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Review

Mind-Body Interactions Across the Menstrual Cycle Phases: A Systematic Review

Rosita Borlimi [1], Greta Riboli [1, 2, *], Mattia Nese [1], Matilde Buattini [1], Marella Colombardo [1], Gianni Brighetti [1]

1. Sigmund Freud University, Milan, Ripa di Porta Ticinese 77, Italy; E-Mails: r.borlimi@milano-sfu.it; g.riboli@milano-sfu.it; m.nese@milano-sfu.it; mati.buattini@gmail.com; marella.colombardo@gmail.com; g.brighetti@milano-sfu.it
2. Sigmund Freud University, Wien, Psychology Department, Sigmund Freud Platz 1, Austria

* **Correspondence:** Greta Riboli; E-Mail: g.riboli@milano-sfu.it

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Abstract

The length of the menstrual cycle (MC) varies among women, with an average regularity between 21 and 40 days. Six temporal frames can be observed within the monthly cycle, based on the fluctuations of the hormone levels. These fluctuations are accompanied by alterations in the central nervous system (CNS) and autonomic nervous system (ANS) and can be quantified using psychophysiological techniques. In this systematic review, we discussed the studies conducted with healthy females that examined aspects associated with the functions of the ANS and the CNS, including psychological, emotional, behavioral, hormonal, and perceptive variables, relating their possible changes and alterations to different phases of the MC. The PubMed and EBSCO databases were searched for articles published between January 2010 and September 2020. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was applied. A total of 64 studies investigating ANS and CNS or perceptual systems across the MC were included in this review. Several studies found more alterations in the heart rate variability components during the days following ovulation compared to the days of the follicular phase. Behavioral alterations included a decrease in the percentage of REM sleep during the mid-luteal phase and an increase in calorie intake during the late-luteal

phase compared to that in the follicular phase. Additionally, the reward system was found to be engaged to a greater extent during the luteal phase than during the follicular phase. The results differed considerably for many cognitive, behavioral, and autonomic variables. No significant alterations were found in most perceptual systems. A variegated picture emerged from the results of the various studies that applied different methodologies and measurements. The results suggested a new methodology that uses the temporal dimension for investigating the interactions between biological systems and psychological effects.

Keywords
Menstrual cycle; menstrual phases; ANS; CNS; perception

1. Introduction

The length of the menstrual cycle (MC) varies among women, with an average of 28 days [1]. The MC is considered regular when it ranges between 21 and 40 days. It coincides with the time from the first day of a woman's period to the day before her next period. The ovulation (O) divides the MC into two distinct phases: during the first half (called follicular phase), an egg develops due to an increase in the levels of the hormone estradiol (a type of estrogen, also called E2), which is released during ovulation. In the second half (the luteal phase), the hormone progesterone (P4) helps to prepare the womb for the implantation of a developing embryo [1-4].

The luteal phase has a standard average length of about 13.3 days (SD = 2.1) [4], and it is more consistent than the follicular phase due to the expectable lifespan of the *corpus luteum.* Accordingly, a greater part of the variance in the length of the MCs of women is due to the fluctuations in the length of the follicular phase, which lasts for about 15.7 days (SD = 3).

Studying the MC can help to describe and examine how sex hormones affect cognition, emotion processing, behavior, and feedback signals of brain regions, such as the amygdala, the anterior cingulate cortex, and the inferior frontal gyrus [2, 5].

Previous studies [2] have demonstrated the validity of examining the MC in healthy women. These studies investigated and explained the cognitive and behavioral functions associated with premenstrual mood disorders, such as premenstrual syndrome (PMS) and premenstrual dysphoric disorder (PMDD). Schmalenberger et al. [6] showed that a wide pattern of emotional, behavioral, and cognitive symptoms can occur during the mid-luteal and perimenstrual phases of the MC due to normal hormone fluctuations.

In this review, we summarized the results of studies analyzing fluctuations of cognitive and autonomic functions across the MC in a non-clinical population. The CNS and the ANS are reciprocal and alternating, owing to the flexible adaptation of the organism to the environmental demands [7]. This adaptation occurs due to the activating function of the ANS on one side and the inhibiting function of the CNS on the ANS on the other side. The two systems constantly communicate with each other. The cardiac vagal tone, reflected in the heart rate variability (HRV) index, is associated with the ability to self-regulate and to be behaviorally flexible or inflexible and adaptable in a changing environment. Therefore, it reflects the neural feedback mechanisms of the integration between CNS and ANS.

Among CNS constructs, perception plays an important role in mediating sensations from within our body (i.e., interoception) and from the external world (i.e., exteroception) [8]. Perception, particularly interoception, also reciprocally communicates with the ANS. Considering these constant and mutual interactions, a complex and exhaustive overview of the fluctuations of both autonomic and central systems might be fundamental when studying the MC [6].

As stated by Schmalenberger et al. [6], most studies on MC distinguish between the two previously described phases of the MC (i.e., the follicular phase and the luteal phase). However, hormone levels show some relevant changes during these two phases, and their influence might be of importance for studying many outcomes of interest. Thus, an adaptation of the model presented by Pitchers and Elliott-Sale [9] has been used in this review to compare the results between studies. This model was applied for studying MC changes among female athletes and represents hormone fluctuations during an idealized 28-day MC. The model considers the occurrence of O on days 13-15 after the beginning of menstrual flow (day 1) and divides the follicular and the luteal phases into an early follicular phase (EFP, days 1 to 5 of the MC), a late follicular phase (LFP, days 6 to 12), an early luteal phase (ELP, days 16-19), a mid-luteal phase (MLP, days 20-23), and a late luteal phase (LLP, days 24-28). The method to count the days for the determination of MC phases varies among studies due to different starting dates (i.e., from the beginning of the menstrual flow or the end of the MC) and the use of different divisions in the MC phases [6]. The authors of the included studies have considered different phases of the MC and used different methods and models to define and name the various phases. Thus, the results might be unreliable and confusing, leading to the non-replicability of this study. According to the studies, given the same month and days considered, different names correspond to the same phases. To solve this issue, the results have been converted by applying the counting model by Pitchers and Elliott-Sale to facilitate the comparison of the results [9]. Although this model is not evidence-based, it has been implemented here because it distinguishes between moments of the MC in which levels of P4 and E2 reach a peak. This provides a better insight into the role of those hormones for changes across the MC.

The targeted outcome measures, based on the studies included, are changes in functions concerning both the ANS and the CNS associated with different phases of the MC. The goal of the review is to elucidate the changes during the phases of the MC involving the two nervous systems and to propose a research strategy that interconnects the cognitive, emotional, hormonal, and physiological components of women's total experience of the MC. This was the first systematic review that collectively examined various psychological and biological variables, specifically outlining the possible networks among the functions of ANS and CNS for understanding mind-body interactions [7, 10, 11] across different MC phases. Specifically, the main outcome of interest was related to the differences in the ANS and CNS functions across the EFP, LFP, O, ELP, MLP, and LLP. The results included psychological, emotional, and perceptional variables, assessed by various authors who also used physiological measurement tools.

2. Materials and Methods

This report followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [12] for Systematic Reviews [13].

2.1 Data Sources and Searches

The research was conducted on the PubMed and EBSCO platforms in August-September 2020. The following keywords were used: on one side "menses" and its synonyms, "luteal phase" and "follicular phase"; on the other side "nervous system", "ANS", and "CNS", "parasympathetic" and "sympathetic", "exteroception", its subdivisions, and "interoception". This was the final string: ("menstrual"[Title/Abstract] OR "menses"[Title/Abstract] OR "menstruations"[Title/Abstract] OR "menstruation"[Title/Abstract] OR "catamenia"[Title/Abstract] OR "luteal phase"[Title/Abstract] OR "follicular phase"[Title/Abstract]) AND ("nervous system"[Title/Abstract] OR "ANS"[Title/Abstract] OR "CNS"[Title/Abstract] OR "parasympathetic"[Title/Abstract] OR "sympathetic"[Title/Abstract] OR "interoception"[Title/Abstract] OR "exteroception"[Title/Abstract] OR "proprioception"[Title/Abstract] OR "mechanoreception"[Title/Abstract] OR "nociception"[Title/Abstract] OR "thermoception"[Title/Abstract] OR "perception"[Title/Abstract]). Study selection was then applied to the publications from the year 2010 to September 2020 and was limited to articles in English.

2.2 Study Selection and Data Extraction

The screening for the eligibility of the studies by title and abstract and then by full-text reading was made separately by the two authors. The list of articles was cross-referenced for additional relevant citations. Accordingly, with the inclusion criteria, the authors accepted every scientific article concerning physical, psychophysiological, psychological, and hormonal changes through the MC after deduction of reviews, meta-analyses, case reports, and studies with animal models. Additionally, we included randomized and non-randomized studies, controlled or clinical trials, and cross-sectional and cohort studies reporting on premenopausal women with menarche.

Finally, the results were divided into categories, clustering them based on the similarities of outcomes identified by the original authors. The list of articles is available upon request to the authors. Any disagreements were resolved by discussion between the authors and the supervisors.

The following data were extracted: year of publication, authors, journal of publication, study design and structure, sample size, the characteristics of the participants, all the considered variables (with particular attention to the presence of the MC phase variable), tests, and other instruments, expected outcome, and synthesis of study results. When necessary, the authors of the studies were contacted for further information.

3. Results

The online search identified 1,076 citations from databases and other sources. A total of 67 studies investigating the association of MC phases with changes in perception, ANS, and CNS functions were included in this systematic review (the inclusion process is shown in Figure 1), 13 of which were added later after searching the cross-references of the studies in the online databases [14-26]. The included studies were mostly observational, designed as longitudinal (n = 52 studies), cross-sectional (n = 10), or cohort (n = 3) studies, one controlled clinical trial, and one cross-over design. Very few studies were designed with a control group (n = 19) which included men, women taking oral contraceptives, or women divided into groups based on different MC phases or conditions. Further details on the characteristics of the studies are presented in Table 1.

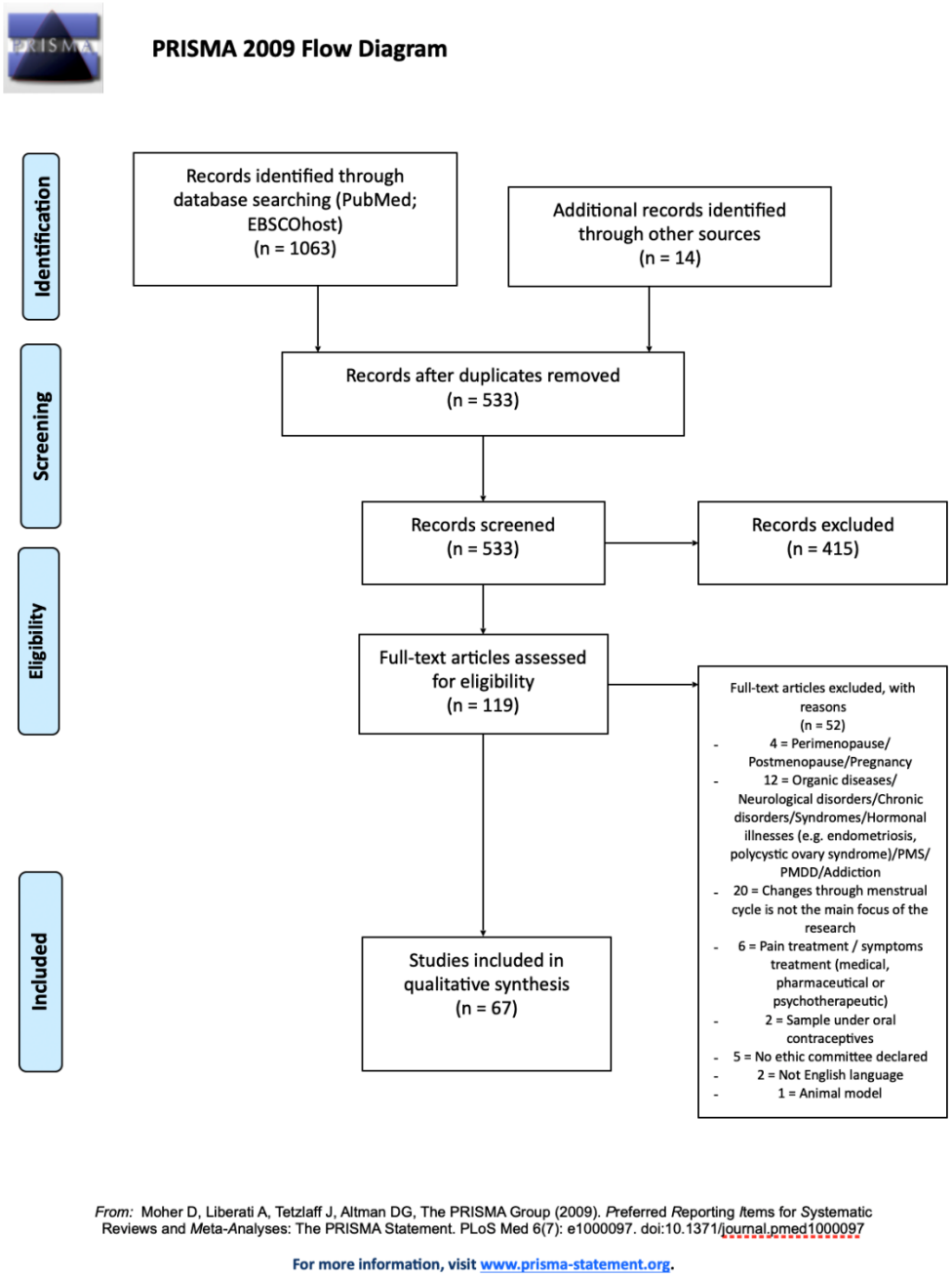

Figure 1 PRISMA flow chart describing the literature search and the number of included studies along with the exclusion criteria of the articles.

Table 1 The characteristics of the study.

Reference N°	Reference, year (study design)	Country	Sample	Regular cycle considered	(*)Control group/(**)Randomization (rnd)	Number of assessed MC and testing time	Primary outcome of interest
[27]	Alves et al., 2017 (LS)	Brazil	39 (all W) age 28.38 ±7.88 y; 5 did not come for L P evaluation	25-30 d	(*)no; (**)no rnd	1 MC/tested on 3 ≠ d: M, F and L P	Trigeminal somatosensory, gustative and olfactory Trs X MC ≠ PS
[28]	Armbruster et al., 2018 (LS)	Germany	45 (all W) age 23.58 ±4.12 y, range 19-35 y	Regular MC (±3 d; length na)	(*)no; (**)pseudo-rnd stimulus order x 3 ≠ cnd: negative/positive/neutral images; no rnd for M P	1 MC/tested on 2 ≠ d: LL and EF P	MC X Emotional processing and startle response
[29]	Armbruster et al., 2014 (CSS)	Germany	218 (107 m and 111 W) age 23.24 y, SD = 3.136, range 18-34 y)	seeArmbruster et al., 2018 (Tab.1)	(*)m; (**)pseudo-rnd stimulus order x 3 ≠ cnd: unpleasant/neutral/pleasant images; no rnd for M P	1 MC/tested on 5 ≠ d: EF, LL, O, EL or LL P	Gender X Startle response and its affective modulation X MC
[14]	Arnoni-Bauer et al., 2017 (LS)	Israel	32 (all W: 20 N and 12 OCs) age 18-35 y	na	(*)OCs; (**)scanning and map presentation rnd order	1 MC/tested on 2 ≠ d: MF and ML P	MC X eating behaviour
[30]	Bartley et al., 2015 (LS)	USA	40 (all W) age 28.98 ±8.57 y	30.29 ±4.02 d	(*)no; (**)rnd assigned to 1 of 6 testing orders (counterbalanced)	3 MC/tested on 3 ≠ d: MF, O and LL P	Nociceptive processing X MC ≠ PS

[31]	Bartley & Rhudy, 2012 (LS)	USA	41 (all W) age 31 y (SD = 8.86)	21.67 to 37.77 d, 28.98 ±3.28	(*)no; (**)randomly assigned to testing order (i.e., MF/LL vs. LL/MF)	1 MC/tested on ≠ d: MF and LL P	MC X brain-to-spinal cord inhibition of spinal nociception
[32]	Bartley & Rhudy, 2013 (LS)	USA	see Bartley & Rhudy, 2012 (Tab.1)	21.67 to 37.77 d, 28.98 ±3.28	(*)no; (**)see Bartley & Rhudy, 2012 (Tab.1)	see Bartley & Rhudy, 2012 (Tab.1)	Pain sensitivity X MC
[15]	Bayer et al., 2013 (LS)	Germany	22 (all W) age 19-33 y, 26 ±3.25]	28.18 ±1.42 d	(*)no; (**)pseudo-rnd order of trial type occurrence; no M P rnd	1 MC/tested on ≠ d: EF and L P	Gain/losses anticipation X MC
[16]	Bayer et al., 2014 (LS)	Germany	see Bayer et al., 2013 (Tab.1)	see Bayer et al., 2013 (Tab.1)	(*)no; (**)Stimuli were pseudo-rnd; no M P rnd	see Bayer et al., 2013 (Tab.1)	Superior consolidation of emotional arousing info X hormonal variations (MC)
[33]	Bosenko et al., 2019 (CSS)	Ukraine	28 (all W) age 17-22 y	na	(*)no; (**)no	1 MC/tested on 5 ≠ d: M, Post-M, O, PoO or Pre-M P	MC X functional capabilities X vegetative status
[34]	Cankar et al., 2016 (LS)	Slovenia	18 (all W) age 31.5 ±5.7 y	na	(*)no; (**)no	1 MC/tested on 2 ≠ d: EF and ML P	Sensitivity to cold X MC
[35]	Carneiro et al., 2019 (CS)	Brazil	20 (9 W/11 m) age 25 ±15 y	27 to 32 d	(*)m; (**)no rnd	1 MC/tested on 2 ≠ d: LL and LF P	Dichotic listening x MC ≠ PS

[17]	Casey et al., 2014 (CS)	USA	19 (all W: 8 N and 11 OCs) age 18-35 y	27-29 d	(*)OCs; (**)see Casey et al., 2016 (Tab.2)	see Casey et al., 2016 (Tab.2)	Muscle stretch reflex X MC
[36]	Casey et al., 2016 (CS)	USA	30 (all W: 15 OCs and 15 N) age 18-35 y	24-35 d (model 28-d)	(*)OCs; (**)subjects rnd to start testing in either F P, O P or L P	1 MC/tested on 3 ≠ d: F, O and L P	Spinal excitability X MC
[37]	Choudary et al., 2016 (LS)	India	100 (all W) age 19-25 y	Normal cycle: 28-to 29-d	(*)no; (**)participants began the study in either M, F P or L P	1 MC/tested on 3 ≠ d: M, F and L P	HRV and sensory-motor association X dietary habits and hormonal levels (MC)
[38]	Dan et al., 2019 (LS)	Israel	40 (20 W and 20 m) age W 24.45 ±2.28 y, m 23.75 ±3 y	na	(*)m; (**) counter-balanced testing order of starting M P	1 MC/tested on 2 ≠ d: MF and LL P	MC X brain activity and functional connectivity during negative and positive emotions
[39]	Dernlt et al., 2013 (LS)	Germany	80 (60 W/20 m) age 26.5 ±5.2 y	28 to 32 d	(*)m; (**)no rnd; 4 ≠ conditions: OCs; FP N; LP N; Men)	1 MC/tested on 2 ≠ d: F and L P	Olfactory performance parameters X MC ≠ PS
[19]	Diekhof et al., 2020 (CSS)	Germany	75 (all W: 36 LF, 25.1 ±0.5 y and 39 ML, 25.2 ±0.6)	Regular: 21-35 d	(*)no; (**)stimuli screen location pseudo-rnd (left or right) from each pair and of stimulus pairs' sequence	1 MC/tested on 2 ≠ d: LF or ML P	Avoidance learning X MC
[18]	Diekhof & Ratnayake, 2016 (LS)	Germany	15 (all W) age 24.9 ±1.8 y	29.8 ±2.6 d	(*)no; (**)pseudo-rnd stimulus pairs sequence (counterbalanced for trial-	1 MC/tested on 2 ≠ d: LF and ML P	Reinforcement learning X MC

					type transitions/screen position)		
[40]	Espin et al., 2019 (CSS)	Spain	76 (25 m, 19.56 ±1.80 y; 26 L P W and 25 F P W; W age 18.90 ±1.48)	Standardized to a 28-d cycle	(*)m; 2 conditions: stress and control; (**)rnd of control/experimental groups assignment	1 MC/tested on 2 ≠ d: F or L P	MC X autonomic nervous system activity
[20]	Farrar et al., 2015 (Cross over design)	UK	12 (all W) age 33.6 ±8.1	Regular: 28-31 d	(*)no; (**)cross-over design was used with the aim of precluding order and learning effects that may occur when repeated assessments are undertaken in this way	2 MC/tested on 2 ≠ d: ML and F P	Effects of fluctuations in hormone and peptide levels on cognitive functions X MC
[41]	Forouzandeh et al., 2020 (CSS)	Iran	15 (all athletes W) age 23.27 ±1.66 y	Normal: 26-32 d	(*)no; (**)no	1 MC/tested on 3 ≠ d: M, O or ML P	MC X shoulder joint stability factors
[21]	Frank et al., 2010 (LS)	Canada	20 (all W) age 22.0 y, range 18-35 y	Regular MC, LH surge: 3.4 ±1.6 d	(*)3 pictures: high and low calories foods and controls; (**) counter-balanced P order; pseudo-rnd condition order	1 MC/tested on 2 ≠ d: O and L P	MC X brain structures associated with reward and cognition responses to visual food cues
[42]	Gonda et al., 2010 (LS)	Hungary	88 (all W) age 27.1 ±5.5 y, range 18-45 y	28.2 ±2.5 d	(*)no; (**)no	3 MC/tested on ≠ d: EF, LF and LL P	Perception of life events X mood and physical symptoms X MC

[43]	Hicks et al., 2017 (LS)	USA	39 (all W) age 26 ±7 y	Regular (a M each month)	(*)no; (**)not rnd; 2 ≠ conditions: BC; non-BC	1 MC/tested in 2 ≠ d: M and PrO P	Body composition assessments X MC ≠ PS
[22]	Hidalgo‐Lopez & Pletzer, 2017 (LS)	Austria	36 (all W) age 23.36 ±3.44 y, range 18-33 y	21-35 d, varying less than 7 d	(*)no; (**)pseudo-rnd trial condition for the N-back Task and rnd task condition for the Stroop Task; counter-balanced testing order of starting M P	MC/tested on 3 ≠ d: M, PrO, and ML P	Cognitive performances X MC and executive functions X eye blink rate (as DA indicator)
[23]	Hidalgo‐Lopez et al., 2020 (LS)	Austria	54 (all W) age 23.9 ±3.68, range 18-35 y	see Hidalgo‐Lopez & Perez, 2017 (Tab.1)	(*)no; (**)counter-balanced testing order of starting M P	see Hidalgo‐Lopez & Perez, 2017 (Tab.1)	Eye blink rate X MC
[44]	Huang et al., 2015 (LS)	Republic of China	20 (10 W and 10 m) age 20.9 ±1.2 y	Regular MC, varying max 7 d	(*)m; (**)phases in a rnd order	1 MC/tested in 2 ≠ d: MF and ML P	Sleep deprivation X MC X cardiac autonomic nervous activity
[45]	Ileri et al., 2016 (CSS, controlled clinical trial)	Turkey	48 (all W: 27 F and 21 L) age 17.8 ±2.0, range 16-20 y	Standard 28-d MC; all regular MC 28.6 ±2.9 d	(*)no; (**)no	1 MC/tested in 2 ≠ d: F or L P	orthodontic pain perception X MC
[46]	James & Murnock, 2015 (LS)	USA	71 (all W) age 34.9 ±7.7 y	28 ±3 d	(*)no; (**)1/2 W began the study in the F P and 1/2 in the L P	1 MC/tested in 2 ≠ d: F and L P	Stress and stress denial X MC X blood pressure

[47]	Kaczmarek & Trambacz-Oleszak, 2016 (CSS)	Poland	330 (all W) age 16.2 ±1.7, range 12-18 y	243 W 28-32 d length, 44 W < 28 d, 33 W > 32 d	(*)no; (**)no	1 MC/tested in 3 ≠ d: M, Pre-M or Inter-M P	Body image perception X MC
[48]	Kayacan et al., 2020 (LS)	Turkey	28 (all W, athletes) age 19.6 ±2.8 y	Regular: 24-35 d	(*)no; (**)no	1 MC/tested in 4 ≠ d: M, O, L and Pre-M P	HRV and cortisol secretion X MC
[49]	Klatzkin et al., 2010 (LS)	USA	97 (48 m, 49 W) range 18-45 y	Regular: 24-32 d	(*)no; (**)rnd M P order; rnd task orders (tourniquet, heat, cold); Stress versus Rest order counterbalanced by gender	1 MC/tested in 3 ≠ d: EF, LF and L P	Pain sensitivity X MC
[50]	Kokts-Porietis et al., 2019 (LS)	Canada	7 (all W) age 28.60 ±8.40 y	26-36 d; 28.40 ±2.30 d	(*)no; (**)no	1 MC/tested daily for 5 w in 2 ≠ P: F and L P	MC X HRV
[51]	Krohmer et al., 2019 (LS)	Germany	35 (all W: 16 N; 19 OCs) age 20.77 ±2.12 y, range 18-27 y	na	(*)OCs; (**) counter-balanced order of testing (mid cycle vs. cycle end) across groups	1 MC/tested in 2 ≠ d: O and LL P	MC X body satisfaction and perception
[52]	Kumar et al., 2010 (LS)	India	90 (60 W, 19.72 ±1.67 y; 30 m, 21.43 ±2.22)	Regular: 28 d MC	(*)m; (**)no	1 MC/tested in 2 ≠ d: 1, 7, 14 and 21	Pain sensitivity X MC (d)

[53]	Lawrence et al., 2010 (LS)	USA	12 (all W) age 21 ±1 y	26-30 d	(*)no; (**)selection of the initial M P was rnd	na/each one was tested in 2 ≠ d: EF and ML P	Vestibular-mediated changes in limb blood flow X MC ≠ P
[54]	Lee et al., 2014 (LS)	Japan	18 (8 W age 25.00 ±1.85 y; 9 m age 26.90 ±2.08 y)	na	(*)m; (**)no	1 MC/tested in 2 ≠ d: MF and L P	Sweat rate and cutaneous blood flow X MC ≠ P
[55]	Matsuda-Nakamura et al., 2015 (LS)	Japan	8 (all W) age 22.0 ±1.4 y	na	(*)no; (**) 2 trials in balanced order	na (each W finished the 2 trials within 3 months)/tested in 2 ≠ d: L and F P	Thermal perception and autonomic thermoregulatory X MC ≠ P
[56]	Meigal et al., 2014 (LS)	Russia	29 (all W) age 19.9 ±1.4 y; results on 23 subjects data	28.84 ±0.32 d	**1.**(*)no; (**)no	na (from autumn-winter to spring)/tested in 4 ≠ d: EF, LF, O and L P	Electromyographic changes X MC ≠ P
[57]	Morotti et al., 2013 (LS)	Italy	24 (all W) age 29.3 ±4.5 y	25-30 d	(*)no; (**)no	1 MC/tested in 3 ≠ d: EF, O and ML P	Clitoral changes, sexual behavior, and perceived body image X MC ≠ P
[24]	Mulligan et al., 2019 (LS)	USA	40 (all W) age 20.78 ±3.37 y	28.65 ±2.97 d	(*)no; (**)counterbalanced test sessions: 1st (23 MF and 17 ML P W), 2nd (opposite)	1 MC (2 weeks between visits)/tested in 2 ≠ d: MF and ML P	Error-related negativity (ERN) and checking symptoms X MC ≠ P

[58]	Nene & Pazare, 2010 (LS)	India	100 (all W) Age 18.06 ±1.11 y	28 to 30 d	(*)no ; (**)no	1 MC/tested on 4 ≠ d: P P, M P, 1 middle of proliferative P, O P and middle of secretory P	Auditory reaction time X MC ≠ PS
[59]	Notley et al., 2019 (LS)	Canada	12 (all W) age 21 ±3 y	na	(*)no; (**)no	1 MC (not 2 subjects: tested in 2 MC)/each one was tested in 3 ≠ d: EF P, LF P and ML P	Dry and evaporative heat exchange and whole-body heat loss X MC ≠ P
[60]	Pallavi et al., 2017 (LS)	India	100 (all W) age 18-24 y	26-32 d	(*)no; (**)no	2 MC/tested in 3 ≠ d: M P, F P and L P	Muscle strength variations and fatigue X MC ≠ P
[61]	Parma et al., 2012 (CSS) (study one)	Italy	205 (W 103 age 22.6 ±1.0 y; m 102 age 22 ±1.2 y)	Standardized to a 28-d cycle	(*)3 control groups: 25 W in F P, 26 W in L P and 26 m; (**)no	1 MC/each one tested according to the MC P: F P or L P	Androstadienone on eye fixation toward female and male faces and objects X MC ≠ P
[61]	Parma et al., 2012 (CSS) (study two)	Italy	103 W (same W who took part in exp 1 during the same M P of exp 1)	See Parma et al., 2012 study one	(*)2 groups: F and L P; (**)rnd assigned to androstadienone group: 26 W in F P or 26 W in L P	See Parma et al., 2012	Facial attractiveness of each of the female faces used for study one X MC ≠ P

[62]	Petrofsky et al., 2015 (LS)	USA	8 (all W) age 25.0 ±1.9 y	28.5 ±2.9 d	(*)no; (**)no	1 MC/tested in 2 ≠ d: MF P and L P	Sympathetic activity, skin vasomotor and sweat gland sudomotor rhythms X MC ≠ P
[63]	Pilarczyk et al., 2019 (LS)	Poland	20 (all W) age 24 ±3.3 y	29.5 ±2.2 d	(*)no; (**)no	1 MC/each one was tested in 2 ≠ d: EF P and ML P	Engagement of attention X MC ≠ P
[64]	Pogatzki-Zahn et al., 2019 (LS)	Germany	15 (alla W) age 24 ±4.0 y	26-30 d	(*)no; (**)rnd time of 1st testing P	4 to 6 months between both testing sessions/tested in 2 ≠ d: F P and L P	Somatosensory perception X MC ≠ P
[65]	Razzak et al., 2015 (CSS)	Bahrain	82 (52 W age 20.16 ±1.02 y, 30 M age 19.72 ±1.20 y)	29.11 ±1.71 d	(*)m; (**)no rnd; 3 ≠ conditions: F P, ML P and men	1 MC/tested on 2 ≠ d: F or ML P	Visual vertical perception (on computerized version of the RFT [CRFT]) X MC ≠ PS
[66]	Reimers et al., 2014 (LS)	Germany	14 (all W) age 24.9 ±1.6 y	26-32 d	(*)no; (**) counter-balanced within-subject study	1 MC/each one was tested twice during 2 ≠ P: F P and L P	Ability to wait for a reward X hormonal levels (MC)
[67]	Rhudy & Bartley, 2010 (LS)	USA	41 (all W) age 31 ±8.86 y	21.67 to 37.67 d	(*)no; (**) counter-balanced testing order	3 MC/tested in 2 ≠ sessions in the 2nd	Affective modulation of pain and

						and 3d MC: MF and LL P	nociceptive flexion reflex X MC ≠ P
[68]	Rhudy et al., 2013 (LS)	USA	40 (all W) age 29 ±8.57 y	na	(*)no; (**)rnd assigned to a P testing order	3 MC/tested in 3 ≠ d: MF, O and LL P	Emotional modulation of pain and nociception X MC ≠ P
[69]	Sao & Jain, 2016 (LS)	India	10 (all W) age 20.61 ±1.88 y	27 to 31 d	(*)no; (**)no	1 MC/tested on 2 ≠ d: F and O P	temporal perception, speech perception in noise, working memory X MC ≠ PS
[4]	Schmalenberger et al., 2020a (LS) (study two)	Germany	50 (all W) age 24.8 ±5.8 y	na	(*)no; (**)counterbalanced visits order	na/tested in 3 ≠ d: ML, M and O P	HRV X salivary ovarian hormones (MC)
[70]	Shechter, 2011 (LS) (study one)	Canada	8 (all W) age 26 ±2.67 y	26-32 ±3 d	(*)no; (**)no	2 MC/entered the lab for 5 d in 2 ≠ P: MF and ML P	Circadian processes X MC ≠ P
[25]	Soni et al., 2013 (CSS)	UK	45 (all W: 15 mid F, 15 EL and 11 LL) age 23.34 ±3.86 y, range 18-35 y	26-34 d	(*)no; (**)no	1 MC/tested on 3 ≠ d: mid-F, EL and LL P	Intrusive memories and anxiety X Stressful film and MC

[71]	Suzuki et al., 2016 (LS)	Japan	8 (all W) age 26.3 ±3.8 y	25-36 d	(*)no; (**)no	2 MC/tested in 6 ≠ sessions: M, F and LL P	HRV between the on- and off-duty days X MC ≠ P
[72]	Tada et., 2017 (CSS)	Japan	21 (all W) age 21.9 ±0.3 y	25-38 d	(*)no;(**)no	1 MC/tested in 1 ≠ d: F or L P	Changes in diet, physical activity, sleep and cardiac autonomic nervous system function X MC ≠ P
[73]	Tatar et al., 2016 (LS: prospective cohort)	Turkey	89 (all W) age 31.5 ±6.0 y	na	(*) no; (**) no	1 MC/tested in 3 ≠ d: M, PostM and PreM P	Perceptual voice quality X MC ≠ PS
[74]	Tenan et al., 2014 (LS)	USA	13 (all W) age 20-31 y	25-32 d	(*)no; (**)rnd for data collection (pseudo-counterbalanced); not rnd for testing sessions	1 MC/tested in 5 ≠ d: EF, LF, O, ML and LL P	Changing in resting HRV X MC ≠ P
[75]	Tenan et al., 2016 (LS)	USA	9 (all W) age 24.7 ±4.5 y	See Tenan et al., 2014	See Tenan et al., 2014	See Tenan et al., 2014	Maximal isometric force (MVC), time to fatigue, and force tremor X MC ≠ P
[26]	Thimm et al., 2014 (LS)	UK	21 (all W) age 24.8 y ±3.5 y	na	(*) no; (**) rnd testing order across subjects	1 MC/tested in 3 ≠ d: M, F and L P	Effects of E2 and P4 on intra- and interhemispheric functional connectivity in the frontoparietal

							selective attention network X MC
[76]	Usselman et al., 2014 (LS)	Canada	18 (W 9 age 24 ±3 y; m 9 age 26 ±2 y)	Around 28 d	(*)m; (**)rnd testing M P order; m tested once	1 MC/tested in 2 ≠ d: EF and ML P	Sympathetic and hemodynamic responses to chemoreflex stimulation X MC ≠ P
[77]	Webb et al., 2018 (LS)	UK	49 (W: 21 N, age 21.6 ±3.8 y; 14 combined OCs, age 20 ±1.3 y; 14 m, age 21.5 ±4.3 y)	Max. 35 d	(*)m; (**)no	1 MC/tested in 3 ≠ experimental sessions: F, O and L P	Contrast sensitivity X MC ≠ P
[78]	Yazar & Yazıcı, 2016 (LS)	Turkey	30 (all W) age 22-37 y	25-31 d	(*)no; (**)no	1 MC/tested in 2 ≠ d: LF and ML P	Autonomic tone X MC ≠ P

Notes: Cit. n°: citation number; MC: menstrual cycle; F: follicular; PrO: pre-ovulatory; O: ovulation/peri-ovulatory; PO: post-ovulatory; L: luteal; EL: early luteal; EF: early follicular; LL: late luteal; LF: late follicular; ML: mid-luteal; P: phase/phases; PDM: primary dysmenorrhea; P4: progesterone; E2: estradiol; N: natural cycling women; OCs: oral contraceptive users; W: women; m: men/males; d: day/days; ≠: different; cnd: condition/conditions; X: throughout; HC: healthy control; ±: standard deviation; rnd: randomization/randomized. LS: longitudinal study; CSS: cross sectional study; CCS: case control study; PCS: prospective cohort study; CS: cohort study; HRV: heart rate variability. Trs: thresholds; y: year/years.

3.1 Study Characteristics and Outcome Measures

The characteristics and primary outcomes of the included studies are presented in Table 1. The exclusion criteria of the included articles were the presence of peri-menopause, post-menopause, or pregnancy; any history of organic diseases; neurological, chronic, or psychiatric disorders, syndromes, or hormonal illnesses (e.g., endometriosis, polycystic ovary syndrome); pain or symptoms treatment (either medical, pharmaceutical, or psychotherapeutic); breastfeeding; symptoms of amenorrhea, Premenstrual Syndrome (PMS), Premenstrual Dysphoric Disorder (PMDD), dysmenorrhea (PMD), or heavy menstrual bleeding (HMB). The measurement tools for each variable of interest are presented in Table 2. Pitchers and Elliott-Sale's model was used, and all results of included studies are reported following this model.

Table 2 Measurements and tools.

Reference N°	Reference	(+)Measurement tools for M symptoms and (++)for MC phase	Natural MC testing phases (estimated d)	(*)Hormones and (**)Hormonal assessment	Outcomes of interest: n)Variables	Outcomes of interest: n)Tools
[27]	Alves et al., 2017	(+)na; (++)Counting d from the onset of M and hormones level	M P (d 1-5), F P (d 6-10) and L P (d 19-24)	(*)E2 and P4; (**)Saliva samples	Gustative and olfactory Trs; thermal detection Trs for cold and warm sensations; mechanical detection Trs for touch, vibration; mechanical pain sensitivity, including superficial and deep pain Trs; electric pain Trs in teeth; corneal reflex	Standardized protocol of quantitative Sensory Testing (Siviero et al., 2010)
[28]	Armbruster et al., 2018	(+)Menstrual Symptoms Questionnaire (MSQ; Chesney & Tasto, 1975); (++)Counting d from the onset of M and hormones level	Mc (O, d 13-15 prior to the next M), EL P (7 d following Mc, d 16-22) and LL P (6 d preceding the estimated onset of the next M, d 23-28)	(*)E2, P4, and T; (**)Saliva samples (SaliCaps; IBL; Hamburg, Germany)	1)Facial EMG; 2)Heart rate (HR)	1)For raw EMG signals: BrainAmp amplifier and BrainVision Analyzer software (Brain Products GmbH, Gilching, Germany); 2)Raw ECG signals (see above)
[29]	Armbruster et al., 2014	(+)na; (++)Counting d from the onset of M (time of O was estimated by	EF and LF P (1st and 2nd halves of d 1-12), Mc (O, d 13-15 prior to the next	(*)na; (**)na	1)Acoustic startle response (ASR); 2)Emotional ratings of ASR	1)EMG activity over the orbicularis oculi muscle beneath the left eye; 2)Self-

		subtracting 14 d from the start of the next M)	M), EL P (the 7 d following Mc; thus, d 16-22), and LL P (the 6 d before M, hence d 23-28)			Assessment Manikin (SAM; Lang, 1980)
[14]	Arnoni-Bauer et al., 2017	(+)na; (++)Counting d from the onset of M and P4, E2 and T levels	MF P (d 7-12) and ML P (d 20-26)	(*)P4, E2, T, cortisol, DHEA-S, TG, CRP, and HDL-cholesterol; (**)Blood samples	1)Brain reward region activation (BOLD); 2)Eating attitudes and behavior	1)fMRI; 2)Eating Attitudes Test (EAT-26; Garner, 1982)
[30]	Bartley et al., 2015	(+)na; (++)Counting d from the onset of M, LH surge and E2, P4, and T levels	MF P (d 5-8), O P (2 d following LH surge), and LL P (1-6 d before M)	(*)LH, E2, P4, and T; (**)Saliva samples and urinary LH surge tests (Clearblue Easy; Swiss Precision Diagnostic, Bedford, UK)	1)Electrocutaneous pain Trs and tolerance; 2)Ischemia pain Trs/tolerance; 3)Sensory/affective ratings of pain stimuli; 4)Nociceptive flexion reflex (NFR) Trs	1)Electric stimuli; a computer-presented numerical rating scale (NRS; France et al., 2002; Rhudy et al., 2005); 2)Dynamometer and NRS; 3)McGill Pain Questionnaire-Short Form (Melzack, 1987); 4)EMG
[31]	Bartley & Rhudy, 2012	(+)PRISM (Reid, 1985); (++)Counting d from the onset of M and LH surge	MF P (d 5-8 following M onset) and LL P (d 1-6 preceding M or 9 to 11 d following the LH surge)	(*)LH; (**)Urine tests (e.g., QTests)	1)Subjective pain; 2)Conditioned pain modulation (CPM; France & Suchowiecki, 1999)	1)Computer-presented numerical rating scale (NRS; France et al., 2002; Rhudy et al., 2005); 2)Dynamometer to induce ischemia and a blood pressure cuff

[32]	Bartley & Rhudy, 2013	(+)see Bartley & Rhudy, 2012 (Tab.2); (++)Counting d from onset of M, LH surge and BBT	MF P (d 5 to 8 after M onset) and LL P (d 1 to 6 preceding M or 9 to 11 d after O)	(*)LH; (**)Urine QTests	1)Electrocutaneous pain Trs and tolerance; Nociceptive flexion reflex Trs; Sensory/affective ratings of pain stimuli; 2)Pressure pain Trs	1)see Bartley et al., 2015 (Tab.2); 2)Mechanical pressure
[15]	Bayer et al., 2013	(+)A mood questionnaire (Pessiglione et al., 2006); (++)Counting d from the onset of M	EF P (0-4 d after the onset of M) and ML P (11 to 5 d before estimated onset of next M)	(*)E2, P4, and cortisol; (**)Saliva samples	1)Neuronal responses to anticipation of high vs. low gains and losses (BOLD)	1)A modified version of the 'Monetary Incentive Delay 'task (MID; Knutson et al., 2001a,b) and fMRI
[16]	Bayer et al., 2014	see Bayer et al., 2013 (Tab.2)	see Bayer et al., 2013 (Tab.2)	see Bayer et al., 2013 (Tab.2)	1)Emotional arousing; 2)BOLD	1)144 stimuli, 'Self-Assessment-Manikin ' (SAM) scale (Bradley & Lang, 1994); 2)fMRI
[33]	Bosenko et al., 2019	(+)na; (++)Calendar method of phase determination (Svechnikova, 2012; 2014; 2015)	M P (na), PoM P (na), O P (na), PO P (na) and PrM P (na)	(*)na; (**)na	1)Systolic, diastolic, pulse (ADs, ADD, PD) measures; 2)HRV	1)Blood pressure; 2)ECG
[34]	Cankar et al., 2016	(+)na; (++)Counting d from the onset of M and hormonal levels	EF P (d 4-5) and ML P (d 22-25)	(*)E2 and P4; (**)Blood samples	Thermal perception Trs	Somedic thermotest (Somedic AB Stockholm, Sweden; (Fruhstorfer et al., 1976)
[35]	Carneiro et al., 2019	(+)na; (++)Counting d from onset of M	LF P (d 8-13) and LL P (d 23-28)	(*)E2; (**)Blood samples	Dichotic listening	Staggered spondaic word, dichotic digits,

						and dichotic consonant-vowel tests (Pereira & Schochat, 1997; 2011)
[17]	Casey et al., 2014	(+)na; (++)Counting d from onset of M	see Casey et al., 2016 (Tab.2)	see Casey et al., 2016 (Tab.2)	Muscle Stretch Reflex (MSR)	see Casey et al., 2016 (Tab.2)
[36]	Casey et al., 2016	(+)na; (++)Counting d from onset of M and a home ovulation kit (Walgreens One Step Ovulation Predictor; Walgreens Corporation, Deerfield IL)	27-to 29-d cycle participants: 1#F P (d 1-3), 2#O P (d 12-14) and 3#L P (d 21-25). 30-to 35-d cycle: 1# (d 1-3), 2# (d 14-16) and 3# (d 23-27). 24-to 26-d cycle: 1# (d 1-3), 2# (d 10-12) and 3# (d 19-23)	(*)E2 and P4; (**)Blood samples	H Reflex (Hmax/Mmax ratio)	Surface EMG
[37]	Choudhary et al., 2016	(+)na; (++)By questionnaire	M P (d 1-2), F P (d 7-10) and L P (3-7 d before M)	(*)na; (**)na	1)HRV; 2)Dietary habits	1)ECG; 2)Participants' infos
[38]	Dan et al., 2019	(+)Prior to inclusion: Daily Record of Severity of Problems (DRSP; Endicott et al., 2006); (++)Counting d from the onset of M, LH surge and	MF P (d 6-12) and LL P (1-7 d before M onset)	(*)E2, P4, and LH; (**)Blood samples	1)Emotion experience; 2)Emotion perception; 3)BOLD	1)Prolonged mood induction (Farb et al., 2010; Gross & Levenson, 1995; Rottenberg et al., 2007; Schaefer et al., 2010); 2)Two versions of the emotional face-

		confirmation by E2 and P4 serum				matching task (Hariri et al., 2002); 3)fMRI
[39]	Derntl et al., 2013	(+)na; (++)By verbal information and counting d from the onset of M	F P (d 1-14) and L P (d 18-28)	(*)na; (**)na	Olfactory parameters (Hummel et al. 1997)	Sniffin 'Sticks test battery (Burghart Instruments; Hummel et al., 1997; Kobal et al., 1996)
[19]	Diekhof et al., 2020	(+)Premenstrual Symptoms Questionnaire (Ditzen et al.) and Multidimensional Mood Questionnaire (Steyer et al., 1997); (++)Counting d from the onset of M (28-d) and from next M (basing on the average length of two previous MC)	LF P (standardized cycle d 2-12) and ML P (standardized cycle d 16-26)	(*)E2 and P4; (**)Saliva samples	see Diekhof & Ratnayake, 2015 (Tab.2)	Probabilistic learning task (Diekhof & Ratnayake, 2015)
[18]	Diekhof & Ratnayake, 2016	(+)na; (++)Urine samples (Clearblue Fertility Monitor) indicating LH surge	LF P (d 13.2 ±0.6: 3.9 ±1.6 d before LH surge) and ML P (d 24.1 ±0.5: 7.3 ±2.6 d after LH surge and 5.4 days ±0.6 d before next MC)	(*)E2, P4 and LH; (**)Saliva samples	1)Ability to learn from probabilistic feedback; 2)BOLD	1)Probabilistic learning task (Frank et al., 2004; Klein et al., 2007); 2)fMRI

[40]	Espin et al., 2019	(+)na; (++)Counting d from the onset of M and converting all cycles to a standard 28-d one	F P (d 5-8) and L P (4-8 d before onset of M)	(*)na; (**)na	1)Stress condition; 2)Heart rate and HRV; 3)Salivary alpha-amylase (sAA)	1)Trier Social Stress Test (TSST; Kirschbaum et al., 1993); 2)HR monitor (Suunto, model T6, Suunto Oy, Vantaa, Finland); 3)Saliva samples
[20]	Farrar et al., 2015 (Cross over design)	(+)na; (++)self-reported counting d forward from the onset of M of the first MC and then confirmed by counting backward from the onset of M of the second MC; plasma hormone, peptide assay, and venous blood samples	F P (d 1-8) and ML P (na) (Selected steroid and peptide levels were used to help provide an objective measure of cycle phase day)	(*)prolactin, cortisol, oestradiol, P4, FSH, LH, T, sex hormone binding globulin, dehydroepiandrosterone sulfate; (**)venous blood sample	1) cognitive performance and wellbeing then the feasibility of these self-reported measures	1) The Cambridge Neuropsychological Test Automated Battery (CANTAB; Sahakian & Owen, 1992; Curtis-Prior, 1996); SRM test (; DMS test; SOC test; IED shift test; The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987, 1996); The National Adult Reading Test (NART; Nelson, 1991)
[41]	Forouzandeh Shahraki et al., 2020	(+)na; (++)Counting d from the onset of M and O test	M P (3 d after the start of M), LF P (24 to 48 h after having positive O test), and ML P (7 d after	(*)na; (**)O test	1)Laxity; 2)Proprioceptive function; 3)Functional stability; 4)Muscle strength	1)Anterior drawer test, posterior drawer test, and sulcus sign clinical tests; 2)An active joint repositioning Test

			having positive O test)			(Dover et al., 2003); 3)The Y Balance Test (Gorman et al., 2012); 4)Lafayette Hand-held Dynamometer (Kolber & Cleland, 2005)
[21]	Frank et al., 2010	(+)Positive Affect Negative Affect Schedule (PANAS; Watson et al., 1988); (++)LH surge and counting from M and subsequent M onset	LF P (mean n of d between the F P scan and the subsequent LH surge averaged 3.4 ±1.6 d) and mid to LL P (average of 4.7 ±2.9 d before M)	(*)LH; (**)Urinary LH monitoring kit (Unipath Ltd., Bedford, MK44 3UP, UK)	1)Brain responsiveness to visual food cues; 2)BOLD	1)Pictures of high calories (HC) and low calories (LC) foods, and control (C) pictures; 2)fMRI
[42]	Gonda et al., 2010	(+)PRISM calendar (Reid & Fretts, 1995); (++)Counting d from the onset of M and converting all cycles to a standard 28-d one	EF P (the first 7 d after the onset of M), LF P (7 d between 21 and 14 d before the onset of the next M), and LL P (7 d preceding the onset of the next M)	(*)na; (**)na	Perception of events	Objective and Subjective Event Checklist (Seidlitz and Diener, 1993)
[43]	Hicks et al., 2017	(+)na; (++)Counting d from the onset of M	M P (d 1 or 2 of their MC) and PrO P (7 to 14 d after their initial visit)	(*)na; (**)na	1)Body composition parameters (e.g., body volume, fat-free mass, water, body fat %); 2)Body satisfaction and bloatedness	1)Air Displacement Plethysmography (ADP), Bioelectrical Impedance Analysis (BIA) and Dual-energy X-ray Absorptiometry

						(DXA); 2)Body satisfaction questionnaire
[22]	Hidalgo‐Lopez & Pletzer, 2017	(+)na; (++)LH surge and counting d from the onset of M, from subsequent M, and from O	M P (d 2-7), PrO P (d 11) and ML P (d 18-25)	(*)LH, E2, and P4; (**)Urine O tests (Pregnafix Ovulationstest) and saliva samples (ELISA kits; DeMediTec Diagnostics, Kiel, Germany)	Spontaneous eye blink rate (EBR, as an indirect measure of baseline dopamine levels) and vertical and horizontal electro-oculograms (EOGs)	EEG system (actiCAP, Brain Products GmbH, Germany) and ActiCHamp Amplifier (Brain Products GmbH, Germany)
[23]	Hidalgo‐Lopez et al., 2020	(+)na; (++)see Hidalgo‐Lopez & Pletzer, 2017 (Tab.2) and hormonal levels	M P (d 2-7), PrO P (d 10-11) and ML P (d 18-25)	(*)LH, E2 and P4; (**)see Hidalgo‐Lopez & Pletzer, 2017 (Tab.2)	Eye blink rate (EBR) and vertical and horizontal electro-oculograms (EOGs)	see Hidalgo‐Lopez & Pletzer, 2017 (Tab.2)
[44]	Huang et al., 2015	(+)na; (++)BBT and progesterone levels	MF P (na) and ML P (na)	(*)P4; (**)Blood samples	HRV	ECG
[45]	Ileri et al., 2016	(+)na; (++)Counting d from onset of M	F P (d 1-12) and L P (d 15-19 and 25-28)	(*)na; (**)na	Orthodontic pain perception	Oral Health Impact Profile-14 (OHIP-14; Slade & Spencer, 1994), VAS and verbal rating scale-4 (VRS-4)
[46]	James & Murnock, 2015	(+)na; (++)Counting d from the onset of M	F P (d 7-10) and L P (d 19-25)	(*)E and P4; (**)Blood samples	1)Perceived stress and denial; 2)Blood pressure (BP) levels	1)Scale from 0 (low) to 10 (high) and item: When you are under stress, does it bother

						you (yes [1], no [2]); 2)Spacelabs 90207 ambulatory BP monitor
[47]	Kaczmarek & Trambacz-Oleszak, 2016	(+)M history and MC infos (Kaczmarek, 2007, unpublished); (++)Counting d from the onset of M and criterion by Altabe & Thompson (1990)	M P (from beginning to cessation of flow), PrM (last 5 days of L P), and InterM P (1 week following the cessation of flow to 1 week prior to the onset of M)	(*)na; (**)na	Body image perception	Figure Rating Scale (FRS; Stunkard et al., 1983)
[48]	Kayacan et al., 2020	(+)Menstrual history questionnaire; (++)Counting d from onset of M	M P (1-3 d), O P (in the middle of the loop), L P (20-21 d) and PrM P (24-27 d)	(*)Cortisol; (**)Saliva samples	HRV	ECG
[49]	Klatzkin et al., 2010	(+)na; (++)Counting d from the onset of M, LH surge, and E2 and P4 levels	EF P (d 2-5), LF P (d 7-12), and L P (d 8-12 after LH surge)	(*)E2, P4, and LH; (**)Urine sample and hormonal serum concentration	Pain Trs and tolerance	The submaximal effort tourniquet procedure (Maixner et al., 1990), Hand cold pressor (na), Heat pain testing (na)
[50]	Kokts-Porietis et al., 2019	(+)na; (++)Oral BBT and counting d from O (or considering Mc)	F P (d prior to O) and L P (d following O)	(*)na; (**)na	HRV	"HRV4training" (Altini, 2013)

[51]	Krohmer et al., 2019	(+)The Positive and Negative Affect Scale (PANAS; Krohne et al., 1996; Watson, et al., 1988) and two 10 cm VAS; Durante et al., 2008); (++)LH surge and counting d from O and next M	Mc (within 48 h following LH surge) and LL P (10-12 d after O and 4 to 2 d prior to next M)	(*)LH; (**)LH test strips (One Step® Ovulation Tests at 20 mlU/mL)	1)Attractiveness perception; 2)Eye movements	1)The Body Shape Questionnaire (BSQ; Cooper et al., 1987; German Version: Waadt et al., 2013); 2)SensoMotoric Instruments 'wearable eye-tracking glasses and a closed mirror
[52]	Kumar et al., 2010	(+)na; (++)Counting d from onset of M	1# measurement (d 1), 2# (d 7), 3# (d 14), 4# (d 21)	(*)na; (**)na	1)Pain Trs and tolerance; 2)Pain rating	1)Cold pressor task (CPT); 2)VAS
[53]	Lawrence et al., 2010	(+)na; (++)Counting d from the onset of M	EF P (3 ±0 d after the start of M) and ML P (23 ±0 d after the start of M)	(*)na; (**)na	1)Muscle sympathetic nerve activity; 2)Heart rate; 3)Beat-to-beat arterial blood pressure; 4)Blood flow	1)Tungsten microelectrode insertion; 2)ECG; 3)Finometer (Finapres Medical Systems, Amsterdam, The Netherlands); 4)Venous occlusion plethysmography (EC6, D.E. Hokanson Inc., Bellevue, WA, USA)
[54]	Lee et al., 2014	(+)na; (++)Body core temperature	MF P (6 to 9 d after M onset) and L P (21 to 24 d after M onset)	(*)na; (**)na	1)Skin blood flow (SBF); 2)Local sweat rates; 3)Skin temperature	1)Moor Laser Doppler flow meter (VMS LDF20, Oxford, England); 2)Q-Sweat measuring system (WR

						Medical Electronics, Stillwater, MN); 3)The SKT 100 thermistor amplifier (Bio Pac Inc., Goleta, CA)
[55]	Matsuda-Nakamura et al., 2015	(+)na; (++)BBT and counting d from the onset of M	L P (4-10 d after the elevation of the BBT) and F P (6-11 d after the onset of M flow)	(*)E2, P4, T, TSH, free triiodothyronine and free thyroxine; (**)Blood samples	1)Skin surface temperature; 2)Heart rate; 3)Blood pressure; 4)Cutaneous blood flow; 5)Metabolic rate; 6)Thermal sensation and pleasantness	1)Copper-constantan thermocouples: 2)ECG; 3)Sonometric pickup; 4)Doppler flowmetry; 5)Indirect calorimetry; 6)Rating scales (Marks et al. m 1988)
[56]	Meĭgal et al., 2014	(+)na; (++)Diary of BBT	EF P (m: d 7), LF P (m: d 13), O P (m: 16) and L P (m: d 24)	(*)na; (**)na	1)Autonomic regulation type; 2)Neuromuscular state	1)Vegetotester (VNSSpectrum, Neurosoft, Ivanovo, Russia); 2)Interference EMG and activity of motor units
[57]	Morotti et al., 2013	(+)na; (++)Counting d from the onset of M, P4 serum levels and ultrasonographic results	EF P (d 3), O P (d 14) and ML P (d 20)	(*)E2, P4, T, and androstenedione; (**)Blood samples	1)Clitoral vascularization (and pulsatility index); 2)Sexual behavior; 3)Perceived body image	1)Color Doppler Examination (Battaglia et al., 2008) and linear US transducer (RSP-16 multifrequency linear array, Voluson 730 Expert, GE Healthcare Ultrasound, Zipf, Austria); 2)Two-factor Italian McCoy Female

						Sexuality Questionnaire (Rellini et al., 2005); 3)Figure Rating Scale (Stunkard et al., 1983)
[24]	Mulligan et al., 2019	(+)na; (++)Counting d from the onset of M	MF P (6 to 8 d following the start of M) and ML P (6 to 8 d before the start of M)	(*)E2 and P4; (**)Saliva samples	1)Checking symptom scores; 2)Error-related neural activity (ERN)	1)Checking subscale (IDAS-II; Watson et al. 2007; Watson et al., 2012); 2)EEG and Electrooculogram
[58]	Nene & Pazare, 2010	(+); (++)Counting d from onset of M and BBT	M P (d 1-2), middle of proliferative P (10th-12th day), O (BBT rise), middle of secretory P (21st-23rd d), and PrM P (1-2 d prior to M)	(*)na; (**)na	Auditory reaction time	Audiovisual reaction time apparatus (RTM-608, supplied by Biotech India, Mumbai)
[59]	Notley et al., 2019	(+)na; (++)Counting d from M	EF P (4 d following M), LF P (10 d following M), and ML P (22 d following M)	(*)na; (**)na	1)Evaporative heat loss and dry heat exchange; 2)Absolute humidity; 3)Oxygen consumption, carbon dioxide production, and minute ventilation; 4)Esophageal temperature and skin temperature; 5)Heart rate	1)The modified Snellen direct air calorimeter (Kenny & McGinn, 1985); 2)Point hygrometry (RH Systems model 373H, Albuquerque, NM, USA); 3)Expired gases and air flows (MOXUS modular metabolic system;

						4)Thermocouples temperature probe; 5)Polar coded WearLink and transmitter
[60]	Pallavi et al., 2017	(+)na; (++)na	M P (na), F P (na) and L P (na)	(*)na; (**)na	Muscle Strength	Mosso's Ergograph and Handgrip dynamometer
[61]	Parma et al., 2012	(+)na; (++)Counting d from onset of M with a cycle-length standardization formula (28-d cycle)	F P (first 14 d of MC) and L P (last 14 d)	(*)na; (**)na	Eye Fixation	Eye Position Detector System (sampling frequency: 40 ms; Farroni et al., 2007)
[62]	Petrofsky et al., 2015	(+)na; (++)Counting d from the onset of M	MF P (d 6-9) and L P (d 21-24)	(*)na; (**)na	1)Sweat rate; 2)Skin temperature; 3)Skin blood flow	1)Q-Sweat measuring system; 2)Thermistor; 3)Moor Laser Doppler flow meter
[63]	Pilarczyk et al., 2019	(+)na; (++)LH surge, P4 and counting d from the onset of M and from O	F P (d 4-6) and ML P (6-8 d following O)	(*)LH and P4; (**)O tests and saliva samples	Engagement of attention	Eye tracking. Eyelink Experiment Builder (SR Research, Ontario, Canada)
[64]	Pogatzki-Zahn et al., 2019	(+)na; (++)Counting d from the onset of M by self-report	F P (4-9 d of MC) and L P (d 19-24 of MC)	(*)E2, P4, follicle-stimulating hormone, LH, T; (**)Blood samples	1)Somatosensory perception and skin sensitivity; 2)Pain ratings; 3)Thermal Trs; 4)Thermal sensory; 5)Mechanical detection Trs and mechanical pain Trs; 6)Secondary hyperalgesia	1)Quantitative sensory testing (QST; Rolke et al., 2006); 2)Rating scale ranging from 0 to 100; 3)TSA 2001-II (MEDOC, Israel); 4)Peltier thermode;

						5)Series of alternating ascending and descending stimulus intensities; 6)Conventional calibrates Semmes-Weinstein monofilament before QST
[65]	Razzak et al., 2015	(+)na; (++)Counting d from onset of M and LH surge	F P (d 5) and ML P (d 21)	(*)LH; (**)Urine ovulation kits	Visual vertical perception	Computerized version of the RFT (CRFT; Bagust et al., 2005)
[66]	Reimers et al., 2014	(+)na; (++)Counting d from the onset of M and from O, LH surge, and E2 and P4 levels	LF P (d 13.3 ±2.3, 3.9 ±1.6 before O) and ML P (d 24.1 ±2.0, 7.3 ±2.8 d after O)	(*)E2, P4, and LH; (**)Saliva samples and LH surge test (Clearblue Fertility Monitor)	Learning style	Clock task (modified from Moustafa et al., 2008) and probabilistic learning task (Frank et al., 2004; Klein et al., 2007b)
[67]	Rhudy & Bartley, 2010	(+)PRISM (Reid, 1985); (++)Counting d from the onset of M, PRISM, LH surge and BBT	MF P (d 5-8) and LL P (1-6 d before M)	(*)LH; (**)Home urine tests (e.g., QTests)	see Rhudy et al., 2013 (Tab.2)	see Rhudy et al., 2013 (Tab.2)
[68]	Rhudy et al., 2013	(+)PRISM modified version (Reid, 1985); (++)LH surge, PRISM and counting d from	MF P (d 5-8), O P (within 48 h after LH surge), and LL P (1-6 d prior to M)	(*)E2, P4, T, and LH; (**)Saliva samples and urinary LH surge tests (Clearblue Easy;	1)Pain ratings; 2)Subjective emotional reactions; 3)Nociceptive flexion reflex (NFR); 4)Skin conductance response	1)Computer-presented numerical rating scale (NRS; France, France, al'Absi, Ring, & McIntyre, 2002;

		the onset of M and from O		Swiss Precision Diagnostic, Bedford, United Kingdom)		France & Suchowiecki, 2001; Rhudy et al., 2005; Terry et al., 2011); 2)Self-Assessment Manikin (SAM; Bradley & Lang, 1994); 3)Corrugator EMG and biceps EMG; 4)11 mm electrodes filled with isotonic paste (EC33, Grass Technologies)
[69]	Sao & Jain, 2016	(+)na; (++)Counting d from the onset of M	F P (d 1-5 of MC) and O P (d 12-15 of MC)	(*)na; (**)na	1)Auditory temporal abilities; 2)Speech perception in noise; 3)Working memory skills; 4)Temporal processing	1)Gap detection test, modulation detection test, and duration discrimination test; 2)Quick-SIN test in Kannada; 3)Forward and backward digit span test; 4)MLP tool box (Grassi et al., 2009) implemented in MATLAB
[4]	Schmalenberger et al., 2020a (study two)	(+)na; (++)3 criteria: forward-and backward-counting (from the onset of M and next M),	M P (2 to 4 d after M onset), O P (d of the positive O test or 1 d after positive O test), and ML P (between d 6 to 8	(*)E2, P4, and LH; (**)Urine-based LH tests by PURBAY® (Münster, Germany) and saliva samples	HRV	ECG

		absolute and relative LH surge, E2, and P4	after positive O test)	(SaliCaps; IBL; Hamburg, Germany)		
[70]	Shechter, 2011 (study one)	(+)na; (++)Counting d from the onset of M and plasma P4 test	MF P (d 5-9) and ML P (d 19-23)	(*)melatonin, E2, and P4; (**)Urinary samples and saliva samples, plasma P4 test	1)Core body temperature; 2)Subjective alertness; 3)Subjective sleep quality; 4)Sleep variables (e.g., total sleep time, non-REM and REM sleep, sleep onset latency, periodic leg movements in sleep)	1)Ultra-rapid sleep-wake cycle procedure (Carskadon & Dement, 1975; Munch et al., 2005) and a thermistor (Steri-Probe, Cincinnati Sub-Zero Products Inc., Cincinnati, OH, USA); 2)Numeric rating and a 10-cm bipolar VAS; 3)A post-nap and a post-sleep questionnaires; 4)Polysomnography
[25]	Soni et al., 2013	(+)VAS for premenstrual tension rating (PMTS-VAS; Steiner et al., 2011); (++)Counting d from the onset of M	mid-F P (d 7-11), EL P (d 16-20) and LL P (d 24-28)	(*)E2 and P4; (**)Saliva samples (Salicaps; IBL International, Germany)	Intrusive memories	An online diary (Bisby et al., 2010) and a 0-100 scale for vividness
[71]	Suzuki et al., 2016	(+)Menstrual Distress Questionnaires (MDQs modified; Moos, 1968); (++)Counting d from the onset of M	M P (d 2-4), F P (d 8-13) and LL P (d 21 to the d before M)	(*)na; (**)na	1)Heart rate and HRV; 2)Physical activity; 3)Work-related fatigue; 4)Systolic and diastolic Blood Pressure	1)ECG; 2)Accelerometer; 3)Modified version of the questionnaire for recording symptoms of fatigue (Working

						Group for Occupational Fatigue of the Japan Society for Occupational Health); 4)Digital automatic sphygmomanometer
[72]	Tada et al., 2017	(+)Menstrual Distress Questionnaires (MDQ; Moos, 1968); (++)BBT, participant's schedule and counting d from the onset of M	F P (from the end of M to O) and L P (from O to M)	(*)na; (**)na	1)Total energy intake; 2)Activity and sleep monitoring; 3)HRV; 4)Eating behavior	1)Standard food composition table (Science and technology Agency of Japan, 2005); 2)Actigraphy device; 3)ECG; 4)Dutch Eating Behavior Questionnaire
[73]	Tatar et al., 2016	(+)na; (++)Counting d from the onset of M	M (d 2-5), PoM P (d 10-14) and PrM P (d 22-28)	(*)na; (**)na	1)Voice analysis; 2)Perceptual voice quality; 3)Self-assessment of voice quality	1)Videolaryngostroboscopy (Xion EndoStrob DX, Berlin, Germany); 2)GRBAS scale (Wood et al., 2014); 3)Turkish version of Voice Handicap Index-10 (Kilic et al., 2008)
[74]	Tenan et al., 2014	(+)na; (++)Oral temperature (BD Basal, Franklin Lakes, NJ) and counting d from O	EF P and LF P (1° and 2° halves before O), O P (lasts 3 d before BBT rise) and ML P and LL P	(*)na; (**)na	QRS wave timing	ECG

			(1° and 2° halves after O)			
[75]	Tenan et al., 2016	(+)na; (++)Oral BBT and counting d from onset of M	EF P (na), LF P (na), O P (lasts 3 d), ML P (na) and LL P (na)	(*)na; (**)na	Maximal isometric force (MVC), time to fatigue, and force tremor	A strain gauge (Entran Sensors & Electronics, Fairfield, NJ) and 12 dynamic submaximal knee extensions without resistance
[26]	Thimm et al., 2014	(+)na; (++)counting d from onset of M	M P (d 1-3), F P (d 10-12) and L P (d 20-22)	(*)E2 and P4; (**)blood sample and eectrochemilumine scence immunoassay	1)Selective attention 2)Effects of E2 and P4 on intra and interhemispheric functional connectivity in the fronto-parietal selective attention network	1)go-no-go experiments; fMRI performed on a 3-Tesla MRI scanner (Philips Systems Achieva) using an eight-channel SENSE head coil and T2⁄-weighted axial EPI sequences 2)Blood samples
[76]	Usselman et al., 2014	(+)na; (++)Counting d from the onset of M and hormonal levels	EF P (d 1-4) and ML P (d 20-24)	(*)E2, P4, and T; (**)Blood samples	1)Muscle sympathetic nerve activity; 2)Systolic, diastolic, and mean arterial (MAP) blood pressure; 3)Heart rate	1)Microneurographic technique (Vallbo et al., 1979); 2)Photoplethysmograp hic methods (Finometer, Finapres Medical Systems, Amsterdam, The Netherlands) and manual

						sphygmomanometry; 3)ECG
[77]	Webb et al., 2018	(+)na; (++)Counting d from M and backwards-counting to calculate O period	EF P (d 1-7), O P (d 11-14) and L P (d 17-28)	(*)na; (**)na	Visual contrast Trs	Sinusoidal Gabor patches
[78]	Yazar & Yazıcı, 2016	(+)na; (++)Counting d from M	F P (d 9-13) and ML P (d 19-23)	(*)na; (**)na	HRV	ECG

Notes: d: day/days; na: not available; Trs: threshold. PRISM: Prospective Record of the Impact and Severity of Menstrual Symptoms (Reid, 1985); VAS: Visual Analogue Scale; BBT: Basal Body Temperature; fMRI: functional magnetic resonance imaging; BOLD: blood oxygen level-dependent; EMG: electromyography; ECG: electrocardiography; HRV: Heart Rate Variability. MC: menstrual cycle; P: phase; M: menstruations/menstrual; PoM: postmenstrual; F: follicular; EF: early follicular; MF: mid-follicular; LF: late follicular; PrO: pre-ovulatory; O: ovulation/peri-ovulation; PO: post-ovulatory; Mc: midcycle; InterM: intermenstrual; L: luteal; EL: early luteal; ML: mid-luteal; LL: late luteal; PrM: premenstrual. LH: luteinizing hormone; E: estrogen; E2: estradiol; P4: progesterone; T: testosterone; H: hormone; TSH: thyroid-stimulating hormone; FSH: follicle-stimulating hormone.

3.2 Findings Categories

3.2.1 Changes in Cognitive Structures

Studies on cognition and processing of emotions are diverse and have investigated the areas of event perception, body image perception, and emotional arousal.

Numerous empirical studies have investigated the influence of the MC on cognitive processes. Clinical experience and anecdotal communication with numerous women have confirmed a reduction in cognitive function during the period and the days immediately preceding it. The rigorous measurements of the level of deficit have been studied extensively [22, 23, 25, 26].

The effects of P4 on the interactions of dopaminergic levels on executive functions during different phases of the MC have been examined [22]. Although numerous studies have been conducted on the role of E2 in cognitive functioning, few studies have investigated the relationship between the hormone P4 and executive functions and, thus, its effects on the CNS. This study demonstrated the role of P4 in the luteal phase of the cycle, using the eye-blink measure. The authors demonstrated the important role of P4 by also highlighting the importance of the eye-blink measure as a non-invasive indicator of baseline dopamine function in MC research.

Furthermore, a recent study [23] conducted with many participants investigated whether the Eye Blink Rate (EBR) changes across the MC. Although the results showed no differences between the phases of the MC, they indicated a high intra-individual consistency of the EBR; thus, suggesting the importance of the EBR for assessing the relationship between the effects of this central index and the MC.

Using the Cambridge Neuropsychological Test Automated Battery (CANTAB) [79] and the Edinburgh Postnatal Depression Scale (EPDS) [80], the feasibility of cognitive and self-reported measures of wellbeing associated with the phases of the MC were investigated [20]. The methodology is interesting because it allowed comparisons of objective measures such as those based on hormone levels with self-reported measures. The results showed substantial individual variations in plasma levels of hormones and peptides, while self-reported measures were statistically not significant. The authors concluded on the feasibility of assessing cognitive performance during the MC; however, understanding how cognitive performance interacts with the hormone levels specific for each phase should be considered for the evaluation of subjects' behaviour.

Finally, a study by Soni et al. [25] highlighted the presence of a narrow post-ovulatory window of vulnerability to distressing involuntary memories. The study, while referring to a process of memory and, therefore, to the CNS, analyzed certain types of memories, those specifically related to traumatic events capable of intruding into the flow of consciousness. The authors argued that while intrusive images are considered to be prototypical of PTSD, they are a trans-diagnostic symptom of psychological disorders. The results of this study might encourage further research on the general prevention and treatment of psychological disorders in women who experience a stressful life event in the ELP of the MC. As mentioned later in the conclusions, through the work of Sundström-Poromaa [81], this study helped to elucidate the role of endocrine transformations of the MC only with central mental processes by introducing emotional effects as a fundamental part of the behavior.

3.2.2 Selective Attention

To assess the effects of the MC, an investigation about its influences on selective attention and its underlying brain functional networks was conducted [26]. The researchers used functional magnetic resonance imaging by applying an experimental paradigm to subjects based on the test go/no-go during the menstrual, follicular, and luteal phases. At the behavioral level, the results indicated a more pronounced functional cerebral asymmetry toward the left hemisphere in selective attention during the menstrual phase with low E2 and P4 levels. Functional imaging, however, did not reveal menstrual phase-related changes in the activation pattern associated with changes in behavioral patterns. The results highlighted a modulatory effect of steroid hormones on networks of lateralized cognitive functions not only due to their effects on interhemispheric inhibition but also due to their effects on the intra-hemispheric functional connectivity.

3.2.3 Visual Attention

Parma et al. [61] and Pilarczyk [63], both using eye-tracking tools, found some significant changes in behavioral functionalities due to specific MC phases. Parma and colleagues [61] observed that women in the first 14 days of the MC engaged in visual attention and spent more time looking at the faces of females than those of males, regardless of whether they took the experimental or control compound, but this intrasexual competition was not found in women in the less fertile period taking the control compound. Pilarczyk and colleagues [63] observed that the proportion of first fixations and the number of fixations were affected by image category and by MC phase. Specifically, they found an increase in visual attention between the ELP and the first days of the MLP. There were significant changes in visual attention between the MC phases in the categories of threat and children. Additionally, only the category of disgust caused a significant difference among the MC phases.

3.2.4 Cognitive Perception of Events and Body Image

According to Gonda and colleagues [42], there is a link between a trait-like bias in the perception of life events and perceived normal symptomatology in the LLP. The results showed that women who are more likely to perceive negative life events are also more likely to judge natural and neutral bodily changes related to the LLP of the MC as negative and stressful. Mulligan et al. [24] also demonstrated that sensitivity to errors is modulated by the tendency toward checking symptoms. Additionally, the differences in checking symptoms across MC phases are associated with phase-related changes in error-related negativity (ERN). The results suggested that ERN measured six to eight days before menses onset significantly predicted checking symptoms, but not when measured six to eight days following menses. Furthermore, the authors demonstrated that in their cohort of women, P4 levels were higher during the LLP than in the LFP.

Kaczmarek and Trambacz-Oleszak [47] investigated body image perception and showed that the tendency of a woman to be unsatisfied with her own body is 2.4 times higher during days 24-28 of the MC compared to that in the EFP among girls with class I obesity (according to the International Obesity Task Force [IOTF] adjusted for Cole's cut-off values). Similarly, Krohmer and colleagues [51] investigated body satisfaction through eye-tracking tools in women looking at their bodies in the mirror. The results showed that during the 10^{th} - 12^{th} days after O and two to four days before

menses, they spent more time looking at the unattractive than the attractive parts of their body, while there was no such difference in O days. According to Hicks et al. [43], women with a natural MC do not significantly differ in overall body satisfaction between the early and the late FP, except for their stomach/abdominal region. Additionally, Morotti et al. [57] found no differences in any of the parameters associated with perceived body image.

3.2.5 Emotional Arousal

After investigating how natural variations in hormonal levels impact the superior consolidation of emotional arousal, Bayer et al. [16] showed that the recollection of negative stimuli tended to be higher in the EFP than in the MLP and the LLP. Accordingly, MC phases did not affect overall recognition accuracy, while there was a variation in recognition quality of negative items. The emotional arousal related to neutral stimuli required less hippocampal activity during the MLP and the LLP than in the EFP. Similarly, Dan et al. [38] examined emotional arousal and found that there is a significant effect during the LFP for which women reported higher arousal when they felt amused rather than when they felt sad compared to men. However, they [38] did not find a similar effect for those women straddling for 1-7 days before the onset of menses compared to men.

3.2.6 Reward and Learning Processes

According to a study by Diekhof et al. [19], women learned to select the better option from a probabilistic feedback learning task regardless of the MC phase. On the other hand, in the vein of the results shown in a previous study by the same authors [18], the consistency of phase-related differences in avoidance learning was demonstrated. The authors found a distinct shift in the sensitivity for reward and punishment between different MC phases. They found an increased reward learning bias in O, which was reversed to a punishment learning bias in the LLP.

The same task was used by Reimers et al. [66], who found a significant interaction between clock type (fast or slow) and MC phases and that for both clock conditions, all women showed greater reaction time changes during the LFP. In the LFP, the enhanced reaction time (in the fast clock condition) was mediated by a preference for "Go learning", while the ability to learn from "NoGo learning", i.e., through punishment, was compromised. A partial preference for avoidance learning is a consequence of a slower initial response in the LFP. In the slow clock condition, women reacted more appropriately solely in the LLP.

Arnoni-Bauer et al. [14] examined the relationship between brain regions associated with reward (amygdala, putamen, and insula) and visual food cues in different MC phases; the amygdala had significantly greater activation in women straddling between the MLP and the LLP than in the LFP women. The activation of the amygdala region, when administering food vs. visual cues, was greater in both the conditions of fasting and feeding for women in the MLP/LLP than in the LFP fasting women. There was also a significant effect of different MC phases in the insula brain region.

According to Bayer et al. [15], in response to the anticipation of gain, the neural activity for the right orbitofrontal cortex was lower during the MLP and the LLP than in the EFP. MC particularly affected the low gain condition. Besides, in response to the anticipation of loss, the neural activity for the left anterior cingulate was lower during the MLP and the LLP than in the EFP. Here, MC affected the high loss condition. E2 or P4 effects occurred from 5 to 11 days before the onset of

menses and modulated different neural processing associated with the anticipation of monetary gains and losses.

3.2.7 Sexual Behavior and Caloric Intake

For sexual behavior, Morotti et al. [57] found similar results in all MC phases. Frank et al. [21] found a significant difference between the LFP and days straddling between the mid and late LP in caloric intake (398 ±178 kcal vs. 536 ±202 kcal), explained by an increase in the intake of calories during breakfast. They also found that the appeal scores of high-calorie pictures from day 8 to day 14 of the MC were significantly less than on the other days of the MC. No significant changes were found in the appeal scores of low-calorie food pictures. Finally, the results revealed significant differences in clitoral volume and clitoral artery, obtained with clitoral ultrasonographic measurements and a Doppler flow evaluation, between the EFP and O and between O and the MLP [57].

3.2.8 Sleep Behavior

Regarding sleep, according to Tada et al. [72], the total sleep time (314.3 ±71.1 to 369.7 ±70.6) and the number of awakenings (8.9 ±5.0 to 12.3 ±5.0) was higher from the O to the EFP than in the LFP. Concerning nocturnal sleep, polysomnography administered by Shechter [70] revealed no significant differences between MC phases for total sleep time, sleep efficiency, rapid eye movement sleep onset latency, stage 1 sleep, stage 2 sleep, slow-wave sleep (stage 3 and 4), non-REM sleep, wake after sleep onset, or movement time. An increase in sleep onset latency was found during the MLP than in the LFP. REM sleep percentage was significantly lower in the MLP than in the LFP but at the circadian phases 0° and 30°. The subjective sleep quality (considered as an eight-hour nocturnal sleep episode) was lower in the MLP than in the LFP.

3.2.9 Muscular System and Body Activation

Different results were found by longitudinal studies regarding muscle sympathetic nerve activity (MSNA) across the EFP and the MLP of the MC [53, 76]. While Lawrence et al. [53] found no alteration of resting MSNA between phases, Usselman et al. [76] reported MSNA to be greater in the MLP than in the EFP (EFP: 466 ±203 and MLP: 714 ±317).

Regarding impulses and reactivity, Meigal et al. [56] measured the impulses of the frequency of motor units and found that they are not affected by any of the considered MC phases (e.g., LFP, O, ELP, and LLP), and that MC, considered as a single factor, does not affect nonlinear parameters of interference electromyogram, measurements taken from the participants' biceps. The results of the study by Casey et al. [17] showed a significantly lower rectus femoris muscle stretch reflex during O than during the EFP.

A few studies investigated changes in muscle strength across the MC [60, 75]. More specifically, Pallavi et al. [60] investigated muscle strength variations among the early and late LP and the whole luteal phase (with no distinctions between its sub-phases). In the LFP, the mean work done was significantly greater than that in the EFP and the luteal phase, as was the dynamic strength-the handgrip strength, whereas the fatigue rate was the highest in the EFP, followed by rates in the luteal phase and the LFP. In the second study, maximal isometric force decreased by 23% from O to

the MLP [75]. Moreover, in absolute time, the MLP had the highest initial tremor than the other MC phases (e.g., early and late FP, O and LLP: no specific days of MC phases were reported), and maximal voluntary contraction in the MLP was significantly lower compared to the LFP, O, and the LLP. Startle magnitude studies showed divergent results [28, 29]. On the one hand, MC phases (e.g., O, days 16-22, and LLP) did not affect the participants' startle modulation when exposed to emotional pictures [29]; on the other hand, startle magnitude was the highest in the LLP, compared to many other MC phases (e.g., EFP, LFP, O, and days 16-22) regardless of the emotional condition [28].

3.2.10 Spinal Excitability

Casey et al. [36] found no significant difference between the EFP and the LLP; hormone levels did not modulate spinal excitability, and the H Reflex (Hmax/Mmax ratio) remained stable across the MC.

3.2.11 Cardiovascular Functions & Stress

Among the studies that measured heart rate (HR) and heart rate variability (HRV) throughout the MC, many of them found few differences between phases, particularly between the follicular and luteal phases [33, 37, 48, 50, 74, 78]. More specifically, the results of a longitudinal study by Choudary et al. [37] with 100 participants showed a higher low-frequency (LF) component and a lower high-frequency (HF) component in days between the middle and the LLP than in the early and the LFP, suggesting a difference in the predominance of the sympathetic nervous activity. Tenan et al. [74] reported a constant increment of HR and breaths per minute from the day of O until menses, with a consequent decrease in HRV. Additionally, rMSSD and SDNN components decreased during the luteal phase more than in the follicular phase [50] and increased in the EFP more than in the LLP [48].

Additionally, even though no significant differences in HRV levels were found from the results of Schmalenberger et al. [4] between the O and the MLP, the P4 hormone was negatively correlated with HRV.

Two studies investigated the relationship between changes in skin conductance rates (SCR) as subjective emotional reactions to pictures and different phases of the MC [67, 68]. Both studies found a significant effect of MC phases on SCR, but while the first study showed higher SCR in the LFP than in the LLP [67], the second one found different results [68]. In contrast to the other two phases, the LLP was related to reduced subjective arousal but higher physiological arousal (SCR). On the other hand, studies by Lee et al. [54] and Petrofsky et al. [62] investigated differences in sweating rates between the LFP and the MLP. In both studies, the sweating rate was higher in the MLP than in the LFP.

Findings from studies considering stressful conditions, such as young female ambulance paramedics shifts [71] and responses to the Trier Social Stress Test [40, 82], showed no significant differences between the LFP and the MLP groups. On the other hand, under sleep deprivation, the sympathetic response was attenuated, and the parasympathetic response was enhanced in the MLP than in the mid-follicular phase (no precise days of MC phases were reported in the article) [44]. In the same study, before the sleep deprivation condition, LF/HF parameter increased in males and MLP women, compared to women in the mid-follicular phase, during two breathing exercises.

Interestingly, the results of a study by Tada et al. [72] showed that LF/HF was initially higher in the whole luteal phase than in the LFP, but that after controlling for diet, physical activity, and sleep, this relationship was lessened.

Regarding blood pressure (BP) values, no significant differences were found between the EFP and LFP, from day 21 till the end of the MC [71], and neither between the LFP and days 19-25 [46].

One cross-sectional [40] and two longitudinal studies [44, 46] examined physiological changes and stress levels across the MC. In a study by Espin et al. [40], LFP women showed a less pronounced salivary alpha-amylase reactivity (as a measure for ANS system) in the Trier Social Stress Test [82] than MLP women and men.

Nevertheless, cortisol awakening response parameters differed across phases (EFP, O, MLP, and LLP) according to Kayacan et al. [48], and stress denial was associated with blood pressure levels regardless of whether the individual was in the LFP or on days 19-25 of the MC [46].

3.2.12 Thermoception

The perception of temperature did not vary across MC phases [34, 55, 59]. Particularly, Cankar et al. [34] found no significant differences in cold perception across phases, while the cold pain threshold was significantly higher for women on days 22-25 of the luteal phase than in the EFP. Furthermore, Matsuda-Nakamura et al. [55] studied women in the LFP and the MLP and found no differences in the thermal sensation of the whole body, thermal pleasantness, and thermal sensation of the hand and toes.

One study investigated proprioception across the MC [41]. While laxity and stability were similar across phases, proprioception was weaker in the MLP than in the O and in the EFP. Moreover, a significant increase in shoulder strength was observed in the same study during O, more than in the other phases.

3.2.13 Nociception and Pain Perception

None of the included studies investigated differences in nociception between two or more MC phases. On the other hand, a few studies found no differences in many objective and subjective pain outcomes between the LFP and the LLP [31, 32, 49, 68], as well as between those phases and O days [30, 67]. Particularly, two types of studies investigated many pain threshold and tolerance values, such as electrodermal and ischemia pain and nociceptive flexion reflex (NFR), with no significant differences but lower electrodermal pain thresholds during the LLP than in the LFP [30, 32]. Moreover, Rhudy and colleagues [68] found that neither emotional modulation of pain nor NFR differed across the MC, whereas weak scores of the two parameters were associated with low E2 and P4 and were correlated with reduced subjective arousal to emotional pictures.

Studies conducted on the EFP, the LFP, and the MLP showed negative correlations between E2 levels and superficial facial pain, deep facial pain, and facial tactile thresholds, whereas high facial deep pain thresholds were correlated with high P4 concentrations [27]. Moreover, Kumar et al. [52] found that pain sensitivity of the participants was the highest on days 7 and 14 of the MC, i.e., during LFP and O, when E2 reaches its peak, compared to the pain sensitivity on days 1 and 21. Pain scores while subjected to an experimental incision were also higher in the MLP than during days between the early and the late FP [64] and in the whole follicular phase of women subjectively evaluating orthodontic pain than in their early and LLP [45].

3.2.14 Interoception

One study investigated the perception of the internal state of the body [43]. The authors investigated how MC phases and variations of hormone levels affected the experience of fluctuations and perception of fluid retention. Feelings of bloating were found to be significantly higher during the EFP than in the LFP.

3.2.15 Olfactory Perception

In a study by Alves et al. [27], the results showed that the bitter threshold was high while the olfactory threshold was low in the LFP. Derntl et al. [39] found that women between the ELP and the LLP outperformed men in olfactory identification, as women between the EFP and O for odor discrimination. Women did not differ from each other, and the MC did not affect odor discrimination. Women who were in the first 14 days of their MC perceived most odors as negative and unpleasant.

3.2.16 Auditory Perception

After assessing auditory perceptions, Carneiro et al. [35] found that the quantitative results of the staggered spondaic word test in the experimental group were significant for the performance of the right ear, which was better for the LFP. On the other hand, no significant differences were found in the percentage of hits for the dichotic digits test, neither for phases nor for sessions. Nene & Pazare [58] found that auditory reaction time was higher in the LLP than in the MLP. Similarly, women during O significantly increased their reaction time compared to women in the LFP and those in the ELP. After assessing voice analysis parameters, Tatar et al. [73] found that the mean jitter, shimmer, and noise-to-harmonic ratio percentage values, were significantly higher in the LLP. According to Sao & Jain [69], gap detection thresholds were better in O than in the EFP for the detection of modulation and the duration of discrimination. Speech perception-in-noise was poorer in the EFP than in O.

3.2.17 Visual Perception

Webb et al. [77] found that O is not associated with visual sensitivity, and women do not experience a mid-cycle peak in contrast sensitivity. The results showed that visual contrast sensitivity does not differ according to sex or variations in hormone levels across the MC. According to Razzak et al. [65], there are differences in vertical visual perception between men and women in the MLP, and women in the LFP have fewer errors compared to those in the MLP.

3.3 Summary

The results did not show substantial evidence of changes through the MC but provided opportunities for future studies to enhance the understanding of this topic. Furthermore, the small samples and the small effect sizes limited the conclusions regarding changes in the ANS and CNS during the MC. Studies on HRV and autonomic activity showed similar results, with a significant change between the follicular and the luteal phases. However, the study by Tada et al. [72] showed how this change can be lessened when controlling for behavioral variables.

Similarly, the field of studies on reward system should be considered as an area of research to be further investigated. As previously suggested, it is important to study this function as a part of a complex network; it is not sufficient to relate it to the endocrine and other biological systems and should also be considered with some other behavioral and autonomic components. An increase in the sample sizes should be considered. Diekhof et al. [19] conducted a study in which they used the probabilistic feedback learning task previously developed by Diekhof and Ratnayake [18]. The task included a learning phase followed by a transfer phase in which participants were able to disentangle the capacity to learn from the positive outcome of their actions. These two elements of learning depend on two neural pathways in the basal ganglia, which promote or hinder action selection depending on the present dopaminergic state. Moreover, E2 and P4 are also involved in the modulation of these pathways. According to the authors [19], they found a significant interaction between the between-subjects component "MC phase" and the within-subject factor "learning preference". This was due to a substantial decrease in the capacity to avoid the choice that often resulted in negative feedback during the follicular phase compared to that in the luteal phase.

Thus, their study represented the first conceptual replication effort in MC research. In the field of cognitive biology, replications are relatively uncommon, yet they are essential to assess the consequences of basic discoveries for social and health-related issues, as well as to provide a strong foundation for research [19].

When these findings were compared to those of Arnoni-Bauer et al. [14], the MC phases were found to vary in brain activity and response to food cues. The authors showed that in women with a regular MC, the brain regions were involved with homeostasis, while the reward system, executive frontal areas, and afferent visual areas were engaged to a greater extent during the luteal phase than during the follicular phase.

In conclusion, it is important to understand the extent to which E2 and P4 affect neuronal transmission in different cognitive networks, which might reflect some behavioral changes during the MC.

The results indicated the need to clarify which monthly changes might be directly or indirectly related to the hormone cycle and better highlight the cognitive, emotional, and autonomic changes across the MC.

4. Discussion

The purpose of this review was to observe the different biological systems that are affected by the experience of the MC in women who do not have symptoms of clinical-organic interest. Our analysis focused on the scientific studies that investigated the effects of the MC on the CNS and ANS and on perceptual alterations, both external and internal (i.e., relating to one's stimuli).

From this literature review, we learned something relevant about different research methods. In the field of psychology, recent studies have developed new research designs. Therefore, investigations through tests and questionnaires are increasingly implemented with physiological measures and functional neuroimaging.

For example, O'Reilly et al. [83] showed that the effects of the fluctuation of sex hormones across the MC should be established at the electrophysiological and behavioral levels. Moreover, the

reporting of several physiological measures is better than reporting the recording of one single measure [84].

Physiological measures are more direct in assessments; however, they are not immune to misinterpretation [85]. Biases may occur during data collection due to tool-or program-related errors, placement of electrodes, and human behavior (e.g., postures, gestures, and speech) during the assessment procedures. However, given the need for more objective measures in psychology and for incorporating the results of studies that have used physiological measures, these study designs are considered to be effective in achieving the aims of this review.

Previous studies have highlighted how the MC offers a model for examining how sex hormones can affect mind-body interactions, as shown in the study by Le et al. [2]. This systematic review was aimed to build on earlier studies by including those that used physiological measurements, which we argue allow us to better describe the relationships between biological and psychological functions.

Earlier studies were primarily concerned with describing and categorizing the phases of the MC. However, we argue that it is not enough to state that different mind-body interactions occurring during menstrual cycles,- specifically the networks among the CNS and ANS,- are only due to hormonal changes. Additionally, we argue that it is not advisable to overlook the subjective qualities of the participants, such as their experienced or perceived life events, as these might be fundamental for understanding the relationship between biological systems and psychological effects.

We did not find a significant difference in functions across different phases of the MC. This might be because not all the studies examined the baseline and altered hormonal levels as part of their applied methodology. The small sample sizes of many of the studies might have also contributed to this outcome (see below). Therefore, a suggestion for future studies to investigate a way for connecting cognitive, emotional, and autonomic changes across the MC is reiterated.

Conversely, within the wide range of studies included in this systematic review, the study by Gonda et al. [42] is important to precisely evaluate the role of individual characteristics in the different perceptions of the intensity of symptoms that characterize the MC.

This provides ideas to develop new methodologies that use the temporal dimension of interactions between biological systems and psychological effects. The MC is a core construct for research based on within-person processes and should be treated as such when examined in other fields, such as clinical psychology, experimental research, and statistical analysis [6]. Therefore, future studies would benefit from designing experiments that determine the relationship between MCs and other biological and psychological functions. A deeper understanding of these interactions could be developed through daily or multi-daily assessments, such as the Ecological Momentary Assessment (EMA).

4.1 Limitations

There are several limitations to consider regarding the studies included in this review. First, the sample size was very small in most cases [4, 6]. Most of the studies [28] were designed without a control group, and those which included a control group used males as the control; thus, the variance among groups could be due to natural differences between women and men.

Some authors studied women who were taking oral contraceptives as the control group; this should be considered as a bias because women on birth control do not ovulate and have specific hormonal variations due to the use of contraceptive medications [6, 14]. Moreover, not all studies used breastfeeding as an exclusion criterion which may be a risk factor for an irregular cycle or amenorrhea. Despite the limitations, these methodologies suggested the generalization of the results to the female population; other methods to select the controls might not be possible.

The use of cross-sectional designs should also be considered as a limit as they prevent the opportunity to assess temporal evidence or a cause-and-effect relationship [6]. Also, most included studies did not report the effect size values. As this has been shown by numerous psychologists and statisticians to be a problem, this aspect should be considered when evaluating the generalizability of the results [86]. However, studies reporting those values did not show large effect sizes. Therefore, future studies on this topic need to be conducted with more participants.

Many of the included studies did not measure hormone levels, which might be an important variable to consider when assessing differences across the MC. Furthermore, not all studies considered hormone fluctuations that may occur due to health status and body weight. In the study by Tenan et al. [74], for example, the minimum weight of participants was 37.6 kg (and 16.2 BMI), and the maximum weight was 104.3 kg (and 36 BMI).

According to the literature, some authors distinguish between an early follicular phase (EFP, corresponding to days 1 to 5 of the MC), or menstruation, and a late follicular phase (LFP, days 6 to 12) [9, 49] and between an early luteal phase and a late luteal phase, or premenstrual period [28, 87]. Using the adaptation of Pitchers & Elliott-Sale's model [9], O occurs on the 13^{th} and 15^{th} day of the MC and, after that, the second half of the cycle is divided into three sub-phases-an early luteal (ELP, days 16 to 19 of the MC), a mid-luteal phase (MLP, days 20 to 23), and a late luteal phase (LLP, days 24 to 28). This model is based on hormone levels across the MC, as previously mentioned.

Besides their study design, many of the studies included in this review evaluated variations of different parameters across phases by taking measurements of only one MC. This might be a limitation, particularly for cross-sectional studies [6]. Moreover, many of those phases were defined as follicular or luteal phases, without regard to the respective sub-phases, which might have significant variations in the hormone levels. Furthermore, many of the included studies did not use ideal procedures for cycle phasing, even though reliable guidelines are available. For that reason, Pitchers and Elliott-Sale's model [9] was useful in this systematic review because it helped to obtain a framework for comparing similar variables within the same phases.

Another limitation was that some studies did not specify the days which defined the phase they were referring to. This meant that comparisons between the results of different studies were not precise. An additional obstacle in the comparison process is related to the different terminologies used for the MC phases, where the same time frames in different studies were reported under different names.

This field of research is new. Furthermore, assimilated a wide range of studies related to the main variable of different MC phases, which might be a limitation due to the identification of many independent variables. A further limitation is associated with the fact that dissimilar measurement tools were used to assess the same variables in different studies. Finally, some variables were rarely assessed, i.e., some of them were present only in a few studies and might therefore appear less significant than they are.

5. Conclusion

Findings regarding the relationship between endocrine variables and many MC phases with autonomic, perceptive, and many cognitive functions were variable and showed conflicting aspects to be considered when treating changes throughout the MC. Some studies, as shown by the review of Sundström-Poromaa [81], elucidated a prominent difficulty in separating the underlying changes between phases. Furthermore, the author showed the importance and the central role of affective changes in women throughout the MC. This statement is in line with some divergent results that emerged for most cognitive, behavioral, and autonomic variables. This also showed the need to conduct studies on the MC to further clarify the role of affective instead of cognitive functions in the differences between phases. No significant results emerged for many perceptual systems. However, many studies found significant associations for some behavioral variables (e.g., sleep, caloric intake, and intrasexual competition) and HRV measurements between cycle phases. Further studies and a deeper understanding of the interactions between affective and cognitive processes in women may be important to improve the measurement tools and treatments for various conditions of distress, such as premenstrual disorders or pain.

Author Contributions

Conceptualization: R.B.; writing—original draft preparation: M.B., M.C.; writing—review and editing: R.B., G.R., M.N., G.B. All authors have read and agreed to the published version of the manuscript.

Competing Interests

The authors have declared that no competing interests exist.

References

1. National Health Service. Periods and fertility in the menstrual cycle [Internet]. Norwich: National Health Service; 2019 [cited date 2021 September 2nd]. Available from: https://www.nhs.uk/conditions/periods/fertility-in-the-menstrual-cycle/.
2. Le J, Thomas N, Gurvich C. Cognition, the menstrual cycle, and premenstrual disorders: A review. Brain Sci. 2020; 10: 198.
3. Eisenlohr-Moul T. Premenstrual disorders: A primer and research agenda for psychologists. Clin Psychol. 2019; 72: 5-17.
4. Schmalenberger KM, Eisenlohr-Moul TA, Jarczok MN, Eckstein M, Schneider E, Brenner IG, et al. Menstrual cycle changes in vagally-mediated heart rate variability are associated with progesterone: Evidence from two within-person studies. J Clin Med. 2020; 9: 617.
5. Toffoletto S, Lanzenberger R, Gingnell M, Sundström-Poromaa I, Comasco E. Emotional and cognitive functional imaging of estrogen and progesterone effects in the female human brain: A systematic review. Psychoneuroendocrinology. 2014; 50: 28-52.
6. Schmalenberger KM, Tauseef HA, Barone JC, Owens SA, Lieberman L, Jarczok MN, et al. How to study the menstrual cycle: Practical tools and recommendations. Psychoneuroendocrinology. 2020; 123: 104895.
7. Thayer JF, Lane RD. A model of neurovisceral integration in emotion regulation and

dysregulation. J Affect Disord. 2000; 61: 201-216.
8. Harrison LA, Kats A, Williams ME, Aziz-Zadeh L. The importance of sensory processing in mental health: A proposed addition to the Research Domain Criteria (RDoC) and suggestions for RDoC 2.0. Front Psychol. 2019; 10: 103.
9. McNulty KL, Elliott-Sale KJ, Dolan E, Swinton PA, Ansdell P, Goodall S, et al. The effects of menstrual cycle phase on exercise performance in eumenorrheic women: A systematic review and meta-analysis. Sports Med. 2020; 50: 1813-1827.
10. Thayer JF, Brosschot JF. Psychosomatics and psychopathology: Looking up and down from the brain. Psychoneuroendocrinology. 2005; 30: 1050-1058.
11. Verkuil B, Brosschot JF, Thayer JF. A sensitive body or a sensitive mind? Associations among somatic sensitization, cognitive sensitization, health worry, and subjective health complaints. J Psychosom Res. 2007; 63: 673-681.
12. Moher D, Liberati A, Tetzlaff J, Douglas GA, The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLoS Med. 2009; 6: e1000097.
13. Siddaway AP, Wood AM, Hedges LV. How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. Annu Rev Psychol. 2019; 70: 747-770.
14. Arnoni-Bauer Y, Bick A, Raz N, Imbar T, Amos S, Agmon O, et al. Is It me or my hormones? Neuroendocrine activation profiles to visual food stimuli across the menstrual cycle. J Clin Endocrinol Metab. 2017; 102: 3406-3414.
15. Bayer J, Bandurski P, Sommer T. Differential modulation of activity related to the anticipation of monetary gains and losses across the menstrual cycle. Eur J Neurosci. 2013; 38: 3519-3526.
16. Bayer J, Schultz H, Gamer M, Sommer T. Menstrual-cycle dependent fluctuations in ovarian hormones affect emotional memory. Neurobiol Learn Mem. 2014 ; 110: 55-63.
17. Casey E, Hameed F, Dhaher YY. The muscle stretch reflex throughout the menstrual cycle. Med Sci Sports Exerc. 2014; 46: 600-609.
18. Diekhof EK, Ratnayake M. Menstrual cycle phase modulates reward sensitivity and performance monitoring in young women: Preliminary fMRI evidence. Neuropsychologia. 2016; 84: 70-80.
19. Diekhof EK, Korf S, Ott F, Schädlich C, Holtfrerich SKC. Avoidance learning across the menstrual cycle: A conceptual replication. Front Endocrinol. 2020; 11: 231.
20. Farrar D, Neill J, Scally A, Tuffnell D, Marshall K. Is objective and accurate cognitive assessment across the menstrual cycle possible? A feasibility study. SAGE Open Med. 2015; 3: 205031211456519.
21. Frank TC, Kim GL, Krzemien A, Van Vugt DA. Effect of menstrual cycle phase on corticolimbic brain activation by visual food cues. Brain Res. 2010; 1363: 81-92.
22. Hidalgo-Lopez E, Pletzer B. Interactive effects of dopamine baseline levels and cycle phase on executive functions: The role of progesterone. Front Neurosci. 2017; 11: 403.
23. Hidalgo-Lopez E, Zimmermann G, Pletzer B. Intra-subject consistency of spontaneous eye blink rate in young women across the menstrual cycle. Sci Rep. 2020; 10: 15666.
24. Mulligan EM, Hajcak G, Klawohn J, Nelson B, Meyer A. Effects of menstrual cycle phase on associations between the error-related negativity and checking symptoms in women. Psychoneuroendocrinology. 2019; 103: 233-240.
25. Soni M, Curran VH, Kamboj SK. Identification of a narrow post-ovulatory window of vulnerability to distressing involuntary memories in healthy women. Neurobiol Learn Mem. 2013; 104: 32-

38.
26. Thimm M, Weis S, Hausmann M, Sturm W. Menstrual cycle effects on selective attention and its underlying cortical networks. Neuroscience. 2014; 258: 307-317.
27. Alves B, Ibuki F, Gonçalves AS, Teixeira MJ, De Siqueira SR. Influence of sexual hormones on neural orofacial perception. Pain Med. 2017; 18: 1549-1556.
28. Armbruster D, Grage T, Kirschbaum C, Strobel A. Processing emotions: Effects of menstrual cycle phase and premenstrual symptoms on the startle reflex, facial EMG and heart rate. Behav Brain Res. 2018; 351: 178-187.
29. Armbruster D, Strobel A, Kirschbaum C, Brocke B. The impact of sex and menstrual cycle on the acoustic startle response. Behav Brain Res. 2014; 274: 326-333.
30. Bartley EJ, Palit S, Kuhn BL, Kerr KL, Terry EL, DelVentura JL, et al. Natural variation in testosterone is associated with hypoalgesia in healthy women. Clin J Pain. 2015; 31: 730-739.
31. Bartley EJ, Rhudy JL. Endogenous inhibition of the nociceptive flexion reflex (NFR) and pain ratings during the menstrual cycle in healthy women. Ann Behav Med. 2012; 43: 343-351.
32. Bartley EJ, Rhudy JL. Comparing pain sensitivity and the nociceptive flexion reflex threshold across the mid-follicular and late-luteal menstrual phases in healthy women. Clin J Pain. 2013; 29: 154-161.
33. Bosenko A, Orlik N, Palshkova I. Dynamics of functional capabilities among 17-22 years old girls with different vegetative status during the ovarian-menstrual cycle. Georgian Med News. 2019; 294: 27-31.
34. Cankar K, Music M, Finderle Z. Cutaneous microvascular response during local cold exposure-the effect of female sex hormones and cold perception. Microvasc Res. 2016; 108: 34-40.
35. Carneiro C, Almeida A, Ribas A, Kluk-De Kort K, Lima D, Araújo A, et al. Hormones and auditory perception: Study of dichotic listening in women during the menstrual cycle. Int Arch Otorhinolaryngol. 2019; 23: 70-76.
36. Casey E, Reese M, Okafor E, Chun D, Gagnon C, Nigl F, et al. Influence of menstrual cycle and oral contraceptive phase on spinal excitability. PM R. 2016; 8: 860-868.
37. Choudhary AK, Alam T, Jiwane R, Kishanrao SS. A comparative analysis of dietary habits on sensory motor association and heart rate variability during menstrual cycle. J Clin Diagnostic Res. 2016; 10: CC04-CC08.
38. Dan R, Canetti L, Keadan T, Segman R, Weinstock M, Bonne O, et al. Sex differences during emotion processing are dependent on the menstrual cycle phase. Psychoneuroendocrinology. 2019; 100: 85-95.
39. Derntl B, Schopf V, Kollndorfer K, Lanzenberger R. Menstrual cycle phase and duration of oral contraception intake affect olfactory perception. Chem Senses. 2013; 38: 67-75.
40. Espin L, Villada C, Hidalgo V, Salvador A. Effects of sex and menstrual cycle phase on cardiac response and alpha- amylase levels in psychosocial stress. Biol Psychol. 2019; 140: 141-148.
41. Shahraki SF, Minoonejad H, Tabrizi YM. Comparison of some intrinsic risk factors of shoulder injury in three phases of menstrual cycle in collegiate female athletes. Phys Ther Sport. 2020; 43: 195-203.
42. Gonda X, Fountoulakis KN, Csukly G, Telek T, Pap D, Rihmer Z, et al. Association of a trait-like bias towards the perception of negative subjective life events with risk of developing premenstrual symptoms. Prog Neuro Psychopharmacol Biol Psychiatry. 2010; 34: 500-505.
43. Hicks CS, McLester CN, Esmat TA, McLester JR. A comparison of body composition across two

phases of the menstrual cycle utilizing dual-energy X-ray absorptiometry, air displacement plethysmography, and bioelectrical impedance analysis. Int J Exerc Sci. 2017; 10: 1235-1249.
44. Huang SC, Wong AM, Ho CW, Weng TP, Cheng SC, Wang JS. Comparison of cardiac autonomic nervous system disturbed by sleep deprivation in sex and menstrual phase. Chin J Physiol. 2015; 58: 114-123.
45. Ileri Z, Baka ZM, Akin M, Apiliogullari S, Basciftci FA. Effect of menstrual cycle on orthodontic pain perception. J Orofac Orthop. 2016; 77: 168-175.
46. James GD, Murnock CG. Denial is associated with higher ambulatory blood pressure across the menstrual cycle. Ann Hum Biol. 2015; 42: 504-506.
47. Kaczmarek M, Trambacz-Oleszak S. The association between menstrual cycle characteristics and perceived body image: A cross-sectional survey of polish female adolescents. J Biosoc Sci. 2016; 48: 374-390.
48. Kayacan Y, Makaracı Y, Ozgocer T, Ucar C, Yıldız S. Cortisol awakening response and heart rate variability in the menstrual cycle of sportswomen. Res Q Exerc Sport. 2021; 92: 760-769.
49. Klatzkin RR, Mechlin B, Girdler SS. Menstrual cycle phase does not influence gender differences in experimental pain sensitivity. Eur J Pain. 2010; 14: 77-82.
50. Kokts-Porietis RL, Minichiello NR, Doyle-Baker PK. The effect of the menstrual cycle on daily measures of heart rate variability in athletic women. J Psychophysiol. 2019; 34: 60-68.
51. Krohmer K, Derntl B, Svaldi J. Hormones matter? Association of the menstrual cycle with selective attention for liked and disliked body parts. Front Psychol. 2019; 10: 851.
52. Kumar M, Narayan J, Verma NS, Saxena I. Variation in response to experimental pain across the menstrual cycle in women compared with one month response in men. Indian J Physiol Pharmacol. 2010; 54: 57-62.
53. Lawrence JE, Klein JC, Carter JR. Menstrual cycle elicits divergent forearm vascular responses to vestibular activation in humans. Auton Neurosci. 2010; 154: 89-93.
54. Lee H, Petrofsky J, Shah N, Awali A, Shah K, Alotaibi M, et al. Higher sweating rate and skin blood flow during the luteal phase of the menstrual cycle. Tohoku J Exp Med. 2014; 234: 117-122.
55. Matsuda-Nakamura M, Yasuhara S, Nagashima K. Effect of menstrual cycle on thermal perception and autonomic thermoregulatory responses during mild cold exposure. J Physiol Sci. 2015; 65: 339-347.
56. Meigal AY, Voronova NV, Yelaeva LE, Kuz'mina GI. Electromyographic characteristics of women in different phases of the menstrual cycle, depending on season and type of autonomic regulation. Hum Physiol. 2014; 40: 97-104.
57. Morotti E, Battaglia B, Persico N, Zampieri M, Busacchi P, Venturoli S, et al. Clitoral changes, sexuality, and body image during the menstrual cycle: A pilot study. J Sex Med. 2013; 10: 1320-1327.
58. Nene AS, Pazare PA. A study of auditory reaction time in different phases of the normal menstrual cycle. Indian J Physiol Pharmacol. 2010; 54: 386-390.
59. Notley SR, Dervis S, Poirier MP, Kenny GP. Menstrual cycle phase does not modulate whole body heat loss during exercise in hot, dry conditions. J Appl Physiol. 2019; 126: 286-293.
60. Pallavi LC, D Souza UJ, Shivaprakash G. Assessment of musculoskeletal strength and levels of fatigue during different phases of menstrual cycle in young adults. J Clin Diagnostic Res. 2017; 11: CC11-CC13.
61. Parma V, Tirindelli R, Bisazza A, Massaccesi S, Castiello U. Subliminally perceived odours

modulate female intrasexual competition: An eye movement study. PLoS One. 2012; 7: e30645.
62. Petrofsky J, Lee H, Khowailed IA. Sudomotor and vasomotor activity during the menstrual cycle with global heating. Clin Physiol Funct Imaging. 2015; 37: 366-371.
63. Pilarczyk J, Schwertner E, Wołoszyn K, Kuniecki M. Phase of the menstrual cycle affects engagement of attention with emotional images. Psychoneuroendocrinology. 2019; 104: 25-32.
64. Pogatzki-Zahn EM, Drescher C, Englbrecht JS, Klein T, Magerl W, Zahn PK. Progesterone relates to enhanced incisional acute pain and pinprick hyperalgesia in the luteal phase of female volunteers. Pain. 2019; 160: 1781-1793.
65. Razzak RA, Bagust J, Docherty S, Hasan Z, Irshad Y, Rabiah A. 'Menstrual phase influences gender differences in visual dependence: A study with a computerised rod and frame test': Corrigendum. J Cogn Psychol. 2015; 27: 80-88.
66. Reimers L, Büchel C, Diekhof EK. How to be patient. The ability to wait for a reward depends on menstrual cycle phase and feedback-related activity. Front Neurosci. 2014; 8: 401.
67. Rhudy JL, Bartley EJ. The effect of the menstrual cycle on affective modulation of pain and nociception in healthy women. Pain. 2010; 149: 365-372.
68. Rhudy JL, Bartley EJ, Palit S, Kerr KL, Kuhn BL, Martin SL, et al. Do sex hormones influence emotional modulation of pain and nociception in healthy women? Biol Psychol. 2013; 94: 534-544.
69. Sao T, Jain C. Effects of hormonal changes in temporal perception, speech perception in noise and auditory working memory in females. Hear Balance Commun. 2016; 14: 94-100.
70. Shechter A. The variation of sleep, hormones, and body temperature across circadian and menstrual phases [dissertation]. Montreal: McGill University; 2013.
71. Suzuki A, Yoshioka K, Ito S, Naito Y. Assessment of stress and autonomic nervous activity in Japanese female ambulance paramedics working 24-hour shifts. J Occup Health Psychol. 2016; 58: 47-55.
72. Tada Y, Yoshizaki T, Tomata Y, Yokoyama Y, Sunami A, Hida A, et al. The impact of menstrual cycle phases on cardiac autonomic nervous system activity: An observational study considering lifestyle (diet, physical activity, and sleep) among female college students. J Nutr Sci Vitaminol. 2017; 63: 249-255.
73. Tatar EC, Sahin M, Demiral D, Bayir O, Saylam G, Ozdek A, et al. Normative values of voice analysis parameters with respect to menstrual cycle in healthy adult turkish women. J Voice. 2016; 30: 322-328.
74. Tenan MS, Brothers RM, Tweedell AJ, Hackney AC, Griffin L. Changes in resting heart rate variability across the menstrual cycle. Psychophysiology. 2014; 51: 996-1004.
75. Tenan MS, Hackney AC, Griffin L. Maximal force and tremor changes across the menstrual cycle. Eur J Appl Physiol. 2016; 116: 153-160.
76. Usselman CW, Gimon TI, Nielson CA, Luchyshyn TA, Coverdale NS, Van Uum SH, et al. Menstrual cycle and sex effects on sympathetic responses to acute chemoreflex stress. Am J Physiol Heart Circ Physiol. 2014; 308: H664-H671.
77. Webb ALM, Hibbard PB, O'Gorman R. Natural variation in female reproductive hormones does not affect contrast sensitivity. Royal Soc Open Sci. 2018; 5: 171566.
78. Yazar Ş, Yazıcı M. Impact of menstrual cycle on cardiac autonomic function assessed by heart rate variability and heart rate recovery. Med Princ Pract. 2016; 25: 374-377.
79. Volkmar FR. Encyclopedia of autism spectrum disorders. New York: Springer New York; 2013.

80. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression: Development of the 10-item edinburgh postnatal depression scale. Br J Psychiatry. 1987; 150: 782-786.
81. Sundström-Poromaa I. The menstrual cycle influences emotion but has limited effect on cognitive function. Vitam Horm. 2018; 107: 349-376.
82. Kirschbaum C, Pirke KM, Hellhammer DH. The "Trier Social Stress Test" a tool for investigating psychobiological stress responses in a laboratory setting. Neuropsychobiology. 1993; 28: 76-81.
83. O'Reilly MA, Cunningham CJ, Lawlor BA, Walsh CD, Rowan MJ. The effect of the menstrual cycle on electrophysiological and behavioral measures of memory and mood. Psychophysiology. 2004; 41: 592-603.
84. Ambach W, Gamer M. Chapter 1, physiological measures in the detection of deception and concealed information. In: Detecting concealed information and deception. Cambridge: Academic Press; 2018. pp.3-33.
85. Worthington Jr EL, Lavelock C, vanOyen Witvliet C, Rye MS, Tsang JA, Toussaint L. Measures of forgiveness: Self-report, physiological, chemical, and behavioral indicators. In: Measures of personality and social psychological constructs. Cambridge: Academic Press; 2015. pp.474-502.
86. Cohen J. Statistical power analysis for the behavioural sciences. 2nd ed. Mahwah: Lawrence Erlbaum Associates; 1988.
87. Ozgocer T, Ucar C, Yildiz S. Cortisol awakening response is blunted and pain perception is increased during menses in cyclic women. Psychoneuroendocrinology. 2017; 77: 158-164.