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Conference Abstract

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The Physiological and Perceptual Effects of the Menstrual Cycle on Performance in Trained Female Cyclists: Preliminary Findings

Megan Smith [1,*], Richard A. Ferguson [1], Laura A. Barrett [1], and Emma O'Donnell [1]

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[1] School of Sport, Exercise and Health Sciences, Loughborough University, LE113TU, UK

Correspondence

Megan Smith

School of Sport, Exercise and Health Sciences, Loughborough University, LE113TU, UK

M.S.Smith@lboro.ac.uk

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1 Introduction

Fluctuations in oestrogen and progesterone across the menstrual cycle (MC) are associated with physiological and perceptual changes that may influence athletic performance (Carmichael et al., 2021; Constantini et al., 2009; de Jonge, 2003; Frankovich & Lebrun, 2000; Lebrun, 1994; Lebrun et al., 2013; McNulty et al., 2020). However, findings remain inconsistent, partly due to methodological limitations such as calendar-based phase classification without hormonal verification, heterogeneous participant training status, and between-subject study designs (McNulty et al., 2020). To address these limitations, this ongoing study will investigate the physiological and perceptual effects of the MC on high intensity cycling performance in competitive female cyclists across three MC phases and over two consecutive cycles. Using both averaged and cycle-to-cycle hormonal and performance analyses, the study will also examine whether different analytical approaches influence the interpretation of findings.

2 Material and Methods

To date, 7 eumenorrheic (MC length ~21-35 days) female cyclists and triathletes (mean age: 26 ± 7 y; body mass: 60.3 ± 9.0 kg; age at menarche: 13.1 ± 0.7 y; mean ± SD), categorised as Tier 2 (McKay et al., 2022) have volunteered for the study. Participants attended the laboratory on eight separate occasions, across three MCs: one monitoring cycle where participants completed a $\dot{V}O_2$max assessment and a familiarisation session, and two

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experimental cycles with exercise trials conducted in the EF, LF, and ML phases. All exercise tests were performed 3 hours fasted and at the same time of day (± 1 h) for each participant, with all cycle testing completed on an electronically braked ergometer (Excalibur Sport, Lode, Groningen, the Netherlands).

Measures included time to exhaustion (TTE), gas exchange threshold (GET), maximal oxygen uptake ($\dot{V}O_2max$), peak work rate (WRpeak), substrate utilisation (carbohydrate oxidation, CHOox; fat oxidation, FATox), blood lactate, heart rate (HR), ratings of perceived exertion (RPE), and MC symptom ratings (Likert scale, 1-7 for perceived bothersomeness). Phases were confirmed using calendar-based methods, urinary luteinising hormone (LH) testing and serum estradiol and progesterone measurements (Schaumberg et al., 2016). Daily self-reported menstrual symptoms were also recorded.

During the monitoring cycle, GET, $\dot{V}O_2max$ and WRpeak were assessed using an incremental ramp test (20 $W \cdot min^{-1}$). For the exercise trial, participants underwent baseline assessments: height, body mass, blood pressure, resting heart rate, and provided a venous blood sample before rating their MC symptoms. The cycling performance protocol started with a 5 min warm-up at a self-selected cadence, followed by three 5 min steady-state exercise bouts at 80%, 100%, and 120% of GET. Expired air was collected during the final 2 min of each bout to determine CHOox and FATox rates. Two min post-exercise, participants completed a 10 min progressive warm-up followed by a 10 min active recovery period, after which participants performed a fixed work rate TTE trial at a work rate equivalent to 80% 'delta' (i.e., 80% of the delta between GET and WRpeak). Breath-by-breath expired air was assessed continuously during TTE (Vyntus CPX, CareFusion, Germany). Post-exercise, participants completed a 15 min active recovery period (20 W and 60 rpm), with capillary blood samples obtained and analysed at 1, 3, 5, 7, 10 and 15 min (Biosen C-Line, EKF Diagnostic GmbH, Germany).

Statistical analyses were conducted in Jamovi using linear mixed-effects models to account for repeated measures within participants across MC phases. Fixed effects included MC phase, with participant included as a random intercept. Where significant main effects were observed, Bonferroni-adjusted pairwise comparisons were performed. Statistical significance was accepted at $p < 0.05$. Data are presented as estimated marginal mean ± standard error.

3 Results

A significant effect of phase was observed for perceived symptom severity, with lower values in LF compared to EF ($p = 0.007$; see Table 1). TTE duration was also significantly longer in LF compared to both EF ($p = 0.006$) and ML ($p = 0.003$). CHOox and FATox, energy expenditure, peak or minimum [BLa], or [BLa] clearance did not differ (all $p > 0.10$).

4 Conclusions

Our preliminary findings suggest that exercise tolerance may be enhanced during the LF, as evidenced by longer TTE and lower perceived symptom severity compared with other phases. Importantly, these differences occurred in the absence of changes in substrate utilisation, energy expenditure, or blood lactate responses, indicating that metabolic factors may not explain the observed performance effects. Although yet to be confirmed, emphasis on subjective menstrual experiences, alongside hormonal fluctuations, may be of importance in shaping exercise capacity in female cyclists across the MC.

Table 1. Physiological, metabolic, and perceptual responses across menstrual cycle phases. Data are presented from 7 participants across two experimental trials (n = 14).

Outcome Measures	EF	LF	ML	p-value	Post hoc
Symptomology Rating (au)	2.6 ± 0.30	1.2 ± 0.31	2.0 ± 0.28	0.007	LF < EF *
Steady-state exercise					
CHO Oxidation (g/min)					
80% GET	0.97 ± 0.13	1.05 ± 0.14	1.05 ± 0.13	0.736	
100% GET	1.04 ± 0.16	1.19 ± 0.17	1.11 ± 0.15	0.590	
120% GET	1.17 ± 0.19	1.26 ± 0.20	1.15 ± 0.18	0.786	
FAT Oxidation (g/min)					
80% GET	0.17 ± 0.04	0.16 ± 0.06	0.21 ± 0.04	0.653	
100% GET	0.25 ± 0.05	0.19 ± 0.05	0.27 ± 0.05	0.305	
120% GET	0.43 ± 0.08	0.17 ± 0.09	0.28 ± 0.07	0.141	
Energy Expenditure (kcal/min)					
80% GET	5.73 ± 0.28	5.98 ± 0.29	5.80 ± 0.27	0.328	
100% GET	6.64 ± 0.33	6.79 ± 0.34	6.53 ± 0.33	0.375	
120% GET	7.37 ± 0.51	7.22 ± 0.52	7.34 ± 0.50	0.827	
Performance trial					
TTE (s)	317 ± 39.5	377 ± 39.7	314 ± 39.3	0.002	LF > EF *; LF > ML*
Peak [BLa] (mmol.L^{-1})	10.0 ± 0.4	10.6 ± 0.4	9.6 ± 0.4	0.144	
Min [BLa] (mmol.L^{-1})	5.4 ± 0.4	5.6 ± 0.4	5.3 ± 0.4	0.616	
[BLa] clearance rate (mmol.L^{-1}min^{-1})	0.4 ± 0.03	0.4 ± 0.03	0.4 ± 0.03	0.146	

Data are presented as estimated marginal means ± standard error derived from linear mixed-effects models. p-values represent the main effect of MC phase. EF = early follicular; LF = late follicular; ML = mid-luteal; GET = gas exchange threshold; CHO = carbohydrate; FAT = fat; BLa = blood lactate; TTE = time to exhaustion. * Indicates significant pairwise difference ($p < 0.05$).

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