, n = 168 women and 78 men, mean age 19, women in different cycle-phases) found that both “cute” and threatening images narrowed attentional scope in both sexes, with women in luteal phases showing slower global processing, suggesting phase-linked shifts in attention breadth

**Spatial Cognition & Motor Learning.** Peragine et al. (2020) also examined visuospatial ability using a mental rotation task and found that individuals in the menstrual (low-estradiol) phase performed better than those in preovulatory or luteal phases. Scheuringer and Pletzer (2017, n not reported) found improved egocentric navigation speed and accuracy in the luteal phase. Ikarashi et al. (2020, n=31, mean age 21) reported enhanced motor learning during ovulation compared to the luteal phase, possibly due to lower PMS symptoms and increased cortical excitability.

### 3.2.3 Sleep

Seven studies explored MC-related changes in sleep using both objective and subjective measures:

Alzueta et al. (2022, n=26) found no significant changes across cycle phases in sleep duration, quality, efficiency, or architecture as measured by the Oura ring, though sleep efficiency was slightly lower in the mid-luteal phase. Similarly, Li et al. (2015, n=19, mean age 34) reported no significant hormonal influence on sleep quality but suspected a decline in sleep efficiency during the luteal phase. Both studies also found no significant associations with self-reported sleep quality. van Reen and Kiesner (2016, n=213, mean age 21) clustered participants into non-cyclic (n=99), mid-cycle increase (n=53), and perimenstrual (n=61) sleep disturbance patterns. Only the mid-cycle

and perimenstrual groups reported phase-related difficulties. Romans et al. (2015) noted similar patterns, but significance disappeared after adjusting for stress and social support. Hamanishi et al. (2019, n=14, mean age 20) examined head cooling during the luteal phase and found improved wakefulness after sleep onset and the proportion of slow-wave sleep, though no effect on overall sleep efficiency. Shuster et al. (2023) reported that poor sleep had a stronger negative impact on mood during menstruation than in other phases, while good sleep buffered mood decline. LeRoux et al. (2014, n=18, mean age 21) found that sleep restriction reduced cortisol awakening response and increased afternoon cortisol only in the follicular phase.

### 3.2.4 Stress

Four studies examined stress reactivity across menstrual phases using physiological markers such as alpha-amylase and cortisol.

Espin et al., n=50, mean age 19 (2019) found lower salivary alpha-amylase levels (i.e., a biomarker for physiological stress, Koh et al., 2014) after stress tasks during the follicular phase compared to the luteal phase, though cardiac responses showed no phase differences. Villada et al., n=31, mean age 19 (2017) reported higher and more prolonged salivary cortisol responses (i.e., another biomarker for physiological stress, Hellhammer et al., 2009) to stress in the luteal phase. Montero-López et al. (2018, n=42, mean age 34) similarly found elevated post-stressor cortisol in luteal vs. follicular phase participants. In contrast, Banis and Lorist, n=18, mean age 21 (2017) found no significant cortisol differences between phases.

### 3.2.5 Nutrition

Three out of four (75%) studies in the field of nutrition found an influence of the cycle phases on nutritional behaviors:

Gorczyca et al. (2016, n=259, mean age 27.3) found increased total protein intake, animal protein, and protein-derived calories in the mid-luteal phase, along with heightened cravings. Krishnan et al. (2018, n=17, mean age not reported) focused on phase-specific cravings and suggested modifying fat intake (especially more monounsaturated, less long-chain polyunsaturated fats) in the follicular phase to curb later cravings and support weight management. Bu et al. (2019, n=88, mean age 21) liked negative mood during the menstrual with higher intake of caffeinated beverages, carbonated drinks, and negative mood during the premenstrual phase with specific fruit intakes (Banana and Chinese dates) among Chinese college women, suggesting emotion-driven eating. In contrast, Rodriguez-Giustiniani and Galloway

(2019, n=10, mean age = 25) found no phase differences in fluid or electrolyte balance, nor thirst perception, or post-dehydration.

### 3.2.6 Relationships

Four studies examined MC-related changes in social cognition and interpersonal perception:

(Lobmaier et al., 2019, n=49, mean age 24) investigated sensitivity to social exclusion across the late follicular and luteal phases using a digital ball-toss game. Participants reported lower mood after exclusion in both phases, with stronger effects in the luteal phase. Yamazaki and Tamura (2017, n=12, mean age 22) observed slower emotional facial recognition and higher neural responses – particularly to happy male faces – during the late luteal phase compared to the follicular phase. Necka et al. (2018, n=56, mean age 22) found that participants showed increased attention to and memory for other AFAB individuals perceived to be in a fertile phase, suggesting sensitivity to fertility cues, especially under low cognitive control. In contrast, Youssef et al. (2022, n=622, mean age 22) found no association between MC phases and interpersonal attraction across any measured dimension.

## 3.3 The Role of Digital Health Technologies in Menstrual Cycle Syncing Research

Looking at the use of DHTs for cycle phase tracking, it is noticeable that only a small proportion (n=4/52, 7%) used smartphone applications for tracking participants' MC phase (cf. Figure 5) and only in the physical activity domain. Three of these studies found that the MC had an influence on the outcomes examined (Lara et al., 2020; Romero-Moraleda et al., 2019b; Santana et al., 2022).

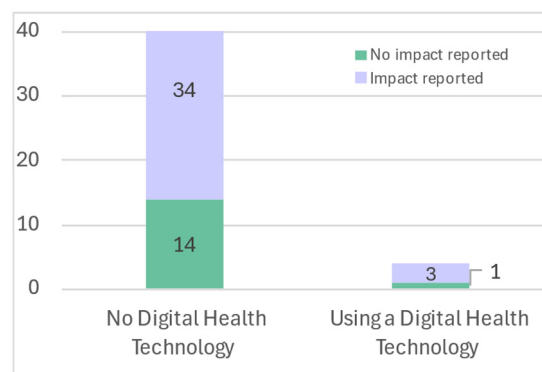


Figure 5: Number of studies reporting an impact of the MC on lifestyle behaviors using digital health technologies to assess MC phases.

## 4 DISCUSSION

### 4.1 Theoretical Contributions

#### 4.1.1 Towards a Revised Definition of Menstrual Cycle Syncing

This scoping review offers a structured synthesis of the existing literature on MC-related variations in lifestyle behaviors and behavioral outcomes in eumenorrheic naturally menstruating non-athletes, thereby contributing to the emerging conceptualization of MCS. While the idea of adapting behaviors across the MC has gained popular traction through self-help literature (Vitti, 2014), our review suggests that the scientific foundation for a generalized, phase-based model remains limited and heterogeneous.

A central theoretical contribution of this scoping review lies in its grounded focus on the experiences of naturally cycling, healthy individuals AFAB of everyday life, excluding elite athletes and people with menstrual disorders. In doing so, we move toward understanding how physiological and behavioral fluctuations may manifest in typical, non-clinical samples, offering a relatively "clean" baseline against which other populations can be contrasted (for instance, individuals with menstrual disorders, individuals using hormonal contraceptives, or extreme athletes).

The review identified that 71.2% of included studies reported at least some influence of MC phases on lifestyle behaviors or outcomes. However, effects varied widely across and within lifestyle domains, and substantial heterogeneity in outcomes, phase definitions, and study designs precluded meaningful aggregation of effect sizes, highlighting that MCS cannot be meaningfully generalized across or within individuals or behaviors at this stage as postulated in popular science.

To the contrary, the hormone sensitivity hypothesis (Peters et al., 2025; Pope et al., 2017) suggests that people with similar hormonal profiles may experience very different symptoms or performance shifts, which reinforces the need for an individualized understanding of phase-related behavioral variation, which is shaped by interindividual subjective profiles, experience, and contexts.

A further theoretical insight concerns the unequal development of research across lifestyle domains. While physical activity (38.5%) and cognitive performance (25.0%) were well-represented in the literature, other central lifestyle domains such as sleep (13.5%), nutrition (7.7%), social behavior (7.7%) or stress (7.7%) remained comparatively underexplored. This

uneven distribution seems to reflect a research bias that favors quantifiable performance metrics and under-scores the need to broaden the empirical base for MCS beyond sports science.

Importantly, the reviewed studies also reveal methodological patterns with potential theoretical implications: Studies using subjective measures reported phase-related differences (8/37, 21.6%) more frequently compared to those using only objective measures (29/37, 78.4%). This suggests that MC influences may manifest most saliently in perceived well-being, energy, mood, or exertion, thus, supporting a reconceptualization of MCS as a well-being-focused rather than performance-driven framework.

Taken together, the evidence partially supports the MCS hypotheses, but calls for its redefinition as a personalized, self-monitoring-based well-being focused strategy. We therefore propose a new, evidence-informed definition of MCS:

*“Menstrual cycle syncing is a personalized approach where individuals monitor their cyclic variations in energy levels, recovery, exertion, hunger cues, energy intake, social behaviors, stress reaction, sleep patterns, and cognitive performance. By tracking these fluctuations, they can integrate evidence-based behavioral strategies. This individualized adaptation includes modifying physical activity, nutrition, cognitive workload, stress management and social engagement to align with the hormonal and physiological fluctuations occurring throughout the menstrual cycle to optimize well-being, performance, and overall health.”*

#### 4.1.2 Supporting Menstrual Cycle Syncing Research through Digital Health Technologies

A final theoretical contribution of this review lies in highlighting the critical yet largely unrealized role of DHTs in advancing scientifically grounded, individualized MCS. Despite ongoing methodological debates about accurately identifying MC phases (Schantz et al., 2021; Schmalenberger et al., 2021), only 7.7% of included studies used DHTs to determine cycle phases – typically simple, smartphone-based menstrual cycle tracking applications (MCTAs).

This stands in stark contrast to the estimated 50 million users of MCTAs worldwide (Schantz et al., 2021) and the growing availability of MCTAs that support MC phase detection or prediction (e.g., Clue<sup>2</sup> or Natural Cycles<sup>3</sup>), some of which explicitly frame themselves as supporting MCS (e.g., FLOLiving<sup>4</sup>,

<sup>2</sup> Clue, <https://helloclue.com>

<sup>3</sup> Natural Cycles, <https://www.naturalcycles.com>

<sup>4</sup> FLOLiving, <https://flliving.com>

Lively<sup>5</sup>, or Ovum<sup>6</sup>) or even integrate at-home hormonal monitoring (e.g., Mira<sup>7</sup>, Oova<sup>8</sup>).

When Apple Health launched in 2014, it promised to monitor “all of your metrics that you’re most interested in,” (Apple Inc., 2014) yet failed to include menstrual tracking until a year later, which led to a public outcry (Eveleth, 2014). Where is this outcry in MCS research?

Given their potential for continuous, low-burden, and large-scale data collection (Karim & Talhouk, 2021; Schantz et al., 2021; Schmalenberger et al., 2021) and, accordingly, increasing real-world adoption in general health research (Cunningham et al., 2024; Gibson et al., 2022), DHTs capable of capturing hormonal, behavioral, and contextual fluctuations could provide the methodological backbone needed to advance individualized MCS *per se* and support scalable, ecologically valid MCS research.

## 4.2 Managerial Implications

The findings of this review also carry managerial implications:

First, given the lack of consistent, generalizable effects across MC phases, fixed phase-based protocols should be applied with caution in both clinical and lifestyle settings. Instead, menstruating individuals may benefit more from flexible, data-informed approaches tailored to their patterns.

Second, DHTs, including MCTAs, could support individualized monitoring and behavioral adaptation – but only if designed with validated prediction algorithms, inclusive datasets, and strong privacy safeguards.

Third, health professionals and developer, should shift from rigid performance-oriented routines toward a dynamic model centered on well-being, self-monitoring, and hormonal literacy. Encourage individuals to observe changes in stress, energy, sleep, and appetite shift across phases and adapt daily practices accordingly without imposing normative prescriptions.

Ultimately, MCS should not be positioned as a universal protocol, but as an optional strategy that may help individuals reflect on and adapt to their personal cyclic variation.

## 4.3 Limitations and Future Research Directions

Despite its contributions, this review presents several limitations that simultaneously allow us to formulate future research directions (RDs).

First, our focus on healthy, eumenorrheic individuals provides a normatively grounded foundation, but limits generalizability as symptoms and phase-linked adaptations may differ markedly in other populations. Rather than extending normative patterns to these groups, future work should disentangle contextual influences within a shared conceptual framework that integrates hormonal fluctuations, health status, and lifestyle conditions (RD1).

Second, similar to prior work (e.g., Blagrove et al., 2020), we observed considerable methodological heterogeneity in how MC phases were defined and measured across studies. Predominant reliance on calendar-based counting or invasive laboratory assessments limit scalability and cross-study comparability. Future research should therefore adopt standardized phase-determination protocols (e.g., Schmalenberger et al., 2021) ideally supported by multi-modal DHT approaches that integrate calendar data with longitudinal symptom tracking, wearable-derived physiological markers (e.g., basal body temperature, resting heart rate, heart rate variability), and at-home hormonal assays to enable probabilistic phase estimation and validation cross cycles (RD2).

Third, most studies used small to medium samples concentrated among participants in their early 20s, restricting insights into age-related, hormonal, or demographic variation. Future work should include larger and more diverse samples across age, ethnicity, and socioeconomic backgrounds (RD3), and apply intersectional approaches to understand how social and structural factors shape cycle-related behaviors (RD4), with mobile and wearable DHTs offering scalable means to support recruitment and longitudinal engagement across diverse populations while reducing participation burden.

Fourth, sample-size limitations and outcome heterogeneity suggest that static, population-level phase recommendations will be insufficient. At the same time, the minimal use of DHTs in MC research highlights a continued dependence on self-reports and invasive laboratory testing. Future research should validate DHTs, assess their performance in longitudinal and real-world settings, and examine their ability to support adaptive N-of-1 approaches. Over time, such architectures may support hypothesis-driven self-experiments, enabling women to explore how specific behaviors or demands interact with their own cycle dynamics while generating high-resolution longitudinal data for research (RD5).

Finally, our broad scope across multiple lifestyle domains required breadth over depth. Future work

<sup>5</sup> Lively, <https://www.livelycycle.com>

<sup>6</sup> Ovum, <https://www.askovum.com>

<sup>7</sup> Mira, <https://shop.miracare.com>

<sup>8</sup> Oova, <https://www.oova.life>

should pursue more granular, domain-specific reviews, particularly in underexamined areas such as nutrition, sleep, social behavior, and cognition (RD6).

## 5 CONCLUSION

This scoping review provides a synthesis of the current evidence on how lifestyle behaviors vary across the MC and evaluates the extent to which this supports the concept of MCS. While some empirical findings align with popular or anecdotal MCS claims, the evidence remains inconsistent, underscoring the need for individualized and context-sensitive approaches. The appeal of summarizing menstrual cycle-related effects into practical phase-specific recommendations is evident, particularly given the growing public interest in menstrual cycle syncing. However, the findings of this scoping review highlight substantial heterogeneity in menstrual phase definitions, outcome measures, study designs, and evidence density across lifestyle domains. As such, synthesizing the current evidence into prescriptive cycle-based recommendations or graded evidence tables risks oversimplification and may inadvertently reinforce unsupported or premature claims. Instead, the present review provides a necessary conceptual and empirical foundation for future work and proposes a new, nuanced and evidence-based definition of MCS that focuses on individual adaptations and discuss the potential of DHTs to scale-up MCS research.

## ACKNOWLEDGEMENTS

We thank Maren Mauerhofer for conducting parts of this study in the context of her Master's thesis at the University of St. Gallen. Language editing and stylistic refinement were supported by Grammarly and ChatGPT (v 5.2). All scientific content, interpretations, and conclusions were solely developed, reviewed, and approved by the authors.

## CONFLICT OF INTEREST

MN, MM, DS, and TK are affiliated with the Centre for Digital Health Interventions (CDHI), which oversees publicly and industry-funded projects. However, the present work was not externally funded, and no industry partners were involved in any aspect of the work.

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## APPENDIX

### Appendix A – Search Strings

**Scopus:** (TITLE-ABS-KEY ( "Menstrual cycle phase" ) AND TITLE-ABS-KEY ( "Exercise" OR "Training" OR "Physical activity" OR "Sports" OR "Food" OR "Nutrition" OR "Diet" OR "Sleep" OR "Recovery" OR "Stress" OR "Emotions" OR "Mood" OR "Depression" OR "Anxiety" OR "Cognition" OR "Memory" OR "Learning" OR "Relationship" OR "Social connection" ) ) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "re" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) )

**PubMed:** ("Menstrual cycle phase") AND ("Exercise" OR "Training" OR "Physical activity" OR "Sports" OR "Food" OR "Nutrition" OR "Diet" OR "Sleep" OR "Recovery" OR "Stress" OR "Emotions" OR "Mood" OR "Depression" OR "Anxiety" OR "Cognition" OR "memory" OR "learning" OR "relationship" OR "social connection") Filters: Abstract, Free full text, Full text, Meta-Analysis, Review, Systematic Review, English, from 2014 – 2024

**Web of Science** (ALL=("Menstrual cycle phase")) AND ALL=("Exercise" OR "Training" OR "Physical activity" OR "Sports" OR "Food" OR "Nutrition" OR "Diet" OR "Sleep" OR "Recovery" OR "Stress" OR "Emotions" OR "Mood" OR "Depression" OR "Anxiety" OR "Cognition" OR "memory" OR "learning" OR "relationship" OR "social connection")

**EBSCOhost** (ALL=("Menstrual cycle phase")) AND ALL=("Exercise" OR "Training" OR "Physical activity" OR "Sports" OR "Food" OR "Nutrition" OR "Diet" OR "Sleep" OR "Recovery" OR "Stress" OR "Emotions" OR "Mood" OR "Depression" OR "Anxiety" OR "Cognition" OR "memory" OR "learning" OR "relationship" OR "social connection")

**Embase** 'menstrual cycle phase' AND ('exercise'/exp OR 'exercise' OR 'training'/exp OR 'training' OR 'physical activity'/exp OR 'physical activity' OR 'sports'/exp OR 'sports' OR 'food'/exp OR 'food' OR 'nutrition'/exp OR 'nutrition' OR 'diet'/exp OR 'diet' OR 'sleep'/exp OR 'sleep' OR 'recovery'/exp OR 'recovery' OR 'stress'/exp OR 'stress' OR 'emotions'/exp OR 'emotions' OR 'mood'/exp OR 'mood' OR 'depression'/exp OR 'depression' OR 'anxiety'/exp OR 'anxiety' OR 'cognition'/exp OR 'cognition' OR 'memory'/exp OR 'memory' OR 'learning'/exp OR 'learning' OR 'relationship'/exp OR 'relationship' OR 'social connection'/exp OR 'social connection') AND [english]/lim AND [2014-2024]/py AND ([article]/lim OR [article in press]/lim OR [review]/lim)

#### JSTOR

##### Search 1:

(( "Menstrual cycle phase" ) AND ( "Food" OR "Nutrition" OR "Diet" OR "Sleep" OR "Recovery" OR "Stress" OR "Emotions" OR "Mood" OR "Depression" ))

##### Search 2:

(( "Menstrual cycle phase" ) AND ( "Anxiety" OR "Cognition" OR "memory" OR "learning" OR "relationship" OR "social connection" ))

## Appendix B – Codebook for Data Synthesis

Table A2: Codebook for data extraction and categorization.

Characteristics	Extracted data item	Categories
<b>Participants</b>	<b>Sample size</b>	Small (1-20 participants) Medium (21-100 participants) Large (>100 participants)
	<b>Mean age</b>	Cluster 1 (<20 years) Cluster 2 (20-24 years) Cluster 3 (25-29 years) Cluster 4 (30-34 years) Cluster 5 (>34 years)
<b>Methodology</b>	<b>Study type</b>	Editorial, expert opinion Mechanistic studies Case report, case studies Cross-sectional studies Case-control studies Cohort studies Randomized control trials
	<b>Intervention/ Experiment/Observation procedure</b>	-
	<b>Menstrual cycle phase determination<sup>a</sup></b>	Low reliability (Level 1) Medium reliability (Level 2) High reliability (Level 3)
	<b>Menstrual cycle phases and sub-phases investigated</b>	2 3 4 >4
	<b>Application of digital tools for cycle syncing</b>	Yes No
<b>Outcomes</b>	<b>Outcome measures</b>	Subjective Objective
	<b>Key findings</b>	-
	<b>Behavioral recommendations</b>	-

*Notes. <sup>a</sup>Reliability of menstrual cycle phase determination was categorized as low, medium, or high based on the methodological rigor and biological specificity of the assessment approach, informed by prior methodological recommendations (Nißen et al., 2024; Schmalenberger et al., 2021). Low reliability methods included calendar-based counting without physiological confirmation. Medium reliability methods comprised approaches combining calendar tracking with symptom reports or single physiological markers. High reliability methods included multi-modal approaches integrating hormonal assays (e.g., blood, saliva, or urine-based measures), basal body temperature, and/or validated ovulation detection protocols.*

### Appendix C – Included Studies

Table A3: Overview of included studies.

ID	Reference	Study Type	Sample Size	Mean Age Cluster	Number of MC Phases	Reliability	Digital Tool	Outcome Measure	Influence of MC on Outcome
<b>Nutrition</b>									
1	(Gorczyca et al., 2016)	Cohort	Large	3	4	2	No	Both	Yes
2	(Rodríguez-Gustimiani & Galloway, 2019)	RCT	Small	3	2	3	No	Objective	No
3	(Krishnan et al., 2018)	Cross-sect.	Small	4	2	2	No	Objective	Yes
4	(Bu et al., 2019)	Cross-sect.	Medium	2	3	1	No	Subjective	Yes
<b>Physical Activity</b>									
5	(Righi & Barroso, 2022)	Cross-sect.	Large	3	3	1	No	Subjective	Yes
6	(Matsuda et al., 2022)	RCT	Small	n/a	2	3	No	Objective	No
7	(Romero-Moraleda et al., 2019b)	RCT	Small	4	3	2	Yes	Objective	No
8	(Arazi et al., 2019)	RCT	Medium	3	3	1	No	Objective	No
9	(Sung et al., 2014)	RCT	Medium	3	2	2	No	Objective	Yes
10	(Santana et al., 2022)	RCT	Small	3	2	1	Yes	Objective	Yes
11	(Benito et al., 2023)	RCT	Small	4	3	2	No	Objective	Yes
12	(Sakamaki-Sunaga et al., 2016)	RCT	Small	2	2	2	No	Objective	No
13	(Hackney et al., 2019)	Cross-sect.	Small	3	2	3	No	Objective	Yes
14	(Delp et al., 2023)	RCT	Small	2	3	2	No	Subjective	Yes
15	(Greenhall et al., 2021)	Cross-sect.	Large	3	2	1	No	Objective	Yes
16	(Recacha-Ponce et al., 2023)	Cohort	Medium	3	3	2	No	Objective	Yes
17	(Poli et al., 2021)	RCT	Small	2	2	1	No	Both	No
18	(Peltonen et al., 2022)	Cross-sect.	Small	3	4	3	No	Objective	Yes
19	(Oğul et al., 2021)	Cross-sect.	Medium	2	2	2	No	Objective	Yes
20	(Wiecek et al., 2016)	RCT	Small	2	2	3	No	Objective	No
21	(Matsuda et al., 2020)	RCT	Small	2	2	3	No	Objective	Yes
22	(Olean-Oliveira et al., 2022)	RCT	Small	2	2	1	No	Objective	Yes
23	(Lara et al., 2020)	RCT	Small	4	3	2	Yes	Objective	Yes
24	(Romero-Moraleda et al., 2019a)	RCT	Small	4	3	2	Yes	Objective	Yes
<b>Relationships</b>									
25	(Lobmaier et al., 2019)	Cross-sect.	Medium	2	2	2	No	Subjective	Yes
26	(Yamazaki & Tamura, 2017)	Cross-sect.	Small	2	2	2	No	Objective	Yes
27	(Neeka et al., 2018)	Mechan.	Medium	2	2	1	No	Objective	No
28	(Youssef et al., 2022)	Cross-sect.	Large	2	4	1	No	Subjective	No

Table A3: Overview of included studies (cont.).

ID	Reference	Study Type	Sample Size	Mean Age Cluster	Number of MC Phases	Reliability	Digital Tool	Outcome Measure	Influence of MC on Outcome
<b>Sleep</b>									
29	(Alzueta et al., 2022)	Cohort	Medium	2	4	2	No	Both	No
30	(Li et al., 2015)	Cohort	Small	4	days	2	No	Both	No
31	(Shuster et al., 2023)	Cohort	Medium	2	2	1	No	Both	No
32	(LeRoux et al., 2014)	Cross-sect.	Small	2	2	2	No	Both	Yes
33	(van Reen & Kiesner, 2016)	Cross-sect.	Large	2	days	1	No	Both	Yes
34	(Romans et al., 2015)	Cohort	Medium	4	3	1	No	Subjective	Yes
35	(Hamanishi et al., 2019)	RCT	Small	2	2	N/A	No	Objective	Yes
<b>Stress</b>									
36	(Espin et al., 2019)	RCT	Medium	1	2	2	No	Objective	Yes
37	(Bamis & Lorist, 2017)	RCT	Small	2	2	2	No	Objective	Yes
38	(Villada et al., 2017)	Cross-sect.	Medium	1	2	2	No	Objective	Yes
39	(Montero-López et al., 2018)	Cross-sect.	Medium	4	2	1	No	Objective	Yes
<b>Work-related cognitive performance</b>									
40	(Lewis et al., 2022)	Cross-sect.	Medium	2	2	3	No	Objective	No
41	(Ikarashi et al., 2020)	RCT	Medium	2	3	2	No	Objective	Yes
42	(Diekhof et al., 2020)	Cross-sect.	Medium	3	3	3	No	Objective	Yes
43	(Kerschbaum et al., 2017)	Cross-sect.	Medium	3	2	2	No	Objective	No
44	(Scheuringer & Pletzer, 2017)	Cross-sect.	Medium	2	2	2	No	Objective	Yes
45	(Diekhof, 2015)	RCT	Medium	3	2	2	No	Objective	Yes
46	(Álvarez-San Millán et al., 2022)	Cross-sect.	Large	2	2	1	No	Objective	Yes
47	(Diekhof & Ratnayake, 2016)	RCT	Small	3	2	2	No	Objective	Yes
48	(Peragine et al., 2020)	Cross-sect.	Large	2	3	N/A	No	Objective	Yes
49	(Derrtl et al., 2014)	Cross-sect.	Medium	2	2	2	No	Objective	Yes
50	(Lazzaro et al., 2016)	RCT	Medium	3	4	3	No	Objective	Yes
51	(Wozniak et al., 2014)	RCT	Large	2	2	1	No	Objective	Yes
52	(Ranehill et al., 2018)	RCT	Large	2	3	3	No	Objective	No