Current Issues in Sports Medicine:
The Knee

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The knee is often the weakest link that defines and limits an athlete's total competitive capacity. The knee is needed for speed, power and strength but is also vulnerable to injury. A knee injury not only means missing practice or competition but may also lead to the loss of scholarship support and potential professional opportunities. Extensive research of the knee, and improved diagnostic, rehabilitation, and surgical methods have brought new hope to athletes and clinicians dealing with the challenges of the injured knee. Two such challenges affected by our improved understanding of the knee are anterior knee pain and anterior cruciate ligament tears in female athletes.

Anterior Knee Pain

The exact cause of anterior knee pain is unknown but frequently debated. All agree that the condition is considered difficult to treat. Most interventions for anterior knee pain are based on one of two popular theories: chondromalacia of the cartilage behind the patella, and malalignment between the patella and femur.

Chondromalacia in the context of anterior knee pain refers to softening and degradation of retropatellar cartilage. Chondromalacia is so commonly considered the cause of anterior knee pain that the word is often used as a synonym for anterior knee pain. "That athlete has chondro."

Articular cartilage between the patella and femur, the thickest in the body, allows almost friction free motion between the adjacent surfaces. Chondromalacia theory says that anterior knee pain occurs when the cartilage is softened or degraded resulting in increased friction and shear forces. Physical therapy for chondromalacia is directed at improving strength of the quadriceps using positions that minimize compression to the patellofemoral joint, such as terminal knee extension.

Rehabilitation to correct chondromalacia has not been shown to provide long-term relief from anterior knee pain. This lack of effect is consistent with what we know about articular cartilage, which does not have nerve endings and therefore cannot be a source of pain. The absence of pain receptors in knee cartilage was confirmed in an unusual experiment carried out on orthopedic surgeon Scott Dye, MD, who reported no sensation during direct probing, without anesthesia, of the cartilage behind his patella.[7]

The presence or absence of chondromalacia does not predict whether someone does or does not have anterior knee pain. Many individuals with advanced chondromalacia do not have anterior knee pain, and many individuals with anterior knee pain do not have chondromalacia.[7]

Malalignment theory proposes that the patella is somehow skewed or is located too far to one side within the femoral trochlea, causing excessive compression and pain. A number of therapies aimed at correcting malalignment have been developed, including:

- using braces or tape applied to the skin to hold the patella in a corrected position
- Selective muscle training exercises aimed at changing the relative position of the patella, specifically targeting the vastus medialis oblique
- specific muscle training exercises aimed at changing the relative position of the femur

Like chondromalacia, patellar alignment or malalignment does not predict whether an individual will experience anterior knee pain,[2,8,6] and statistical evidence to support the long-term benefit of non-surgical treatments for patellar malalignment is limited and inconclusive.[4] Considering that neither chondromalacia nor patellar malalignment are sufficient to cause anterior knee pain alone, we suggest that anterior knee pain results from a plurality of causes, including chondromalacia, patellar tracking disorders, and specific quadriceps eccentric muscular strength deficits, which must be evaluated while the knee is in motion.

Anatomy books describe the primary function of the quadriceps as extending the knee. However, when we are standing and walking the quadriceps primary function is to eccentrically control knee flexion, thus allowing the calf muscles to become the primary knee extensors in gait. Treating anterior knee pain with eccentric muscle strengthening was described by Bennet and Stauber 1986. They noticed that in some individuals with anterior knee pain, the amount of torque produced around the knee joint by the quadriceps muscles during eccentric contraction was abnormal in its relationship to the quadriceps concentric contraction torque.[1] Depending on the tested speed, the expected relationship of eccentric torque is 130% to 300% of concentric torque. Bennet and Stauber's torque measurements of affected knees revealed deficient eccentric torque. Bennet and Stauber also found that a computer-controlled isokinetic dynamometer (KIN-COM) could be used effectively to retrain the quadriceps and restore eccentric torque and torque curves to normal. Most patients' pain was relieved within two to four weeks of KIN-COM training three times per week.

Correcting abnormal eccentric muscular strength profiles does not require expensive computer dynamometers. Resistance forces required for strength training can be provided manually by the physical therapist and by gravity. When gravity is used, a progression of partial step downs can furnish the correct level of muscular challenge at each stage of rehabilitation. In addition to quadriceps strengthening, he partial step down allows for corrective strengthening of the dysfunctional hip and ankle by changing the position of the upper body and trunk relative to the knee. With the trunk leaning forward, as ascending a hill, part of the knee extensor load is shared between the quadriceps and gluteals. With the trunk leaning back, as descending a hill, the contribution of the gluteal muscles is reduced. The ankle muscles can be strengthened by adding rotational forces to the partial step down. The myriad of variations to the partial step down enables the therapist to design an individualized exercise program providing significant functional carry over to the athlete's sport.

Regardless of whether isokinetic resistance or other means are used, treatment designs for each patient must consider the specific causes and location of his or her anterior knee pain. Ficat and Hungerford reported the contact area between the patella and femur moves from distal to proximal and increases in size from 2.0 cm at 30-degrees, to 3.1 cm at 60-degrees, to 4.7 cm at 90-degrees of flexion. In near full knee extension, the contact area is at the inferior aspect of the patella. At 90-degrees of knee flexion the contact area moves to the middle portion of the patella. At 135-degrees of flexion the contact area is near the superior pole of the patella and its odd facet. Specific evaluation and compression of the patellofemoral joint can determine where the lesion is located on the patella or femur and whether excessive compression is the actual provocation of anterior knee pain. Therapeutic strengthening then can be accomplished while protecting a specific patellofemoral contact area.

The enigma of anterior knee pain has been refractory to solutions designed to address singular etiologies. Treatments that acknowledge that anterior knee pain arises from multiple causes and occurs on different aspects of the patellofemoral joint, and utilize multi-pronged rehabilitation strategies, offer the greatest likelihood of returning patients and athletes to their pre-symptom state.

Anterior Cruciate Ligament Tears in Female Athletes

An unintended consequence of the increase in sports participation by girls and young women over the past thirty years has been an extraordinary rise in the incidence of anterior cruciate ligament (ACL) injuries in young female athletes. At the college level, one in ten young female athletes participating in sports such as soccer, volleyball, and basketball will suffer an ACL injury. This equals more than 10,000 knee injuries per year. A widely cited 1985 study found that at the high school level, the knee injury rate for female athletes was 3.76 times great than male athletes. In 1983, sports medicine researchers determined that four-fifths of ACL injuries are non-contact injuries, that is, they are caused by the athlete's own motions rather than collisions with other players. To the researchers, this finding meant that the high incidence of ACL tears in young female athletes might be greatly reduced if those motions could be identified and avoided.

The ACL is one of four major ligaments that connect the upper and lower leg at the knee. The ACL provides joint stability in all three planes and supports cutting and pivoting motions. Oftentimes, the ACL will tear with a "pop" that can be heard by spectators and other players. Pain and immediate swelling follow. ACL tears require surgical reconstruction using tendon grafts from other areas of the knee or from cadavers, followed by a long period of rehabilitation.

The frequency and seriousness of ACL tears in young female athletes has led to research studies aimed at understanding the problem. These studies are now yielding valuable data. Three major hypotheses to account for the higher number of ACL tears in female athletes versus male athletes have been examined: hormonal differences causing laxity of the female athlete's ACL, a smaller and more narrow intercondylar notch for the female athlete's ACL, and sex-based differences in lower extremity strength and neuromuscular control.

The last of these three hypotheses is receiving the most scientific support from study data. Certain aspects of lower extremity strength and coordination can be captured and measured by videotaping athletes while they perform athletic movements in the research lab. While video recordings do not capture complex three-dimensional movements and the rotational stresses that these movements place upon the knees, the recordings do enable researchers to make close measurements of joint and limb positions in a single plane. These measurements were found to have predictive value.

Hewett et al, in their well-designed study of 205 young female athletes, found that athletes with greater valgus posturing of their lower extremities during jump and landing movements were more likely to suffer ACL injury than athletes with more "neutral," or straighter lower extremity alignment. This valgus alignment can be seen by analyzing the angles formed between the ankles, knees, and hips when the athlete lands from a jump off a small box and when she jumps vertically from a crouched position. A separate study that included videographic analysis of 325 young female athletes showed that a six-week neuromuscular training program corrected the lower limb valgus alignment associated with injury during jump landing and takeoff.

Muscular strength training is a well-accepted and valuable aspect of knee rehabilitation following ACL repair surgery. Muscular strength stabilizes the knee by helping to maintain the correct relative positions of knee structures and tightens ligaments *via* muscle attachments during sports movements. Muscular strength also enables muscles in the legs to absorb forces that would otherwise subject the joint to potential injury. Despite these compelling benefits, new research tells us that muscular strength training, though necessary, cannot comprise complete rehabilitation. Physical therapists familiar with the newer studies realize that rehabilitation from ACL injury must, in addition to conventional strength training treatment methods, include specific neuromuscular training aimed at improving the athlete's ability to avoid valgus alignment of the lower extremities during high-risk sports. *It is no longer acceptable to reconstruct the ACL but leave neuromuscular control deficient.*

Creating a rehabilitation program to retrain athletes' neuromuscular control must consider multiple factors. It requires the clinician to determine the mechanism of injury, reactivity of the athlete's symptoms, the stage of healing of the injured body part and match those factors with the appropriate therapeutic treatment and dosage. One must be aware of and take into account the recovery time lines of different soft tissues across their inflammatory phase, reparative phase and remodeling phases of healing. It is imperative that the clinician apply sufficient stress to the recovering tissue to promote full restoration of its strength but not exceed its capacity as it is healing.

Modeled after Hewitt's successful program, the jump strength training program at Physical Therapy of Los Gatos is an element of the rehabilitation process for patients recovering from injury and surgical reconstruction of the ACL, as well as a standalone performance improvement module. The program includes jump analysis, education, strength training and neuromuscular control designed to improve balance, power and acceleration. The neuromuscular training component includes visual, auditory and proprioceptive facilitation to train athletes to use muscular strength to absorb jump impacts in a controlled fashion and to correct the lower extremity's alignment when jumping, landing, and pivoting in order to avoid forces associated with injury.