Selected range of motion measures including fifth metacarpophalangeal joint extension, and handgrip strength across menstrual cycle phases in young, physically active women

Marta A. Grychtoł[1]*, Weronika Nalewajka[2], Emilia Głowacka[3], Bartosz Głowacki[4], Jitka Malá[5], Agnieszka Opala-Berdzik[6]

[1]Department of Clinical Physiotherapy, Academy of Physical Education in Katowice, Katowice, Poland
[2]Department of Biomedical Sciences and Physical Medicine, Academy of Physical Education in Katowice, Katowice, Poland
[3]Students' Scientific Association on the Analysis of the Influence of Pregnancy on the Musculoskeletal System, Academy of Physical Education in Katowice, Katowice, Poland
[4]Department of Mathematics and Statistics, University of Ottawa, ON, Canada
[5]Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic
[6]Institute of Physiotherapy and Health Sciences, Department of Clinical Physiotherapy, Academy of Physical Education in Katowice, Katowice, Poland

***Corresponding author:**
Marta A. Grychtoł
Department of Clinical Physiotherapy
Academy of Physical Education in Katowice, Katowice, Poland
E-mail: m.grychtol@awf.katowice.pl

Submitted: 25 September 2026; **Accepted:** 31 October 2026
Online publication: 31 October 2026

Arch Med Sci
DOI: https://doi.org/10.5114/aoms/242432
Copyright © 2026 Termedia & Banach

Fluctuations in estrogen levels across the menstrual cycle may influence musculoskeletal function [1, 2]. Estrogen influences muscle function and the mechanical properties of connective tissues, including tendons and ligaments [1]. Estrogen concentrations are the lowest during the early follicular phase (FP) and the highest during the ovulatory phase (OP) [3, 4].

However, evidence regarding menstrual cycle effects on joint mobility and muscle strength remains inconclusive. Studies have reported greater hamstring extensibility during the OP [5, 6] and greater passive knee extension range of motion (ROM) during the OP and luteal phase (LP) than during the FP [7]. In contrast, no changes in hamstring stiffness [6], passive fifth metacarpophalangeal (MCP5) joint extension or cervical spine rotation [8], or muscle strength, power, and velocity [9] have been reported. Conversely, other studies found greater isometric muscle force during the LP than the OP [7] and greater lower-limb muscle strength during the OP [10].

Given these inconsistent findings, further research is warranted, with potential implications for sports training, injury prevention, research, and clinical practice [2]. Therefore, this study aimed to determine whether selected active ROM measures and handgrip strength differ across menstrual cycle phases. We hypothesized that these measures would be greater during the OP than during the early FP and the mid-LP.

Methods. This study was conducted as part of the project "Assessment of the Psychophysical Aspects of Health in Physically Active Women of Reproductive Age", approved by the university bioethics committee (KB 2/2023). Forty-eight women were recruited from the university student and staff populations. Recruitment was conducted through announcements disseminated via social media and the university. Eligible volunteers were enrolled consecutively as they responded to the recruitment

Creative Commons licenses: This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY -NC -SA 4.0). License (http://creativecommons.org/licenses/by-nc-sa/4.0/).

announcements and met the predefined eligibility criteria; 45 met the inclusion criteria: age 18–30 years, body mass index (BMI) < 30 kg/m^2, regular menstrual cycles (24–35 days), and at least 150 min/week of moderate- or 75 min/week of vigorous-intensity physical activity. Exclusion criteria were hormonal contraception or medication, pregnancy history, irregular or abnormal-length cycles [11], musculoskeletal conditions affecting ROM, and insufficient physical activity. All participants provided written informed consent.

Participants underwent three assessment sessions during the early FP, the OP, and the mid-LP. The FP assessment was performed during menstruation, the OP within 48 h of a positive urine One Step LH Ovulation Test, midstream (Testeo, LOT no. 23081801, Gaobeidian PRISES Biotechnology Co., Ltd., Gaobeidian City, Hebei Province, China), and the LP approximately midway between ovulation and the expected subsequent menstruation. Menstrual cycle phases were estimated using the mobile application (Flo Health, London, UK) and established criteria [3, 4].

Active MCP5 joint extension, cervical extension, and the finger-to-floor distance (FFD) were assessed with a semirigid tape measure using standardized procedures described in our reliability study [12]. All assessments were performed by an examiner with excellent intra-rater reliability (ICC 0.90–0.97) [12].

Handgrip strength was measured bilaterally using a spring-type dynamometer (EH101, Camry, Zhongshan, China), with excellent reliability and validity [13]. The dynamometer was set to the second handle position. Participants sat in an armchair with forearms on the armrests, wrists neutral and just beyond the edges, and thumbs pointing upward. The dynamometer base rested on the first metacarpal, with the handle across the middle of the four fingers and the index finger flexed approximately 90° around it. Participants performed maximal grips for 5 s. Three alternating trials per hand were performed with 1-min rest intervals; the highest value was analyzed [14, 15].

An a priori sample size calculation for the primary outcome, active MCP5 joint extension, was performed using data from the first 10 participants. For comparisons between menstrual cycle phases, the estimated effect size was moderate (Cohen's d = 0.57), indicating that 35 participants were required to achieve 95% statistical power at α = 0.05. To account for potential dropouts, the target sample size was increased to 45 women. Normality and sphericity were assessed using the Shapiro–Wilk and Mauchly tests, respectively. Cervical extension was analyzed using one-way repeated-measures ANOVA. For MCP5 extension, FFD, and handgrip strength, the Friedman test was used, followed by Wilcoxon signed-rank tests with Holm correction for significant effects.

Results. Of the 48 participants screened for eligibility, three were excluded (two due to hormonal therapy and one due to age > 30 years), leaving 45 participants for the study. All 45 participants completed the follicular phase assessment; two subsequently withdrew, and 43 underwent the ovulatory phase assessment. Three participants had a negative ovulation test and did not proceed to the luteal phase assessment. Thus, 40 participants completed assessments in all three menstrual cycle phases and were included in the final analysis.

Characteristics of study participants are presented in Table I. Measurement outcomes for the specific joint/segment active ROM and handgrip strength are included in Table II.

The Friedman test indicated systematic differences between the magnitude of active right MCP5 extension ROM across the three phases of the menstrual cycle. Wilcoxon signed-rank test with Holm correction indicated no differences between the FP and the OP, nor between the FP and the LP; however, a difference was observed between the OP and the LP (Figure 1).

RM-ANOVA showed no differences between the measurements of active cervical extension ROM across the three phases of the menstrual cycle ($F(2, 78) = 0.82$; $p = 0.45$).

Table I. Characteristics of 40 young, healthy, physically active nulliparous women with normal menstrual cycles

Parameter	Mean	SD	95% CI	Range
Age [years]	21.9	2.27	21.17–22.58	18–29
Body mass [kg]	64.7	6.86	62.56–66.82	53.3–82
Body height [m]	1.68	0.06	1.66–1.70	1.57–1.82
BMI	23.0	2.21	22.31–23.68	19.1–28.6
Cycle length [days]	29.3	2.64	28.51–30.14	24–34
FP [days]	3.3	1.24	2.89–3.66	1–6
OP [days]	17.0	3.18	16.14–18.11	10–23
LP [days]	23.3	3.30	22.43–24.47	17–30

FP – follicular phase, OP – ovulatory phase, LP – luteal phase. Values represent measurement timing (days) from the onset of menstruation.

Table II. Measurement outcomes of the specific joint/segment active range of motion* and handgrip strength** in 40 healthy, physically active, nulliparous women during three phases of their normal menstrual cycles

Variable	Follicular phase	Ovulatory phase	Luteal phase
Right MCP5*** extension [cm]	4.9 ±0.97 (4.63–5.24)	5.0 ±0.99 (4.73–5.34)	4.9 ±1.0 (4.57–5.19)
Cervical extension [cm]	21.4 ±1.57 (20.93–21.94)	21.5 ±1.39 (21.01–21.90)	21.3 ±1.49 (20.87–21.82)
FFD test**** [cm]	–5.0 ±7.01 ([–7.20]–[–2.86])	–5.7 ±6.99 ([–7.82]–[–3.49])	–5.1 ±7.48 ([–7.39]–[–2.76])
Right-handgrip strength [kg]	26.7 ±6.0 (24.88–28.60)	26 ±6.32 (24.03–27.95)	26.3 ±6.51 (24.24–28.27)
Left-handgrip strength [kg]	24.3 ±4.86 (22.81–25.82)	24 ±5.55 (22.24–25.68)	24.1 ±5.18 (22.46–25.67)
Dominant-handgrip strength [kg]	26.6 ±6.11 (24.75–28.53)	26.0 ±6.21 (24.11–27.96)	26.4 ±6.30 (24.48–28.38)
Non-dominant-handgrip strength [kg]	24.4 ±4.78 (22.93–25.90)	23.9 ±5.64 (22.16–25.66)	23.9 ±5.36 (22.23–25.55)

*Data are presented as means ± SD (95% CI); *tape measurements; **hand dynamometer measurements; ***fifth metacarpophalangeal joint; ****finger-to-floor distance test.*

There was no overall effect of the menstrual cycle phase on the FFD test outcome [Friedman test: $\chi^2(2) = 1.08$, $p = 0.58$].

The Friedman test revealed no differences across measurements of right- and left-handgrip strength performed at the three phases of the menstrual cycle: $\chi^2(2) = 3.28$, $p = 0.19$ and $\chi^2(2) = 0.79$, $p = 0.68$, respectively.

There were no differences in dominant- and non-dominant-handgrip strength across measurements at three menstrual cycle phases: $\chi^2(2) = 2.39$, $p = 0.30$ and $\chi^2(2) = 1.51$, $p = 0.47$, respectively.

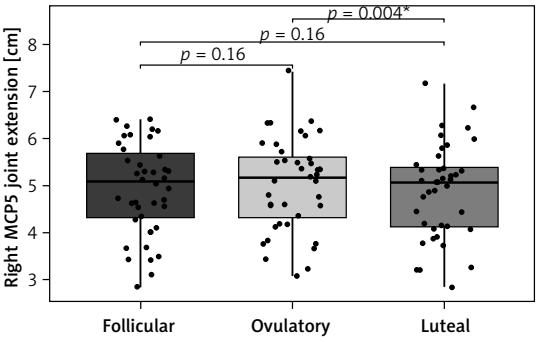


Figure 1. Active right fifth metacarpophalangeal (MCP5) joint extension ROM across the three menstrual cycle phases in 40 young healthy physically active nulliparous women; Friedman test: $\chi^2(2) = 7.14$, $p = 0.03$; *ovulatory phase vs. luteal phase: Wilcoxon signed-rank test with Holm correction ($p = 0.004$). Bolded horizontal lines – median values; boxes – interquartile range (IQR), representing the 25th to 75th percentiles (first and third quartiles); narrow vertical lines (whiskers) – the most extreme values within 1.5 × IQR from the first and third quartiles; dots – individual observations

Discussion. This study investigated whether selected active ROM measures and handgrip strength differ across the early FP, the OP, and the mid-LP in 40 young, healthy, physically active nulliparous women. The hypothesis that ROM and handgrip strength would be the greatest during the OP [3, 4] was partially confirmed. Active MCP5 extension ROM was significantly greater during the OP than the LP, but did not differ significantly between the OP and the early FP. The greater ROM during ovulation may reflect elevated estrogen concentrations, which may reduce connective tissue stiffness and increase extensibility [1, 3, 4]. The absence of a significant difference between the OP and the early FP may indicate that menstrual cycle-related changes in tissue extensibility were too small to affect active ROM, which depends not only on connective tissue properties but also on neuromuscular activation and voluntary movement control. Thus, menstrual cycle-related changes may be more pronounced when passive rather than active ROM is assessed. Previous studies reported greater passive hip flexion ROM during the OP than the early FP, although the LP was not assessed [6], and greater passive knee ROM during the OP and the LP than during the FP [7]. Our finding of no difference between the FP and the LP is consistent with previous findings for passive MCP5 extension ROM, although the OP was not assessed [8].

No significant phase-related differences were observed in active cervical extension ROM. This finding is consistent with previous research showing no effect of the menstrual cycle phase on passive cervical rotation ROM [8]. Similarly, FFD did not differ across phases, consistent with findings for the sit and reach test [16], although greater hamstring extensibility during the OP has also been reported using the FFD test [5]. These discrepancies may reflect differences in measure-

ment methods. Both active cervical extension ROM and the FFD test involve movement of multiple joints/body segments, which may make subtle changes in the mechanical properties of individual tissues more difficult to detect. In contrast, measurements targeting a single joint may be more sensitive to menstrual cycle-related changes.

Handgrip strength did not differ across phases, supporting evidence of small or negligible menstrual cycle-related changes in muscle strength [9, 17]. In contrast, greater lower-limb strength during ovulation [10] and differences in handgrip strength across phases [18] have been reported. However, the latter study did not assess the OP and did not specify the timing of measurements within phases [18].

Overall, discrepancies among studies may result from differences in measurement methods, phase identification, assessment timing, and participant characteristics. A limitation of the present study is that only active ROM was assessed, which may be influenced by neuromuscular activation as well as tissue properties. Subtle changes may also have been below the detection threshold. Future studies should assess both active and passive ROM using precise, reliable methods, standardized phase identification, and assessment timing. Given the variability in findings across studies, the menstrual cycle phase should be considered alongside individual responses and other relevant factors rather than used as a sole basis for modifying physical training or sports participation, including for injury prevention.

In conclusion, this study demonstrated significantly greater active MCP5 extension ROM during the OP than the LP, with no systematic differences in active cervical extension ROM, FFD test outcomes, or handgrip strength across the menstrual cycle. These findings do not support phase-specific modifications of physical training or sports activities based solely on the menstrual cycle phase. However, the assessment of active ROM may be insufficient to detect cycle-related changes in connective tissue extensibility, particularly when evaluating movements involving multiple joints. Further research is needed to determine the functional and clinical relevance of the observed active MCP5 extension ROM difference.

Acknowledgments

The authors acknowledge all participants for their participation in this study and the Academy of Physical Education in Katowice for funding the article's editorial expenses.

Funding

No external funding.

Ethical approval

Approval number: KB 2/2023.

Conflict of interest

The authors declare no conflict of interest.

References

1. Chidi-Ogbolu N, Baar K. Effect of estrogen on musculoskeletal performance and injury risk. Front Physiol 2019; 9: 1834.
2. Fischetto G, Sax A. The menstrual cycle and sport performance. New Stud Athl 2013; 28: 57-69.
3. Stricker R, Eberhart R, Chevailler MC, Quinn FA, Bischof P, Stricker R. Establishment of detailed reference values for luteinizing hormone, follicle stimulating hormone, estradiol, and progesterone during different phases of the menstrual cycle on the Abbott ARCHITECT analyzer. Clin Chem Lab Med 2006; 44: 883-7.
4. Anckaert E, Jank A, Petzold J, et al. Extensive monitoring of the natural menstrual cycle using the serum biomarkers estradiol, luteinizing hormone and progesterone. Pract Lab Med 2021; 25: e00211.
5. Szajnowska M, Stróż J, Bula A, Głowacki B, Rudek-Zeprzałka M, Opala-Berdzik A. The influence on menstrual cycle phases on trunk flexion mobility assessed with finger-floor distance test: a preliminary study. Med Sci Pulse 2022; 16: 71-6.
6. Bell DR, Myrick MP, Blackburn JT, Shultz SJ, Guskiewicz KM, Padua DA. The effect of menstrual-cycle phase on hamstring extensibility and muscle stiffness. J Sport Rehabil 2009; 18: 553-63.
7. Miyazaki M, Maeda S. Changes in hamstring flexibility and muscle strength during the menstrual cycle in healthy young females. J Phys Ther Sci 2022; 34: 92-8.
8. Weis CA, Grondin D, Vernon H. The effect of phase of menstrual cycle on joint mobility in the cervical spine and extremities in nulliparous women: a cross-sectional study. J Manipulative Physiol Ther 2016; 39: 393-400.
9. Romero-Moraleda B, Coso JD, Gutiérrez-Hellín J, Lara B, Ruiz-Moreno C, Grgic J. The influence of the menstrual cycle on muscle strength and power performance. J Hum Kinet 2019; 68: 123-33.
10. Pournasiri F, Zarei M, Mainer-Pardos E, et al. Isometric and isokinetic strength of lower-limb muscles in female athletes during different phases of menstrual cycle: a causal-comparative study. BMC Womens Health 2023; 23: 657.
11. Qu Q, Li Z, Rui J, Zhu W. Mendelian randomization analysis: exploring the causal relationship between menstrual cycle length and bone mineral density. Arch Med Sci 2025; 21: 320-6.
12. Grychtoł M, Nowak W, Głowacki B, Nalewajka W, Gural W, Opala-Berdzik A. Reliability for the measurements of the active neck and little finger extension, and trunk flexion ranges using a tape measure in healthy young adults. Physiother Rev 2024; 28: 74-87.
13. Huang L, Liu Y, Lin T, et al. Reliability and validity of two hand dynamometers when used by community-dwelling adults aged over 50 years. BMC Geriatr 2022; 22: 580.
14. Roberts HC, Denison HJ, Martin HJ, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. Age Ageing 2011; 40: 423-9.

15. Mehmet H, Yang AWH, Robinson SR. Measurement of hand grip strength in the elderly: a scoping review with recommendations. J Bodyw Mov Ther 2020; 24: 235-43.
16. Teixeira ALS, Fernandes Júnior W, Marques FAD, Lacio ML, Dias MRC. Influência das diferentes fases do ciclo menstrual na flexibilidade de mulheres jovens. Rev Bras Med Esporte 2012; 18: 361-4.
17. Blagrove RC, Bruinvels G, Pedlar CR. Variations in strength-related measures during the menstrual cycle in eumenorrheic women: a systematic review and meta-analysis. J Sci Med Sport 2020; 23: 1220-7.
18. Pallavi L, Souza UJ, Shivaprakash G. Assessment of musculoskeletal strength and levels of fatigue during different phases of menstrual cycle in young adults. J Clin Diagn Res 2017; 11: CC11-3.