

HABILITATION THESIS REVIEWER'S REPORT

Masaryk University

Applicant	Mgr. Marta Gimunová, Ph.D.
Habilitation thesis	Postural stability and gait during menstrual cycle
Reviewer	Wanda Forczek-Karkosz Ph.D, DSc
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The habilitation thesis “**Postural Stability and Gait During Menstrual Cycle**” by Mgr. Marta Gimunová, Ph.D. presents a timely and important contribution to the growing body of research on how hormonal fluctuations across the menstrual cycle may influence key aspects of physical performance. While the menstrual cycle is becoming an increasingly important topic in sports and health science, the precise physiological mechanisms through which it influences motor behavior remain underexplored. Up to 41.7% of female athletes report that menstruation negatively affects their performance (Bruinvels et al., 2016), yet the underlying causes and biomechanical correlates are still not fully understood. By focusing on two fundamental components of human movement - postural stability and gait - the Author addresses both the subtle and potentially impactful ways in which physiological changes might affect balance, fall risk, and locomotor patterns in women.

Previous reviews on this topic have either shown inconsistent findings or pointed to a decline in performance during menstruation and the late luteal phase (Carmichael et al., 2021; McNulty et al., 2020), while other studies suggest a highly individualized response depending on the type of motor task or physical demand (Meignié et al., 2021; Paludo et al., 2022). In response to this knowledge gap, the author has structured her work around six research questions (RQ), each aiming to clarify the influence of menstrual cycle phases and age at menarche on postural and locomotor performance:

- *RQ1: How do different menstrual cycle phases affect postural stability parameters?*
- *RQ2: How do different menstrual cycle phases affect postural stability parameters in situation with dual-task?*
- *RQ3: How does the age at menarche influence postural stability parameters in adult women?*
- *RQ4: How do different menstrual cycle phases affect spatiotemporal and dynamic gait parameters?*
- *RQ5: How do different menstrual cycle phases affect spatiotemporal and dynamic gait parameters in situation with dual-task?*

- *RQ6: How does the age at menarche influence spatiotemporal and dynamic gait parameters in adult women?*

The first chapter provides a clear and well-structured introduction to the physiological and biomechanical background necessary to understand the impact of the menstrual cycle on postural stability and gait. It lays the theoretical and methodological foundation, offering an overview of the menstrual cycle's hormonal regulation, menstrual cycle's monitoring techniques, and approaches used in postural stability assessment and gait analysis. This section provides a solid theoretical basis that supports the rationale for the study.

The second chapter addresses RQ1 through RQ3. It begins with a systematic review of 22 studies exploring menstrual cycle-related variations in postural stability. Six found no significant variation across the menstrual cycle, while sixteen indicated that menstrual phases do affect both static and dynamic postural stability. The review revealed a trend toward reduced dynamic stability during the early follicular phase and lower static stability around ovulation, although not all studies found significant changes. This was followed by the Author's original research that examined dual-task interference (e.g., performing math or reading while standing). In this experimental study, 28 women completed postural stability measurements three times during their menstrual cycle (at the early follicular phase, ovulation, and mid-luteal phase). Results showed that postural stability is affected during ovulation when the Center of Pressure (CoP) path and CoP average velocity were significantly higher. A deterioration in postural stability is likely linked to increased joint laxity. These findings show the influence of hormonal fluctuations across the menstrual cycle on postural stability and the related risk of injuries which confirmed some of the previous study (e.g. Petrofsky and Lee 2015). The Candidate suggests that future research might explore these associations, focusing on interventions enhancing postural control tailored to the specific menstrual cycle phases. A feasibility study on the effect of age at menarche adds a developmental perspective, though only weak-to-moderate correlations were identified. The Author underlined, there is a need for caution when generalizing the results due to a low number of participants and use of basic statistics of this pilot studies. However, the observed small correlations suggest a potential relationship that requires further research on a larger sample.

The third chapter mirrors this structure for RQ4 through RQ6. The systematic review covers six studies on gait, showing some phase-related differences - such as increased step cadency near ovulation and altered perceived gait attractiveness - but lacks depth in dynamic gait analysis (no study used force plates to analyze the effect of different menstrual cycle phases on dynamic gait parameters). The Author's original investigations filled this gap, analysing the effect of different phases of the menstrual cycle on gait patterns (using Zebris platform (FDM GmbH, Munich, Germany) for the gait registration) and investigating the impact

of dual-tasks on gait across the menstrual cycle to clarify the influence of estrogen variation on cognitive processing relationship to motor behaviour. Due to dual-task protocols the Author revealed menstrual phase-specific alterations in cadence and stride length, especially during the early follicular phase.

The final section of the Thesis introduces a pilot study examining the relationship between age at menarche and gait. While no strong associations were found, moderate correlations between gait variables (e.g., gait speed, stride length, step width) and age at menarche were observed. According to the Author, these preliminary findings suggest that larger-scale studies could further elucidate the long-term biomechanical impacts of hormonal exposure beginning in adolescence.

The discussed Thesis presents a scientifically rigorous original research conducted by the Author and provides a comprehensive perspective on a topic that has been historically underrepresented in movement science and sports medicine literature. The quality of the included papers reflects a strong awareness of the methodological limitations in the Haibilitation Candidate's research. What I need to emphasize notably, the integration of systematic reviews with original empirical studies enhances the validity of the findings, ensuring that the conclusions are well-founded in both existing literature and new data. Therefore I would like to underline that I do appreciate such an approach: at first identifying the gaps in current knowledge and then addressing them through carefully designed empirical research which demonstrates a thoughtful and comprehensive research strategy of the Candidate.

The habilitation Thesis by Mgr. Marta Gimunová, Ph.D. not only synthesizes existing knowledge but also opens new avenues for research, particularly concerning the role of hormonal fluctuations in motor control and injury prevention. It emphasizes the practical implications of these findings for clinical practice, rehabilitation, and athletic training. Tailoring physical activity and motor tasks to specific menstrual phases could enhance performance and reduce risk, while improved awareness among coaches and healthcare providers could foster more supportive and personalized interventions for women.

In sum, the Monography "Postural Stability and Gait During Menstrual Cycle" deepens our understanding of the biomechanical and physiological interplay throughout the menstrual cycle and makes a significant contribution to the research on female physiology and motor performance, providing both a solid evidence base and thoughtful directions for future inquiry. I have no hesitation in recommending the Candidate be permitted to proceed to the defence of the Thesis.

Reviewer's questions for the habilitation thesis defence

1. In the paper *"The effect of the menstrual cycle on postural stability in situations with and without dual-task"*, you noted that all participants reported experiencing adverse menstrual symptoms during menstruation, and 10 out of 28 used painkillers. Could you elaborate on how the remaining participants managed their symptoms? Understanding their coping strategies might help clarify potential influences on the study's outcomes.
2. Based on your findings, do you see potential for phase-based training periodization in female athletes — for example, adapting balance or coordination-focused sessions to phases with greater postural stability?
3. Dual-task paradigms were used to assess cognitive-motor interference across the menstrual cycle. How were these dual-tasks selected, and do you consider them valid for daily life or sport-specific environments?
4. Given the reported effects of dual-task interference during various menstrual phases, how should coaches and trainers address cognitive-motor demands in sport situations that require multitasking or rapid decision-making?

Conclusion

The habilitation thesis entitled "Postural stability and gait during menstrual cycle" by Mgr. Marta Gimunová, Ph.D. **fulfils** requirements expected of a habilitation thesis in the field of Kinanthropology.

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