



Grant Information Summary:

The Effects of Endogenous Estradiol Levels at Three Phases of the Menstrual Cycle on Anterior Cruciate Ligament Stiffness in Active Females

Practical Significance:

As the concentration of the sex hormone estradiol increases in healthy, active women the stiffness of the anterior cruciate ligament (ACL) decreases. This relationship is greatest around ovulation. Reduced stiffness may make the ACL less able to withstand high loads and be more susceptible to injury.

Background

Female athletes experience a higher risk of anterior cruciate ligament (ACL) injury than do males participating in similar activities. There are several physiological and anatomical differences that may contribute to this increased risk of injury in female athletes. One physiological difference is the fluctuation of estradiol concentrations throughout the female menstrual cycle. Estradiol concentrations are highest during the follicular phase of the cycle in preparation for ovulation. In animals, exposure to estradiol has

resulted in reductions in collagen content and load to failure in the ACL. It is possible that the higher concentration of estradiol during the follicular phase of the menstrual cycle may similarly affect the structural properties of the ACL in humans. If this is the case, then the female's ACL may not be able to withstand high loads during the follicular phase of the menstrual cycle and be more susceptible to injury.

Objective

To determine if a negative correlation between the levels of estradiol and the stiffness of the

ACL was present at the onset of menses, the follicular phase, and the luteal phase of the menstrual cycle in healthy, active females.

Design & Setting

A single blind repeated measures design was used. The study was completed at the University of Maryland, Baltimore School of Medicine.

Subjects

Twenty healthy, active eumenorrhic females (age = 25.9 ± 5.1 years; height= 166.16 ± 8.4 cm; weight= 71.3 ± 25.9 kg), not using oral contraception (regular cycle 28-32 days) were studied.

Measurements

At the onset of menses, ovulation, and the luteal phase of their menstrual cycle, subjects had 10 ml of blood drawn and were tested with the KT-2000. The phase of the menstrual cycle when subjects began testing was randomly assigned. Estradiol levels were determined via radioimmunoassay. Ligament stiffness was determined between 89N and 134N using the force-displacement curve generated by the KT-2000.

Results

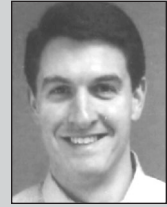
A Pearson correlation for estradiol concentration and stiffness of the ACL was determined. Statistical analysis indicated a moderate correlation of $R=-.32$ ($P=.013$). The correlation between estradiol concentration and stiffness near ovulation was $R= -.71$ ($P<.001$).

Conclusions

As the concentration of estradiol increased there was a moderate decrease in the stiffness of the ACL throughout the three phases of the subject's menstrual cycle. While this data suggests a moderate relationship between estradiol concentration and ACL stiffness, it does not suggest causality. The current study examined ligament stiffness and estradiol concentration at three points in the menstrual cycle, but several other hormones and proteins fluctuate throughout the menstrual cycle and may contribute to changes in ligament stiffness. Future studies should examine the relationship of other hormones and proteins to the stiffness of the ACL.

Principal Investigator:

**William A.
Romani, PhD, PT,
ATC**



University of Maryland, Baltimore
Phone: (410) 706-8410

Co-Investigators:

Leigh Ann Curl, MD
Richard M. Lovering, MS, PT

Publication & Presentation List

NATA Annual Meeting,
Los Angeles, CA, June 19-23, 2001

Romani WA, Curl LA, Lovering RM. *Anterior cruciate ligament stiffness at three stages of the menstrual cycle in healthy, active females.* Platform Presentation. Symposium on Gender Differences in ACL Injuries. Lexington, KY, April, 2001.

Romani WA, Curl LA, Lovering RM. *Estradiol concentration is related to anterior cruciate ligament stiffness near ovulation in healthy active females.* Poster Presentation. Women's Health Research Group Poster Day. University of Maryland, Baltimore School of Medicine, Department of Epidemiology, Baltimore, MD. May, 2001.



2952 Stemmons • Dallas, TX 75247
214-637-6282

The mission of the NATA Research and Education Foundation is to enhance the healthcare of the physically active through funding and support of research and education.