

LEVEL 6 ASSESSMENT SPECIFICATION

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Programme:	BSc. Sport and Exercise Therapy		
Module:	Exercise and Specific Populations		
Module code:	SHSS6061	Contribution to Overall Module Assessment (%):	50
Lecturer:	David Gardner	Internal Verifier:	
Assignment Title:	Systematic Review	Word count (or equivalent):	2500
Submission deadline:	25 th March 2022	Return date of provisional marks & written feedback:	22 nd April 2022
Submission method:	Submit the systematic review through turnitin. (Only submit the student feedback form associated with this research task. DO NOT put the entire assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

1. Identify and integrate current legislation and guidance when working with people from specific populations or needs.
2. Conduct and evaluate information collected from appropriate assessments in order to identify the specific needs of individuals.
3. Plan, manage and critically review the impact of exercise programmes for people with particular needs.

TASK DESCRIPTION

Systematic Review (2500 words)

Conduct a systematic review to develop a consensus recommendations on the role of exercise related to a specific clinical population group of your choice.

Tasks

1. Develop a specific a well-defined research question.
2. Critically review a minimum of 25 general and 8 key studies that will inform the review (***If you cannot find sufficient studies then choose another research topic***).
3. Complete a systematic review for submission to the Journal of Sport Sciences, using the PRISMA format.
 - Abstract (150 words)
 - Introduction (700 words)
 - Methods (350 words)
 - Results (550 words)
 - Discussion (650 words)
 - Conclusions (100 words)
 - References (25-35) - see the University reference guide for required format.

Generic guidance for completing the assignment is described below.

*Further support relating to the collection, analysis and presentation format of data is available on the Exercise and Specific Populations Moodle page (**Assignment support**). You are also advised to seek individual tutorials for specific queries or help regarding your personal research topic.*

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS

NOTE: The guidance offered below is linked to the five generic assessment criteria overleaf.

1. Engagement with Literature Skills

Your work must be informed and supported by scholarly material that is *relevant* to and *focused* on the task(s) set; you should make use of scholarly reviews and primary sources, where appropriate (for example, refereed research articles and/or original materials appropriate to the discipline). You should provide evidence that you have accessed a wide *range* of sources, which may be academic, governmental and industrial; these sources may include academic journal articles, textbooks, current news articles, organisational documents, and websites. You should consider the *credibility* of your sources; academic journals are normally highly credible sources while websites require careful consideration/selection and should be used sparingly. Any sources you use should be current and up-to-date, mostly published within the last five years or so, though seminal/important works in the field may be older. You must provide *evidence* of your research/own reading throughout your work, using a suitable referencing system, including in-text citations in the main body of your work and a reference list at the end of your work.

Guidance specific to this assessment:

You must ensure that you reference UK dietary guidelines and Dietary Reference Values.

2. Knowledge and Understanding Skills

At level 6, you should be able to demonstrate coherent and detailed knowledge and a systematic understanding of the subject area, at least some of which is informed by the latest research and/or advanced scholarship within the discipline. You should be aware of the uncertainty, ambiguity and limits of knowledge. Your work must demonstrate the growing extent of your knowledge and systematic understanding of concepts and underlying principles associated with the subject area. *Knowledge* relates to the facts, information and skills you have acquired through your learning. You demonstrate your *understanding* by interpreting the meaning of the facts and information (knowledge). This means that you need to select and include in your work the concepts, techniques, models, theories, etc. appropriate to the task(s) set. You should be able to explain the theories, concepts, etc. meaningfully to show your understanding. Your mark/grade will also depend upon the *extent* to which you demonstrate your knowledge and understanding; ideally each should be complete and detailed, with comprehensive coverage.

Guidance specific to this assessment:

3. Cognitive and Intellectual Skills

You should be able to: critically evaluate evidence, arguments, assumptions, abstract concepts and data some of which are at the forefront of a discipline (and that may be incomplete) to devise and sustain arguments, to make judgements and/or solve problems; describe and comment upon particular aspects of current research, or equivalent advanced scholarship, in the discipline. Your work must contain evidence of logical, analytical thinking, evaluation and synthesis. For example, to examine and break information down into parts, make inferences, compile, compare and contrast information. This means not just describing what! But also justifying: Why? How? When? Who? Where? At what cost? At all times, you must provide justification for your arguments and judgements. Evidence that you have reflected upon the ideas of others within the subject area is crucial to you providing a reasoned and informed debate within your work. Furthermore, you should provide evidence that you are able to make sound judgements and convincing arguments using data and concepts. Sound, valid conclusions are necessary and must be derived from the content of your work. Where relevant, alternative solutions and recommendations may be proposed.

Guidance specific to this assessment:

4. Practical Skills

At level 6, you should be able to apply the methods and techniques that you have learned to review, consolidate, extend and apply your knowledge and understanding, and to initiate and carry out projects. You will deploy accurately established techniques of analysis and enquiry relevant to the discipline, and apply them in complex and unpredictable contexts, to devise and sustain arguments and/or to solve problems. You should be able to frame appropriate questions to achieve a solution - or identify a range of solutions. You should be able to demonstrate how the subject-related concepts and ideas relate to real world situations and/or a particular context. How do they work in practice? You will deploy models, methods, techniques, and/or theories, in that context or circumstances, to assess current situations, perhaps to formulate plans or solutions to solve problems, or to create artefacts, some of which may be innovative and creative. This is likely to involve, for instance, the use of real world artefacts, examples and cases, the application of a model within an organisation and/or benchmarking one theory or organisation against others based on stated criteria. You should show awareness of the limitations of concepts and theories when applied in particular contexts.

Guidance specific to this assessment:

5. Transferable Skills for Life and Professional Practice

Your work must provide evidence of the qualities and transferable skills necessary for graduate-level employment requiring the exercise of initiative and personal responsibility and decision-making in complex and unpredictable circumstances. This includes demonstrating: the learning ability for professional development to advance existing skills and acquire new competences of a professional nature that will enable you to assume significant responsibility within organisations; that you can initiate and complete tasks and procedures, whether individually and/or collaboratively; that you can use appropriate media to effectively communicate information, arguments and analysis in a variety of forms to specialist and non-specialist audiences; fluency of expression; clarity and effectiveness in presentation and organisation. Work should be coherent and well-structured in presentation and organisation.

Further support relating to the collection, analysis and presentation format of data is available on the Kinesiology Moodle page (**Assignment support**). You are also advised to seek an individual tutorial for specific queries or help regarding your personal research topic.

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	30	
Quality of research studies and data bases used. Scope of research		
2. Knowledge and Understanding Skills	20	
Depth of theoretical understanding of the condition, populations etc. Consideration of limitations and contraindications for exercise and the participant. Explanation of mediating factors such as medication & lifestyle etc.		
3. Cognitive and Intellectual Skills	40	
The structure and format of the systematic review. PRISMA, Bias evaluations Writing style Critical analysis Correct information and presentation in each section		
4. Practical Application Skills	0	
5. Transferable Skills for Life and Professional Practice	10	
Identification of a position statement or summative findings based on evidence previously identified in the review.		

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

A Systematic Review: The Effects of Menstrual Cycle Phases on Exercise Performance

EXERCISE & SPECIFIC POPULATIONS (SHSS6061)
EIRA SIAN WILLIAMS (1906134)

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Abstract (150)

Background - Female sport has grown considerably in recent years, but males have been the subjects of much sports science research, with the findings being inappropriately applied to female athletes. Most females train throughout their reproductive years when they are exposed to continuously changing hormone profiles due to the menstrual cycle. As a result, it's critical to consider how female hormones may influence performance levels throughout the different phases of the menstrual cycle.

Objective - To systematically review the current body of research investigating the effects on exercise performance during different phases of the menstrual cycle in Eumenorrheic women.

Method - A literature search was conducted in UWTSD online library, SPORTDiscus and Google Scholar using search terms related to the menstrual cycle and exercise performance measures. 26 studies met the criteria for inclusion and 10 were evaluated.

Results – A total of 3634 articles were found, 10 matched the criteria and were included in this systematic review. Five studies found a significant difference in exercise performance over the natural menstrual cycle, while Five studies showed no changes. One study found changes in performance but no difference throughout each menstrual phase.

Conclusion - The reviewed articles reported conflicting findings and were often limited by small participant numbers and methodological issues but do appear to suggest female hormones may affect exercise performance responses. The findings of this review highlight the need for further experimental studies on the effects of the menstrual cycle responses to exercise performance.

Keywords - Menstruation, exercise performance, systematic review.

Introduction (700)

The majority of research in the field of sport science uses male participants, possibly due to the consistency of their physiology, but these findings may not be relevant to female athletes (Carmichael *et al.*, 2021).

From the ages of around 13, when a girl reaches puberty, up until around 50- perimenopausal, women receive their menstrual cycle lasting on average 23-38 days (Oosthuyse and Bosch, 2010). It is well-known that the female hormones oestrogen and progesterone fluctuate throughout the menstrual cycle. These fluctuations in hormones primarily function to support reproduction but may influence changes in the physiological systems such as respiratory, cardiovascular, thermo-regulatory and muscular (Rael *et al.*, 2021). This potentially leads to implications for exercise performance.

Menstrual Cycle Physiology

Eumenorrheic can be defined as the regular menstruation that lasts between 23-38 days (Carmichael *et al.*, 2021) and continues regularly until perimenopause or is interrupted by pregnancy, contraception or ovulatory dysfunction. The hormones oestrogen and progesterone fluctuate throughout different phases of the menstrual cycle. These are divided into two phases - the follicular phase and the luteal phase – both phases separated by ovulation (Thompson *et al.*, 2020). Menstruation, or the early follicular phase begins on day 1 of menstrual bleeding, lasting up to day 14 and where hormone levels remain low and stable (Maki, Rich and Shayna Rosenbaum, 2002). The late follicular phase which occurs just before ovulation, can be characterised by high oestrogen and low progesterone. The luteal phase extends from day 14 to 28 where levels of both oestrogen and progesterone are high (Thompson *et al.*, 2020). However, due to the use of contraceptives many females of reproductive age do not experience these fluctuations as the production of these hormones are suppressed. Menstrual bleeding, which occurs towards the end of the luteal and the start of the follicular phase is an external indication of menstrual cycles (Mihm, M Gangooly, s Muttukrishna, 2010). This occurs over 3–6 days commonly with the heaviest flow on Day 2, and with an average blood loss of 33.2 ml.

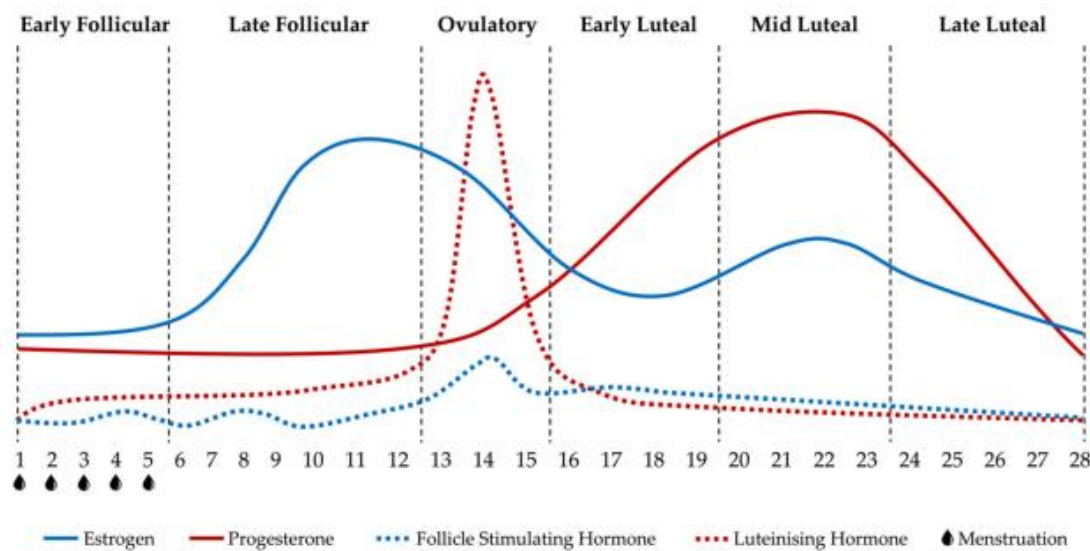


Figure 1: Hormonal events and phases of a Eumenorrheic 28-day menstrual cycle (Carmichael *et al.*, 2021).

Figure 1 demonstrates the hormonal events and phases of a Eumenorrheic 28-day menstrual cycle.

During the typical ovulatory cycle, regular fluctuations in ovarian hormone levels, particularly oestrogen and progesterone, cause significant changes in body homeostasis (Janse De Jonge *et al.*, 2001). Marsh and Jenkins (2002) state that at rest, progesterone can enhance ventilation and body temperature, and oestrogen has been shown to have a considerable influence on vascular flow.

Oosthuyse, Bosch and Jackson (2005) have stated that although higher progesterone levels can raise core temperature, oestrogen administration can counteract these thermoregulatory effects, and a balance of the two hormones may alter the response to thermoregulation during exercise.

Menstrual Cycle on Exercise Performance

A significant loss of muscle strength has been recorded after menopause, a period characterised by decreasing levels of oestrogen and progesterone (Lowe, Baltgalvis and Greising, 2011). According to the findings of a meta-analysis, hormone replacement therapy, particularly oestrogen replacement, can reverse these initial strength losses (Greising *et al.*, 2009).

To date, the effects of oestrogen and progesterone changes across the menstrual cycle on exercise performance have been controversial. With studies reporting improved performance outcomes during the follicular and luteal phases (Rodrigues, Wharton and Correia, 2019), (Romero-Moraleda *et al.*, 2019), (Sung *et al.*, 2014), whereas, others have shown no changes in exercise performance between menstrual cycle phases (Arazi, Nasiri and Eghbali, 2019), (Köse, 2018) (Sakamaki-Sunaga *et al.*, 2016). It is therefore clear that a clarity on the effects of the menstrual cycle on exercise performance has yet to be formed. Consequently, neither athletes nor coaches have access to evidence-based guidelines for monitoring exercise performance throughout the menstrual cycle. Therefore, the objective of this review was to investigate the literature and the effect of the menstrual cycle phases on exercise performance.

Method (350)

UWTSD online library, SPORTDiscus and Google Scholar were used to conduct an electronic database search of title and abstract in February 2022. One reviewer carried out the electronic searches and evaluated the titles and abstracts. The search terms used were menstrual cycle, luteal phase, follicular phase, oestrogen, progesterone, resistance training, strength training, exercise performance. Dates were limited to 2010 and reference lists of the included articles were manually searched. Only full-text articles that looked at the impact of menstrual cycle phases on exercise performance were included. Studies that did not make a comparison between menstrual cycle phases were omitted. Studies were also excluded if they involved male or amenorrhoeic groups.

Figure 2 demonstrates the flow of studies through the review process.

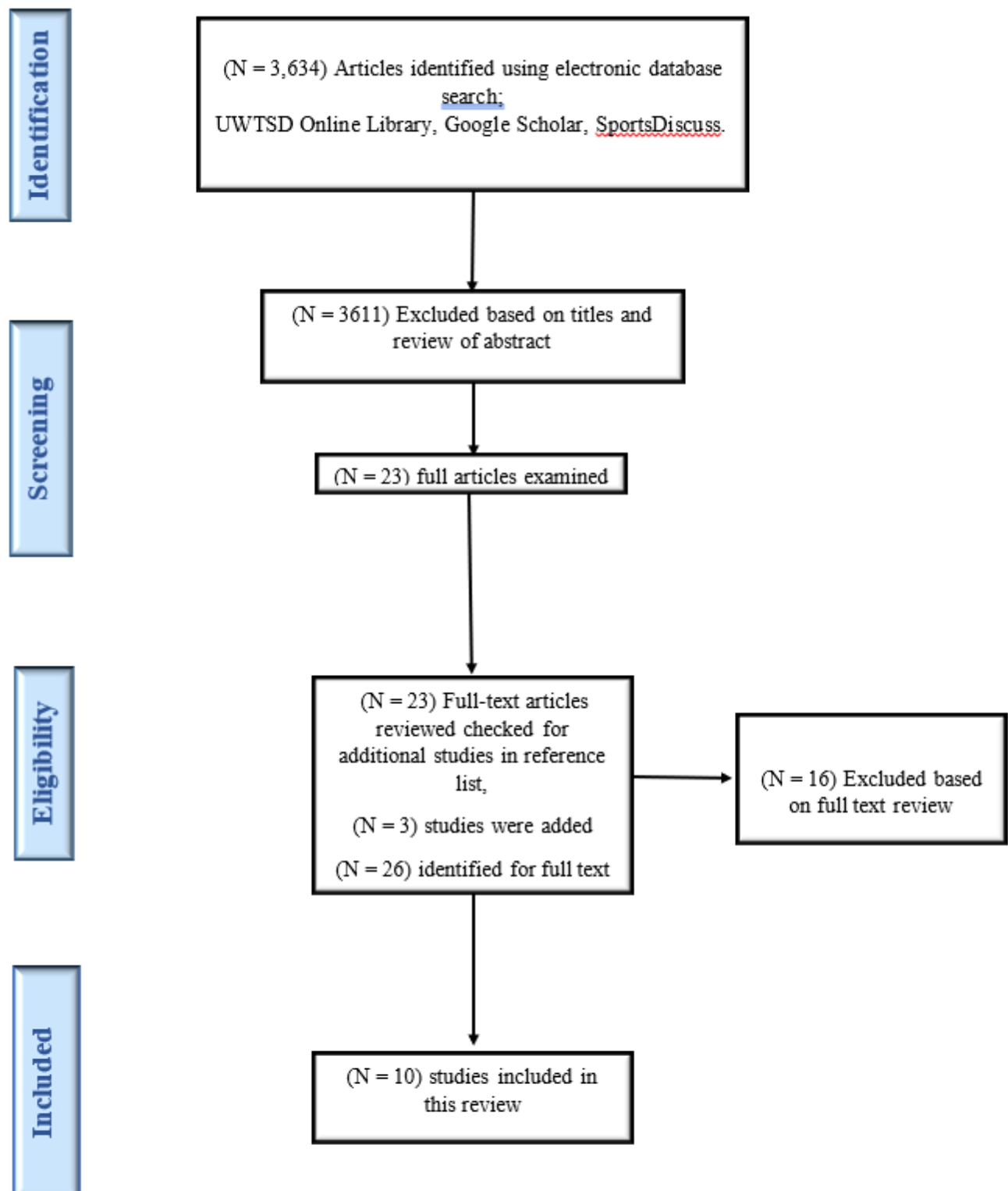


Figure 2: Flow of studies through the review process

Results (550)

A total of 3634 articles were found in the initial database search. Following the removal of 3611 articles, the remaining 23 articles were evaluated, 3 studies were added after reviewing additional studies in reference lists, with 26 of them being declared potentially acceptable based on title and abstract. 16 articles were eliminated after a full-text examination. Ten studies remained to be discussed in this review. Because of the wide range of study designs and outcomes, the data is presented in narrative form. Table 1 summarises the findings and characteristics of the studies included.

Table 1: Summary of Study Characteristics and Results

Reference	Aim	Participants	Test Measures	MC Phases	Results	Conclusion
(Arazi, Nasiri and Eghbali, 2019)	To investigate the differences toward strength, muscular endurance, anaerobic power and hormonal changes between the three (follicular, ovulation, luteal) phases of the menstrual cycle of active young girls.	Gender- Female N=20 Ages-26.27 ± 2.75years Height- 161±4.25cm Weight- 60.14±7.6kg	Anaerobic RAST test 1RM Bench Press 1RM Leg Press 60%RM Bench Press 60%RM Leg Press	Follicular Ovulation Luteal	No significant difference between muscular strength and endurance in the three phases of the menstrual cycle. No significant difference in anaerobic power in the three phases.	The different phases of the menstrual cycle do not limit the physical and physiological performance of active young girls.
(Goldsmith and Glaister, 2020)	To examine the effect of the menstrual cycle on running economy	Gender – Female N=10 Ages- 32±6years Height- 1.69±0.08m Weight- 58.4±7.8 kg	Sub maximal incremental step test. V02max	Early Follicular Late Follicular Mid-Luteal	Significant difference on running economy in the mid-luteal phase. Elevated core temperature and minute ventilation in mid-luteal phase.	Running economy is impaired at exercise intensities that are applicable to training and performance. In physiologically stressful environments, this impairment in running economy may have a significant impact on training and performance in the mid-luteal phase.

<i>(Julian et al., 2017)</i>	To investigate potential effects of menstrual cycle phase on performance in soccer specific tests	Gender- Female N= 9 Ages- Height- Weight-	Yo-Yo Intermittent endurance test. Counter movement jump. 3x30 m sprints	Follicular phase. Luteal Phase.	Yo-Yo Intermittent endurance test performance was considerably lower during the mid-luteal phase. Counter movement jump and sprint performances results were unclear.	Monitoring a player's endurance capacity during different cycle phases.
<i>(Köse, 2018)</i>	To examine the effect of menstrual cycle phases on aerobic-anaerobic capacity and muscle strength.	Gender – Female N=10 Age- 21.4±2years Height- 169.6±6.1cm Weight- 63.9±5.8kg	1RM Strength Endurance Wingate	Follicular Phase (2-3 days of menstrual bleeding) Mid-follicular Phase Luteal Phase	1RM, strength endurance and heart rate were not affected by follicular phase, mid-follicular phase and luteal phase.	Menstrual cycle does not influence performance parameters such as muscle strength, muscle endurance and aerobic-anaerobic capacity.

<i>(Rael et al., 2021)</i>	To analyse the impact of sex hormone fluctuations throughout the menstrual cycle on cardiorespiratory response to high-intensity interval exercise in athletes.	Gender – Female N=21 Age- 30.5±6.5years Height- 163.1±6.4cm Weight- 58.4±8.7kg	Interval Running: 8 × 3-min bouts at 85% of their maximal aerobic speed with 90-s recovery at 30% of their maximal aerobic speed.	Follicular Phase Late-follicular Phase Mid-luteal p Phase	Oxygen consumption, carbon dioxide production, respiratory exchange ratio, breathing frequency, energy expenditure, relative perceived exertion and perceived readiness were unaltered by menstrual cycle phase.	Hormone fluctuations throughout the menstrual cycle are not high enough to disrupt tissues' adjustments caused by the high-intensity exercise.
<i>(Rodrigues, Wharton and Correia, 2019)</i>	To compare the maximal voluntary contraction of lower limbs pre-, during, and post-menstruation periods.	Gender – Female N=12 Age- 27.2±3.4years Height- 168.6±5.2cm Weight- 61.4±6.3kg	Leg Press 45°	Follicular Phase Mid-follicular Phase Luteal Phase	Maximal voluntary contraction produced in the early follicular phase was significantly greater than in the course of the late luteal phase. The maximal strength produced post-menstruation in the mid-follicular phase was greater than the follicular and luteal phases.	Menstruation cycle can alter the maximal muscle force capacity in women who are not using oral contraceptives.

<i>(Romero-Moraleda et al., 2019)</i>	To investigate the fluctuations of muscle performance in the Smith machine half-squat exercise during three different phases of the menstrual cycle.	Gender – Female N=13 Age- 31.1±5.5years Height- 1.66 ± 0.06 m Weight- 58.6±7.8 kg	Half Squat 1RM	Early Follicular Phase, Late Follicular Phase Mid-Luteal Phase	Eumenorrheic females have similar muscle strength and power performance in the Smith machine half-squat exercise during the Early Follicular Phase, Late Follicular Phase and the Mid-Luteal phases of the menstrual cycle.	Resistance-trained eumenorrheic females have similar velocity, force, and power performance when exercising with loads equivalent to 20, 40, 60 and 80% of 1RM in the Smith machine half-squat exercise during the different phases of the menstrual cycle.
<i>(Sakamaki-Sunaga et al., 2016)</i>	To investigate how different training frequencies during menstrual phases affect muscle hypertrophy and strength.	Gender – Female N=14 Age- 21.2±1.9years Height- 162.9±3.4cm Weight- 57.1±5.4kg	3 sets of bicep curls (8-15 repetitions) until failure.	Follicular Phase Luteal Phase	Arm curl 1RM and maximum voluntary contraction significantly increased in both trials with no significant differences between menstrual phases.	Variations in female hormones induced by the menstrual cycle phases do not significantly contribute to muscle hypertrophy and strength gains during 12 weeks of resistance training.
<i>(Sung et al., 2014)</i>	To investigate the effects of a follicular phase-based strength training on muscle strength, muscle volume	Gender – Female N=20 Age- 25.9±4.5years Height- 164.2±5.5cm	Leg Press	Follicular Phase Luteal Phase	Increase in maximum isometric force after follicular phase training was higher compared to Luteal Phase training. Follicular phase training showed a higher gain in	Eumenorrheic females without oral contraception should base the periodization of their strength training on their

	and microscopic parameters, comparing to a luteal phase-based training.	Weight- 60.6±7.8kg			muscle strength and muscle diameter than Luteal phase training.	individual Menstrual Cycle.
<i>(Tsampoukos et al., 2010)</i>	To examine the effects of menstrual cycle phase upon sprinting and recovery as well as upon metabolic responses to exercise.	Gender- Female N=8 Age- 20.1±0.3years Height- 168±1cm Weight- 64.5±1.7kg	Repeated 30-s sprint on a non-motorised treadmill interspersed with a 2-min rest	Early Follicular Phase, Late Follicular Phase Luteal Phase	Peak power output and mean power output were unaltered due to Menstrual Cycle Phases. Blood lactate, blood pH and plasma ammonia after sprinting and estimated plasma volume were also unaltered by Menstrual Cycle Phases.	Hormonal fluctuations due to Menstrual Cycle Phases do not interfere with maximal intensity whole body sprinting and the metabolic responses to such exercise.

The results displayed above show a breakdown of ten different studies and the effects on exercise performance during different phases of the menstrual cycle in Eumenorrheic women.

Subjects consisted of athletes participating in various levels of recreational activities (Arazi, Nasiri and Eghbali, 2019), (Köse, 2018), (Rael *et al.*, 2021), (Rodrigues, Wharton and Correia, 2019), (Romero-Moraleda *et al.*, 2019), (Goldsmith and Glaister, 2020), (Julian *et al.*, 2017), (Tsampoukos *et al.*, 2010) and untrained individuals (Sakamaki-Sunaga *et al.*, 2016), (Sung *et al.*, 2014). Seven studies compared the response of exercise during the early follicular phase, mid-follicular phase and the luteal phase (Arazi, Nasiri and Eghbali, 2019), (Goldsmith and Glaister, 2020), (Köse, 2018), (Rael *et al.*, 2021), (Rodrigues, Wharton and Correia, 2019), (Romero-Moraleda *et al.*, 2019), (Tsampoukos *et al.*, 2010). Three studies compared the follicular phase and luteal phases on performance (Julian *et al.*, 2017), (Sakamaki-Sunaga *et al.*, 2016), (Sung *et al.*, 2014). Five studies suggested that menstrual cycle phases didn't significantly affect performance (Arazi, Nasiri and Eghbali, 2019), (Köse, 2018), (Rael *et al.*, 2021), (Sakamaki-Sunaga *et al.*, 2016), (Tsampoukos *et al.*, 2010), conflicting with five studies proposing differences in performance (Goldsmith and Glaister, 2020), (Julian *et al.*, 2017), (Rodrigues, Wharton and Correia, 2019) (Romero-Moraleda *et al.*, 2019), (Sung *et al.*, 2014).

Aerobic Exercises

One study by Rael *et al.*, (2021), evaluated the effects of menstrual cycle phases on cardiovascular response to high-intensity interval training. Measures evaluated were Oxygen consumption, carbon dioxide production, respiratory exchange ratio, breathing frequency and energy expenditure. Participants who were recreationally trained in endurance events were selected for this study. Results from this study indicate that hormone fluctuations throughout different phases of the menstrual cycle do not affect cardiorespiratory variables during high intensity exercise.

Köse (2018) studied 10 female kickboxing athletes examining the effects of menstrual cycle on aerobic-anaerobic capacity and muscular strength. Bench-press 1RM tested maximal strength and strength endurance was tested with 65% of 1RM until they exhausted. WAnT test was used to test anaerobic power and capacity. The following day Aerobic capacity was tested using the Bruce protocol with a start speed of 2.7km and 10% incline- speed was

increased every 3 minutes. This running test continued until the participant exhausted or met the criteria. Tests were conducted in the follicular phase (2-3 days of first bleeding), mid-follicular phase (8 and 9 day) and the luteal phase (the 22 and 23rd day). Results indicate the 1RM, strength endurance and heart rate were not affected by the difference menstrual phases.

Anaerobic/Strength Exercises

Eight studies evaluated the effects of menstrual cycle phases on anaerobic or strength-based exercise. Arazi, Nasiri and Eghbali, (2019), Goldsmith and Glaister, (2020), Rodrigues, Wharton and Correia (2019), Romero-Moraleda et al., (2019) Tsampoukos *et al.*, (2010) and tested during the early follicular phase, mid follicular phase and the luteal phase and on recreationally trained subjects. Julian et al., (2017), Sung *et al.*, (2014) and Sakamaki-Sunaga *et al.*, (2016) tested during the follicular and luteal phases on untrained subjects.

Rodrigues, Wharton and Correia (2019) study used 12 healthy recreationally trained females. The leg-press 45° determined lower limb maximal voluntary contraction. Testing was carried out during the luteal phase (2/3 days before evidence of menstruation), the early follicular phase (1/2nd day of bleeding) and the mid-follicular phase (2/3 days after bleeding had stopped). Maximal voluntary contraction produced in the early follicular phase was significantly greater than during the late luteal phase. The maximal strength produced post-menstruation in the mid-follicular phase was greater than the follicular and luteal phases.

Romero-Moraleda *et al.*, (2019) study was carried out on 13 resistance trained eumenorrheic women. The half squat 1RM was measured. On the second day of each phase, half squat on the smith machine was assessed using 20, 40, 60 and 80% 1RM. Force, velocity and power output were measured. Results demonstrated that muscle strength and power remained similar during each phase of the menstrual cycle.

Tsampoukos *et al.*, (2010) studied 14 sport science students who were active members of various sports teams for their university. Repeated 30-s sprint with a 2-minute passive recovery period was tested throughout three phases of the menstrual cycle (follicular, just prior to ovulation and the luteal phase) on a non-motorised treadmill. Peak power and mean power output were unaltered due to Menstrual Cycle Phases. Blood lactate, blood pH and

plasma ammonia after sprinting and estimated plasma volume were also unaltered by Menstrual Cycle Phases.

Sakamaki-Sunaga *et al.*, (2016) studied 14 eumenorrheic women performing 3 sets of bicep curls until failure for 12 weeks. Subjects trained each arm separately for either the follicular phase training or luteal phased training. After 2 weeks of one protocol with one arm, subjects switched to the remaining protocol using their other arm. 1RM and maximum voluntary contraction significantly increased but no major differences between protocols could be seen.

Sung *et al.*, (2014) studied 20 untrained or moderately trained students who partly participated in aerobics and/or yoga and who took part in less than 2 hours of physical activity a week. Subjects completed strength training on the leg press for three menstrual phases. One leg had eight training sessions in the follicular phases and two sessions in the luteal phases for the follicular phase-based training, while the other leg had eight training sessions in the luteal phase and only two sessions in follicular phase for luteal phase-based training. Increase in maximum isometric force after follicular phase training was higher compared to Luteal Phase training. Follicular phase training showed a higher gain in muscle strength and muscle diameter than Luteal phase training.

Discussion (650)

Although there are reasonable amounts of research into the effects of menstrual cycle phases on exercise performance, there is also conflict between results and what could be deemed acceptable with regards to training strategies for each phase. Studies differ in testing approaches, making it difficult to fully compare outcomes. The aim of this systematic review was to investigate the effect of the menstrual cycle phases on exercise performance. Ten studies met the inclusion criteria for this review. These studies looked at a variety of different research questions, measured different responses to training and often produced conflicting results. Overall, five studies found an increase in exercise performance throughout different phases of the menstrual cycle, leaving five with no significant results.

Rael *et al.*, (2021) suggests heart rate-based training programs should be considered during each phase due to altered heart rates throughout HIIT sessions and during different cycle phases. This appears to be in agreement with Goldsmith and Glaister, (2020) who's study found participants to be less economical when endurance racing during the luteal phase. Oestrogen and Progesterone levels drastically change during the luteal phase, with elevated body temperatures and potentially an increased cardiovascular strain (Janse De Jonge, 2003) which may influence additional physiological systems (Janse DE Jonge, Thompson and Han, 2019) and ultimately effecting performance levels. Although both studies conflict with Greenhall *et al.*, (2021), who state that runners produce better marathon times during the luteal phase of their cycle. Tsampoukos *et al.*, (2010) also found that menstrual cycle phases do not interfere with maximal intensity sprinting and the metabolic responses to exercise.

It has been suggested that menstrual cycle phases have a greater impact on muscular strength than on aerobic performance. This is reflected in results from Rodrigues, Wharton and Correia, (2019) who found that maximal voluntary contraction and maximal strength were significantly higher in the follicular phase than the luteal phase. Sung *et al.*, (2014) also found a higher gain in strength and isometric force when training in the follicular phase than the luteal phase. Studies have shown a decrease in muscle strength when oestrogen levels decline at menopause (Lowe, Baltgalvis and Greising, 2011). Oestrogen levels are high during the later follicular phase which may reflect in strength gains seen by Rodrigues, Wharton and Correia, (2019) and Sung *et al.*, (2014).

Sakamaki-Sunaga *et al.*, (2016) found a significant increase in strength and voluntary contraction over 12 weeks of resistance training in untrained individuals, although there was

no significant difference in gains between the different menstrual phases. Arazi, Nasiri and Eghbali, (2019) also found no significant difference between muscular strength and endurance in the three phases of the menstrual cycle. Performance in tasks requiring rapid force production was largely unaffected by menstrual phases; explosive half squat (Romero-Moraleda et al., 2019) and countermovement (Julian et al., 2017) did not vary by menstrual phase.

According to a cross-sectional study on the impact of menstruation symptoms on performance, 44.6% of college athletes believed that menstrual symptoms hindered their training or competition performance (Takeda *et al.*, 2015). Evidence has suggested that psychological alterations such as irritation, anger, moderate depression, and anxiety appear to be more prevalent during the mid-luteal phase than during the mid-follicular phase, interfering with motivation to engage in exercise (Freemas *et al.*, 2021). It should be investigated further to see if menstrual cycle-related changes in motivation have an impact on a variety of performance outcomes.

Further research should also be conducted to measure the exact volume of blood lost during menstruation and the degree of symptoms experienced by each individual. These measurements should be included in future studies since they could be a key aspect in determining whether performance levels are impacted at each phase.

Conclusion (100)

This review explored the current body of research investigating the effects on exercise performance during different phases of the menstrual cycle in Eumenorrheic women. Ten research studies were reviewed and analysed with the results discussed and compared.

As a result, future studies should consider including more controls to improve the accuracy and fairness within research/trials. Individual considerations should also be taken into account when training females and during each cycle phase.

References

- Arazi, H., Nasiri, S. and Eghbali, E. (2019) 'Is there a difference toward strength, muscular endurance, anaerobic power and hormonal changes between the three phase of the menstrual cycle of active girls?', *Apunts Medicina de l'Esport*, 54(202), pp. 65–72. doi: 10.1016/j.apunts.2018.11.001.
- Carmichael, M. A. *et al.* (2021) 'The impact of menstrual cycle phase on athletes' performance: a narrative review', *International Journal of Environmental Research and Public Health*, 18(4), pp. 1–24. doi: 10.3390/ijerph18041667.
- Findlay, R. J. *et al.* (2020) 'How the menstrual cycle and menstruation affect sporting performance: Experiences and perceptions of elite female rugby players', *British Journal of Sports Medicine*, 54(18), pp. 1108–1113. doi: 10.1136/bjsports-2019-101486.
- Freemas, J. A. *et al.* (2021) 'Exercise Performance Is Impaired during the Midluteal Phase of the Menstrual Cycle', *Medicine and Science in Sports and Exercise*, 53(2), pp. 442–452. doi: 10.1249/MSS.0000000000002464.
- Greising, S. M. *et al.* (2009) 'Hormone therapy and skeletal muscle strength: A meta-analysis', *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, 64(10), pp. 1071–1081. doi: 10.1093/gerona/glp082.
- Janse De Jonge, X. A. K. *et al.* (2001) 'The influence of menstrual cycle phase on skeletal muscle contractile characteristics in humans', *Journal of Physiology*, 530(1), pp. 161–166. doi: 10.1111/j.1469-7793.2001.0161m.x.
- Janse De Jonge, X. A. K. (2003) 'Effects of the menstrual cycle on exercise performance', *Sports Medicine*, 33(11), pp. 833–851. doi: 10.2165/00007256-200333110-00004.
- Janse DE Jonge, X., Thompson, B. and Han, A. (2019) 'Methodological Recommendations for Menstrual Cycle Research in Sports and Exercise', *Medicine and science in sports and exercise*, 51(12), pp. 2610–2617. doi: 10.1249/MSS.0000000000002073.
- Köse, B. (2018) 'Analysis of the Effect of Menstrual Cycle Phases on Aerobic-Anaerobic Capacity and Muscle Strength', *Journal of Education and Training Studies*, 6(8), p. 23. doi: 10.11114/jets.v6i8.3207.
- Lowe, D. A., Baltgalvis, K. A. and Greising, S. M. (2011) 'Strength in Females', *Exerc Sport Sci Rev*, 38(2), pp. 61–67. doi: 10.1097/JES.0b013e3181d496bc.Mechanisms.
- Maki, P. M., Rich, J. B. and Shayna Rosenbaum, R. (2002) 'Implicit memory varies across the menstrual cycle: Estrogen effects in young women', *Neuropsychologia*, 40(5), pp. 518–529. doi: 10.1016/S0028-3932(01)00126-9.
- Marsh, S. A. and Jenkins, D. G. (2002) 'Physiological responses to the menstrual cycle: Implications for the development of heat illness in female athletes', *Sports Medicine*, 32(10), pp. 601–614. doi: 10.2165/00007256-200232100-00001.
- Mihm, M Gangooly, s Muttukrishna, S. (2010) 'The normal menstrual cycle in women'.
- Oosthuyse, T. and Bosch, A. N. (2010) 'The Effect of the Menstrual Cycle on Exercise Metabolism', *Sports Medicine*, 40(3), pp. 207–227. doi: 10.2165/11317090-000000000-00000.
- Oosthuyse, T., Bosch, A. N. and Jackson, S. (2005) 'Cycling time trial performance during different phases of the menstrual cycle', *European Journal of Applied Physiology*, 94(3), pp.

268–276. doi: 10.1007/s00421-005-1324-5.

Patel, H. *et al.* (2017) ‘ Aerobic vs anaerobic exercise training effects on the cardiovascular system ’, *World Journal of Cardiology*, 9(2), p. 134. doi: 10.4330/wjc.v9.i2.134.

Rael, B. *et al.* (2021) ‘Menstrual cycle phases influence on cardiorespiratory response to exercise in endurance-trained females’, *International Journal of Environmental Research and Public Health*, 18(3), pp. 1–12. doi: 10.3390/ijerph18030860.

Rodrigues, P., Wharton, L. and Correia, M. (2019) ‘Effect of Menstrual Cycle on Muscle Strength’, *Society*, 12(3), pp. 12–22. Available at: <http://faculty.css.edu/tboone2/asep/Russell.pdf>.

Romero-Moraleda, B. *et al.* (2019) ‘The influence of the menstrual cycle on muscle strength and power performance’, *Journal of Human Kinetics*, 68(1), pp. 123–133. doi: 10.2478/hukin-2019-0061.

Sakamaki-Sunaga, M. *et al.* (2016) ‘Effects of Menstrual Phase-Dependent Resistance Training Frequency on Muscular Hypertrophy and Strength’, *Journal of Strength and Conditioning Research*, 30(6), pp. 1727–1734. doi: 10.1519/JSC.0000000000001250.

Sung, E. *et al.* (2014) ‘Effects of follicular versus luteal phase-based strength training in young women’, *SpringerPlus*, 3(1), pp. 1–10. doi: 10.1186/2193-1801-3-668.

Takeda, T. *et al.* (2015) ‘Premenstrual Syndrome and Premenstrual Dysphoric Disorder in Japanese Collegiate Athletes’, *Journal of Pediatric and Adolescent Gynecology*, 28(4), pp. 215–218. doi: 10.1016/j.jpog.2014.07.006.

Thompson, B. *et al.* (2020) ‘The Effect of the Menstrual Cycle and Oral Contraceptives on Acute Responses and Chronic Adaptations to Resistance Training: A Systematic Review of the Literature’, *Sports Medicine*, 50(1), pp. 171–185. doi: 10.1007/s40279-019-01219-1.

Tsmpoukos, A. *et al.* (2010) ‘Effect of menstrual cycle phase on sprinting performance’, *European Journal of Applied Physiology*, 109(4), pp. 659–667. doi: 10.1007/s00421-010-1384-z.

Bibliography

Bossi, J. et al. (2013) 'Effects of Menstrual Cycle on Exercise in Collegiate Female Athletes', *Research Quarterly for Exercise and Sport*, 84(1), p. A-xxii-A-xxvii.

Blagrove, R. C., Bruinvels, G. and Pedlar, C. R. (2020) 'Variations in strength-related measures during the menstrual cycle in eumenorrheic women: A systematic review and meta-analysis', *Journal of Science and Medicine in Sport*, 23(12), pp. 1220–1227. doi: 10.1016/j.jsams.2020.04.022.

Bushman, B., Masterson, G. and Nelsen, J. (2006) 'Anaerobic power performance and the menstrual cycle: Eumenorrheic and oral contraceptive users', *Journal of Sports Medicine and Physical Fitness*, 46(1), pp. 132–137.

Cook, C., Kilduff Crewther, B. and Crewther, L. (2017) 'Basal and stress-induced salivary testosterone variation across the menstrual cycle and linkage to motivation and muscle power'.

Dokumacı, B. and Hazır, T. (2019) 'Effects of the Menstrual Cycle on Running Economy: Oxygen Cost Versus Caloric Cost', *Research Quarterly for Exercise and Sport*, 90(3), pp. 318–326. doi: 10.1080/02701367.2019.1599800.

Findlay, R. J. et al. (2020) 'How the menstrual cycle and menstruation affect sporting performance: Experiences and perceptions of elite female rugby players', *British Journal of Sports Medicine*, 54(18), pp. 1108–1113. doi: 10.1136/bjsports-2019-101486.

Giersch, G. E. W. et al. (2020) 'Menstrual cycle and thermoregulation during exercise in the heat: A systematic review and meta-analysis', *Journal of Science and Medicine in Sport*, 23(12), pp. 1134–1140. doi: 10.1016/j.jsams.2020.05.014.

Julian, R. et al. (2017) 'The effects of menstrual cycle phase on physical performance in female soccer players', *PLoS ONE*, 12(3), pp. 1–13. doi: 10.1371/journal.pone.0173951.

Julian, R. et al. (2021) 'Menstrual cycle phase and elite female soccer match-play: influence on various physical performance outputs', *Science and Medicine in Football*, 5(2), pp. 97–104. doi: 10.1080/24733938.2020.1802057.

Kikuchi, H. et al. (2010) 'Decreased blood serotonin in the premenstrual phase enhances negative mood in healthy women', *Journal of Psychosomatic Obstetrics and Gynecology*, 31(2), pp. 83–89. doi: 10.3109/01674821003770606.

Lara, B. et al. (2020) 'Acute caffeine intake increases performance in the 15-s Wingate test during the menstrual cycle', *British Journal of Clinical Pharmacology*, 86(4), pp. 745–752. doi: 10.1111/bcp.14175.

Pisapia, F., Senatore, B. and Fattore, S. (2019) 'Correlation between menstrual cycle and performance', *Journal of Physical Education and Sport*, 19(5), pp. 1972–1975. doi: 10.7752/jpes.2019.s5293.

Smith, J. R. et al. (2015) 'Does menstrual cycle phase affect lung diffusion capacity during exercise?', *Respiratory Physiology and Neurobiology*, 205, pp. 99–104. doi: 10.1016/j.resp.2014.10.014.

Stone, T. et al. (2021) 'Menstrual cycle effects on cardiovascular drift and maximal oxygen uptake during exercise heat stress', *European Journal of Applied Physiology*, 121(2), pp. 561–572. doi: 10.1007/s00421-020-04542-y.

Vaiksaar, S. et al. (2011) 'No effect of menstrual cycle phase and oral contraceptive use on endurance performance in rowers', *Journal of Strength and Conditioning Research*, 25(6), pp. 1571–1578. doi: 10.1519/JSC.0b013e3181df7fd2.