

ACL research retreat: the gender bias April 6–7, 2001

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1. Overview of the retreat

The first research retreat focused on the factors associated with the well-established gender bias seen in the incidence of anterior cruciate ligament (ACL) injuries was held at Kentucky Sports Medicine in Lexington, KY on April 6–7, 2001. The retreat was co-sponsored by Kentucky Sports Medicine and Joyner Sportsmedicine Institute and was attended by both clinicians and scientists with a common interest in ACL injuries. The 40-plus participants included registrants from across the US as well as Canada and Norway. The group consisted of physicians, physical therapists, athletic trainers, and scientists in the areas of biomechanics, motor control, and neuromuscular function. The objective of the retreat was to shed light on the factors contributing to the gender bias in ACL injuries through the presentation of research findings with the mission of developing a consensus regarding future research directions.

The format of the meeting included one keynote presentation each day along with 20 min podium presentations made by some of the participants. The keynote presenters were chosen for their scientific contribution to the understanding of factors associated with the gender bias seen in the incidence of ACL injuries. Scott Lephart, PhD, ATC from the University of Pittsburgh gave the first keynote titled “Gender differences in neuromuscular patterns and landing strategies”. The other keynote presenter was Tim Hewett, PhD from the University of Cincinnati whose talk was titled “Biomechanical issues related to the gender bias in ACL injuries”.

A scientific call for abstracts for the retreat was announced in the fall of 2000. All abstracts were then peer-reviewed for scientific merit and relevance to the retreat. In the end, 16 abstracts were accepted for podium presentations. These were grouped into sessions addressing

neuromuscular, biomechanical, hormonal and structural factors which may influence the gender bias in ACL injury incidence.

It was clear from all of the participants’ evaluations that while the science was excellent, the strength of this retreat was in the exchange of ideas that took place. The retreat format was designed with ample time for discussions. Following each keynote address, there was an hour long panel led discussion. In addition, a 30 min discussion followed each group of three papers. Once all of the papers addressing a particular factor were presented, the participants took part in constructing a consensus statement regarding that factor.

There was a general consensus that the cause of the gender bias seen in ACL injuries is multifactorial in nature and requires a multidisciplinary approach to the research process. In addition, it was agreed that while the seriousness of an ACL injury is high, the incidence is relatively low compared to other lower extremity injuries seen in athletes. Therefore, multicenter studies are needed in order to develop a research design with adequate statistical power. It was also generally agreed upon that lumbopelvic (or core) stability plays an important role in controlling the knee, as well as the entire lower extremity. This may explain, in part, the significantly lower gender bias in ACL injuries seen in gymnasts whose sport requires a stable trunk and a high level of neuromuscular control and balance. Finally, it was agreed that, if the long term goal was to reduce the rate of ACL injuries in these athletes, that research needed to be focused on those factors that are known to be modifiable.

In summary, all agreed that this research retreat provided a unique opportunity for clinicians and scientists from a variety of disciplines and geographical regions to come together to discuss the current and future research focused on the gender bias reported in ACL injuries. Much enthusiasm was generated for another research retreat with this focus, possibly to be held in 2 years.

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2. Consensus statement

The participants of the ACL research retreat have developed the following consensus regarding factors influencing the gender bias in ACL injuries. Each factor has been subdivided into:

What we know – based upon the research presented at the retreat as well as other relevant literature

What is still unknown – based upon what is currently lacking in the literature

Where do we need to go – provides a direction for future research based upon what is currently lacking in the literature.

2.1. Neuromuscular factors

What we know

- Females are weaker when strength adjusted for body weight
- Females have diminished proprioception
- Females demonstrate a quadriceps activation preference
- Females demonstrate decreased joint stiffness

What is still unknown

- How do neuromuscular factors relate to injury
- Are the factors modifiable
- Are the factors population specific in terms of athletes
- At what age do these gender differences emerge
- Is the male neuromuscular pattern necessary the optimal pattern for females
- How do factors such as postural control, lower extremity alignment and core stability influence dynamic control at the knee
- What is the best way to measure stiffness in vivo

Where do we need to go

- Prospective, multicenter, multifactorial studies to assess relationship between neuromuscular factors and injury
- Development of valid and reliable dynamic and functional test
- Studies involving multiple age groups and multiple athletic populations
- Do males who have sustained noncontact ACL injuries exhibit similar neuromuscular patterns as females

2.2. Biomechanical factors

What we know

- Females exhibit greater frontal plane motion of the knee
- Females exhibit greater frontal plane moments of the knee

Females land in less knee flexion during cutting and landing

What is still unknown

- Are knee and hip flexion strategies different between genders
- Are movement pattern differences related to social/cultural factors
- How does the core stability relate to abnormal knee mechanics and subsequent ACL injury
- Is rate of loading an important factor in ACL injury risk
- Are mechanisms of injury different between genders and sport
- How are lower extremity mechanics related to injury
- Is variability in movement patterns a protective mechanism for ACL injury
- How does the foot–ground interface influence ACL injury risk
- Are there clinical tests or measurements that can be used to predict potentially injurious loading patterns at the knee

Where do we need to go

- Develop more valid methods of kinematic measurements
- Develop functionally valid tests
- Prospective epidemiologic studies correlating strength, alignment and biomechanics with ACL injury across genders
- Develop biomechanical models so that factors can be manipulated with a level of control not possible in the laboratory setting
- Investigate the role of movement variability in ACL injury

2.3. Hormonal factors

What we know

- There are estrogen and progesterone receptors in the ACL ligament
- Increased estrogen leads to a decreased load to failure in an animal model
- Estrogen peaks at ovulation
- Time of ovulation is quite variable between women
- The effects of estrogen are modulated by proteins, binding globulins, and hormones in other, nonligamentous tissue

What is still unknown

- How do sex hormones and other proteins interact with each other across the phases
- Do sex hormones influence the neuromuscular system
- What effect does the birth control pill have on ACL laxity
- Does laxity increase the risk of ACL injury

What is the variability in response to sex hormones between individuals
Can cyclic hormonal change cause structural changes in ACL properties

Where do we need to go

Need more accurate recording of daily hormonal levels
More valid measures of joint stiffness
Effect of birth control pills and irregular menses on joint laxity
Basic research in the area of ligament remodeling
Assess the influence of sex hormones on ligaments other than the ACL
Understand the factors that modulate the effect of estrogen on the physical properties of the ACL

2.4. Structural factors

What we know

Smaller femoral notch widths are associated with increased risk of ACL injury regardless of gender
Methods of obtaining notch views and measures influence the results

Notch shape is not related to increased risk of ACL injury

Females do not have wider pelves

Q-angles are larger in females on average, however there is a large overlap in this measure between genders

What is still unknown

Is a smaller ligament associated with a smaller notch

Are ligaments scaled to body size

Is structural alignment of the lower extremity a factor in ACL injuries

Where do we need to go

Investigate the relationship between lower extremity structure and ACL injury across gender

Develop more reliable and valid techniques of structural measurements

Investigate the relationship between lower extremity structure and function

Identify clinical tests and measures that can be used to identify individuals at risk for ACL injury