Lower Extremity Review
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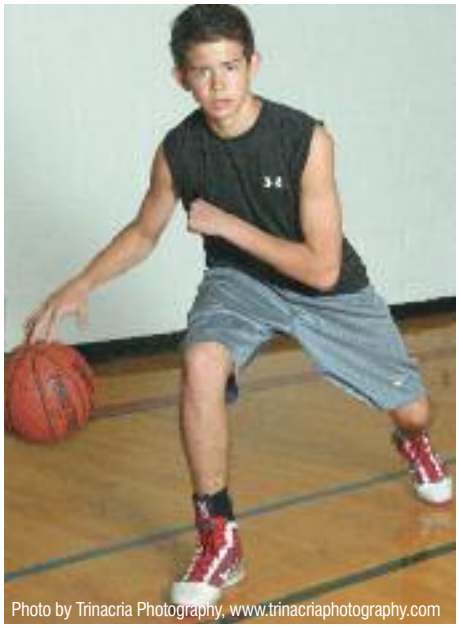
DEFENSIVE GAME PLANNING
Global insights on sports injury prevention

Multinational all-star teams of sports medicine experts convened in Monaco in April for the World Conference on Prevention of Injury & Illness in Sport, now under the direction of the International Olympic Committee. LER's exclusive coverage of this event details clinical and scientific progress toward prevention of lower extremity injuries in sports including basketball, soccer, volleyball, running, and ice hockey.

By Jordana Bieze Foster

Lace-up ankle braces reduce risk of sprain in basketball players regardless of history

Findings contrast with prior reports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Lace-up ankle braces can significantly reduce the risk of ankle sprain in high school basketball players, even those with no history of injury, according to findings from Wisconsin that challenge current evidence-based thinking about prophylactic ankle bracing.

In a cluster randomized controlled trial, researchers from the University of Wisconsin in Madison studied ankle injury incidence in 1440 male and female high school basketball players, of whom half were randomized to wear a lace-up ankle brace during a single season. All players wore similar mid-top style shoes. An ankle sprain injury was defined as one that led the athlete to cease sports participation for that day and also miss the next day of practice or competition.

Ankle sprain injuries occurred in 3.6% of players in the braced group, compared to 11% of players in the control group. Overall, the ankle sprain rate was 0.47 per 1000 exposures in the braced players and 1.41 per 1000 exposures in the unbraced players. This difference was consistent regardless of whether players had a history of ankle sprain injury (0.83 vs 1.79 per 1000 exposures) or no history of injury (0.40 vs 1.35 per 1000 exposures).

Because athletes with a previous history of ankle sprain tend to have significantly more instability than those with no similar history, the findings may suggest that mechanical resistance to inversion may not be the primary mechanism by which lace-up bracing prevents injury.

"I used to believe there was a mechanical effect of ankle bracing. Now I'm starting to think there's more of a neuromuscular effect," said Tim McGuine, PhD, ATC, senior athletic trainer and research coordinator at the university, who presented the findings in Monaco in April.

Most previous studies of prophylactic ankle bracing in sports—and in basketball in particular—have found interventions to be more effective in athletes with a previous history of injury than those without, which makes sense intuitively given that history of prior ankle sprain is itself a risk factor for incident sprain. However, those studies involved rigid or semi-rigid bracing rather than lace-up devices.

For example, in a 1994 study in the *American Journal of Sports Medicine*, a study of intramural basketball players at West Point found that a semirigid brace was associated with significantly lower injury rates in braced than unbraced athletes overall (1.6 vs 5.2 per 1000 athlete exposures) but that the effect was more dramatic in those with a history of injury (1.4 vs 8.0 per 1000 athlete exposures).

Similarly, a 2007 prospective cohort study of female Greek professional basketball players published in the *Journal of Athletic Training* found that unbraced athletes were 2.5 times more likely to be injured than braced athletes overall, but four times more likely if they had a previous history of injury.

One recent study in high school volleyball players actually came to the opposite conclusion, finding that rigid or semi-rigid bracing was associated with reduced injury risk only in athletes with no history of injury (see "Net gain for ankle bracing," May 2010, page 11). That study, published in the April 2010 issue of *Foot & Ankle International*, did randomize one group of players to wear a nonrigid ankle brace, but no effect of bracing on injury risk was seen in that group regardless of injury history.

Postural stability decreases with taping but not bracing in Gaelic football study

Athletes concerned about dynamic postural stability, such as those with a history of ankle sprain, may be better off with ankle bracing than taping, according to an Irish study presented in Monaco in April.

In a study of 15 male Gaelic football players with no history of ankle injury, investigators from University College Dublin found that dynamic postural stability index scores were significantly higher (indicating less postural stability) when subjects' ankles were taped than when they wore a lace-up ankle brace or no brace. The DPSI was calculated as subjects performed single leg drop landings from a 40-cm step onto a force plate. The three ankle support conditions were tested in random order.


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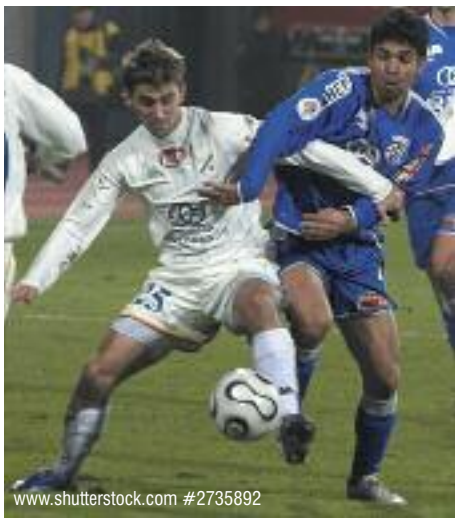
DPSI did not differ significantly between braced and unbraced (control) conditions. This finding is consistent with those of a 2006 *Journal of Athletic Training* study from the University of Florida, which found that neither a lace-up brace nor a semirigid brace significantly affected DPSI in 28 subjects with functional ankle instability. The 2006 study did find that both braces improved postural stability in the vertical direction specifically, suggesting that ankle braces may play a role in attenuating vertical forces during jump landings even if they do not directly affect dynamic postural stability.

Data support use of multimodal approach for decreasing incidence of groin injuries

Specific mechanisms remain unclear



Multimodal warm-up exercise programs appear to have benefits for reducing the incidence of groin injuries in athletes, but researchers are working to identify which specific training components have the greatest effect.

Almost an afterthought at the 2008 sports injury prevention congress in Tromso, the topic of groin injury prevention was deemed worthy of a three-hour symposium in Monaco just three years later. Presenters from Copenhagen and Santa Monica, CA, reported on the results of two similarly conceived exercise prevention programs implemented in elite soccer players.

"We need to address dynamic stability and address faulty biomechanics of the pelvis and core," said Holly Silvers, PT, PhD, project coordinator for the Santa Monica Orthopedic Sports Medicine/Research Foundation.

In a study published in the December issue of the *Scandinavian Journal of Medicine & Science in Sports*, researchers from Copenhagen University Hospital randomized 27 of 55 soccer teams to perform an six-exercise intervention focused on pelvic strengthening, coordination, and core stability. The six exercises included: supine adduction with a soccer ball between the feet or the knees, simultaneous abdominal situps and hip flexion with a ball between the knees, "cross-country skiing" on one leg, partner-based abduction/adduction while seated, and iliopsoas stretches.

The incidence of groin injury was 31% lower in the group that performed the intervention than in the control group, but that difference was not statistically significant. More than four times as many subjects would have been required for that finding to have been significant, said lead author Per Holmich, MD, an associate research professor of anatomy and orthopedic surgery at the university, who presented the findings in Monaco.

The gods of statistical significance were a bit more generous with Silvers and colleagues, best known for the PEP anterior cruciate ligament injury prevention program, as they tested the effectiveness of a similar program designed to prevent groin injuries.

Like the PEP program, the Santa Monica groin prevention program started with a dynamic warm-up of running and shuttle drills. Players then performed strengthening exercises including supine ball rotations, bridges, side planks, and lateral adductor exercises with abduction of the contralateral leg. Cool down involved static stretching.

During a single season, the incidence of groin injuries in the 106 Major League Soccer players who performed the intervention was 28% lower than in the 209 players in a control group, a statistically significant difference. However, the incidence of groin injuries requiring surgery did not differ between groups.

Though it is difficult to tease out the benefits of specific components of a multimodal exercise program, a more focused study from the Copenhagen group may help. In a randomized controlled trial, researchers are studying the effects of a single elastic band-based adductor strengthening exercise (performed concentrically, isometrically, and concentrically) after eight weeks of training in sub-elite Danish soccer players. Preliminary results, which have not been analyzed for statistical significance, suggest improvements of 15% to 30% in isometric and eccentric muscle strength, according to graduate student Kristian Thorborg, PhD, who described the protocol in Monaco. Whether those improvements translate into reduced injury risk may be a topic for the next international sports injury prevention conference in 2014.

Screening has benefit, but Philippon calls for more action to save hips in hockey

His research group has identified three physical exam findings that can effectively screen for risk of femoral acetabular impingement in adolescent hockey players, but the world's most famous hip surgeon thinks more drastic preventive measures may be warranted much earlier in a young player's career.

Marc Philippon, MD, a partner at the Steadman Philippon Research Institute in Vail, CO, was in Monaco to present his group's findings on the use of physical exam tests to screen for risk of FAI in 18 asymptomatic Major Midget hockey players (average age 17.1). The 12 players with positive scores on the FABER (flexion, abduction, external rotation) and impingement tests and with decreased internal rotation were 15 times more likely than the remaining players to have an alpha angle greater than 64° as measured on MRI.

But, noting the high percentage of players with alpha angle values that many would consider a clinically significant indicator of FAI—not to mention that two players (both goalies) were excluded from the study because they had already undergone bilateral arthroscopic FAI surgery—Philippon suggested that prevention efforts should focus on the risk to young ice hockey players of intense skating before their physes have closed.

"We have to determine if ice time at a young age is related to alpha angle," he said. "It may be that, like we do with pitch counts in baseball, we need to limit ice time in young hockey players."

Volleyball findings link training volume to symptoms of patellar tendinopathy

Jumping ability not implicated

Hard work can make up for a lack of natural talent in sports, but research from Norway suggests that may not be true when it comes to the risk of patellar tendinopathy (jumper's knee) in young volleyball players.

In two separate studies of junior high school volleyball players presented in Monaco in April, investigators from the Oslo Sports Trauma Research Center found that high sport-specific training loads were associated with increased risk of patellar tendinopathy but that baseline jumping ability was not.

Both studies utilized data from a single Patellar Tendinopathy Cohort analyzed over a five-year period. The training study prospectively followed 140 male and female athletes for a mean of 1.8 years; all were asymptomatic at baseline but 28 went on to develop symptoms of patellar tendinopathy. Training volume was determined from an internet-based weekly training diary as well as interviews with players and coaches.

Athletes who developed jumper's knee spent significantly more hours per week in training than those who remained asymptomatic, with indoor volleyball training accounting for most of that difference. Volumes of strength, flexibility, and other types of training did not differ significantly between groups.

The findings are generally consistent with those of a 2004 *American Journal of Sports Medicine* study from the same group, in which high-level male volleyball players with existing symptoms of patellar tendinopathy reported training for more hours per week than asymptomatic players. However, in that study, strength training accounted for the only statistically significant component of that difference. And because the players were already symptomatic at baseline, it's possible that the difference simply reflects the fact that weight training was less painful than volleyball-specific training or jump training.

The jumping ability study prospectively followed 113 male and female athletes for the same mean length of time in as the previous study; 19 went on to develop symptoms of jumper's knee, but only three were girls, so the analysis focused on male athletes only. Standing jump height and countermovement jump height was assessed at baseline and twice a year during the study period.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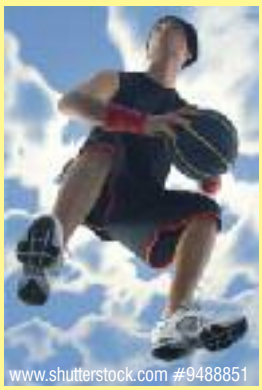
Jumping ability at baseline was not significantly different in those who became symptomatic and those who did not, with respect to either jump test. However, although jumping improved in both groups, those who remained asymptomatic demonstrated significantly greater improvements on both jump tests.

The jumping ability findings appear to contrast with those of the 2004 study, in which the players with patellar tendinopathy had significantly higher composite jump scores than the asymptomatic players. The authors designed the composite jump score to reflect a player's ability to load the extensor muscles, and theorized that the observed differences suggest that players with patellar tendinopathy may be subjected to higher loads.

It may also be worth noting that the composite jump score was based on a rating system in which each individual test result was assigned a score according to its position relative to the highest and lowest scores among all players' results for that test. But in terms of jump heights for each specific test, there were no statistically significant differences between the symptomatic and asymptomatic groups.

Soccer, basketball athletes demonstrate differences in plantar pressure patterns

Dynamic plantar pressure distributions vary between soccer and basketball players in ways that may have implications for preventing injuries related to repetitive loading, according to research from Spain presented in Monaco in April.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Investigators from Catholic University San Antonio in Murcia, Spain, analyzed dynamic plantar pressures in 72 elite male athletes, 40 soccer players and 32 soccer players. Pressure maps were subdivided into nine anatomical regions, and the regions associated with highest and lowest plantar pressure values were identified.

Peak plantar pressures for athletes from both sports occurred most frequently in the central forefoot (50% of each sport group) followed by the hallux (25% of each group). However, 20% of soccer players had peak pressures in the medial forefoot, compared to just one basketball player.

The lateral arch was most often the site of the lowest pressure areas for athletes from both sports, but more so for soccer players (58%) than basketball players (50%). The lowest pressures were seen in the medial arch in 14 soccer players (35%) and 13 basketball players (41%). And the lateral heel was more likely to experience the lowest pressures in basketball players than in soccer players (12.5% vs 5%).

Although the assessments were not sport-specific, the findings suggest a trend toward more medial loading in soccer players than in basketball players.

Hamstring trial confirms effectiveness of eccentric strengthening exercises

Efforts focus on soccer players

Norway and Denmark are traditionally rivals in soccer. But an increasingly popular Norwegian eccentric strength training technique for preventing hamstring injuries recently got a big assist from Danish researchers.

An open cluster randomized controlled trial of 50 elite male Danish soccer teams found that players who performed so-called Nordic hamstring lowers exercises during preseason training were three times less likely than those in a control group to suffer a hamstring injury during the season that followed. The results were particularly striking with respect to recurrent injuries, which were more than seven times less likely to occur in the intervention group than in the controls.

Nordic hamstring lowers are partner exercises in which one athlete starts from an elevated kneeling position and then lowers (and raises) his or her body without flexing at the hips, while the other athlete holds the feet of the kneeling partner to provide an anchor. Nordic hamstring lowers made their literature debut in the October 2004 issue of the *Scandinavian Journal of Medicine & Science in Sports*, in a Norwegian study demonstrating that the exercises were more effective than conventional hamstring curls for improving maximal eccentric hamstring strength.

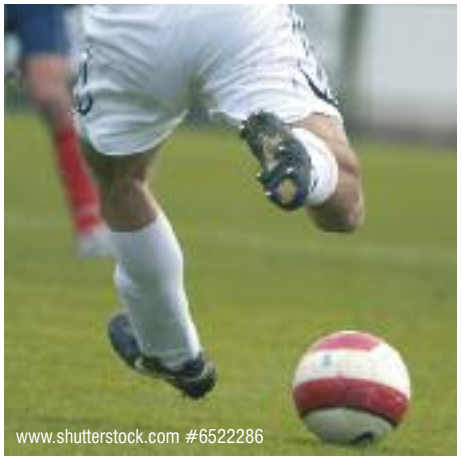
But in recent years, as hamstring injuries in soccer have become as serious an issue as ankle sprains, researchers' interest in the Nordic lowers has been increasingly proactive. Hamstring injuries have now been in the spotlight for the last two international conferences on sports injury prevention.

In Tromso in 2008, researchers from the Oslo Sports Trauma Research Center presented the results of a four-season intervention in which the same eccentric strength training exercises were associated with a 65% lower incidence of hamstring injury than a flexibility training program. But that study, which was published in the February 2008 issue of *SJMSS*, was not randomized; the "control" group consisted of teams that opted out of the intervention program.

That's why the 2008 study was not included in a January 2010 Cochrane review of interventions for preventing hamstring injuries, which concluded that there was insufficient evidence to draw conclusions about the effectiveness of interventions including hamstring strengthening protocols. That analysis included only four randomized controlled trials involving 287 subjects.

Although it is not yet published, the 942-player Danish study presented in Monaco in April would seem to help fill that void. In that study, the 10-week eccentric strength training protocol began with one session the first week, then progressed to two sessions the second week and three sessions in weeks three through 10, with numbers of sets and repetitions gradually increasing over time. After the start of the season, players in the intervention group continued to perform the exercises once a week.

Clinicians should be aware that some



degree of temporary delayed onset muscle soreness is to be expected in athletes who perform Nordic lowers without previous eccentric training experience, according to Jesper Petersen, MD, PhD, a physician in the department of orthopedic surgery at Amager Hospital in Copenhagen, who presented the findings in Monaco. For this reason, Petersen said, timing needs to be considered when introducing athletes to this type of exercise.

"I wouldn't recommend using this type of protocol during the season," Petersen said. "I would recommend doing it in a progressive way during the preseason."

Kinetic testing variables fail to predict which novice runners will stay healthy

Kinetic variables, including impact peaks, do not predict risk of running related lower extremity injury in novice runners, according to research from the Netherlands.

Investigators from University Medical Center Groningen prospectively analyzed kinetics in 181 novice recreational runners (mean BMI of 25) as they ran on an instrumented treadmill during a testing session, prior to initiating a nine-week running training program. The training required subjects to run three times per week, gradually increasing their mileage over time.

Running related injuries, defined as three consecutive training sessions of pain resulting in an inability to run, were self-reported by 37 subjects. Injured subjects did not differ significantly from uninjured subjects with regard to any kinetic variables, including impact peak force, active peak force, or loading rate.

The findings, presented in Monaco in April, contrast with those of a study presented in August at the American Society of Biomechanics meeting, in which baseline kinetics of experienced female runners differed between those who went on to sustain an injury and those who did not (see "Impacts spell injury," September, page 11). Baseline levels of peak tibial shock, vertical impact peak, and vertical average load rate were all significantly higher in the runners who were subsequently injured.

Tibial internal rotation emerges as theme in debate over mechanism of ACL rupture

Valgus may play supporting role

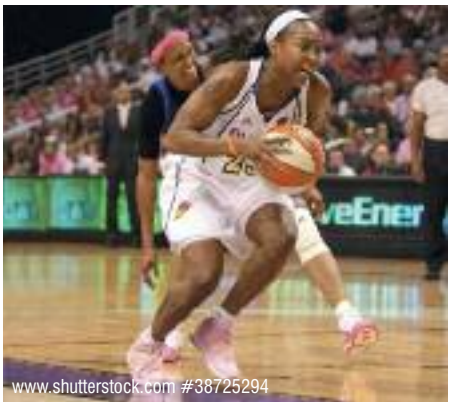
The usual luminaries were on hand in Monaco to exchange familiar barbs over the relative contributions of knee valgus and knee flexion to anterior cruciate ligament injury, but much of the new research being presented suggests that other kinematic variables may play significant roles as well.

One emerging theme is the importance of tibial internal rotation. Tibial IR is a key component of the complex injury mechanism proposed by researchers from the Oslo Sports Trauma Research Center in a November *American Journal of Sports Medicine* study based on model-based image-matching technology. Hideyuki Koga, MD, PhD, a researcher from the Tokyo Medical and Dental University who recently completed a stint as a guest researcher in Oslo, presented the study results in Monaco.

Computer models were created based on video images of 10 ACL injuries that occurred in female handball and basketball players. Analysis of the models revealed that injury consistently occurred within 40 msec of initial contact, and that those 40 msec were characterized by valgus motion and tibial internal rotation; however, the direction of tibial rotation reversed after ligament rupture. This may explain why video often appears to show tibial external rotation in conjunction with ACL injury even though tibial ER does not increase ACL strain in cadaver studies.

The mechanism suggested by the findings, Koga said, starts with valgus loading, which tightens the medial collateral ligament and increases lateral tibiofemoral compression. This compressive load leads to posterior displacement of the lateral femoral condyle, anterior tibial translation, and tibial internal rotation—a combination that results in ACL rupture.

A case study from the same group, published in the May issue of the *Clinical Journal of Sports Medicine*, confirmed using more advanced MBIM techniques that valgus and internal rotation occur within 30 msec after initial contact, and that anterior tibial translation occurs between 20 msec and 30 msec after initial contact.



"Valgus and internal rotation are important," Koga said. "But anterior tibial translation is also an important factor."

A sophisticated cadaver study from the University of Michigan also identifies tibial internal rotation torque as a significant contributor to ACL injury, in this case considerably more so than knee valgus moment.

Researchers subjected the tibias of 12 cadaveric knees to compound test loads, which included a compression load and flexion moment combined with either an internal tibial torque or a valgus knee moment. The cadaver experiment was designed to simulate a one-foot jump landing.

Normalized peak anteromedial ACL relative strain increased by 30% when subjected to knee valgus loading, but increased by 117% in the presence of internally directed tibial torque, according to Edward Wojtys, MD, professor of orthopaedic surgery and chief of sports medicine at the university, who presented the findings in Monaco.

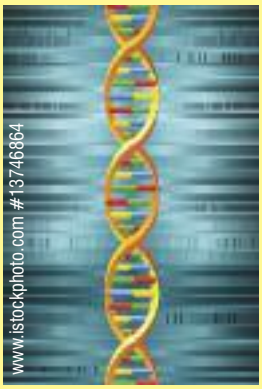
"When valgus was combined with tibial internal rotation, there was no additional increase in ACL strain," Wojtys said. "So it's mostly internal rotation, not valgus, that's involved."

Researchers from the Steadman Philippon Research Institute in Vail, CO, also challenged the idea that knee valgus angles or moments contribute to anterior tibial translation during landing.

The investigators analyzed 15 healthy female athletes during drop landings, using motion capture and inverse dynamics to calculate valgus angles and moments and high speed biplane fluoroscopy to measure tibial translation. They found that neither knee valgus angles nor knee abduction moments were significantly associated with peak anterior tibial translation or lateral tibial translation.

Researchers make early progress toward understanding genetics of sports injuries

Genetics may be the final frontier of sports injury prevention, and researchers are only beginning to explore it. But investigators from South Africa are slowly making progress in identifying specific gene variants associated with risk of anterior cruciate ligament injury or Achilles tendinopathy.



Researchers from the University of Cape Town have previously linked the COL5A1 gene to risk of ACL injury and the MMP3 gene to AT. But when studying heterogeneous conditions, a single gene is only one piece of a complex genetic puzzle.

"Multifactorial phenotypes are more likely to be polygenic," said Mike Posthumus, PhD, a research fellow in exercise science and sports medicine at the University of Cape Town.

In Monaco in April, Posthumus presented findings that two genotypes of the MMP12 gene were significantly less likely to be present in 54 subjects with noncontact ACL injuries than in 216 control subjects.

Further down the kinetic chain, another Cape Town study found that variations within interleukin genes combined with one COL5A1 genotype were associated with AT. And a third study found that a polygenic profile based on scoring the presence or absence of five single nucleotide polymorphisms, could discriminate between 69 AT patients and 93 controls.