Department of Athletic Training

The Effect Menstrual Cycles Phases Have on Ligament Laxity as a Risk Factor for ACL Injuries in Female Athletes: A Critically Appraised Topic

OKLAHOMA STATE UNIVERSITY
CENTER FOR HEALTH SCIENCES

Amber Sons B.S., Lauren Ford B.S., and Matthew O'Brien PhD, LAT, ATC, PES, CES

INTRODUCTION

Women are 2-6 times at a higher risk of suffering from an Anterior Cruciate Ligament (ACL) rupture compared to men; hormonal factors are thought to predispose them to this injury.[1] Within a female's menstrual cycle, there are four unique phases-the menstrual, follicular, ovulation, and luteal phase.[2] Typically, each menstrual cycle spans 28 days beginning with the follicular phase from days 1-9 which is when estrogen predominates. Followed by the ovulatory phase from days 10-14, where estrogen continues and reaches its peak. The cycle continues with the luteal phase from days 15-28 where progesterone surpass.[3] The length of each phase can differ from female to female and can change over the course of time, although the hormones are consistent among all females. Given the ramifications of ACL injuries, prevention is critical, and clinicians are actively seeking ways to decrease the risk of ACL injuries. This critically appraised topic looked at the four unique phases of the menstrual cycle and the increase of risk ACL injury may have within each phase.

METHODS

Terms Used to Guide Search Strategy:

- Female Athletes
- Menstrual cycles, menstruation, hormone fluctuations
- ACL laxity injury risk, ligament laxity

Sources of Evidence Searched:

- PubMed, Google Scholar, EBSCO, Sage Journals

Inclusion Criteria:

- Limited to Human Studies
- Limited to English Language
- History of a normal (28-35 days) menstrual cycle
- No history of any type of hormonal therapy for the previous 3 months
- No history or injury involving the MCL, LCL, PCL, menisci, or cartilage defects
- Physically Active Individuals

Exclusion Criteria:

- History of oral contraceptive or other hormone-stimulating medications within the past 6 months
- History of pregnancy
- History of either irregular or missed menstrual cycle

Summary of Evidence Table

Characteristics	Heitz et al[4]	Van Lumen et al[5]	Maruyama et al[6]	Wojtys et al[7]
Participants	7 female subjects ranging in age from 21 to 35 years old. Subjects were excluded if they had bilateral knee pathology, use of hormone therapy, a 90-degree tubercle sulcus angle of more than 10 degrees.	12 females' subject mild to moderately active with a mean age of 24.3 ± 4.9 years. Subjects reported no use of hormonal therapy, history of pregnancy, and an average menstrual cycle of 28-35 days.	15 female university students aged ≥ 20 years old in Japan. Subjects reported an average menstrual cycle of 28-35 days. Each menstrual cycle was divided into four phases early follicular, late follicular, ovulation, and luteal.	69 female athlete subjects ranging in age from 15-46 years old. Each subject was recruited after sustaining an acute noncontact ACL within the first 24 hours. Recruited from local high schools, colleges, and four orthopedic clinics.
Interventions	On the onset of menses, a blood sample and ACL laxity measurement were taken. This procedure was repeated on days 10, 11, 12, 13, 20, 21, 22, and 23 of participant's menstrual cycle.	After the onset of menses and two other separate occasions, near ovulation, and on day 23 of the midluteal phase 14 mL of blood was drawn followed by ACL laxity measurements and plain radiographs.	Measurements were taken once during each phase, 3-4 days after to consider possible diurnal variations. Anterior knee laxity was measures in loads of 44 N, 89 N, and 133 N using the KS Measure KSM-100, Japan Sigmax Co function tester.	A questionnaire was given to record the mechanism of injury, menstrual cycle details, use of oral contraceptives, and history of previous injuries. Urine samples were collected to determine the estrogen, progesterone, and LH metabolites and creatinine levels. Those samples were taken within 24 hours of injury and at the start of their next menstrual cycle.
Interventions Investigated	Estrogen and progesterone levels were determined via radioimmunoassay. ACL laxity was measured with the KT-2000 knee arthrometer. Values were plotted on an X-Y plotter for 67, 89, and 133 N of pull force.	Hormones were determined via radioimmunoassay. ACL laxity was measured with the KT-2000 knee arthrometer and plan radiographic films. Values from the knee arthrometer were plotted on an X-Y plotter for a force equaling 133 N or 30 lbs.	ACL laxity was measured with the using the KS Measure KSM-100, Japan Sigmax Co function tester. GR was defined as hyperextension of the knee ≥ 10 degrees. Subjects were classified into the GR group or non-GR group.	Oral contraceptive was not considered; however, they still took documentation for a subgroup that could be analyzed separately. A Pearson chi-square test and kappa coefficient were used.
Inclusion & Exclusion Criteria	<u>Inclusion</u>: 28–30-day menstrual cycle; no know knee anomalies <u>Exclusion</u>: bilateral knee pathology, use of hormone therapy, 90-degree tubercle-sulcus angle of more than 10 degree.	<u>Inclusion:</u> Dominant right leg; No history of knee-joint laxity; No use of hormonal therapy; history of pregnancy; history of eumenorrhea; 28-35 days menstrual cycle; less than 15-degree Q-angle. <u>Exclusion</u>: none	<u>Inclusion</u>: Female university students; no history of injury involving ligament, tendon, capsule, menisci, or osteochondral surface; no use of oral contraceptives or hormone-stimulating medications; less than 3 times per week physically active. <u>Exclusion:</u> Monophasic basal body temperature, menstrual cycle greater than 38 days	<u>Inclusion:</u> Sustained acute noncontact ACL injuries <u>Exclusion:</u> Pregnant women; women with a history of irregular or missed menstrual cycles.
Outcome Measures	This study assessed estrogen and progesterone plasma levels during the 3 phases of a single menstrual cycle; the follicular and luteal were used to establish peak values.	This study assessed the associations between ACL laxity and concentration of estrogen, estradiol, progesterone, LH, FSH, and testosterone during the 3 phases of a single menstrual cycle.	This study assessed the relationship of anterior knee laxity with that to the menstrual cycle. They also looked at genu recurvatum (GR) with respect to menstrual phases.	This study assessed the distribution of injury during the cycle using hormone metabolite measurements. They wanted to look at if there is an association between each phase and distribution of ACL injuries.
Main Findings	When comparing baseline levels of estrogen (phase 1) with peak levels (phase 2) there was a significant difference in ACL laxity. (P=.048) When comparing baseline levels of progesterone (phase 1) with peak levels (phase 3) there was a significant difference in ACL laxity. (P=.006) Differences were statistically significant at an α level of 0.05 or less.	With phases of the menstrual cycle there was no statistically significant difference. (P=.632) They noticed there was a greater laxity measurement using the KT-2000 (8.08 ± 0.52 mm) than the radiographs (4.24 ± 0.36 mm). Differences were statistically significance at α level of 0.05.	There was no statistically significant with AKL among the phases, but with subjects in the GR group; AKL vales at 89N and 133N were higher in the ovulation phase (P=.025 and .018, respectively)	In women not taking oral contraceptives, a higher number of ACL injuries occurred during the ovulatory phase than during the follicular or luteal phases. Urine assays found that hormones at all levels were significantly higher than on the 1st day of the subjects next menstrual cycle (P=0.001)
Level of Evidence	2b	2b	2b	2b
Conclusion	During the normal menstrual cycle, female ACL laxity significantly increased in conjunction with surging levels of estrogen and progesterone, comparing baseline with peak levels. ACL laxity occurring in conjunction with the approximate time of ovulation and preovulation (days 10-13). The greatest ACL laxity was associated with the luteal phase.	During the normal menstrual cycle, there was no differences between laxity and the phase of menstrual cycle regardless of measurement technique as well. They also found a negative relationship during the follicular phase between LH, unable to determine why though.	Among the phases of the menstrual cycle, anterior knee laxity did not vary significantly. However, in the GR group, it was found there was an increase in AKL in the ovulation phase; this may be a risk factor for ACL injuries. The ovulation phase may be related to that of a greater incidence of ACL injuries in subjects with GR.	In women not taking oral contraceptives, a higher number of ACL injuries occurred during the ovulatory phase than during the follicular or luteal phases. Association was not found in women taking oral contraceptives. There were no measurements taken regarding ACL laxity to compare. Increased likelihood for ACL injury in ovulatory phase.

Focused Clinical Question

In a normal menstrual cycle, what effects do each phase and hormone fluctuation play on ligament laxity regarding an increase in ACL injury risk in female athletes?

CONCLUSION

Three out of the four studies appraised in this Critically Appraised Topic suggest that there is an increased likelihood for ACL injuries late in the follicular phase near the time of ovulation, when estrogen levels begin to rapidly rise during this time. This is a transitional period when hormone concentrations are rapidly changing; each phase of the menstrual cycle presents new and different physiological events. There is not one hormone that acts independently, but instead there is a complex interaction between several hormones and other relevant factors associated. Educating females on the different phases and how they could possibly affect musculoskeletal health can be used to as insight on how to improve training as well as injury prevention.

Clinical Bottom Line

Moderate evidence to support the notion that women are at a greater incidence of ACL injures during the preovulatory and ovulatory phase of menstrual cycle, when estrogen predominates.

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