

# Changes in Genu Recurvatum Throughout the Menstrual Cycle in College Female Athletes

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## Introduction

Compared to male athletes, female athletes face a 2 to 8 times increased risk of knee ligament (ACL) injuries ("The Female ACL," 2016). Elite female soccer players specifically, face nearly 7 times the risk of sustaining an ACL tear than their male counterparts (Allen et al., 2016). These injuries are often the result of non-contact mechanisms, meaning that intrinsic female factors, like anatomical and hormonal differences, are likely the culprits of this sex disparity (Cullen, n.d.). Recent literature has shown significant genu recurvatum (GR) fluctuations during the menstrual cycle (Maruyama et al., 2022; Shagawa et al., 2021). Women with increased genu recurvatum may have increased anterior knee laxity during the ovulatory phase, which may be a risk factor for ACL injury (Maruyama et al., 2021). Exploring and understanding the effect that female menstrual cycle hormones have on knee hyperextension (genu recurvatum) is valuable to understanding the increased risk female athletes face.

## Research Goal

The purpose of this study was to observe the changes in GR throughout the phases of the menstrual cycle and determine if certain phases exhibit higher correlations between GR and female hormones than others.

## Methods

Seventeen, college female soccer athletes (age=20.4±1.28 years) who were not pregnant, nor amenorrheic, volunteered to participate in this prospective cohort study conducted at a university research laboratory.

Figure 1 provides a visual schematic of the data collection timeline. Once participants reported menstruation, GR was measured with an inclinometer (Figure 2) within 2-4 days (early follicular phase). 2-4 days after menstruation ceased, GR was remeasured, and hormone levels were measured (late follicular phase) through urinalysis with an Inito™ Fertility Monitor (Figure 3). 5 days after menstruation, participants performed a daily ovulation test at home until a positive result was reported. 12-48 hours after ovulation, GR and hormone levels were remeasured (early luteal phase). 7-9 days after ovulation, GR and hormone levels were measured a final time (late luteal phase).

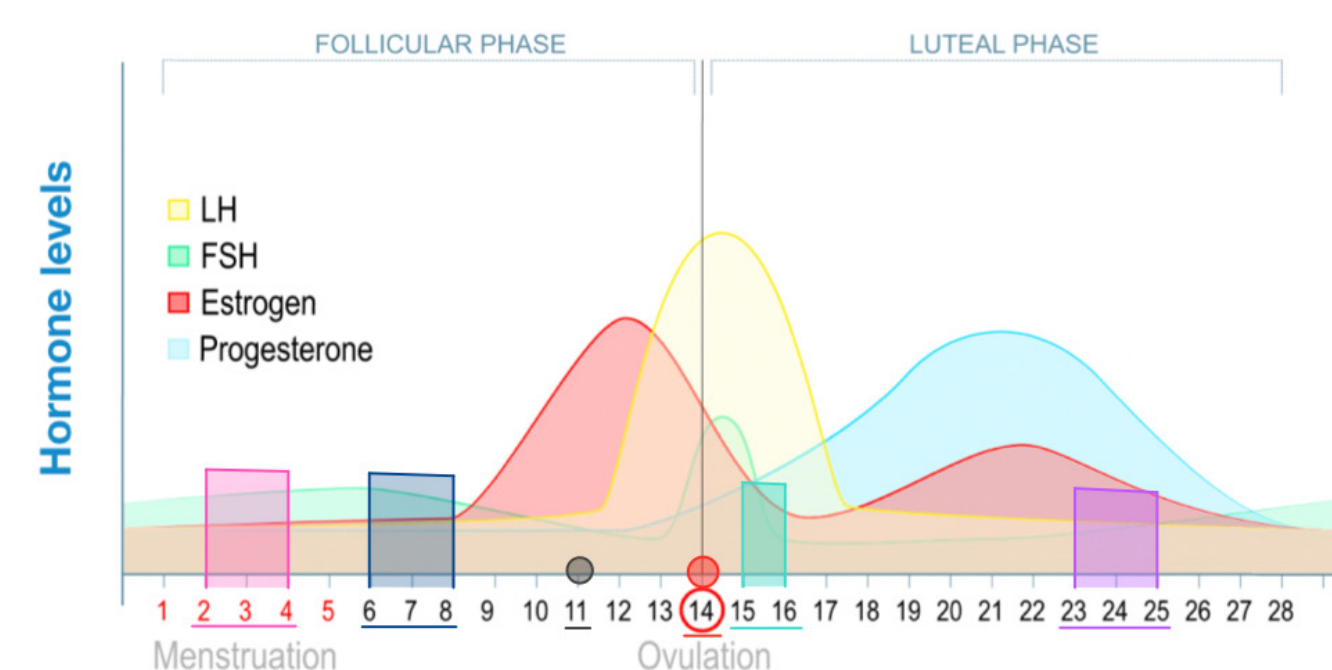


Figure 1. Schematic of the measurement time points throughout the menstrual cycle. Adapted from: [https://crh.ucsf.edu/media/2021/09/graph-Menstrual\\_Cycle.png](https://crh.ucsf.edu/media/2021/09/graph-Menstrual_Cycle.png)

A 1-way repeated measures ANOVA was performed to compare changes in GR over time. Pearson Correlations were performed to determine the relationship between GR and female hormones in each phase. Lastly, groups were divided into high and low-hormone groups (using the median as the cutoff) based on significant correlations. From these groups, independent t-tests and 2-way mixed ANOVAs were performed to assess for group differences and time by group interactions, respectively. The alpha level was set to 0.05 for all statistical tests.

## Figures and Results

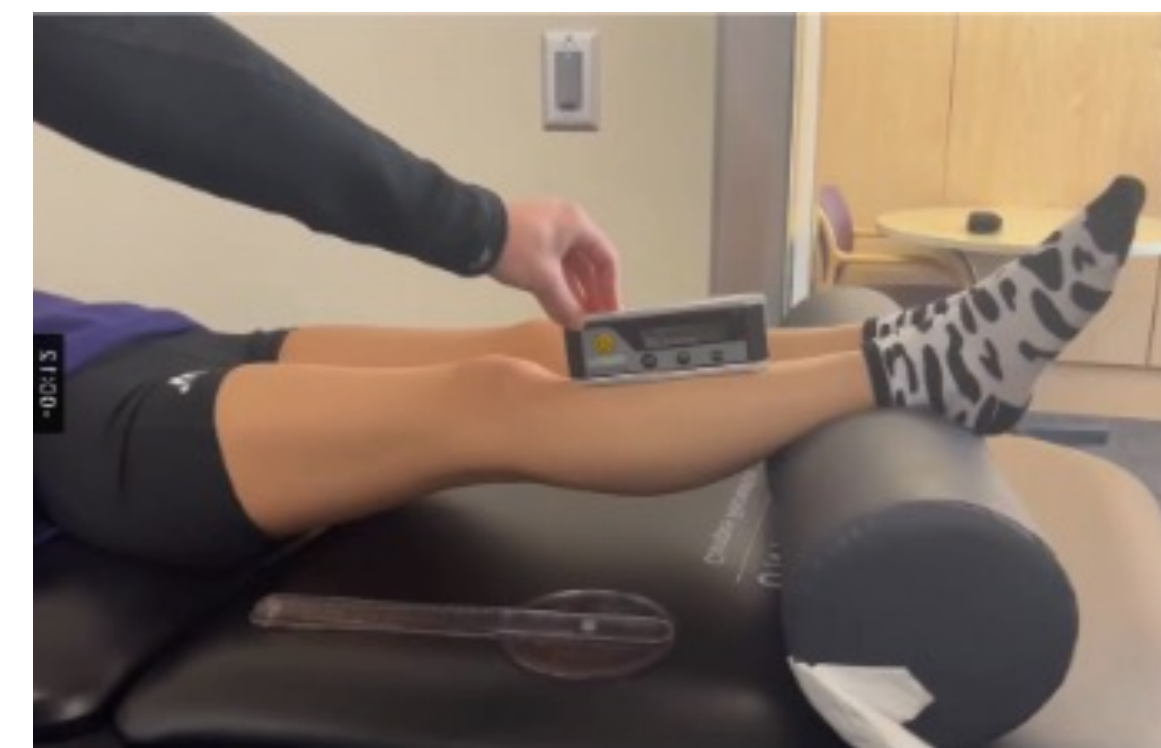


Figure 2. Participant position and inclinometer placement for genu recurvatum measurements.



Figure 3. Schematic of protocol for the Inito™ Fertility Monitor. Adopted from Pattnaik et al., 2023.

There was no significant difference in mean GR throughout the phases of the menstrual cycle ( $F = 0.825$ ,  $p = 0.48$ ). A strong, negative correlation was found between GR and E3G in the late luteal phase ( $r = -0.705$ ,  $p = 0.002$ ). A strong negative correlation was found between GR and PdG during the luteal phase ( $r = -0.657$ ,  $p = 0.006$ ).

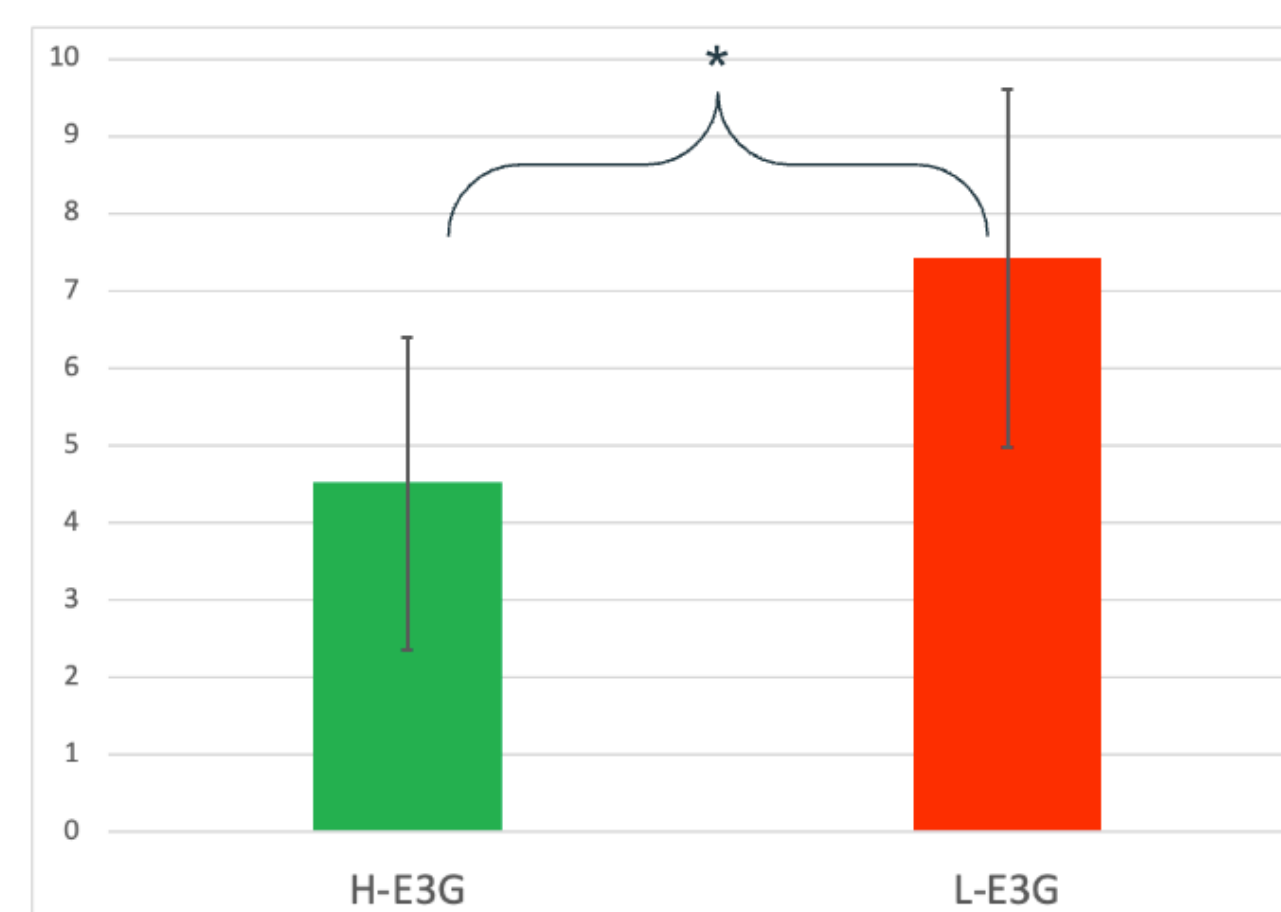


Figure 4. Genu recurvatum mean degrees between high and low E3G (late luteal phase) groups. \*Statistically significant group difference ( $p < 0.05$ )

Group	GR° (Mean ± SD)
H-E3G	4.53 ± 1.87
L-E3G	7.42 ± 2.19

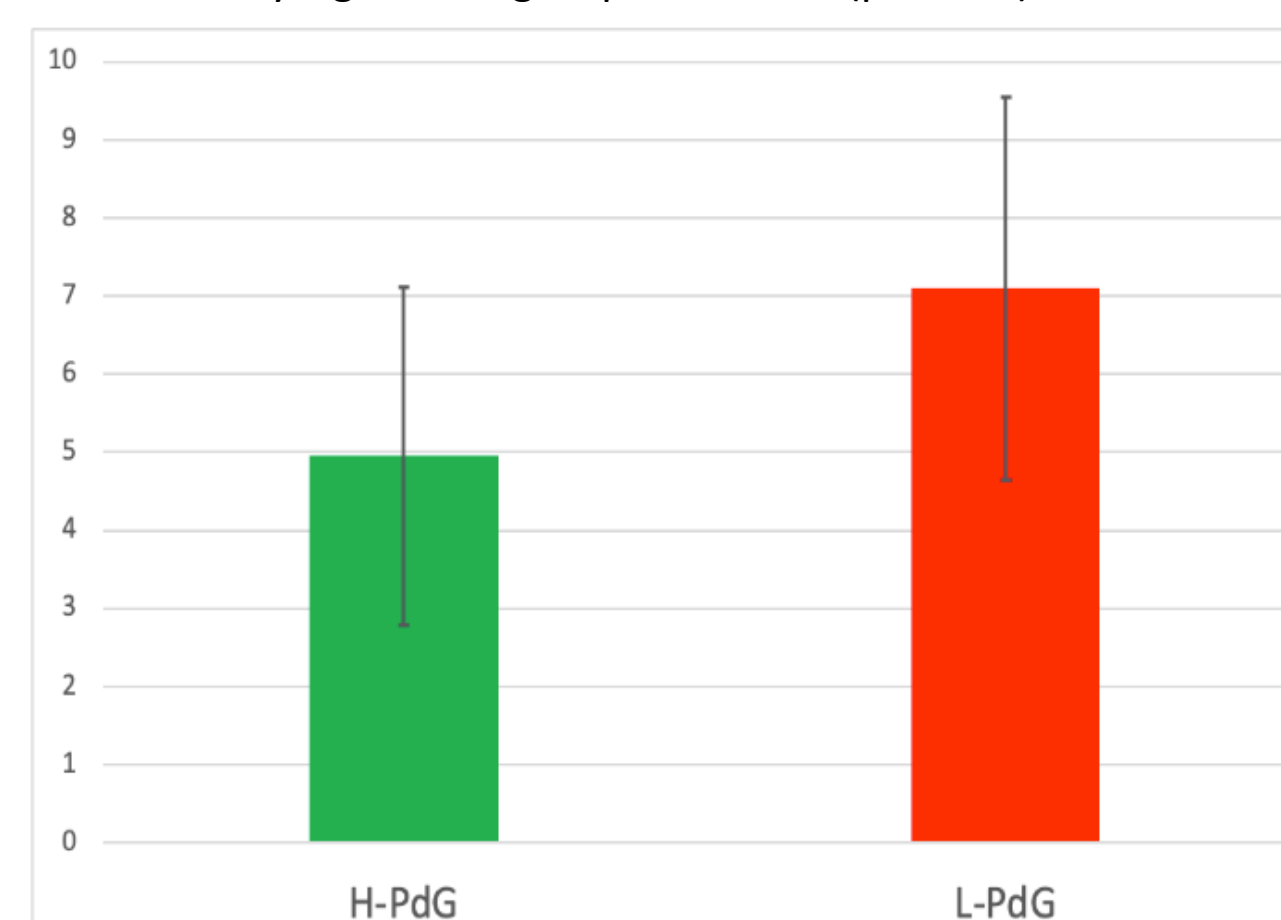


Figure 5. Genu recurvatum mean degrees between high and low PdG (late luteal phase) groups.

Group	GR° (Mean ± SD)
H-PdG	4.95 ± 2.17
L-PdG	7.10 ± 2.45

Mean GR was significantly higher in the low E3G group compared to the high E3G group in the late luteal phase ( $t = 2.94$ ,  $p = 0.011$ ; Figure 4). Mean GR was not significantly different between high and low PdG groups in the late luteal phase ( $t = 1.86$ ,  $p = 0.084$ ; Figure 5). A main effect was found for the group, with GR being 2.79 degrees higher in the low E3G group compared to the high E3G group, regardless of phase ( $F = 6.89$ ,  $p = 0.02$ ; Figure 6).

## Conclusion

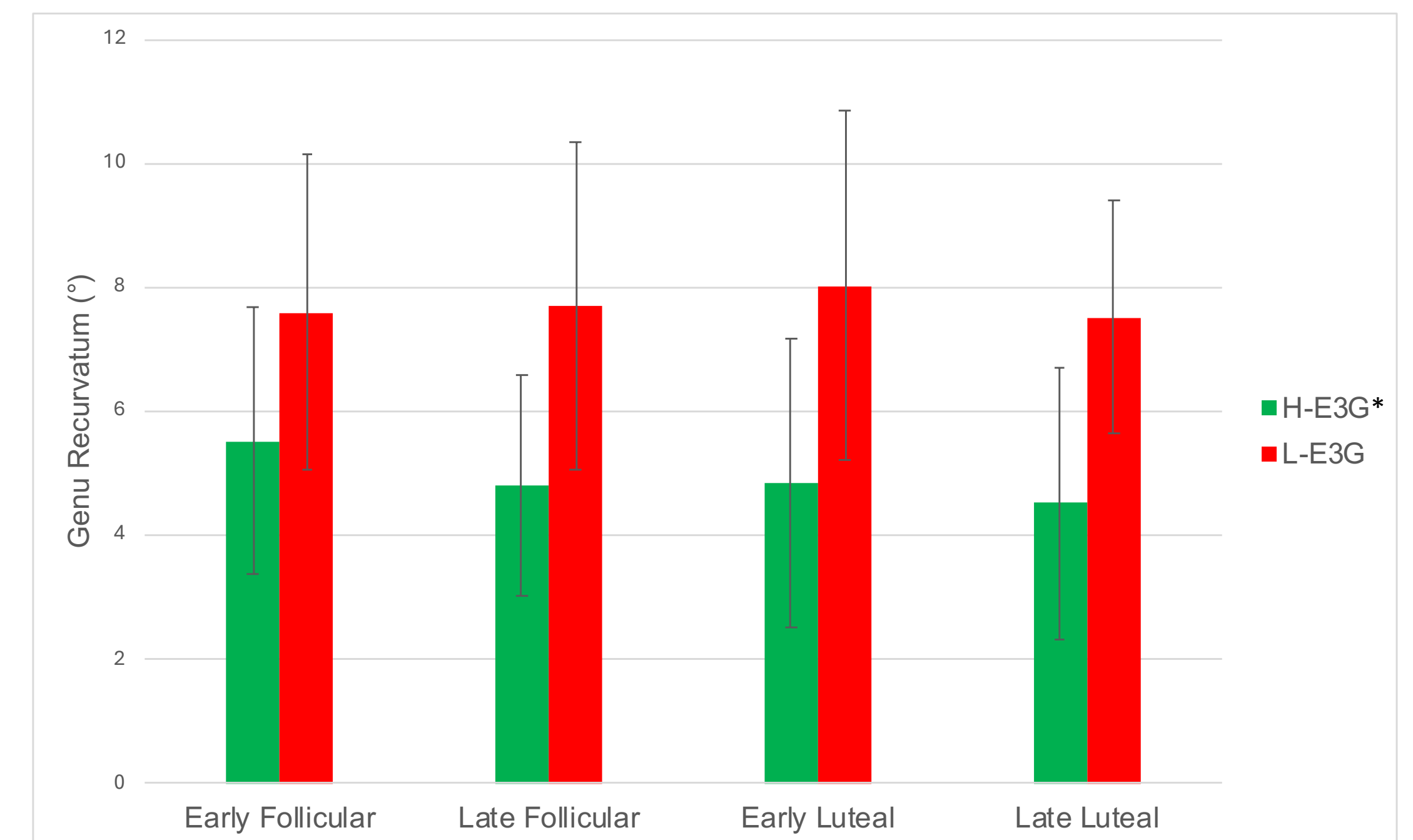


Figure 6. Genu recurvatum mean degrees between high and low E3G (late luteal phase) groups throughout the menstrual cycle.

\*Statistically significant between-subjects effect ( $p < 0.05$ )

Female athletes with lower estrogen levels in the late luteal phase may have higher rates of genu recurvatum related injuries. Because of this, it may be in the best interest of an athlete that falls into this group to work with a sports medicine professional to implement protective measures such as bracing, modify training conditions, or supplement estrogen during the luteal phase. Implementing menstrual cycle tracking in female sports can not only aid clinicians in identifying times where risk of injury is highest, but also provide a more holistic understanding of the female athlete. Further research is needed to investigate the relationship between GR and knee injuries in female athletes, and whether E3G can mitigate the injury risk.

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