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ACL Injury In the Female Athlete— What Research Says and What You Can Do

Edited by Ken Kontor, Publisher

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Women who participate in jumping and pivoting sports, such as basketball, volleyball, and soccer, are up to eight times more likely to rupture the anterior cruciate ligament of the knee than are same-size men participating in these same sports, according to a study in the May 2003 issue of *The Journal of Bone and Joint Surgery*.

But a University of Michigan Health System study, presented at the annual meeting of the American Academy of Orthopedic Surgeons shows that female athletes may be at an even greater risk for a certain type of knee injury than their male counterparts due to the differences in the muscle structure around the knee.

"Knee muscles are capable of protecting ligaments and preventing injury," says Edward M. Wojtys M.D., professor of orthopedic surgery, U-M Medical School, and Director of Sports Medicine at UMHS. "Female athletes are two to eight times more likely to tear their anterior cruciate ligament because they may not be able to achieve the same muscle stiffness across the knee joint."

Wojtys calls the U-M study "one piece of the puzzle" in determining the differences between female and male athletes and, consequently, providing for the training and conditioning needs of female athletes in a safe and effective way.

Injury to the anterior cruciate ligament - the ligament behind the kneecap that connects the thigh bone to the shin bone and is responsible for knee stability - is common in athletes. The U-M study measured the muscle protection, or rotational knee stiffness, present in size- and sport-matched young males and females, to determine if females are more susceptible to anterior cruciate ligament injury. In addition to gender differences, the study looked at whether the types of sports the athletes played made a difference in knee stiffness.

In the study, researchers examined 24 NCAA Division I athletes - 12 males and 12 females - who compete in basketball, volleyball

and soccer. All three are "pivot" sports that, because of turning, twisting and jerking, put players at high risk for injury to the anterior cruciate ligament. Another 28 collegiate athletes - 14 males and 14 females - who participated in the "non-pivot" sports of cycling, running and crew also were examined.

Male-female pairs were matched for age, height, weight, body mass index, shoe size and activity level - making them all but equal except for gender.

Researchers used a device specifically designed for this study to measure the rotational motion of the knee when it was bent at 30 degrees and 60 degrees, both when the muscles were relaxed and when the muscles were contracted, or tensed. Knee stiffness, a gauge of joint stability and resistance to injury, was measured as a function of muscle contraction.

In both the pivoting and non-pivoting sports, males were shown to produce more knee stiffness and therefore, better protection against anterior cruciate ligament injury.

Results showed that, when an athlete's muscles went from a relaxed to a tensed state, knee stiffness increased by 258 percent for male athletes in pivoting sports and 171 percent for female athletes involved in pivoting sports. Male athletes in non-pivoting sports had an increase of 207 percent versus 198 percent for their female counterparts.

Wojtys expected the higher knee stiffness for males in pivoting sports compared to males in non-pivoting sports.

"The thought is, if you play jumping, turning, twisting sports, that you should be better prepared to protect your knee against rotational forces," Wojtys says.

That's why the measurements for the females involved in non-pivoting sports were surprising when compared to females in the pivoting sports. Females in non-pivoting sports had an increase in knee stiffness of 198 percent - 27 percent higher than the females in pivoting sports.

"Women who played jumping, turning,

twisting sports actually had the poorest ability to protect themselves against rotational strains," Wojtys says.

Wojtys says that male and female athletes are generally trained the same way. But based on his recent research and that of other researchers, that could be a big mistake.

"We may need to train female athletes differently," Wojtys says. "The long term scenario is to try to find rehabilitation and training tools that will specifically help female athletes because they seem to be more susceptible to this type of injury."

Co-authors on the study were James Ashton-Miller, Ph.D., distinguished research scientist, U-M Department of Engineering; Laura J. Huston, M.S., senior health science research associate, U-M Section of Orthopaedic Surgery; James P. Boylan, B.S.; and Harold J. Schock, B.S.

How to Prevent ACL Injury

This program is designed specifically for the female athlete. What is interesting is that most of the ACL injuries occur in non-contact situations. Many of these injuries occur when an athlete is landing or cutting, what is commonly called, receiving a load. This can occur in a variety of sport-specific skill activities. Once an athlete lands or plants, deceleration occurs. If the muscle is fatigued or in an uncompromised position during the action of receiving a load, the chance of injury increases. The intent of this program is to narrow the training gap and introduce athletic skills to women athletes at an early age. While this program focuses on ACL injury prevention, it is also appropriate in the prevention of other related leg injuries.

Prevention Principles

#1 Start Young- Start injury prevention conditioning to gain strength in muscle bone tendon and ligaments at an early training age. Most experts agree

that for the female athlete preventative training can start as early as later elementary-middle school ages. This differs from athlete to athlete.

#2 Learn Mechanics- Teach proper jumping, landing and change of direction mechanics to reduce the number of uncompromised positions the female athlete may find themselves in during practice and competition. Better balance will help in improving mechanics.

#3 Train in a Quality Environment-Since fatigue during training and competitions is unavoidable in most sports, coaches should be attentive to the environment of fatigue. Fatigued muscles will react slower providing a challenge to executing proper exercise technique. Injury prevention training presented in these training cards should be done when an athlete is fresh and recuperated. This ensures quality training. Ideally this program can be part of an overall warm-up at the start of practice. This is the best assurance that the athlete is not fatigued and ready to learn proper body mechanics. The exercises can also be done in the early morning allowing several hour of recuperation time before an afternoon practice. The can also be done on weekends that are free of practice or competitions.

#4 Build Strength-Stronger joints, tendons, ligaments and muscles in the lower body and core will potentially prevent or reduce the severity of injury. Being stronger will improve mechanics, balance. The strength goal of the young female athlete is to effectively control their own bodyweight.

Balance activities should be performed as an introduction to jumping and change of direction mechanics skill training. Balance is basic to any ground-based sport. Exercises challenging balance should be done during every phase of conditioning. Balance starts at the feet but uses the entire kinetic chain from knees, to hips, to torso and head. Working on balance improves kinesthetic awareness—knowing where the body is in relation to surrounding space. It will also improve muscle coordination and bilateral movement. Balance can be trained and practiced with little or no equipment. All athletes must master stationary balance skills before adding outside equipment. Athletes should perform balance drills when rested in order to improve technical skills. Here are sample exercises you can do following a three step progression.

Step One - Beginning Stationary, Standing

-One Leg: Hold for 30 seconds. Alternate legs.

-One Leg, Eyes Closed: Hold for 30 seconds. Alternate legs.

-One-Legged Ground Touches: With one leg extended, lower hips at the waist and with your heel, touch cones placed in front, diagonally forward and to the side while maintaining balance forward. Repeat with the opposite leg to the other side. Do 10 times each leg.

Step Two – Beginning to Intermediate Stationary,

Standing with a Ball and Partner

-One Leg: Play catch in all directions.

-One-Legged Squat Position: Play catch in all directions.

-One-Legged Side Toss: Rotate to each side.

Step Three - Intermediate to Advanced

Perform steps one and two on a balance pad, disc or board, or do balance beam exercises.

Balance Beam Exercises

On a 10-20 foot long balance beam perform the following exercises:

-Walk forward and backward, heel-toe across beam.

-Walk forward and backward, dipping down with each step.

- Lateral steps across beam, lead leg behind trail leg.

After balance the next issue the coach should address is jump mechanics and directional change.

Jumping Safety

DURING TRAINING

Warm-up: Do a complete warm-up.

Surface: Jumping exercises should be done on a semi-resilient surface. This includes well maintained natural and artificial grass; rubberized tracks, exercise mats and artificial turf are excellent surfaces. The surface should be level, dry and obstacle free.

Footwear: Shoes should provide good lateral stability, heel cushion, arch support, with non-slip soles.

Fatigue Factor: Do go beyond the point of moderate fatigue. Perfect technique must be maintained to gain maximal training effect and decrease the possibility of injury. Rest period between sets should allow for full recovery.

Jumping Mechanics

To learn how to jump properly and land it's important to understand the proper mechanics of the jump. The three contributing joints of the body are the hip, knee and ankle. Visually think of these joints as having three large rubber bands at the location of each joint the hip, knee and ankle. These rubber band increase in energy as they are tightened. As the athlete crouches down this puts the rubber bands (muscles) in a stretched position. This is how plyometrics work. The result is a stronger contraction or movement of the muscles that are a stretched the muscles crossing the hip, knee and ankle. The end game is an increase in the force into the ground which raises the center of gravity to the max. Here's the progression that takes

place:

1) Arm Swing - This action raises the center of gravity to the max before takeoff and then transfers the momentum to the entire body, thus increasing ground reaction force.

2) Trunk Extension - This is where the most power is generated. The muscles of the hip are the largest and strongest in the body. Therefore, they have the most impact on the height of the jump and proper jump mechanics.

3) Knee Extension - This area where most injury occurs. Its proper alignment with the feet and hips are critical.

4) Ankle Extension - Severs a minor role in jump mechanic force production.

Landing is the opposite sequence from the takeoff. The order is reversed starting sequentially with the ankle, knee and hip bending to absorb force. The takeoff is a chain reaction sequence where one segment begins decelerating as the next segment begins accelerating. Proper jumping technique is a result of effective movement in which the timing and coordination of the muscles accelerating and decelerating in the different segments of the body is sequenced properly. This must be taught and emphasized constantly, especially for the beginning young female athlete.

Learning Progression of Proper Change of Direction through Jumping Technique

Step 1

The task here is to get the feet in proper position to change direction in proper sequence. Start with learning proper jumping.

JUMPS IN PLACE: Use proper jump techniques as described.

TUCK JUMPS: Use proper jump techniques as described only on ascent bring the knees as close to the chest as possible. (Figure 1).



Figure 1

Step 2

The next progression is learning change of direction on flat surfaces.

PIVOTS:

-Feet/hips shoulder width toes slight ahead of the knee or slightly rotated out with feet under the knees.

-The back should be neutral and flat. The small of

the back should not be arched inward. This is done by tilting the pelvis forward to position. Stomach muscles tight.

-Head forward looking chest up.

-Pivot right to left on the balls of the feet, rotating at the hips leading with the hands. Then pivot left to right.

Step 3

The next progression is to add sprints to jumping and direction change activities

Step 4

While maintaining good jumps and change of direction mechanics, introduce sport-specific skills at game action speed work. Bring in sport-specific implements such as a ball. Perform the skill at the end of the sprint. You can be creative integrating sports skills that challenge the athlete.

Core and Leg Strength (CS) (LS)

The primary function of core strength is to maintain dynamic stability of the body's center of gravity. This is where all movement originates. Actions of the core include trunk flexion, extension, lateral flexion and rotation; also, hip flexion, extension, abduction (moving toward the midline of the body), adduction (moving away from the midline of the body), internal and external rotation. Leg strength is necessary to develop joint, tendon and ligament as well as muscle integrity to overcome potential situations where injury can occur during competition. Presented are exercises that combine all these motions and train the body as an integrated unit. To be functional for sports, the movements must be multi-plane to include diagonal and rotational patterns. Presented are three types of exercises—without equipment, with a physioball and with medicine balls.

No Equipment

The following exercises are separated by the major functions of the core and then categorized as beginner, intermediate or advanced.

- Beginner exercises should be selected early in a strength program and done at high repetitions (20-30) in a slow and controlled manner.

- Intermediate exercises should be selected during the strength phase of a strength program. They should be performed at a 2-0-1 tempo (2 seconds-hold-1 second).

- Advanced exercises are done at low repetitions (10-15) and should be performed in a fast, explosive manner.

Follow each category as a progression. Once mastered, move to the next level. Train one exercise from each major function category on a daily basis.

Trunk and Hip Flexion - Beginner

ABDOMINAL CRUNCHES: Lying supine (on the back), knees flexed to 90 degrees with feet planted on the ground, arms crossed over the chest. Contract upper abdominal muscles, lift shoulders off the ground, hold and slowly return to the

ground. (Figure 2).



Figure 2

Trunk and Hip Flexion - Intermediate

SEATED ROWS: Sit in an upright position, knees bent and feet off the ground. Straighten legs and lower torso toward the ground. When legs are straight and torso is approximately six inches off the ground, contract lower abdominal muscles and bring knees to chest. Raise torso to starting position. (Figure 3).



Figure 3

Trunk and Hip Flexion - Advanced

V-UPS: Start in a supine position with arms extended above head. With straight legs, flex hips to 90 degrees and lift your torso off the ground bringing the hands up meeting the feet in a V position. Return to ground in a controlled manner (Figure 4).



Figure 4

Trunk and Hip Extension - Beginner

SUPERMANS: Lying prone with hands out in front of the body about shoulder width apart, lift arms, head and feet off the ground and hold for a two count (Figure 5).



Figure 5

Trunk and Hip Extension - Intermediate

PRONE OPPOSITES: Same as Supermans only lift single arm and opposite leg. Repeat with the other arm and leg. Hold for a two count.

Trunk and Hip Lateral Flexion - Beginner

PILLAR BRIDGE: Using elbows for stabilization while lying on your side, hold the body in a flat, straight position. Emphasize a hips up, straight body position with only the feet and elbows touching the ground. Hold for 30 seconds and work toward one minute. Perform on each side (Figure 6).



Figure 6

Trunk and Hip Lateral Flexion - Intermediate

PILLAR SIDE TOUCHES: From the pillar bridge position, lower the buttocks to touch the ground and return to starting position. Let the muscles of the transverse (side) abdominal muscles do the work.

Trunk and Hip Rotation - Beginner

SIDE CRUNCH: Lie in supine position with legs bent 45 degrees. Hands are interlocked behind the head. Raise and rotate your torso so the opposite elbow rotates to the knee of the externally rotated leg in the up position. Reverse feet positions and repeat (Figure 7).



Figure 7

Trunk and Hip Rotation - Advanced

BICYCLES: Lying supine with knees and hips flexed at 90 degrees and hands interlocked behind the head, rotate your torso bringing elbow to touch opposite knee while extending the other leg into a straight position. This action is performed to each side in a bicycling motion (Figure 8).



Figure 8

Leg Strength

These exercises should be done using body weight only. Intermediate and advanced athletes can perform these exercises with a medicine ball, weighted vest and/or dumbbells.

SPLIT SQUAT:

- Feet parallel and slightly wider than shoulder-width and toes pointed out slightly with back flat and tight.

- Take one step forward. Keep the shin perpendicular to the ground. Try to keep the knee behind the toe and avoid the knee moving past the knee, as in the lung position.

- Keep the back flat and in neutral position. Knee almost, or slightly touches, the ground (Figure 9).



Figure 9

LATERAL LUNGE:

Start

•Stand with feet shoulder width apart.

Movement

- In a slow, controlled manner step sideways far enough to allow the knees to extend over but not beyond the toes.
- Trail leg remains straight with ball of the foot or heel in contact with the floor. Be sure to be in a deep stretched position.
- Accelerate out of the deep position by pushing off the trail leg.
- Alternate ball of foot, heel position with each repetition. Repeat with the other leg (Figure 10).



Figure 10

Equipment: Medicine Balls

Getting Started

Programs should begin using basketball, soccer or volleyball to insure correct technique, then move to medicine balls. As the core becomes stronger, progress from strength to power development. This is accomplished by increasing weight of the ball and changing speed of movement from slow to fast.

To strengthen the torso, medicine ball exercises emphasize flexion, extension, rotation, chopping, throws and catches. The following provides information about functional warm-up, individual exercises, partner work and power exercises.

Individual Exercises

LEG RAISES: On your back, squeeze medicine ball between feet and lift it so the hips are flexed to 90 degrees (Figure 11).



Figure 11

DIAGONAL LEG RAISES: Turn hips at a 45-degree angle to the side. Alternate from side to side.

Emphasize these exercises during the strength phase.

ONE LEGGED CATCHES: Partner stands five feet away and throws ball to one side of athlete, who is standing to the side on one leg. Athlete catches the ball, stabilizes, rotates, and then throws back to partner. Repeat with opposite leg and receive from both sides.

MEDICINE BALL SIT-UP THROWS: Partner stands three feet away and throws medicine ball to athlete who is in an upright, sit-up position. Athlete controls the ball, performs a sit-up with the ball overhead and comes up forcefully throwing the ball back to partner (Figure 12).

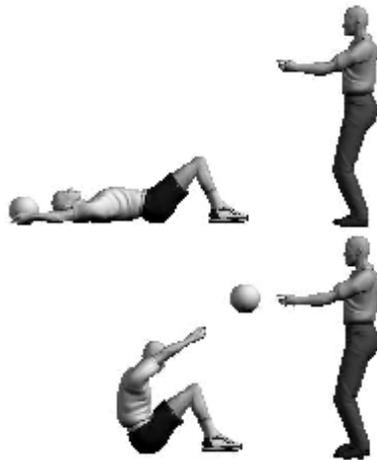


Figure 12

SQUAT: With ball at the chest, perform a parallel squat. As an option press ball above head and return to starting position (Figure 13).



Figure 13

LUNGE TO PRESS OVERHEAD: With ball at the chest, perform a lunge pressing the ball above head and return to starting position (Figure 14).

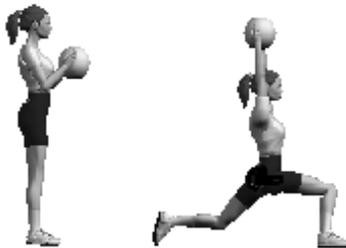


Figure 14

STIFF SINGLE LEG DEADLIFT:

- Hold medicine ball or weighted object at chest level. The back is straight, knees only slightly bent.

- Bending at the waist and on one leg. Bring the weighted object to a point just touching the ground.
- Front leg knee is slightly bent the opposite leg extend backwards to aid in maintaining balance. Repeat the other side (Figure 15).

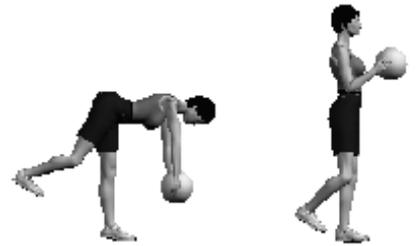


Figure 15

Medicine Ball Power

Emphasize these exercises to develop power.

THROW DOWNS: Holding the ball with both hands, take it directly behind the head and forcefully throw it directly down to the ground. Force of the throw down should be strong enough to elevate feet off the ground. Catch the bouncing ball and repeat quickly (Figure 16).



Figure 16

FEET PICK UPS: With feet on each side of a medicine ball, flex knees and hips performing a tuck jump. Lift the ball off the ground and catch it in the hands (Figure 17).

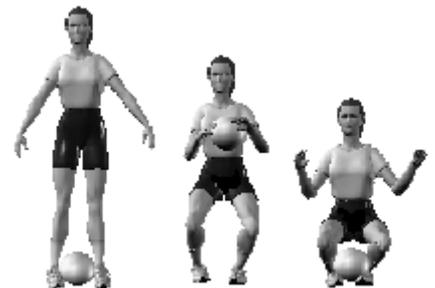


Figure 17