medical sciences forum

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Proceeding Paper

The Efects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis †

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† Presented at the 2nd International Electronic Conference on Healthcare, 17 February–3 March 2022. Available online: https://iech2022.sciforum.net/.

Abstract: Concentrations of endogenous sex hormones fluctuate throughout the menstrual cycle, which may affect a woman's athletic performance. Current data are conflicting and there is no consensus as to whether athletic performance is affected by the Menstrual Cycle stage. To investigate the influence of menstrual cycle on women's exercise, and to provide evidence-based and practical suggestions for women's exercise performance. This review followed the preferred reporting items of the Systematic review and Meta-analysis (PRISMA) guidelines. Four databases were searched for published experimental studies of the effects of menstrual cycles on lung ventilation as well as power output, including at least one outcome measure taken over two or more defined menstrual cycle phases. All data were meta-analyzed using a multi-level model based on Bayesian principle. The meta-analysis pooled paired effect sizes to compare lung ventilation in early follicular and mid-luteal stages and performance of motor power output in late follicular and mid-luteal stages. Study quality was assessed using a modified Down's and Black Checklist, and additional questions about menstrual cycle phase confirmation were identified. Data from 10 studies were eligible for inclusion in the meta-analysis. The results showed that the menstrual cycle had no significant effect on women's athletic performance based on the analysis of lung ventilation and power output at different stages of menstruation. Comparison of lung ventilation between early follicular phase and middle luteal phase (ES0.5=-0.49 [95%CRI: -1.17 to 0.19]) and power output between late follicular phase and middle luteal phase (ES0.5=-0.12 [95%CRI: −5.92, 5.68]). The quality of the literature reviewed was classified as "medium". The results of this systematic review and meta-analysis showed that the menstrual cycle s tage had no significant effect on women's athletic performance..

Keywords: Menstrual cycle; Sport performance**;** Meta-Analysis; Eumenorrheic Women

Citation: Yuan, X. The Efects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Me-ta-Analysis. *Med. Sci. Forum* **2022**, *2*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Published: date

1. Introduction

Because of the differences between men and women, it would be biased to apply all the research on men directly to women. There are differences between the sexes in anatomy, physiology and endocrinology. Therefore, targeted studies should be carried out on female athletes[1-3].One of the major obstacles to the significant underrepresentation of women in sports medicine research is the complexity of women's menstrual cycles compared to men's[3-5].Regular fluctuations in ovarian hormone levels, particularly estrogen and progesterone during the normal ovulation cycle, can dramatically alter homeostasis in women aged 13-50[6-7].For a long time, there has been a general debate among scholars about whether a woman's menstrual cycle affects her athletic performance. Several studies have shown that exercise matrix metabolism changes throughout the menstrual cycle[8-10].In the middle luteal phase, lipid metabolism increases. Other investigations have found no difference in matrix metabolism between stages of the menstrual cycle[11-12].Articles on the athletic performance of women with menstrual cycles have been inconsistent, and artificial periods are a common way for elite athletes to cope with competition. For normal exercisers, small differences in exercise ability during the menstrual cycle have little effect on the purpose of exercise, but for elite athletes who aim to excel in competition, any small difference can affect their performance. In the international arena such as Olympic Games, for example, athletes in order to obtain excellent results and refresh the existing records as possible, and stood in the gap between the Olympics athletes are negligible, the nuances of the menstrual cycle phase exist different also may decide the final competition results. For elite athletes, more careful attention should be paid to the stage of the menstrual cycle at which they compete. Therefore, whether the menstrual cycle will affect women's athletic ability is worthy of our in-depth exploration, and give reasonable suggestions.

2. Method

This article was based on the Cochrane guidelines and reported according to the PRISMA guidelines [13-14].

2.1. Information retrieval

This paper searched for randomized controlled trials published in English before May 2020，use“Menstrual”、“ Menstrual Cycles ”、“follicular phase ”、“ early Follicular Phase ”、“ late follicular ”、“ ovulation ”、“ early luteal ”、“ mid-luteal ”、“ late luteal”、“exercise ability ”、“ exercise performance ”、“ exercise efficiency”、“aerobic ability ”、“ aerobic performance ”、“ aerobic capability ”、“aerobic capacity ”、“aerobic sports ability ”、“ oxygen endurance ”、“ vo2max”、“sports performance ”、“ athletic performance ”and“ Strength ”、“ Muscle Strength ”、“ muscular strength ”、“ Muscle Power ”、“ Muscle contractility ”、“ maximal voluntary contraction ”、“ MVC ”、“ nerve-muscle contraction force ”、“ muscular forces ”、“ anaerobic capacity ”、“ endurance power ”、“ endurance capacity”as the key word，Systematic electronic literature search was conducted on PubMed, Web of Science, Medline and other databases to determine all relevant articles. In addition, in order to make the retrieval more comprehensive, the references of the retrieved articles are also reviewed to ensure the comprehensiveness of the included literature. When there are differences in the retrieval of the research, another researcher will participate in resolving them.

2.2. Inclusion and exclusion criteria for the study

The surveyed population, intervention, comparison, outcome and study design (PICOS) were investigated to determine the parameters for conducting the survey. First of all, in order to meet the research conditions, the included articles must be RCT studies, and the inclusion criteria include:

2.2.1. Population

Healthy women between the ages of 18 and 40; She is not pregnant or has any dysfunction related to menstruation; Did not take any hormone drugs known to affect the hypothalamic-pituitary-ovarian axis; Normal menstruation; No injury, no influence on activity level and study status.

2.2.2. Intervention

No specific interventions were investigated, but participants were assured that they were women with regular menstrual cycles, defined as having at least nine cycles per year with a menstrual cycle length between 21 and 35 days.

2.2.3. Comparator

The early follicular stage of the menstrual cycle was used as the "control period", compared with late follicular stage and mid luteal stage. Menstrual cycles were classified as follows: early follicular (days 1 to 5), late follicular (days 6 to 12), ovulation (days 13 to 15), early luteal (days 16 to 19), mid luteal (days 20 to 23), and late luteal (days 24 to 28).

2.2.4. Outcomes

The results are the subjects' performance on motor tests.

2.2.5. Study design

If experimental studies meet the inclusion criteria below, then analysis is considered. Published in peer-reviewed journals; Have a primary or secondary objective to evaluate the overall MC performance; Including intra-group comparisons; Outcome measures are taken in two or more defined monitoring phases. Therefore, case studies, review articles, research protocol documents and conference abstracts were excluded. In addition, articles are searched and reviewed for full text published in Chinese and English or with existing translations. There is no limit to the date of publication.

3. Study selection, data extraction and study quality assessment

3.1. Study selection

Selection of eligible studies is carried out independently by two researchers. When differences arise, a third researcher resolves them.

3.2. Data extraction and management

The data were extracted by one researcher using a specific data extraction table and checked by another researcher, and the differences that arose were resolved through discussion. The following information was extracted from eligible articles: (I) study design, quality, sample size; (ii) Characteristics of participants (age, sex, state of health); (iii) The judgment method of the menstrual cycle stage of the subject; (iv) Outcome measurements (exercise failure time and vo2 Max at different menstrual cycle stages); And (v) research quality index.

When the above information, data are found to be insufficient or unclear in the article, the corresponding author or author will be contacted by email. If the other party did not reply, they sent the email again a week later for practice. If they still did not reply, they were not included in the study

3.3. Quality assessment of included studies

Cochrane's Risk assessment of bias tool was used to evaluate the quality of the included studies.Cochrane's Risk assessment of bias tool was used to evaluate the quality of the included studies[15], The tools include random allocation method, allocation scheme hiding, blind method, result data integrity, selective reporting of research results and other bias, 6 fields, 7 items. Each item was evaluated by "high risk of bias", "low risk of bias" and "uncertain risk of bias". At the same time, the research quality of the literature was divided into three grades, namely, GRADE A (no risk for 4 or more items), grade B (low risk for 2 or 3 items) and grade C (low risk for 1 or no items, possibly offset). Two researchers separately evaluated the quality of the included articles, then checked the evaluation results, and discussed with the third researcher to resolve the differences.

3.4. Data synthesis

Excel is used for data extraction and sorting, Review Manager5.3 software for analysis. Standardized Mean Difference (SMD) and 95% confidence interval (95%CL) were used as effect scales to combine effect sizes for sports performance indicators as continuous variables. According to Cohen, 0.2, 0.5 and 0.8 are used as evaluation criteria for effect size[16]. I2 is used for heterogeneity test in the analysis. When I2=0, it indicates that there is no heterogeneity between studies and Fixed Effects Model can be directly selected. When I2 < 20%, it indicates that there is small heterogeneity among studies and can be ignored. When 20%≤I2 < 50%, the heterogeneity was moderate. When I2≥50%, high heterogeneity is indicated. When heterogeneity appeared in the analysis, Randomized Effects Model was used to summarize the effect size, and subgroup or sensitivity analysis was used to find the source of heterogeneity.

4. Results

4.1. Screening of studies

A total of 6386 articles were retrieved, among which 288 were related to the topic. After reviewing the title and abstract of the article, 92 articles were obtained. Further screening was carried out according to the inclusion criteria, and finally 13 articles were included (Figure 1).

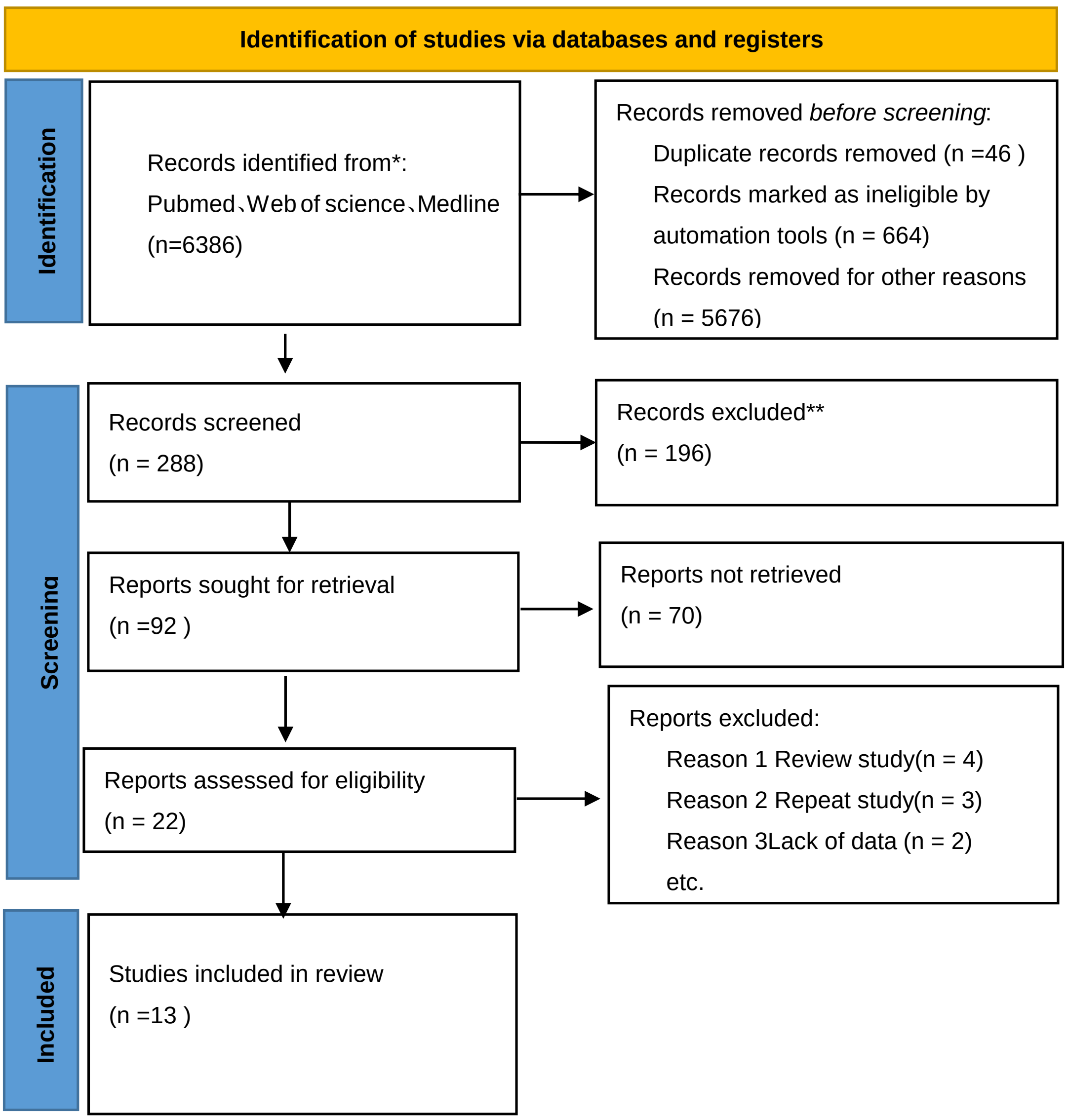

Figure 1. Identification of studies via databases and registers.

4.2. Basic information of the study was included

Study	Aim	Population	MC phases tested	Methods of determining MC phase	Outcome measure(s)	Conclusion
Bandyopadhyay A et al.(2012)	To determine whether MC phase influences endurance capacity and cardiorespiratory responses	Sedentary females (n = 45)	EF, LF and ML	Counting of days and BBT	*Maximum Pulmonar* − 1)	EF stage exercise performance is slightly weaker
Beidleman et al. (1999)	To determine whether MC phase affects maximal and submaximal exercise performance at sea level and acute altitude	Physically active females (n = 8)	EF and ML	MC history, counting of days, urinary ovulation detection test and serum oestrogen and progesterone	Maximum Pulmonary Ventilation (L.min-1)	No differences
Casazza et al. (2002)	To determine whether MC phase affects peak exercise capacity, as measured by O2peak	Healthy, habitually exercised females (n = 6)	LF and ML	MC history, counting of days, urinary ovulation detection test and serum oestrogen and progesterone	Power output (W), Maximum Pulmonary Ventilation (L.min-1)	No differences
de Souza MS	To determine whether MC phase affects the physiological and metabolic responses to maximal and submaximal exercise in eumenorrheic runners	Well-conditioned female athletes (n = 8)	EF and ML	MC history, counting of days, urinary ovulation detection test (one month prior, during and one month post) and serum oestrogen and progesterone	Maximum Pulmonary Ventilation (L.min-1)	No differences
Lebrun *et al.* (1995)	To determine whether MC phase affects four selected induces of athletic performance: aerobic capacity, anaerobic capacity, isokinetic strength and high intensity endurance	Trained female athletes (n = 16)	EF and ML	MC history, ovulatory and menstrual symptoms, BBT and serum oestrogen and progesterone	Maximum Pulmonary Ventilation (L.min-1)	A higher $\dot{V}O_{2max}$ was reported in the EF phase compared to the ML phase
Mattu *et al.* (2019)	To determine whether MC phase affects submaximal and maximal responses to exercise	Active females (n = 15)	LF and ML	MC history and urinary ovulation detection test	peak power output (W)	No differences
Redman LM et al. (2003)	To determine whether MC phase affects the metabolic response to exercise	Sedentary females (n = 14)	LF and.ML	MC history, counting of days, urinary ovulation detection test and serum oestrogen and progesterone	Peak power output (W)	No differences
Stanford KI et al. (2006)	To investigate whether there is a relationship between menstrual cycle phase and exercise-induced bronchoconstriction (EIB) in female athletes with mild atopic asthma	Eumenorrheic subjects with regular 28-day menstrual cycles	EF and ML	MC history and assessment of moliminal symptoms	Maximum Pulmonary Ventilation (L.min-1)	No differences
Vaiksaar S et.al (2011)	To determine whether MC phase affects endurance performance in trained rowers	Competitive female rowers (n = 8)	LF and ML	MC history, counting of days and serum oestrogen and progesterone	maximal power output (W)	No differences

4.3. Results of meta-analysis

4.3.1. Meta-analysis of aerobic capacity at different stages of the menstrual cycle

Meta-analysis included a set of paired effect sizes to compare motor performance during early follicular phase with other menstrual cycles (late follicular phase, mid luteal phase). Seven studies of women's menstrual cycle included pulmonary ventilation in early follicular and mid luteal phases. The seven studies, which included 90 subjects, identified one outlier (one study had an effect size of less than −2 (favorable for mid-luteal period) and was subsequently removed from the analysis. Median set effect size based on three-level hierarchical model (ES0.5=-0.49 [95% CrI: Figure 2) showed that the pulmonary ventilation decreased at the early follicular stage in MC, but it was negligible. Since p>0.05 was not significant in the results, it was considered that there was no significant difference between the pulmonary ventilation at the early follicular stage and the middle luteal stage.

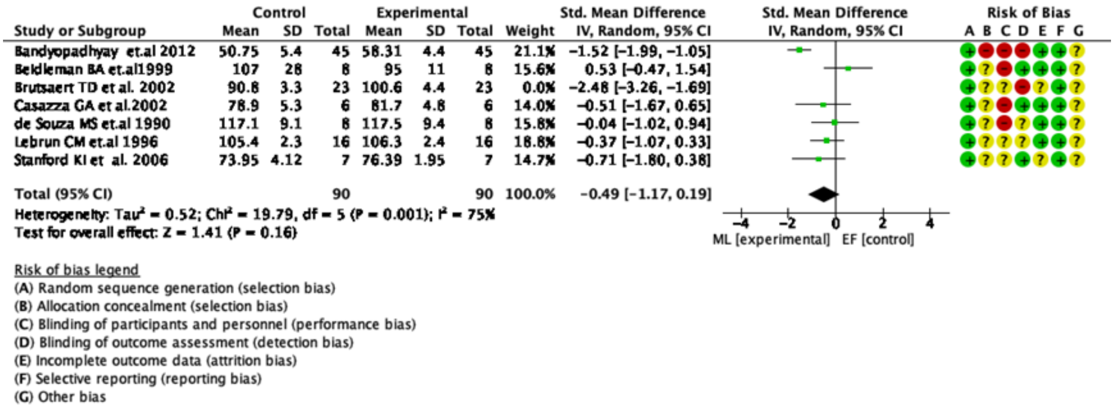

Figure 2. Comparison of early follicular volume with mid-luteal volume.

A multi-level meta-analysis of Bayesian forest plots comparing motor performance measurements at various menstrual cycle stages. Study specific intervals to represent individual effect size estimates and sampling errors. The square represents the set estimate 95% confidence interval (95%CrI) generated in conjunction with Bayesian inference. Compared with the control period, the negative value is favorable for the experimental menstrual cycle. EF: Early Phase ML: Mid-Luteal phase.

Meta-analysis included a set of paired effect sizes to compare motor performance during early follicular phase with other menstrual cycles (late follicular phase, mid luteal phase). Seven studies of women's menstrual cycle included comparisons of power output between early follicular and mid luteal phases. Forty-three subjects were included in the seven studies. There were three outliers in the results, with the absolute value of effect size greater or less than 2, which were removed to obtain the final result (ES0.5=-0.12 [95% CrI: Figure 3). After the removal of outliers, it was found that the total effect size reached the invalid line, P =0.97>0.05, that is, the results were not significant, and there was no significant difference in the output power between the early follicular stage and the middle luteal stage.

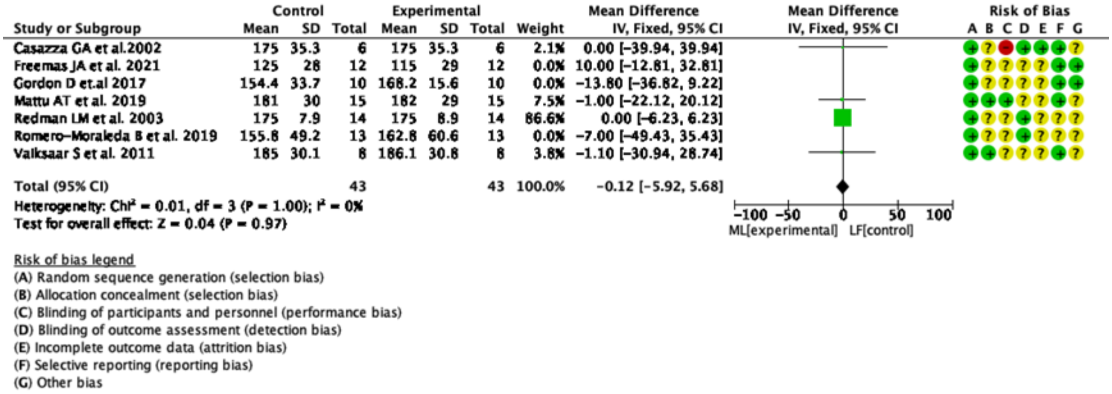

Figure 3. Late follicular power output compared with mid luteal output.

A multi-level meta-analysis of Bayesian forest plots comparing motor performance measurements at various menstrual cycle stages. Study specific intervals to represent individual effect size estimates and sampling errors. The square represents the set estimate 95% confidence interval (95%CrI) generated in conjunction with Bayesian inference. Compared with the control period, the negative value is favorable for the experimental menstrual cycle. LF: Late Follicular ML: Mid-Luteal phase.

5. Discuss

The purpose of the review was to investigate whether a woman's menstrual cycle affects her aerobic exercise performance. To summarize the current experience and evidence for comparison between early follicular, late follicular and mid luteal vo2 Max in women. The results showed that there was no significant difference in aerobic capacity in early follicular stage compared with late follicular stage and mid luteal stage, that is, the menstrual cycle had no significant effect on aerobic capacity.

Female hormones change throughout the menstrual cycle. Estrogen begins to increase late in the follicle and peaks just before ovulation, while both estrogen and progestin rise in mid-luteum. The three phases of the menstrual cycle explored in this review -- early follicular, late follicular and mid luteal -- are characterized by distinct features. Estrogen and progesterone in early follicular stage were both at low levels. Estrogen in late follicular stage is at its peak while progesterone is still at a low level. Estrogen reaches the second peak and progesterone reaches the maximum peak in mid luteal phase.

Studies of large fluctuations in female steroid hormones (e.g., during pregnancy, menopause, and hormone administration) have shown that both estrogen and progestin cause a number of physiological effects, including changes in heat regulation, respiration, and the renal system. These secondary effects of estrogen and progesterone and their interactions may in turn affect athletic performance [17].

Estrogen is also thought to have excited effect, reduce the inhibition and increase voluntary muscle activation, based on the above evidence, we can reasonable to speculate that when estrogen began climbing in the late follicular oviposit period kept a higher level and in the middle of the corpus luteum once again usher in a new peak, hormone levels will to a certain extent, affect the efficiency of muscle, Thus affecting the maximum or submaximum intensity of women's exercise performance in the above stages[8-22]。Some studies suggest that [22-23] estrogen can enhance skeletal muscle to a certain extent. Several determinants of VO2max may be affected by fluctuations in estrogen and progesterone during the menstrual cycle, and the three main physiological factors involved in VO2max are fuel supply, circulation, and respiration. Fuel supply depends on food intake, fuel storage, and fuel mobilization, which in turn may affect lactate blood levels during exercise. Animal studies have shown that progesterone can increase ventilation (VE) through a central role in the hypothalamus, and this respiratory response to progesterone is modulated by estrogen [24]. VE has been shown to be affected by body temperature. Therefore, during the luteal phase of the menstrual cycle, when both progesterone and core temperature are elevated, an increase in VE is expected [25-27].

The concern is that it is unfair to judge performance at a given stage based on the effects of a single hormone on women's athletic performance. The interaction between estrogen and progestin has been a major difficulty in interpreting female menstrual cycle studies. Two women may have the same concentration of estrogen at one point in their menstrual cycle, but progesterone levels may be very different。Therefore, the effects of the same estrogen concentration in an individual may vary due to the interaction with progesterone. To emphasize the importance of interactive effects, some studies have reported not only estrogen and progestin concentrations, but also estrogen/progestin ratios [27]. This ratio may provide information about the opposite effects of estrogen and progestin. In addition, products of estrogen and progestin may reveal synergistic effects of estrogen and progestin. This interaction between estrogen and progestin needs to be considered in menstrual cycle studies, especially in the mid-luteal phase, when both hormones are present in large concentrations.

6. Conclusion

This review reviews past experience and evidence and uses a meta-analysis to reliably assess the impact of women's menstrual cycle on aerobic exercise performance. The data provide new evidence that the menstrual cycle has no significant effect on a woman's aerobic capacity. Therefore, women's participation in physical exercise does not need to be concerned about the menstrual stage to affect exercise behavior.

References

1. Emmonds, S., O. Heyward and B. Jones, The Challenge of Applying and Undertaking Research in Female Sport. Sports Med Open, 2019. 5(1): p. 51.
2. Sheel, A.W., Sex differences in the physiology of exercise: an integrative perspective. Exp Physiol, 2016. 101(2): p. 211-2.
3. Green, D.J., et al., Sex differences in vascular endothelial function and health in humans: impacts of exercise. Exp Physiol, 2016. 101(2): p. 230-42.
4. Bates, G.W., D.E. Garza and M.M. Garza, Clinical manifestations of hormonal changes in the menstrual cycle. Obstet Gynecol Clin North Am, 1990. 17(2): p. 299-310.
5. Fanchenko, N.D., Some aspects of hormonal regulation of the menstrual cycle. A review. Acta Med Hung, 1986. 43(2): p. 83-91.
6. Marsh, S.A. and D.G. Jenkins, Physiological responses to the menstrual cycle: implications for the development of heat illness in female athletes. Sports Med, 2002. 32(10): p. 601-14.
7. Janse, D.J.X., Effects of the menstrual cycle on exercise performance. Sports Med, 2003. 33(11): p. 833-51.
8. Hackney, A.C., Influence of oestrogen on muscle glycogen utilization during exercise. Acta Physiol Scand, 1999. 167(3): p. 273-4.
9. Dombovy, M.L., et al., Exercise performance and ventilatory response in the menstrual cycle. Med Sci Sports Exerc, 1987. 19(2): p. 111-7.
10. Braun, B., et al., Women at altitude: carbohydrate utilization during exercise at 4,300 m. J Appl Physiol (1985), 2000. 88(1): p. 246-56.
11. Nicklas, B.J., A.C. Hackney and R.L. Sharp, The menstrual cycle and exercise: performance, muscle glycogen, and substrate responses. Int J Sports Med, 1989. 10(4): p. 264-9.
12. De Souza, M.J., et al., Effects of menstrual phase and amenorrhea on exercise performance in runners. Med Sci Sports Exerc, 1990. 22(5): p. 575-80.
13. Liberati, A., et al., The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ, 2009. 339: p. b2700.
14. Higgins JPT, Green S, editors. Cochrane handbook for systematic reviews of interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011.
15. Cumpston, M., et al., Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. Cochrane Database Syst Rev, 2019. 10: p. ED000142.
16. 温煦, 效应量:体育科研中不应忽略的统计量. 中国体育科技, 2011. 47(03): 第 142-145 页.
17. Grucza, R., et al., Influence of the menstrual cycle and oral contraceptives on thermoregulatory responses to exercise in young women. Eur J Appl Physiol Occup Physiol, 1993. 67(3): p. 279-85.

18. Isacco L, Boisseau N. Sex hormones and substrate metabolism during endurance exercise. In: Hackney AC, editor. Sex hormones, exercise and women: scientifc and clinical aspects. London: Springer; 2017. p. 35–58.
19. Baltgalvis, K.A., et al., Estrogen regulates estrogen receptors and antioxidant gene expression in mouse skeletal muscle. PLoS One, 2010. 5(4): p. e10164.
20. Lowe, D.A., K.A. Baltgalvis and S.M. Greising, Mechanisms behind estrogen's beneficial effect on muscle strength in females. Exerc Sport Sci Rev, 2010. 38(2): p. 61-7.
21. Sarwar, R., B.B. Niclos and O.M. Rutherford, Changes in muscle strength, relaxation rate and fatiguability during the human menstrual cycle. J Physiol, 1996. 493 (Pt 1): p. 267-72.
22. Phillips, S.K., et al., Changes in maximal voluntary force of human adductor pollicis muscle during the menstrual cycle. J Physiol, 1996. 496 (Pt 2): p. 551-7.
23. Bayliss, D.A. and D.E. Millhorn, Central neural mechanisms of progesterone action: application to the respiratory system. J Appl Physiol (1985), 1992. 73(2): p. 393-404.
24. Dempsey, J.A., et al., Pulmonary adaptation to exercise: effects of exercise type and duration, chronic hypoxia and physical training. Ann N Y Acad Sci, 1977. 301: p. 243-61.
25. MacDougall, J.D., et al., Effects of metabolic hyperthermia on performance during heavy prolonged exercise. J Appl Physiol, 1974. 36(5): p. 538-44.
26. White, M.D. and M. Cabanac, Exercise hyperpnea and hyperthermia in humans. J Appl Physiol (1985), 1996. 81(3): p. 1249-54.
27. Bunt, J.C., Metabolic actions of estradiol: significance for acute and chronic exercise responses. Med Sci Sports Exerc, 1990. 22(3): p. 286-90.