



Yoga for Psychophysiological Wellbeing during Menstrual Phases in Eumenorrheic Females

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Abstract

Hormonal shifts during the menstrual cycle (MC) cause autonomic imbalances and psycho-physiological distress in eumenorrheic females. This present study reveals that yoga proactively improves the overall psychophysiological health and wellness in eumenorrheic female college students during different phases of MC. Healthy eumenorrheic female college students ($M_{age} = 20.11 \pm 5.39$ years, $n = 82$) were randomized to a control and yoga group ($n = 41$). A well-conceptualized yoga module (CYM) for 5 days/week for 3 months (1 h daily in the morning) was practiced by the yoga group volunteers. Intra and intergroup comparisons were performed for the estimation of mindfulness awareness scale (MAAS), menstrual distress questionnaire (MDQ), cardiometabolic risk factors, heart rate variability (HRV), and endurance fitness during the luteal (LP) and follicular (FP) phases. Psychophysiological discomforts before CYM practice were mostly observed during LP compared to FP due to significant changes in mindfulness, pain, concentration, autonomic reactivity, negative affect, double product (DoP), rate pressure product (RPP), and HRV values. CYM practice influenced HRV parameters for an increase in parasympathetic activity and a decrease in sympathetic balance for better cardiac-autonomic functioning, with significant improvement in maximal oxygen consumption (VO_{2max}) and physical work capacity (PWC_{170}). Accordingly, MAAS and MDQ scores also improved significantly after yogic practice. The intra-group and inter-group significant improvements in psychophysiological parameters through CYM practice are relevant in eumenorrheic females to perform effectively throughout their MC period, by improving MC distress and sympathovagal (LF/HF) balance.

Keywords Eumenorrheic females · Menstrual cycle · Yoga · Heart rate variability · Physical fitness · Psychophysiological well-being

Abbreviations

ANS	Autonomic nervous system
BP	Blood pressure
CG	Control group
CYM	Conceptualized yoga module
DBP	Diastolic blood pressure
DoP	Double product

FP	Follicular phase
FSH	Follicle-stimulating hormone
HF	High frequency
HGS _L	Left-hand grip strength
HGS _r	Right-hand grip strength
HR	Heart rate
HRV	Heart rate variability
LF	Low frequency
LF/HF	Ratio between low and high frequency
LH	Luteinizing hormone
LP	Luteal phase
MAAS	Mindful attention awareness scale
MBP	Mean blood pressure
MC	Menstrual cycle
MDQ	Menstrual distress questionnaire
MeanRR	Mean of the RR peak intervals
pNN50	Percentage of successive RR peak intervals that vary more over by 50s

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PWC	Physical work capacity
RMSSD	Root mean square of successive differences between normal heartbeats
RPP	Rate pressure product
SBP	Systolic blood pressure
SDNN	Standard deviation of all normal RR peak intervals
TP	Total power
VO _{2max}	Maximal oxygen consumption
YG	Yoga group

Introduction

The general psychophysiological health and performance of eumenorrheic females are impacted by the frequent fluctuations in progesterone and estrogen hormonal levels (Prado et al., 2021; Bhuvaneswari et al., 2019). In healthy, eumenorrheic females, the hypothalamic-pituitary-adrenal axis (HPA) regulates the follicular phase (FP) and luteal phase (LP) in response to menstruation, follicular maturation, ovulation, and corpus luteum formation (Reed et al., 2005). The transition from the first day of menstruation to the end of ovulation (14th day) during FP is induced by an increase in estrogen level, follicle-stimulating hormone (FSH), and luteinizing hormone (LH). Estrogen levels in this phase begin low, stabilize during menstruation, steadily increase and peak in the final few days. A mid-cycle LH surge, followed by cessation of ovulation marks the LP beginning and lasts until the initiation of the next menstrual flow (15th -to-28th day) (Reed et al., 2005). Progesterone dominates along with some estrogen in this phase. Lack of bodily activity and mild discomfort (pain, cramps, headaches) due to perimenstrual distress during LP, leads to increased neuroticism (Direkvand et al., 2014) causing a refrain from exercise, and cardiovascular fitness with a higher rate of perceived exertion (RPE) and heart rate (HR) (Barba et al., 2022). Healthy females during the peak reproductive epoch also show musculoskeletal and abdominal pain throughout the different menstrual cycle (MC) stages which may provoke anxiety, fear, and stress, (Martin et al., 2009) inducing an overall feeling of abstaining from endurance performance which can ultimately raise cortisol levels (Graja et al., 2022). This may negatively impact aerobic fitness as measured by physical work capacity (PWC) and maximum oxygen uptake (VO₂ max), the gold standard for assessing adults' cardiorespiratory power (CRP). Therefore, stress might lead to a change in the behavioural response due to an increase in the sympathetic nervous system activation, which alters cardiac autonomic activity and heart rate variability (HRV). The prefrontal cortex mediates the interaction between physiological feedback afferent impulses and cognitive

components to generate affective responses, or sensations of pleasure or displeasure which influences the adoption of exercise for enhancing well-being (Williams et al., 2008). Estrogen prevents cardiovascular distress by regulating blood pressure (BP) and has been shown to positively effect females' autonomic balance (Brar et al., 2015). Further, it possesses an anabolic impact on skeletal muscle (Baltgalvis et al., 2010) due to muscle glycogen storage capabilities (Campbell et al., 2001). Progesterone, on the other hand, has anti-oestrogenic characteristics. The rapid switch-over of hormones during phase transition can dramatically alter a female's hormonal environment, making it difficult to maintain homeostasis. These variations in biological rhythms harm female students' overall academic performance due to poor concentration, attention, alertness and motor abilities promoting physiological discomfort leading to absenteeism with decreased self-efficacy and low-grade reward sensitivity (Bhuvaneswari et al., 2019).

Many Indian women, especially those living in rural regions, are ashamed of their menstruation patterns, symptoms, and flow. This also leads to psychological discomfort and distress, which can negatively impact social interaction, education, endurance capacities, cardiovascular capabilities and career opportunities (Patil et al., 2011). Hormonal medication supplementation to regulate MC discomforts may further cause harmful side effects in females (Chaudhuri et al., 2013; Çaykoyiu et al., 2004). Therefore, non-medical therapeutic intervention like yoga may be accepted, since it is easy to practice and benefit general health with no side effects.

Yoga combines moderate musculoskeletal stretching exercises with mind-concentration and breath-regulation techniques to formulate a psycho-physiological self-wellness practice. Thus, yoga initiates the practice of a greater focus and attention to physical exercises (asanas), breath regulatory practices (pranayama), and meditations (dhyana) for a positive lifestyle (Evans et al., 2009). Meditative breathing and rhythmic breath control during differential postural asanas lower BP and HR, which improves parasympathetic activity by reducing anxiety, insomnia, or depressive symptoms and encourages mental calmness (Ma et al., 2017). Asanas, are recreations of natural motions, which provide a variety of isometric contractions for improving physical activity by stimulating pressure sensors underneath the skin to reduce cortisol (Cahn et al., 2017). Thus, the repetitive yoga practice strengthens muscular flexibility due to the integration of bodily movements (strengthening and stretching postures). The term "mindfulness" refers to a multifaceted notion that may be substantially comprehended by one's ability to focus intently on thoughts, emotions, physical sensations, sights and sounds, which brings equanimity and awareness and are especially useful in learning

to accept sensations for conscious adjustments and mindful changes (Khazan et al., 2013). Regular moderate-intensity exercise, meditation, and breathing cause a controlled surge in endorphins or hormonal variations in uterine epithelial cells that have been shown to reduce the frequency and severity of menstrual discomforts (Shahr et al., 2012) and thus may improve HRV which favourably correlates with positive emotions, self-regulation, and negatively correlates with neuroticism (Brown et al., 2003). Thus, females suffering from MC discomforts may benefit from moderate-intensity strengthening, stretching, breathing, and meditation activities.

HRV is a neurocardiac functional measure, that illustrates the dynamics of the autonomic nervous system (ANS) and heart-brain interactions. The ANS relies on baroreceptors and baroreflexes to regulate HRV and autonomic functions (Mitra et al., 2023). HRV comprises frequency-domain indices i.e., low frequency (LF), high frequency (HF), sympathovagal index (LF/HF), total power (TP) and time-domain indices i.e., the mean of the RR peak intervals (Mean RR), the standard deviation of all normal RR peak intervals (SDNN), the root mean square of successive differences (RMSSD) between normal heartbeats, the percentage of successive RR peak intervals that vary more over by 50s (pNN50). HF indicates parasympathetic or vagal stimulation of the ANS which is correlated with respiratory sinus arrhythmia, whereas, LF, indicates ANS sympathetic activity, and is linked to BP regulation. Stress responses may cause sympathetic activation in the LF peaks. A decline in tonic or phasic HF is closely associated with symptoms of psychopathology. The LF/HF indicates the sympathovagal balance (Mitra et al., 2023).

Conversely, there is disagreement regarding the interpretation of the LF band. Research suggests that LF power may not accurately reflect cardiac sympathetic tone activity. It has been observed, that sympathetic activation lowers the overall HRV indices, including the LF component, while vagal stimulation generates the opposing effects even after adjusting HF or TP values, which therefore aren't correlated with sympathetic neurotransmitter release activity (Rahman et al., 2011; Reyes et al., 2013). Therefore LF power appears to be a measure of baroreflex function rather than cardiac sympathetic tone activity (Goldstein et al., 2011).

However, low LF and high HF variables indicate the suppression of the hypothalamus's posterior, or sympathetic region, which maximizes the body's parasympathetic reactivity against stressful stimuli after yogic interventions (Pal et al., 2014). RMSSD is the strongest indicator of the heart's quick adaptation to sudden changes brought on by both internal and external stimuli whereas pNN50 is a cardiac variability index. The quality of cardiac chronotropic adaptation is measured by pNN50, in conjunction with the

RMSSD test (Shaffer et al., 2017). The degree of adaptation for improved parasympathetic dominance following yoga practice is determined by these measures and is caused by yogic breathing, meditation, relaxation and body position alterations. Yoga further improves the diastolic phase, by increasing the rate pressure product (RPP) through declining HR. Such fluctuations in the duration of diastole are determined by SDNN variables (Vinay et al., 2016). Therefore, the present study shall serve as a model of neurovisceral integration, showing how physiological functions and HRV are associated with cognitive, emotional, and autonomic responses.

To determine the variables affecting HRV, which is thought to be a measure of autonomic control associated with cardiovascular health, an adequate sample of a young, healthy student population aged between 18 and 24 years was examined. The current study was thus designed to assess the efficacy of the conceptualized yoga module (CYM) on psychophysiological fitness during LP and FP in eumenorrheic female college students from Midnapur, West Bengal, India. The current study aimed to evaluate how regular yoga practice, enhances total psychophysiological well-being, through HRV analysis that has been used as a non-invasive benchmark technique to evaluate the autonomic nervous system's control over the sinoatrial node and to understand how better these parameters relate to mindfulness and physiological fitness capabilities.

Materials and Methods

Selection of Participants

PS Power software 3.0.43 was used to calculate the sample size. Accordingly, Power and confidence intervals were set at 80% and 95%. However, 45% more participants were registered, considering the high probability of dropout. By simple randomization, one-hundred-fifty ($n=150$) sedentary female college students (18–24 years) from homogenous socioeconomic origins were selected. Thirty-two participants were eliminated initially due to not meeting the inclusion criteria.

Inclusion criteria: (a) Sedentary female college students (b) Normal MC period (28–32 days) for the past 3 months (c) healthy and diseased free.

Exclusion criteria: a) Self-reported psychological, gynecological, musculoskeletal and cardiological ailments (b) supplementation of daily hormonal medications or nutraceuticals (c) regular practice of yoga, meditation or strength and conditioning programs.

Ethical Consent

This longitudinal experimental trial (Fig-1) follows the Helsinki Declaration guideline (2013) and was approved by the Institutional Ethical Committee (01/IEC-ICMR/RNLKWC/2019; date 7/12/2019). Duly signed informed consent was also received.

Estimation of the MC Phases

A calendar-based self-reported counting method was selected to screen the distinct MC stages. Subjects were also advised to evaluate and record their basal body temperature using a clinical thermometer early in the morning. Ovulation was stated to occur with a temperature increase of 0.4 to

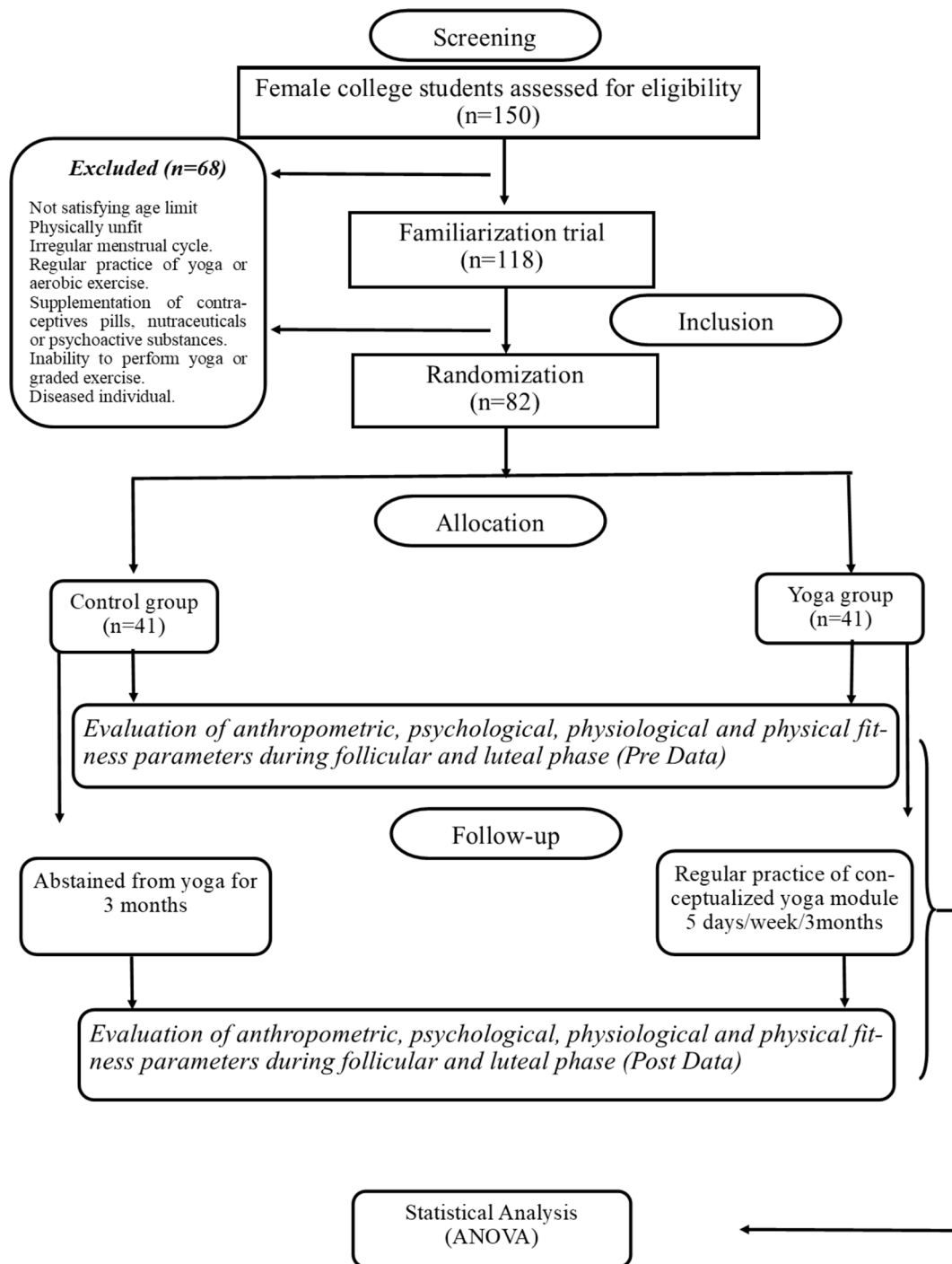


Fig. 1 Experimental Design (CONSORT Flow Diagram)

0.6 °F (Gamberale et al., 1975). As per, Doskin et al. (1979) the different experimental days of LP and FP were selected.

Familiarization Trial

A certified yoga instructor conducted a week-long early morning practice trial (60 min) of the proposed CYM (Table 1), for the recruited participants. Additionally, the participants underwent a trial to adjust with the mechanically braked bicycle-ergometer (Monark-928E bicycle, Sweden). Due to certain discomforts during familiarization, thirty-six ($n = 36$) participants were further eliminated.

Experimental Protocol

Eighty-two ($n = 82$) volunteers were equally allocated randomly into a two-arm ($n = 41$), control group (CG) and yoga group (YG) for pre-post estimation of MC phases. CYM

Table 1 Conceptualized yoga Module

Name of Yoga Practice	Duration
Prayer	2 min
SukshmaVyayamas and SthulaVyayamas	5 min
Griva-Shakti Vikasaka (2 rounds each)	
Anguli Shakti Vikasaka (2 rounds each)	
Kati-Shakti Vikasaka (2 rounds each)	
Sarvangapushhti (2 rounds clockwise, 2 rounds anti-clockwise)	
Surya Namaskara	5 min
12 step SuryaNamaskara (2 rounds each)	
Yoga Asanas (1 min per asana x 2 round)	30 min
Meditative Asanas	
Padmasana, Vajrasana	
Standing Posture Asanas	
Tadasana	
Sitting Posture Asanas	
Yogamudra, Gomukhasana, Paschimottanasana	
Prone Lying Posture Asanas	
Bhujangasana, Dhanurasana, Supta Vajrasana, Sarvangasana	
Supine Lying Posture Asanas	
Supta Pawanmuktasana, Matsyasana, Halasana	
Relaxative Asanas	
Savasana (relaxation with abdominal breathing in supine position, 12 rounds for 2 min)	
Suddhi Kriya	2 min
Kapalabhati (@ 60 strokes per minute)	
Pranayama	8 min
Vibhagiya savasana	
Anulomviloma (6 rounds in 1:2:2, inhalation: retention: exhalation respectively)	
Bhastrika (3 rounds of 7-10 breaths)	
Bhramari (9 rounds)	
Om meditation	8 min
Total Duration	60 min

(Table 1) was practiced early morning (60 min) by the volunteers (5 days/week/ 3 months), whereas, the control group abstained from this practice. Post-data estimation for both groups was assessed after 3 months in accordance with the pre-MC phases. Subjects were assembled in the Human Performance Laboratory for pre-post data collection at 8 AM. They were instructed to settle down to maintain a steady-state HR. Mindful attention awareness scale (MAAS) (Brown et al., 2003) and menstrual distress questionnaire (MDQ) (Moos et al., 1968) were completed by each participant before physiological estimations.

Anthropometric Measurements

Participants with barefoot minimal clothing stood vertically erect on a height cum weight measuring scale (Delmer stadiometer, India) for standing height (cms) and body mass (kg) measurement having the least count of ± 0.5 cm and ± 0.1 kg. Body mass index (BMI) was computed by a standardized equation (Gallagher et al., 2000).

Resting Physiological Parameters

With a portable chest strap (Gamin HRM Pro, 010-12955-01, Taiwan), the resting HR was measured. An aneroid sphygmomanometer (Doctor-R, D1208, Japan) and stethoscope were used to record the systolic (SBP) and diastolic blood pressure (DBP) by an auscultatory method. The following calculations were made for the estimation of pulse pressure (PP) by $SBP - DBP$, mean blood pressure (MBP) by $DBP + 1/3 PP$, double product (DoP) by $MBP \times HR$, and rate pressure product (RPP) by $SP \times HR$ (Pal et al., 2014). The gold standard for cardiac workload is DoP and RPP for myocardial oxygen demand (Gobel et al., 1978). PP, a reliable indicator of perfusion pressure, was used to determine MBP. MBP may be a superior metric to SBP and DBP since it is less affected by damping and more accurate in determining blood flow to vital organs. Damping or dissipation in arterial lines might lead to inaccurate SBP and DBP measurements. DoP might identify potential cardiovascular pitfalls by considering the predictive power of HR, which SBP alone could overlook.

Electrocardiograph (ECG) recording for 10 min at 600 Hz was used to estimate HRV. BIOPAC MP-45 hardware (Biopac, CA, USA) interfaced with BSL pro-software (version 3.7.5) registered the R-R intervals (time between two successive R peaks). Kubios HRV 2.0 version software (Biosignal Analysis and Medical Imaging Group, Kuopio, Finland) was used to remove or edit all the artifacts, and missing peaks and finally estimated the time and frequency domain parameters of the R-R interval for 5 min by Fast-Fourier-transformation (FFT). Time domain metrics include

the mean RR, SDNN, RMSSD, pNN50 and frequency domain metrics like LF, HF, LF/HF, and TP were all calculated. For all the above proceedings participants were laid in the supine position (Mitra et al., 2023). Since the population's spectral power is not normally distributed, using normalized values for LF and HF is the best possible course of procedure that has been adopted in the current study.

Physical Fitness Estimation

Maximum oxygen uptake (VO_{2max}) and physical work capacity (PWC_{170}) tests were done on the Monark 928-E bicycle-ergometer. The electrode sensors on the chest strap of an HR monitor (Garmin HRM Pro, 010-12955-01, Taiwan), fitted in xiphisternum, predicted the HR and transmitted telemetrically the HR value over the Monark G3 display system for recording. Paddling motion was fixed at 60 rpm. min^{-1} . A submaximal incremental workload of 25 watts/2 minutes at 60 rpm. min^{-1} was used to estimate VO_{2max} ($ml\ kg^{-1}\ min^{-1}$). The protocol continued until 80% of the predicted HRmax was reached.

After a gap of 24 h (for the elimination of psychomotor stress, muscular fatigue and pain), PWC_{170} submaximal graded exercise was performed to determine the power output (Watts) at 170 bpm. Workload at 25 W/2 min was successively increased till the attainment of 170 bpm, followed by a cool-down graded protocol.

A handgrip dynamometer (Inco, Ambala) was used to assess the handgrip strength (HGS) by instructing participants to fix their arm at 90° before maximal voluntary contraction. The best of the three readings for both hands was noted down.

In our prior study, sedentary female college students performed the aforementioned standardized exercise protocols for evaluating physical fitness. As a result, these exercise procedures were validated in our lab and are reliable for Indian sedentary college females (Mitra et al., 2024).

Self-Reported Questionnaires

MAAS was used to evaluate the mindfulness of each participant. It consists of 15 attention and awareness assertions of the current situation. Scores ranged from 1 to 6 on a Linkert-type scale, with a total score between 15 and 90. A higher score signifies a greater mindfulness level. The MAAS's Cronbach alpha coefficient has been measured as 0.81 (Brown et al., 2003) and 0.87 (Carlson et al., 2005). Structural equation modeling, confirmatory and exploratory factor analysis proved the MAAS reliability and validity (Carlson et al., 2005). For college students, MAAS is a reliable and trustworthy measurement (Brown et al., 2003).

Pain, concentration, behavioural change, autonomic reaction, water retention, negative affect, arousal, and control are the eight subscales that make up the 46 items of MDQ (Moos et al., 1968). The responses were graded on a 6-point Likert scale, with 1 being the least reaction and 6 being the most severe, with greater scores revealing more severe symptoms. MDQ's internal consistency has been well-established (Moos et al., 1968), and validated among the Indian women population (Chowdhury et al. 1987).

Statistical Analysis

Data analysis was performed by the statistical package, GraphPad Prism (GraphPad Software version 5.00 for Windows, San Diego, California, USA). Univariate analysis of variance (ANOVA) followed by Tukey's post hoc test was conducted, considering, state (baseline vs. post) as a within-subject factor and group (control vs. yoga) as a between-subject factor to examine differences between the two groups. MAAS and MDQ scores were analyzed using Kruskal-Wallis's test followed by Dunn's multiple comparisons tests. The effect size for pairwise comparison was done by Cohen's d (small: 0.2, medium: 0.5, large: 0.8). Level of significance was set at p -value < 0.05 .

Results

The results summarized in Table 2, illustrate that weight (Kg), height (cms) and BMI (Kg/m^2) didn't change significantly when intragroup and intergroup comparisons were made for both the MC phases (LP and FP).

The scores of MAAS, tabulated in Table 3, illustrate, that FP ($d=0.73$) and LP ($d=0.88$) show significant positive changes ($P<0.01$) after CYM practice. When compared to the CG, both the MC post-phase values showed significant changes ($P<0.01$). During the intragroup comparison, LP showed a significant decline in pre-value ($P<0.05$). No significant changes were observed in the CG.

The eight subscale scores of MDQ are presented in Table 4. Pain ($P<0.001$, $d=1.37$), behavioural change ($P<0.05$, $d=0.46$), autonomic reaction ($P<0.05$, $d=0.59$), negative affect ($P<0.01$, $d=0.40$) and the total score ($P<0.001$, $d=0.94$) exemplified a significant improvement in LP after CYM practice by the YG. In addition, both phases also depicted a significant change ($P<0.001$) in concentration scores ($d=1.82$, $d=1.49$). Intergroup comparison scores for pain, concentration, total score ($P<0.01$) and for negative affect, control ($P<0.05$) illustrate significant changes in LP. In contrast, FP showed significant changes ($P<0.001$, $P<0.05$) in concentration and control values when compared to the CG. Further, concentration, autonomic

Table 2 Anthropometric parameters

Anthropometric Parameters	Groups	Menstrual Cycle Phases				Effect size (Cohens d)	
		FP		LP		LP	FP
		Pre	Post	Pre	Post		
Weight (Kg)	CG	60.65 ± 1.25	60.67 ± 1.30	60.67 ± 1.26	60.69 ± 1.31	0.002	0.002
	YG	61.95 ± 1.35	61.26 ± 1.26	61.98 ± 1.35	61.35 ± 1.27	0.14	0.15
Height (cms)	CG	163.2 ± 3.31	-	-	-	-	-
	YG	165.5 ± 4.06	-	-	-	-	-
BMI (Kg/ m ²)	CG	22.8 ± 0.32	22.8 ± 0.37	22.8 ± 0.44	22.8 ± 0.45	-	-
	YG	22.6 ± 0.21	22.4 ± 0.20	22.6 ± 0.23	22.4 ± 0.27	0.17	0.14

Abbreviations: LP, luteal phase; FP, follicular phase; CG, control group; YG, yoga group; BMI, body mass index. Note: Values are expressed as Mean ± SEM

Table 3 Mindful attention awareness scale (MAAS; Brown & Ryan, 2003)

MASS	Groups	Menstrual Cycle Phases				Effect size (Cohens d)	
		FP		LP		FP	LP
		Pre	Post	Pre	Post		
Mindfulness	CG	3.62 ± 0.26	3.59 ± 0.34	3.48 ± 0.39	3.08 ± 0.33	0.15	0.35
	YG	4.06 ± 0.28	4.29 ± 0.41 ^{***††}	3.66 ± 0.24 [#]	4.15 ± 0.37 ^{***††}	0.73	0.88

Abbreviations: LP, luteal phase; FP, follicular phase; CG, control group; YG, yoga group. Note: Values are expressed as Mean ± SEM

^{**} $P < .01$, when compared between pre-post-trial

[#] $P < .05$, when compared between different menstrual phases

^{††} $P < .01$, when compared to control group

Table 4 The menstrual distress questionnaire (MDQ; Moos, 1968)

MDQ	Groups	Menstrual Cycle Phases				Effect size (Cohens d)	
		FP		LP		FP	LP
		Pre	Post	Pre	Post		
Pain	CG	6.5 ± 0.85	6.7 ± 0.90	7.2 ± 0.92	7.9 ± 0.90	0.26	0.50
	YG	6.4 ± 0.22	6.1 ± 0.46	7.9 ± 0.35 ^{##}	6.4 ± 0.45 ^{***††}	0.23	1.37
Concentration	CG	9.9 ± 0.76	10.7 ± 0.79	10.8 ± 0.34	12.0 ± 0.39	0.42	0.80
	YG	9.8 ± 0.59	9.0 ± 0.60 ^{***††}	10.3 ± 0.53 [#]	9.5 ± 0.56 ^{***††}	1.82	1.49
Behavioural change	CG	11.8 ± 0.94	12.2 ± 1.00	11.6 ± 0.92	12.3 ± 0.92	0.29	0.20
	YG	12.5 ± 0.55	11.8 ± 0.67	13.1 ± 0.75	11.1 ± 0.78 [*]	0.14	0.46
Autonomic reaction	CG	4.0 ± 0.18	4.5 ± 0.16	4.4 ± 0.24	4.9 ± 0.11	0.49	0.64
	YG	4.3 ± 0.36	4.1 ± 0.41	4.9 ± 0.44 [#]	3.6 ± 0.45 ^{##}	0.37	0.59
Water retention	CG	5.4 ± 0.58	6.0 ± 0.43	5.7 ± 0.58	6.1 ± 0.33	0.19	0.29
	YG	4.6 ± 0.07	4.1 ± 0.05	5.1 ± 0.16	4.7 ± 0.09	0.44	0.24
Negative affect	CG	10.4 ± 0.18	10.8 ± 0.23	11.6 ± 0.26	12.2 ± 0.32	0.12	0.38
	YG	11.1 ± 0.27	10.6 ± 0.36	12.3 ± 0.42 [#]	9.9 ± 0.49 ^{***††}	0.32	0.40
Arousal	CG	7.0 ± 0.11	7.3 ± 0.09	6.8 ± 0.12	7.7 ± 0.13	0.34	0.15
	YG	6.2 ± 0.05	5.9 ± 0.03	6.6 ± 0.07	6.2 ± 0.06	0.33	0.54
Control	CG	5.9 ± 0.77	6.3 ± 0.71	6.0 ± 0.92	6.7 ± 0.87	0.19	0.23
	YG	4.5 ± 0.16	4.1 ± 0.13 [†]	4.8 ± 0.24	3.6 ± 0.19 ^{††}	0.19	0.34
Total	CG	60.9 ± 6.23	64.5 ± 5.94	64.1 ± 7.31	69.8 ± 7.77	0.39	0.42
	YG	59.4 ± 4.45	55.7 ± 3.89	65 ± 4.67 [#]	55 ± 4.20 ^{***††}	0.50	0.94

Abbreviations: LP, luteal phase; FP, follicular phase; CG, control group; YG, yoga group. Note: Values are expressed as Mean ± SEM

^{*} $P < .05$, ^{**} $P < .01$, and ^{***} $P < .001$, when compared between pre-post-trial

[#] $P < .05$, ^{##} $P < .01$, when compared between different menstrual phases

[†] $P < .05$, ^{††} $P < .01$, when compared to control group

Table 5a Resting physiological parameters (HR and BP)

HR and BP	Groups	Menstrual Cycle Phases				Effect size (Cohens d)	
		FP		LP		FP	LP
		Pre	Post	Pre	Post		
HR (beats/min)	CG	77.90 ± 1.15	78.79 ± 1.19	78.59 ± 1.25	80.56 ± 1.23	0.11	0.24
	YG	78.98 ± 1.28	76.02 ± 1.17	80.05 ± 2.91	75.64 ± 1.73**	0.45	0.69
SBP (mmHg)	CG	115.2 ± 3.46	117.9 ± 3.49	118.9 ± 3.25	121.8 ± 3.37	0.34	0.28
	YG	115.4 ± 3.73	113.5 ± 1.32*†	116.1 ± 1.69	112.9 ± 1.49††	0.29	0.11
DBP (mmHg)	CG	75.00 ± 0.73	77.71 ± 1.34	76.02 ± 1.51	78.22 ± 1.41	0.34	0.39
	YG	77.34 ± 1.39	76.78 ± 1.36	79.10 ± 1.15	76.73 ± 1.48	0.17	0.27
MBP (mmHg)	CG	88.4 ± 3.81	91.10 ± 3.07	90.31 ± 3.07	92.74 ± 2.85	0.13	0.14
	YG	90.02 ± 3.07	89.02 ± 2.8	91.43 ± 3.33	88.78 ± 3.01	0.17	0.19
DoP (mmHg.bpm)	CG	6886.36 ± 250.2	7177.76 ± 269.9	7097.46 ± 252.1	7471.13 ± 249.7	0.15	0.28
	YG	7109.77 ± 232.8	6767.30 ± 158.2*	7318.97 ± 243.4 ^{##}	6715.31 ± 210.6**	0.54	0.40
RPP (mmHg.bpm)	CG	8974.08 ± 257.4	9289.34 ± 200.3	9344.35 ± 304.2	9812.20 ± 277.6	0.34	0.21
	YG	9114.292 ± 311.4	8628.27 ± 223.2†††	9293.80 ± 309.6 ^{##}	8539.75 ± 314.3 ^{***†††}	0.46	0.56

Abbreviations: LP, luteal phase; FP, follicular phase; CG, control group; YG, yoga group; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; MBP, mean blood pressure; DoP, double product; RPP, rate pressure product. Note: Values are expressed as Mean ± SEM

* $P < .05$, ** $P < .01$, when compared between pre-post-trial

^{##} $P < .01$, when compared between different menstrual phases

† $P < .05$, †† $P < .01$, and ††† $P < .001$, when compared to control group

reaction, negative affect, total score and pain were significantly higher ($P < .05$, $P < .01$) in LP, compared to pre-FP. Autonomic reaction, negative affect and control were significantly lower ($P < .05$) in post-LP compared to FP. No significant changes were observed in the CG.

Resting physiological parameters (HR, BP) are tabulated in Table 5a. Results indicate that CYM practice significantly decreases ($P < .01$) the HR ($d = 0.69$), DoP ($d = 0.40$) and RPP ($d = 0.56$) during FP. SBP ($d = 0.29$) and DoP ($d = 0.54$) were significantly lower ($P < .05$) in LP after yoga practice. Intergroup comparison for SBP and RPP depicts a significant decline for FP ($P < .05$, $P < .001$) and LP ($P < .01$, $P < .001$). Intragroup LP post-RPP value also depicted a significant decline ($P < .001$). No significant changes were observed in the CG.

The assessment of HRV parameters in Table 5b, summarizes that HF ($d = 0.63$), LF ($d = 0.62$), LF/HF ($d = 0.68$), Total power ($d = 0.73$), Mean RR ($d = 0.75$), SDNN ($d = 1.07$), RMSSD ($d = 0.67$) and pNN50 ($d = 0.64$) tends to significantly improve ($P < .01$) in LP after CYM practice. Mean RR ($d = 0.74$), RMSSD ($d = 0.33$), pNN50 ($d = 0.41$) significantly improve ($P < .01$) after yogic intervention in FP. Intergroup comparison in LP post values noted a significant change ($P < .05$, $P < .01$, $P < .001$) in LF, LF/HF, Total power, Mean RR, SDNN, RMSSD and pNN50. Mean RR ($P < .01$), RMSSD ($P < .05$) and pNN50 ($P < .01$) also signify an improvement in comparison to the CG during FP. The intragroup comparison also observed significant changes in LP pre-post values. The CG showed no significant changes.

Physical fitness values in Table 6, illustrate a significant improvement in VO_{2max} ($d = 0.55$, $d = 0.37$) and PWC_{170}

($d = 0.42$, $d = 0.40$) during FP ($P < .01$), LP ($P < .05$). Intergroup LP post values also showed significant changes ($P < .01$) for above parameters. Significant changes in the control group were negligible. No significant changes in HGS were observed.

Discussion

This present research study assessed the multiple aspects of psychophysiological flow experiences in yoga practitioners in response to different phases of MC. The current study includes a well-organized CYM for holistic well-being. It consists of a series of yoga postures, breathing maneuvers and meditation practices with definite time periods, which were performed in sequential order by participants. The YG exhibited an overall higher autonomic variability and vagal activity than the non-yoga practitioners and thus resulted better in responding and recovering from menstrual distress.

In this present study, significantly higher scores (i.e., greater distress) in four of the eight MDQ scales (pain, concentration, autonomic reaction, negative affect) were noted during the LP which corroborates with other lines of evidence in eumenorrheic females when compared to FP (Prado et al., 2021). Such undesirable autonomic responses may be frequently triggered by the progesterone-facilitated pathway because of the peak production of allopregnalone ($\sim 7.00 \text{ nmol L}^{-1}$) during LP in comparison to FP (1.50 nmol L^{-1}). This neurosteroid exerts anxiolytic effects in women mostly during LP and mediates the uterine muscles to contract, which causes pain and discomfort. Riley

Table 5b Resting physiological parameters (HRV)

HRV	Groups	Menstrual Cycle Phases				Effect size (Cohens d)	
		FP		LP		FP	LP
		Pre	Post	Pre	Post		
HF (nu)	CG	66.52 ± 1.96	64.81 ± 1.73	71.01 ± 1.63	67.54 ± 1.83	0.14	0.31
	YG	60.66 ± 1.53	63.11 ± 1.62	64.76 ± 1.58	68.84 ± 1.66***	0.39	0.63
LF (nu)	CG	55.04 ± 2.47	57.38 ± 3.01	53.11 ± 1.99	56.72 ± 2.73	0.29	0.35
	YG	51.31 ± 2.42	48.43 ± 2.08	53.49 ± 2.33 ^{##}	43.37 ± 1.86***††	0.26	0.62
LF/HF	CG	0.82 ± 0.03	0.88 ± 0.01	0.74 ± 0.04	0.84 ± 0.05	0.34	0.71
	YG	0.84 ± 0.15	0.76 ± 0.07	0.82 ± 0.03	0.63 ± 0.02***†	0.43	0.68
Total power (ms ²)	CG	4415.5 ± 321.4	4283 ± 339.6	4378.31 ± 387.4	4048.66 ± 324.8	0.16	0.32
	YG	4580.11 ± 323.6	5247.79 ± 363	4186 ± 316.5 ^{##}	6559.02 ± 449.6***†††	0.44	0.73
Mean RR (ms)	CG	907.1 ± 20.57	890.9 ± 37.12	859.1 ± 23.9	888.4 ± 36.90	0.15	0.08
	YG	1004 ± 32.20	1149.6 ± 29.05***††	948.5 ± 21.45	1257.1 ± 24.28***†††	0.74	0.75
SDNN (ms)	CG	73.39 ± 1.75	80.36 ± 2.79	69.33 ± 1.58	75.88 ± 2.07	0.55	0.46
	YG	79.29 ± 2.02	90.31 ± 2.16	73.71 ± 1.68 [#]	97.36 ± 2.97***†	0.62	1.07
RMSSD (ms)	CG	65.69 ± 2.7	62.02 ± 2.41	60.81 ± 3.49	54.60 ± 2.26	0.22	0.22
	YG	67.78 ± 3.55	76.59 ± 3.75*†	61.13 ± 3.67 ^{##}	84.07 ± 3.73***†††	0.33	0.67
pNN50%	CG	31.44 ± 1.65	27.79 ± 1.61	29.45 ± 1.54	26.81 ± 1.56	0.26	0.34
	YG	37.73 ± 1.56	41.41 ± 1.17***††	33.64 ± 1.62	54.27 ± 1.87***†††	0.41	0.64

Abbreviations: LP, luteal phase; FP, follicular phase; CG, control group; YG, yoga group; HF, high-frequency power; HRV, heart rate variability; LF, low-frequency power; LF/HF, ratio of low frequency to high frequency; Mean RR, mean of all R–R intervals; pNN50, percent difference between adjacent NN intervals that are greater than 50 ms; RMSSD, root mean square of successive differences; SDNN, SD of all NN interval; TP, total power; nu, numeric unit; ms, milliseconds. Note: Values are expressed as Mean ± SEM

* $P < .05$, ** $P < .01$, when compared between pre-post-trial

[#] $P < .05$, ^{##} $P < .01$, when compared between different menstrual phases

[†] $P < .05$, ^{††} $P < .01$, and ^{†††} $P < .001$, when compared to control group

Table 6 Physical fitness indices

Physical fitness	Groups	Menstrual Cycle Phases				Effect size (Cohens d)	
		FP		LP		FP	LP
		Pre	Post	Pre	Post		
VO _{2max} (ml. kg ⁻¹ min ⁻¹)	CG	30.14 ± 1.04	30.01 ± 0.92	28.48 ± 0.92	25.75 ± 0.96	0.28	0.15
	YG	28.81 ± 1.07	32.16 ± 0.78**	26.07 ± 0.93	29.90 ± 0.82*†	0.55	0.37
HGS _r (N)	CG	217.44 ± 26.63	218.44 ± 25.42	215.69 ± 31.05	212.92 ± 33.18	0.35	0.26
	YG	214.94 ± 22.93	215.66 ± 20.84	213.33 ± 21.77	215.14 ± 19.30	0.24	0.26
HGS _l (N)	CG	204.67 ± 20.58	203.91 ± 20.03	204.15 ± 24.13	204.82 ± 23.27	0.17	0.12
	YG	207.85 ± 29.10	207.36 ± 28.00	206.44 ± 25.42	208.96 ± 22.66	0.34	0.27
PWC ₁₇₀ (W)	CG	79.76 ± 6.63	78.50 ± 4.48	76.12 ± 4.67	73.23 ± 4.13	0.01	0.01
	YG	81.16 ± 5.97	85.93 ± 5.11**	78.29 ± 7.84	81.04 ± 8.30*†	0.42	0.40

Abbreviations: LP, luteal phase; FP, follicular phase; CG, control group; YG, yoga group; VO_{2max}, maximal oxygen consumption; HGS_l, left-hand grip strength; HGS_r, right-hand grip strength; PWC, physical work capacity. Note: Values are expressed as Mean ± SEM

* $P < .05$, ** $P < .01$, when compared between pre-post-trial

[†] $P < .05$, when compared to control group

et al. (1999) postulated that pain perception is reduced in the FP but contradictorily Martin et al. (2009) concluded, that pain sensibility tends to be higher in the FP than in LP. After CYM practice, scores for pain, behavioural change, autonomic reaction, negative affect and control significantly improved in LP whereas mindfulness and concentration scores showed remarkable significant improvement during both MC phases which are in parallel to the findings of mindfulness-based stress reduction program (Bluth et

al., 2015) for enhancement of better wellbeing. Thus, the current findings suggest that yogic practice helps eumenorrheic female college students to concentrate, focus and regulate their mental processes, emotions, breathing patterns and physical fitness. Yoga poses such as Sukhasana, Bhujangasana, Dhanurasana, Pawanmuktasana, Matsyasana, and Bidalasana help to improve spinal flexibility by stretching the back muscles and alleviate stiffness in the neck, shoulders and pelvis primarily during dysmenorrhea

(Rakhshaei et al., 2011). In addition, the vagus nerve activated by the mindful voluntary twitching of the muscles and limbs during asanas improves autonomic processes (Rani et al., 2013). Therefore, these yogic postures improve blood flow circulation to the pelvic organs, which may help to reduce the discomforts associated with perimenstrual pain. Additionally, it has been marginally demonstrated experimentally (Brinkmann et al., 2020) that mindfulness-based therapy can lessen stress, which is linked to several psychophysiological ailments (nervousness, depression, shoulder and neck pain, with poor cardiovascular functioning). When coping with challenging emotions or physical discomfort, mindfulness practice will help to create space for all the sensations, by viewing each one as only a portion of the entire experience, rather than focusing primarily on negative ones (Khazan et al., 2013). Meditation and slower diaphragmatic breathing may also promote relaxation and tolerance, which energize brainwaves to relieve emotional stress and discomfort. Report suggests that, aerobic, low-intensity strength and conditioning exercises may additionally induce estradiol (the most potent estrogen) to release, possessing antioxidative properties (Kraemer et al., 1995). These above factors improved menstrual distress symptoms mostly in LP as reported in our study after CYM practice.

The current study further displays an increase in HR that causes a substantial drop in RMSSD, SDNN, and TP, confirming a decrease in vagal activity during LP in comparison to FP baseline values which is consistent with a prior study (Tenan et al., 2014). The primary cause for poor vagal balance is due to the elevated levels of progesterone hormone during LP, which provokes and affects several physiological systems to increase BP, HR, DoP and RPP values (White et al., 1996). As stated earlier, in LP progesterone predominates and actively suppresses parasympathetic supremacy by triggering oxidative stress, which reduces estradiol and HRV dominance. Myocardial oxygen consumption is measured by RPP, while cardiac load is measured by DoP (Gobel et al., 1978). After CYM practice, reduced oxygen consumption and load in the myocardium were displayed for both MC phases which may influence a calming effect on the heart and thus contribute to lower HR and BP. This may be due to the mindful repetition of pranayama with slow-alternative breathing practice, which lowers neurocardiogenic sympathetic tonic activity among yogic practitioners. According to research, regular practice of yoga reduces RPP and DoP values due to a substantial drop in HR and BP causing an increased variance in inter-RR intervals for a relaxing impact on the heart (Pal et al., 2014). HR was traditionally believed to be impacted by stress or emotions (Young et al., 2018), but it is now evident from present findings that the intervals between heartbeats indicate the body's ability to regulate both internal and external demands.

Reyes et al. (2013) discussed that moderate physical activity reduces both HF and LF powers when represented in absolute units but increases LF and decreases HF powers in normalized units (nu). Reyes et al. (2013) further investigated the correlation between baroreflex activity and fitness efficiency by comparing the HRV of sedentary and regularly exercised individuals. The exercisers' overall HRV power was evaluated to be higher, contrary to conventional beliefs, which suggest that the exercisers' LF and HF powers would be lower and higher respectively. Similarly, metronome breathing in a supine position was found to lower LF power in subjects by 84% after atropine injection. It has been reported by Pomeranz et al. (1985) that the parasympathetic nervous system activity was involved entirely in controlling the LF power of the subjects at least in the supine position and under the condition of controlled respiration. However, from the analysis of intra-group and inter-group HRV data among yoga volunteers, the current study demonstrated that pranayama and mindfulness meditation may have resulted in a decrease in LFnu and LF/HF and an increase in HFnu, suggesting the execution of parasympathetic dominance throughout. This implies that, among yogic meditators, sympathovagal balance is beneficial for parasympathetic activation mostly during LP. Yoga helps to stabilize LFnu levels which improve blood flow circulation and normalizes the circulatory system for both sympathetic and parasympathetic activities. Since the fact that population's spectral power is not normally distributed, using normalized values is the best possible course of procedure. Majority of previous research showed that exercise tended to decrease rather than increase HRV in the LF band, both for absolute and normalized values (Warren et al., 1997; Mitra et al., 2023; Pal et al., 2014). Normalization of the spectral power components in HRV and the computation of the LF/HF ratio of the autonomic balance relies on the psychophysiological assumption of autonomic reciprocity. A higher ratio of LF/HF implies a mostly sympathetic activity, whereas a lower ratio denotes a predominately parasympathetic activity. This ratio is frequently employed in the evaluation of the sympathovagal balance. Based on the hypothesis that LF, when expressed in nu, is a quantitative indication of sympathetic and vagal activity, researchers also asserted that the LF/HF ratio exclusively indicates either sympathetic modulations or sympathovagal balance (Malik et al., 1996).

Additionally, practicing CYM significantly elevated the time domain markers, such as pNN50, RMSSD in both MC phases, and SDNN in LP only. These changes are believed to be caused by a shift in the autonomic balance (Vinay et al., 2016). SDNN reflects the ability of the heart to function properly and is influenced by the diastolic duration variability. A rise in RMSSD and pNN50 points towards a parasympathetic predominance which are indicative markers for

a prolonged cardiac cycle (McCall et al., 2007) that helps in chronotropic adaptation. Meditative and breathing practices in the present study may also boost naturally occurring antioxidants which consistently raise and improve parasympathetic tone (HFnu) and decrease sympathetic response (LFnu and LF/HF), signifying that sympathovagal balance improves one's attitude, attention, and intention for achieving higher standards of bio-psychophysiological performances (Mitra et al., 2023; Rani et al., 2013). Breathing exercises therefore support the development of an instinctive body control system, which yoga has taught for ages (Khazan et al., 2013). Since HF power is influenced by breathing rate, it is often best to couple it with other time-based domain metrics designed to measure vagal tone to see how much they relate, such as RMSSD, which is assumed to be less affected by respiratory effects. Thus, our findings are strengthened by the significant improvements in the frequency domain and the time domain metrics mostly during LP. Therefore, optimizing autonomic activity is crucial for preserving health and wellness during times of stress or illness (Herbert et al., 2021).

Primarily, the current study resembles proof-of-concept by undergoing real-time estimation of HRV which delivers a fine-tuned scientific evaluation of healthy eumenorrheic females' psychophysiology during cyclical phases. Secondly, the potentiality and capability to visualize the impacts of yoga on cyclical phases show that yoga practice had a significant effect on the HRV response and determines when and how yoga affects HRV more significantly. In our study, after yoga practice self-recorded MASS improved in both MC phases, although participants seem to respond better to its effects on psychophysiology (HRV) when they are in LP, supported by self-recorded MDQ scores. The HRV-mediated activity was improved by CYM intervention which led to a rise in coping strategies and strengthened the cortex in certain brain regions to improve emotional regulation that promoted feelings of wellbeing. Frequent yoga practice improves prefrontal brain function, which may help to repair the inhibitory influences along with benefits in mood and overall well-being (Mitra et al., 2020). Thus, eumenorrheic females reported better overall health status during the LP as compared to FP after CYM practice due to positive regulation of emotions, feelings and physiological responses. Additionally, yogic asanas like Bhujangasana, Dhanurasana, Sarvangasana, Pawanmuktasana, Chakrasana, and Shavasana may revitalize the dormant baroreflex sensitivity and abate stress-excitatory sympathetic hyperactivity, to effectuate the BP and HRV back to normal. In addition, OM-based meditation induces an oscillating sensation in the auditory cortex that transmits via the auricular branch, stimulating vagal centers and shifting the sympathetic towards a parasympathetic tone. The above-mentioned yogic activities

have been previously justified for stress management in Indian female college students (Mitra et al., 2023).

High estrogen is hypothesized to have neurocardiac excitative stimulative actions that decrease inhibition and promote voluntary activation which is conceivable throughout the late follicular and ovulatory phases and persists in part during the mid-luteal phase (Baltgalvis et al., 2010; Campbell et al., 2001). Furthermore, anti-estrogenic progesterone effects could be mitigated by regular practice of yoga which may enhance the production of estradiol for improving overall physical fitness (Kraemer et al., 1995) and cardiorespiratory power in conjugation with HRV and psychological (MDQ and MASS) parameters. Hence, the ANS plays a major role in the efficient functioning of the cardiovascular system which has been shown to influence general well-being and may be a measurable indicator of the balance between sympathetic and parasympathetic tone (Singh et al., 2018). Musculoskeletal activation during the Sun Salutation (Surya Namaskar) stimulates a slow-fast twitch of muscle fibres to increase sub-maximal aerobic power (Mitra et al., 2024). The present CYM consists of various yoga postures that may enhance endurance fitness by strengthening limbs, calf muscles, and quadriceps through the slow-fast twitch of muscle fibres. Yoga increases parasympathetic drive, soothes physiological stress reactions, and stimulates thalamic generators, for better aerobic endurance performance. As per the results of the current study, improvement in work capacity and cardiorespiratory power is profound after CYM practice in both MC phases, but a higher degree of significance during FP was noted. Although, differential studies claim physiological fitness improvements during the early follicular, ovulatory and mid-luteal phases, along with non-significant improvements during MC phases (Bambaeichi et al., 2004; Oosthuyse et al., 2005; Casazza et al., 2002; Davis et al., 2017). Insignificant variations in the HGS were seen in the current investigation throughout various MC stages after following yoga exercise. It's unclear why HGS remained unchanged in this investigation. One possible hypothesis is that numerous variables, such as nutrition availability in the blood, psychological drive, and muscle biochemical levels which might change throughout during hormonal fluctuations can also impact endurance levels differently (Nicolay et al., 2008). It is naive to expect that CYM practice will affect all parameters equally.

The strength of conducting this experimental study includes the real-time evaluation of distress sensations and feelings during the MC, which may be a barrier to regular exercise, owing to sympathetic overactivation. The aforementioned symptoms might have a substantial impact on the quality of life of female college students. Previous biofeedback research has provided compelling evidence regarding the mind's ability to influence ANS function (Khazan et al.,

2009). Hence, the current study may aid female college students who experience MC discomforts by comprehending the biofeedback HRV approach for determining how CYM might assist in modulating these physiological and psychological processes. The present CYM protocol provides a natural, thoughtful, non-pharmacological intervention strategy to enhance psychophysiological stress-free health throughout the MC for better well-being. Previous research (Pal et al., 2014; Mitra et al., 2023) on the studies regarding various aspects of HRV metrics on yoga revealed the impact of autonomic para-sympatho dominance on practitioners, and therefore the current study showed a similar tendency with a different demographic cohort which strongly supports our findings for Indian eumenorrheic female college students.

Limitations

The major limitation of this study is the lack of biochemical estimation for hormone and stress level measurement. Another crucial factor is that the design examining the effect of MC phase on psychophysiological reactions was unblinded with a high drop-out rate. Further, a comparative study between menstruation, follicular maturation, ovulation and corpus luteum formation phases would have better cross-validated and generalized the results. Another limitation of the study is that the MC phase was identified by the participant's self-reports rather than by medical diagnosis. Lastly, the relationship between LF power and reliable markers of sympathetic cardiac activity is still hypothetical and debatable. Individuals with menstrual irregularities were not included in this present study and thus finally, our study's result is only generalizable for the female college students of the current target population. The current study may thus serve as a prototype for a future investigation that may employ a bigger sample size, a longer intervention period (> 3 months), and explore molecular and genetic pathways to fully uncover the potential therapeutic effects of yogic training on stress-related psychophysiological ailments. Yoga exercises and postures, such as those used in this study, may be an effective short-term intervention for reducing the detrimental effects of menstrual stress. Future research on the patterns, depth, and intensity of breath alongside how it synchronizes with movements during yoga practice may also be beneficial, for buffering menstrual discomfort as opposed to the current study's reliance on respiration estimations.

Conclusion

This investigation involved a thorough multidomain assessment of a reasonable sample (healthy eumenorrheic female college students) by standardized methods during different MC follow-up schedules. The CYM intervention rejuvenated psychophysiological homeostasis for regulating, buffering, and minimizing distress by improving mindfulness levels and cardiovascular risk factors during different MC phases. Our findings are encouraged and proved by the significant improvements in the frequency domain and the time domain metrics after CYM practice which reflect real-time estimations of HRV parameters. HRV metrics consistently showed a rise in vagal tone (parasympathetic activation) and decreased sympathetic response. Developing a positive mood and well-being was an essential objective and goal of the present study during different MC phases since the present CYM protocol used a variety of synergistic strategies for achieving better parasympatho dominance. The results of this study may encourage health-promotive initiatives through the progression of regular yoga practice for coping with psychophysiological distress. Lastly, the current study may potentially serve as a source for reference HRV responses for other similar future investigations.

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Author Contributions S.M, M.M conceived and planned the experiment. M.S conceptualized the yoga module. S.M, M.M collected, evaluated and curated the data. S.M drafted the original manuscript and assessed the statistical analysis. S.M, M.S visualized, reviewed and validated the data and manuscript. D.K.N, M.S acted as study's administrator and technical facilitator. D.K.N assisted in overall resource acquisition, supervision and administration. All authors have read and approved the final manuscript.

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Data Availability The data used to support the findings of this study are included in this article.

Declarations

Ethical Approval The ethical approval was approved by the Institutional Ethical Committee (01/IEC-ICMR/RNLKWC/2019; date 7/12/2019).

Consent to Participate Duly signed informed consent was also received from all participants involved in the study.

Use of Artificial Intelligence (AI) AI was used to improve the English language.

Competing Interests The authors declare no competing interests.

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