

# Changes in maximal force production across the menstrual cycle

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## PURPOSE

- To examine differences in maximal muscular strength across the early follicular (EF), late follicular (LF), and mid-luteal (ML) phases of the menstrual cycle (MC).

## METHODS

- Fourteen healthy women (71.4% White/Caucasian; age,  $21 \pm 2$  y; age of menarche,  $12 \pm 2$  y; body mass index,  $23.8 \pm 4.3$  kg·m<sup>-2</sup>) with a history of regular menstruation, abstinence from hormonal contraception use, and no current or past eating disorders participated in this study.
- Participants completed three lab visits over the course of one menstrual cycle; visit 1 (EF phase) was scheduled within 5 days of self-reported onset of menstruation, visit 2 (LF phase) was scheduled within 48 hours of a positive urinary ovulation test, and visit 3 (ML phase) was scheduled 7-9 days after the positive ovulation test.
- At each visit, participants completed a series of four-second maximal voluntary isometric contractions (MVIC) of the knee extensors against an anchored dynamometer with the knee joint fixed at 90 degrees. The best of three trials was used for analysis. A familiarization trial was performed prior to the initial study visit to minimize the order effect. Primary outcome measures included relative peak and average force (N·kg<sup>-1</sup>), and time-to-peak (s).
- Mean differences between MC phases for peak force, average force, and time-to-peak were assessed using repeated measures ANOVA with an alpha level of significance of 5.0%. Magnitudes of the differences were expressed using the partial eta squared ( $\eta_p^2$ ) effect size.

## RESULTS

- Standardized residuals of all outcome variables were approximately normally distributed with equal variances between all within-subject conditions.
- Peak and average force were 0.3 (10%) and 0.2 (7%) N·kg<sup>-1</sup> higher, respectively, during the LF phase compared to the EF and ML phases, though the effects were small (peak:  $\eta_p^2 = 0.08$ ; average:  $\eta_p^2 = 0.04$ ) and not significant (all  $p > 0.100$ ).
- Time-to-peak was similar across all three MC phases ( $\eta_p^2 = 0.05$ ,  $p = 0.486$ ).

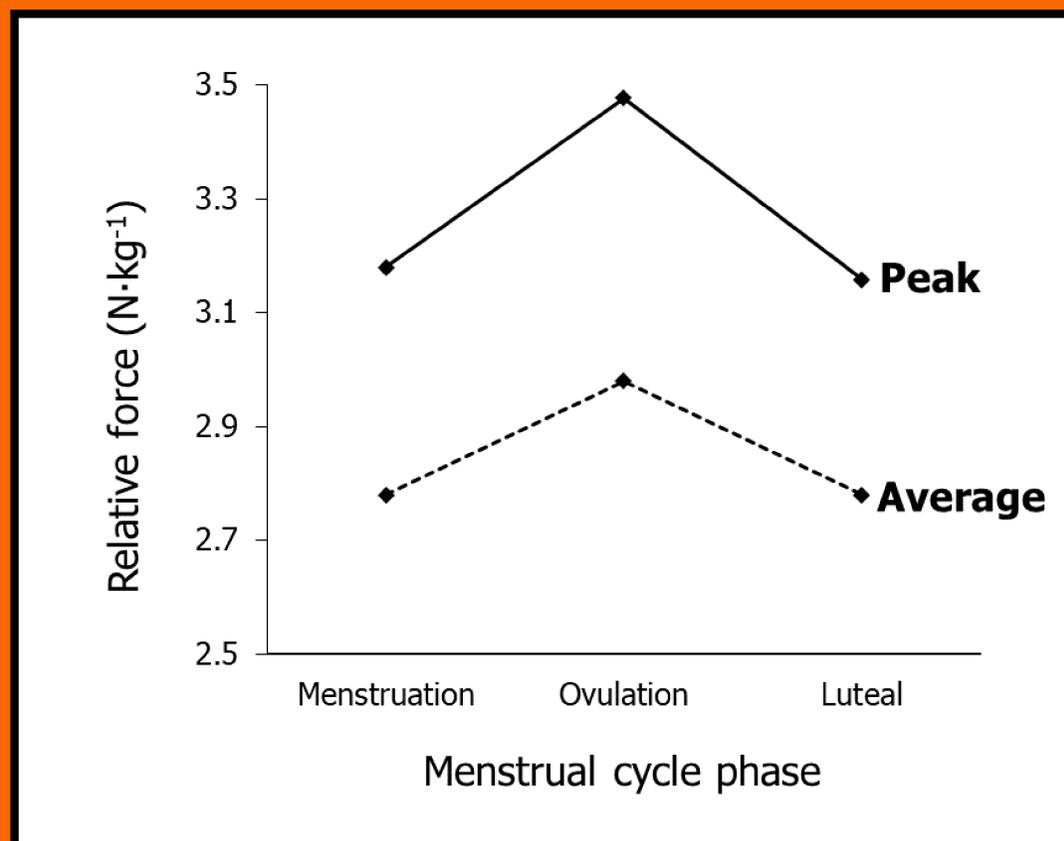
## CONCLUSIONS

- Measures of maximal muscular strength including peak force, average force, and time-to-peak were not significantly different across MC phases.

## PRACTICAL APPLICATIONS

- These results suggest that fluctuations in female reproductive hormones do not affect muscular strength.
- Consequently, strength and conditioning professionals should not implement blanket training modifications for female athletes based on presumed strength enhancements or decrements throughout the MC.

## Isometric strength *does not* change across the menstrual cycle



## Study protocol

Menstrual phase  
• Visit within 5 days of period  
• Body mass assessment  
• Isometric strength testing

Ovulation phase  
• Visit within 48 hours of positive ovulation test  
• Body mass assessment  
• Isometric strength testing

Luteal phase  
• Visit 7-9 days after positive ovulation test  
• Body mass assessment  
• Isometric strength testing

## Participant characteristics (n = 14)

Age (y)	21 ± 2
Age of menarche (y)	12 ± 2
Height (cm)	168.9 ± 9.5
Body mass (kg)	68.1 ± 15.0
Body fat (%)	23.8 ± 4.3
Athlete (% yes)	28.6
Race/ethnicity (%)	
White/Caucasian	71.4
Asian/Pacific Islander	14.3
Black/African American	7.1
Mixed/Other	7.1

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