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 Sportmedic 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 Leiphart, 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 land in less knee flexion during cutting and landing
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
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 pelvises
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