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LOWER EXTREMITY REVIEW

October 17 / volume 9 / number 10

HANDLE WITH CARE:

How sports equipment affects biomechanics and injury risk

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Clinicians know that handling a lacrosse stick or other types of sport-specific equipment can affect an athlete's movement patterns in potentially harmful ways. Now researchers are beginning to quantify these types of effects and explore their clinical implications.

By Jill R. Dorson

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Lower Extremity Review informs healthcare practitioners on current developments in the diagnosis, treatment, and prevention of lower extremity injuries. LER encourages a collaborative multidisciplinary clinical approach with an emphasis on functional outcomes and evidence-based medicine. LER is published monthly, with the exception of a combined November/ December issue and an additional special issue in December, by Lower Extremity Review, LLC.

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Everyone has days when we just go through the motions—at our jobs, in social situations, at the gym—and tell ourselves it isn't a big deal. But as clinicians you know that when patients just go through the motions of complying with prescribed treatments, their outcomes are almost certainly going to suffer. And new research suggests that can literally be a matter of life and death.

Multiple national healthcare organizations now recommend that older adults participate in strength training at least twice a week, and research suggests the benefits of complying with those recommendations include an extended life expectancy (see "Get stronger, live longer: But few older adults meet US guidelines," April 2016, page 13).

The problem with these types of guidelines, however, is their lack of specificity. For some people, a 30-minute session of strength training might involve pushing their muscles to the limit; for others, that same 30-minute session might involve more sitting and socializing than actual strengthening.

It makes sense intuitively, of course, that strengthening exercises are more likely to have the desired effects on mortality in the results-oriented group of individuals than in those who put in minimal effort. And, as we report in this issue of *LER*, a new study supports this concept: Researchers from the University of Mississippi found individuals' self-reported compliance with national strength training guidelines was not associated with cancer-specific mortality, but lower extremity strength was (see "Strength drives survival: But benefits of training appear complex," page 13).

In other words, the mortality-related benefits of strength training require more than just showing up and going through the motions.

Experts say lower extremity clinicians can help improve the effectiveness of their patients' strength training endeavors by offering specific advice about training approaches that are most likely to actually increase strength, and by monitoring patients' strength over time to see if significant increases are being achieved.

This, obviously, is a lot more work for clinicians than simply telling patients about the national guidelines and asking them to self-report their level of compliance. For many clinicians, it's already difficult to find enough time to give each patient the care he or she needs without adding to the workload. Those who do have the time may not have the appropriate equipment for monitoring lower extremity strength during patient visits.

> The mortality-related benefits of strength training require more than showing up and going through the motions. You can help.

But, knowing patients left to their own devices are likely to fall short of the strength levels needed to improve outcomes, I hope most clinicians will try to find ways to give those patients more constructive guidance. Maybe that means having them bring copies of their resistance training worksheets from the gym every time they have a clinic visit. It's not the same as measuring strength directly, but it could still make a meaningful difference.

National guidelines serve a valuable purpose. But it's becoming more apparent that such guidelines are unlikely to translate to improved outcomes unless both patient and practitioner are committed to doing more than just going through the motions.

Jordana Bieze Foster, *Editor*

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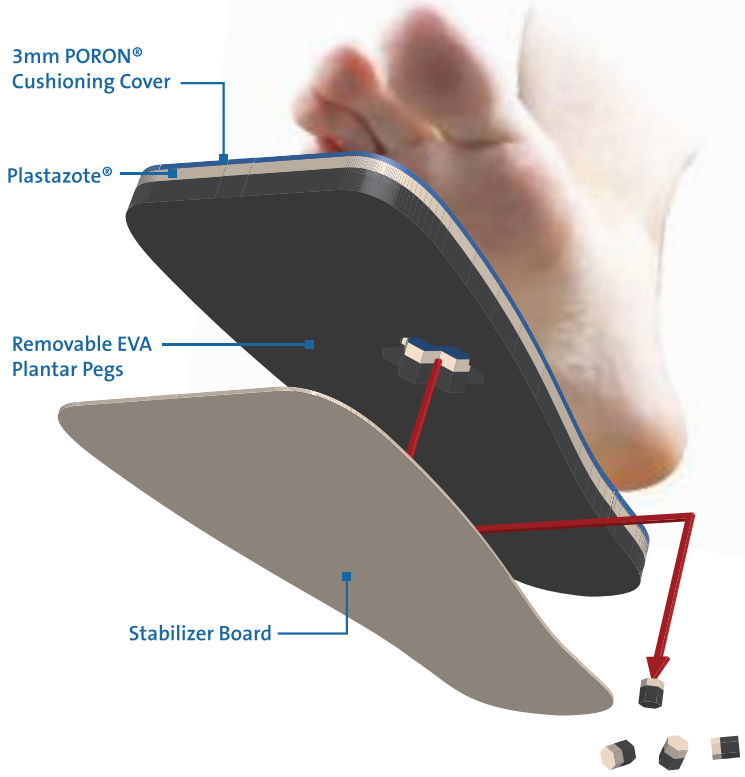

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Equinus and RA

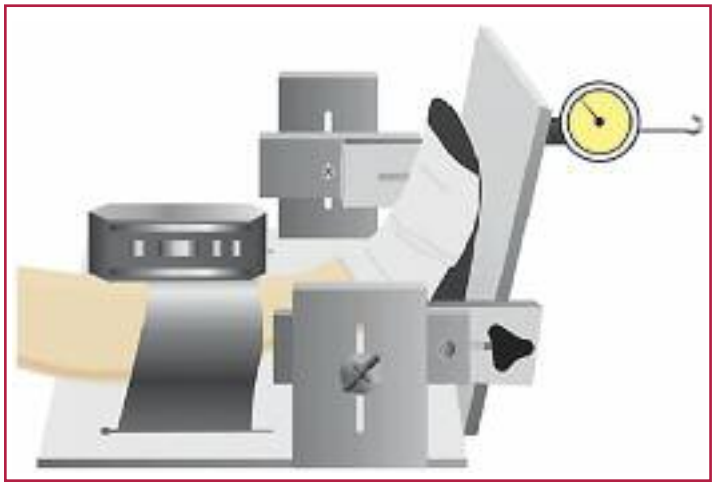
Limited dorsiflexion exists without pain

By Katie Bell

Patients with rheumatoid arthritis (RA) have decreased ankle dorsiflexion due to gastrocnemius contracture, even in the absence of foot and ankle pain, according to research from Michigan that may have implications for early intervention to minimize pain and dysfunction in this patient population.

"We think that the tight gastrocnemius causes an increase in the tension on the plantar soft tissues, causing overuse and with time increasing the chance of having pathology," said corresponding author James R. Jastifer, MD, an orthopedic surgeon with Borgess Orthopedics in Kalamazoo, MI.

The study included 70 patients (53 women) with a clinical diagnosis of RA after presenting to an orthopedic clinic with hand pain; the control group consisted of 70 participants (42 women) with no history of inflammatory arthritis or foot or ankle pain or injury.



Schematic of the Iowa ankle range of motion device used to assess ankle dorsiflexion. (Reprinted with permission from Jastifer JR, Green A. Gastrocnemius contracture in patients with rheumatoid arthritis. Foot Ankle Int 2017 Sep 1. [Epub ahead of print].)

All participants underwent measurement of their ankle range motion and isolated gastrocnemius contractures via clinical examination, goniometer, and a version of the previously validated Iowa ankle range of motion (IAROM) device. For all three measurement techniques, ankle dorsiflexion was significantly more limited in the RA group than in the control group. The findings were epublished by *Foot & Ankle International* in September.

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Dialysis patients, even without diabetes, have high risk for ulceration, amputation

Patients with end-stage renal disease undergoing dialysis are at high risk for foot ulcerations and amputation, regardless of whether they also have diabetes, according to research from La Trobe University in Melbourne, Australia, that underscores the need for foot screening in this population.

Investigators analyzed 450 patients, half of whom had diabetes. Foot ulcers were present in 10%, 21.6% had a history of foot ulceration, and 10.2% had undergone a lower extremity amputation.

The authors found a prevalence of 50.2% for peripheral neuropathy (including 35.3% of those without diabetes) and 52.4% for peripheral arterial disease (PAD); however, only 15.6% of neuropathy cases and 17.6% of PAD cases were documented in patients' medical records prior to the study.

Diabetes was not a significant risk factor for either foot ulceration or amputation. Previous amputation, PAD, and serum albumin were associated with foot ulceration; previous and/or current ulceration and foot deformity were associated with amputation. The findings were published in September by *BMC Nephrology*.

–Jordana Bieze Foster

Source:

Kaminski MR, Raspovic A, McMahon LP, et al. Factors associated with foot ulceration and amputation in adults on dialysis: a cross-sectional observational study. BMC Nephrol 2017;18(1):293.

Textured insoles enhance stride length, plantar sensation in individuals with PD

One week of textured insole wear is associated with improved plantar sensation and stride length in patients with Parkinson disease (PD), according to research from São Paulo State University in Brazil.

In 19 patients with PD, investigators assessed plantar sensation and gait before and after one week of wearing textured insoles. Plantar sensation was measured using Semmes-Weinstein monofilaments. Gait was assessed using an optoelectronic system as patients walked without insoles at a self-selected speed. The textured insoles featured half-sphere elevations in the distal phalanx of the hallux, heads of metatarsophalangeal joints, and heel.

After one week of insole wear, plantar sensation and stride length were significantly improved relative to baseline; the improvement in plantar sensation was maintained after another week of wearing conventional insoles.

The findings, which were epublished in September by *Gait & Posture*, suggest enhanced somatosensory feedback provided by the insoles results in improved gait-related motor output.

–Jordana Bieze Foster

Source:

Lirani-Silva E, Vitorio R, Barbieri FA, et al. Continuous use of textured insole improve plantar sensation and stride length of people with Parkinson disease: A pilot study. Gait Posture 2017;58:495-497. [Epub ahead of print]

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Between-group differences in ankle dorsiflexion were greatest (12.3° vs 17.3°) when the IAROM device was used for measurement. For that assessment, patients had the knee extended and the tibia aligned perpendicular to the device's foot plate, while the device's axis of motion was aligned with that of the ankle. The authors noted that three measurements were taken with the hindfoot kept in neutral, while participants were encouraged to relax their leg muscles and keep their hip flexed to 90°.

Within the RA group, further analysis showed that the seven patients presenting with foot or ankle pain had 12.3° of ankle dorsiflexion compared with 12.5° in those with no pain, a difference that was not statistically significant. Sex, body mass index, age, and presence of inflammatory markers also were not significantly associated with ankle dorsiflexion.

Because there is a high incidence of foot and ankle pain in the general population of patients with RA, the study findings suggest limited ankle dorsiflexion contributes to this pain, and that limited ankle dorsiflexion in RA patients who do not yet have foot and ankle pain may represent an opportunity for intervention, such as stretching or orthotic management.

"Should we be screening for it? Should we be treating it with a stretching program? Maybe," Jastifer said, noting further research is needed.

Patrick A. DeHeer, DPM, principal at Hoosier Foot & Ankle in Franklin, IN, agreed gastrocnemius equinus could contribute to foot and ankle pain in RA patients.

"Both pressure and biomechanical abnormalities associated with gastrocnemius equinus contribute to foot and ankle pain in the RA patient," DeHeer said. "Increased forefoot and midfoot pressures produce obvious pathological stress on an at-risk forefoot."

DeHeer said a critically important point of the Michigan study was the evaluation technique used, including supination of the foot while dorsiflexing the ankle joint with the knee extended.

Anthony Redmond, PhD, FFPM, RCPS(Glasg), FCPM, professor of clinical biomechanics at the Leeds Institute of Rheumatic and Musculoskeletal Medicine in the UK, agreed with Jastifer that it is too early to determine the clinical implications of the findings.

"We cannot assume that an intervention, eg, stretches, would just 'work' in this population. There might be something about the joint damage, soft tissue fibrosis, pain, etcetera, that means the gastric shortening is irreversible. We need to do trials before rolling out intervention programs," Redmond said. "Establishing whether there is a causal relationship between the [ankle dorsiflexion] observation and any symptoms is what needs to come next. Only then should we be throwing treatments at the problem." ler

Source:

Jastifer JR, Green A. Gastrocnemius contracture in patients with rheumatoid arthritis. Foot Ankle Int 2017 Sep [Epub ahead of print]

Strength drives survival

But benefits of training appear complex

By Keith Loria

Lower extremity strength appears to be a key variable in the relationship between mortality and compliance with national resistance exercise guidelines, according to research from the University of Mississippi in University, MS.

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The study, which was epublished in September by the *Journal of Physical Activity & Health*, found greater knee extensor strength was associated with lower rates of cancer-specific mortality. Of the 2773 individuals aged 50 years and older who were analyzed, those in the highest quartile for knee extensor strength had a 50% lower risk of cancer-specific mortality after a mean of 9.7 years of follow-up, compared with those in the three lower quartiles.

Interestingly, however, the study also found self-reported participation in resistance training was not significantly associated with cancer-specific mortality. Individuals who said at baseline that they had participated in at least eight muscle-strengthening sessions in the previous 30 days (13.8% of the study population) were classified as meeting US Department of Health & Human Services guidelines recommending strengthening activities at least two days per week. Members of that group had an 8% lower risk of cancer-specific mortality than those who said they did strength training less frequently; the between-group difference, however, was not statistically significant.

"The actual outcome of strength appears to be more important than the behavioral engagement in resistance exercise," said lead author Scott Dankel, MS, a graduate teaching assistant in the university's

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Return to activity after Achilles repair parallels heel-rise performance recovery

Recovery of triceps surae muscle strength, as indicated by heel-rise test performance, is associated with the ability to return to jogging and other athletic activities after an Achilles tendon repair, according to research from Teikyo University School of Medicine in Tokyo, Japan.

The investigators found that 96 individuals who had undergone Achilles repair needed an average of 14 weeks after surgery to be able to complete a one-time full weightbearing heel rise, and 21 weeks to be able to complete 20 heel rises at a time. The time required after surgery to achieve either of those two heel-rise objectives was not significantly related to patient age or sex.

The ability to do a one-time heel rise was significantly associated with jogging ability (achieved at an average of 15 weeks), and the ability to do 20 heel rises was significantly associated with the ability to return fully to sports (22 weeks).

The findings, which were epublished in September by *Foot and Ankle International*, underscore the importance of training and monitoring triceps surae strength during rehabiliation after Achilles repair. ler

–Jordana Bieze Foster

Source:

Toyooka S, Takeda H, Nakajima K, et al. Correlation between recovery of triceps surae muscle strength and level of activity after open repair of acute Achilles tendon rupture. Foot Ankle Int 2017 Sep 9. [Epub ahead of print]

Pathomechanics in patients with hip OA suggest need for gait retraining

Altered hip mechanics during gait in patients with hip osteoarthritis (OA) suggest a role for rehabilitation interventions focused on more than hip abductor strengthening alone, according to research from the University of Leuven in Belgium.

Investigators analyzed the walking gait of 20 patients with hip OA and 17 healthy volunteers matched for age and body mass index. Compared with the controls, the hip OA patients had less hip adduction range of motion, smaller hip abduction and external rotation moments, decreased hip joint contact forces, and less work generated by the hip abductors during stance.

The findings, epublished in September by *Gait & Posture*, suggest patients with hip OA develop gait alterations over time to improve mediolateral stability and decrease demand on the hip abductors. These compensations suggest rehabilitation focused solely on hip strengthening may not be sufficient to normalize muscle function and gait in patients with hip OA; gait retraining may also be warranted, the authors wrote. ler

–Jordana Bieze Foster

Source:

Meyer CA, Wesseling M, Corten K, et al. Hip movement pathomechanics of patients with hip osteoarthritis aim at reducing hip joint loading on the osteoarthritic side. Gait Posture 2017 Sep 22. [Epub ahead of print]

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Department of Health, Exercise Science, and Recreation Management.

This finding suggests monitoring knee extensor strength can help clinicians identify individuals at increased risk for cancer-specific mortality, and can also help determine if patients' resistance training is actually resulting in improved strength.

"We feel that a large amount of the individual differences in muscle strength are simply genetic, but individuals can increase their strength to some extent via resistance exercise," Dankel said. "We feel that the type of resistance exercise may be important to consider, as the exercise load or intensity used is directly proportional to the improvements in strength."

The findings also suggest the potential health benefits of resistance exercise other than increased strength (eg, improvements in blood pressure or cholesterol level) do not appear to affect cancer-specific mortality.

"Thus, we recommend that resistance exercises specifically targeting improvements in strength may be beneficial, since it is strength that is associated with cancer-specific mortality," Dankel said.

Even though many clinicians do not have access to an isometric dynamometer to assess knee extension strength, Dankel said they could use an alternative assessment of lower body strength, such as a simple isotonic knee extension strength test that can be performed on a standard piece of gym equipment.

The lack of a statistically significant association between training and mortality in the Mississippi study contrasts to an extent with a 2016 study, in which older adults who said they met national guidelines for strengthening exercises had lower all-cause mortality rates than those who didn't (see "Get stronger, live longer: But few older adults meet US guidelines," April 2016, page 13).

But the lead author of that study, Jennifer Kraschnewski, MD, MPH, associate professor of medicine and public health sciences at Penn State College of Medicine in Hershey, PA, said the new findings add to the argument that successful strength training is associated with decreased mortality.

Although clinical documentation of improved strength as a result of training in every individual would be ideal, Kraschnewski noted it may be impractical for busy practitioners, and that having the national guidelines be a goal for patients could still be valuable.

"The ability to have clinicians routinely measure lower extremity strength is unlikely to be successful, given other clinical demands," Kraschnewski said. "Having clinicians encourage increased strength training activities is definitely an important step to help patients live healthier lives." ler

Sources:

Dankel S, Loenneke JP, Loprinzi PD. Cancer-specific mortality relative to engagement in muscle strengthening activities and lower extremity strength. J Phys Act Health 2017 Sep 5:1-19. [Epub ahead of print]

Kraschnewski JL, Sciamanna CN, Poger JM, et al. Is strength training associated with mortality benefits? A 15 year cohort study of US older adults. Prev Med 2016;87:121-127.

HANDLE WITH CARE:

How sports equipment affects biomechanics and injury risk

Clinicians know that handling a lacrosse stick or other types of sport-specific equipment can affect an athlete's movement patterns in potentially harmful ways. Now researchers are beginning to quantify these types of effects and explore their clinical implications.

By Jill R. Dorson

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If you're walking down the street carrying two bags of groceries, you'll move differently than when you're walking unencumbered. Taking that idea a step further, it makes sense intuitively that carrying a lacrosse stick, football, or any other sports implement will affect an athlete's biomechanics. This phenomenon, often observed anecdotally by lower extremity clinicians, is increasingly becoming a focus of biomechanical research.

"You're holding an implement way away from the body, and now your trunk has to compensate for that implement, so the whole [kinetic] chain is compromised," said Lenny Macrina, PT, SCS, CSCS, cofounder and director of physical therapy at Champion Physical Therapy and Performance in Waltham, MA.

Macrina isn't the only physical therapist who works with elite athletes to note key changes in the way the body moves when an athlete carries a piece of equipment. In fact, multiple studies[1-5] have investigated the particulars of how carrying or holding a piece of equipment affects lower extremity biomechanics.

But it is really on the front lines—from the sidelines, in the training rooms, and in physical therapy clinics—where practitioners see these effects firsthand.

"Because athletes carry an implement of some kind, there is so much need for appropriate hip and spine mobility and stability," said Dan Lorenz, DPT, PT, LAT, CSCS, director of physical therapy at Specialists in Sports and Orthopedic Rehabilitation in Kansas City, MO. "The implement is an extension of your trunk, so you need a lot of deceleration ability, as well, to control the follow-through."


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In the lab

A 2005 study published in the *American Journal of Sports Medicine (AJSM)*[6] bears out what Lorenz and Macrina see on a day-to-day basis. Athletes were videotaped doing cutting moves, first with no arm constraints and later holding a lacrosse stick, cradling a football with the cutting-side arm, and, finally, cradling a football with the plant-side arm.

The study showed, to varying degrees, the constraints were associated with greater knee abduction moment, which can increase the possibility of anterior cruciate ligament injury, according to lead author Ajit Chaudhari, PhD, FACSM, an associate professor of physical therapy, mechanical engineering, biomedical engineering, and orthopedics at The Ohio State University in Columbus.

A shorter distance between the plant-side arm and the center line of the body—which occurred while carrying the lacrosse stick and carrying the football in the plant-side arm—was associated with significantly greater loading at the knee. The findings suggested, of the three conditions, carrying a lacrosse stick created the most risk.

"Basically, what we're seeing is the distance between the body and the plant-side or cut-side arm. So we're thinking from a mechanical point of view, 'How are these conditions going to predict something?'" Chaudhari said. "The further away, the bigger the lever arm, so it can create more torque. In different conditions, arms are in different positions. … And the more they [lacrosse players and football players carrying the ball on the plant side] brought their arm in more, the bigger the valgus knee moment."

And, though Chaudhari's study and others[1-5] have shown higher stress on the knee and other joints can be related to carrying a piece of sports equipment,


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questions remain regarding why and how this happens.

Clinicians and academics all point to changes in arm position, but are quick to add they believe other factors—including playing defense versus offense and gender and distraction—may play key roles in altering how the body moves.

Sport-specific effects

A 2015 *AJSM* study[7] reported a higher incidence of lower extremity injury during defensive actions versus ball-handling actions in high school basketball players. The study, which collected data over seven years and included 6.4 million athlete exposures, noted no significant differences between offense and defense in soccer for the group overall.

"Defending and ball handling showed an increase in [basketball] injuries, so the supposition was, 'Why?'" said lead study author Scott Monfort, PhD, who did his doctoral studies in mechanical engineering at Ohio State and is now an assistant professor in the Department of Mechanical and Industrial Engineering at Montana State University in Bozeman. "Our thought is that it is related to some of the sport-specific demands. We know that every sport has constraints—they could be equipment-related; for example, dribbling a basketball with the hand or a soccer ball with the feet, or it could be direct one-on-one defending."

Although the study did not compare kinematics or kinetics during offensive and defensive actions, Monfort said the effects of ball handling could have been offset by other factors that can also affect biomechanics.

In basketball, defensive moves tend to occur in response to movements by an offensive player that are hard for the defender to anticipate; this may play a greater role in terms of injury risk than any potential effects of ball handling, Monfort noted.

"A defensive move would be representative of a reactive movement, and would put those athletes at more risk for lower extremity injuries because [the movement is] unanticipated," he said. "We did see that for basketball. In soccer, the demands are different and impose additional constraints on the lower extremities."

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Monfort pointed out that the relevance of particular constraint-related factors can vary for different sports.

"We found that unanticipated movement may play a greater role in basketball, but with soccer, having to move with the ball may play a more dominant role," he said.

This phenomenon may also be mediated by gender. In the study, girls had significantly higher rates of ankle injury than boys when ball handling in soccer, but not when playing defense in soccer or when playing basketball.

"The added demands of positioning the ball may play a relatively more dominant role in the multifactorial injury factor in girl soccer players," Monfort said.

A 2014 meta-analysis published in *Sports Medicine*[8] underscores the relationship between unanticipated movements and injury risk. The analysis of six studies on how unplanned sidestepping affects knee mechanics found athletes had an increased risk of knee injury during unplanned moves, particularly

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upon landing. The study also noted noncontact ACL injuries were most prevalent during a change of direction.

Losing focus

Carrying a piece of sports equipment can compound the effects of unanticipated movements and other variables that can increase injury risk, experts said. To put it simply, carrying a big stick can take an athlete's focus off the task at hand.

"The influence of holding something in their hand and having to focus on that, now we're just relying on response from the lower extremities, and I think you do see a movement that you're not expecting or that is not ideal because of the inability to use that visual input," Macrina said. "They are so focused on holding the stick that they [can't focus] on an unstable surface [or an opponent]."

Chaudhari agrees. He pointed out that his 2005 study wasn't conducted in a game or practice setting or across enough different sports to develop empirical evidence showing distraction may be a factor affecting biomechanics. Anecdotally, however, Chaudhari believes distractions can have an effect on how the body moves.

"I think that those [distractions] affect biomechanics, from the standpoint that then you're spending less of your brain planning how you are going to plant that leg," he said. "So you are more likely to plant that leg in a way that creates a situation that gets you closer to an ACL tear or other injury."

Monfort was the lead author of a 2017 study presented in June at the annual meeting of the American College of Sports Medicine[9] investigating how visual memory (as determined using the Immediate Post-Concussion Assessment and Cognitive Test [ImPACT] battery) influenced the effect of soccer-ball dribbling on biomechanics in male athletes. Monfort said the results suggest that dribbling a soccer ball is a visually demanding task, and that athletes with diminished capacity for visual memory may be less able to maintain optimal biomechanics while performing sport-specific tasks that require visual attention.

"As someone is making some athletic movement, like dribbling, then they are only periodically looking at the ball and only periodically looking at opponent or field," Monfort said. "So there is less time to scan the field. In soccer, we saw the demands of [dribbling] are different [than in basketball] and are now imposing additional constraints on the lower extremities."

Although Monfort's two studies may appear at odds, they underscore the idea that basketball and soccer, specifically, may have inherently different sport-specific constraints. As such, it can be difficult to compare the effects of equipment-handling constraints on biomechanics, and any resulting effect on injury risk, from sport to sport. Monfort was quick to say more study in this area is needed.

A study from Quinnipiac University in Hamden, CT, presented at the 2016 Combined Sections Meeting of the American Physical Therapy Association also found that knee biomechanics during cutting were affected when a visual-attention task was added.[10] However, that study found women were more likely to be affected than men.

Expecting the unexpected

Both Macrina and Lorenz believe "distractions"—whether an unplanned movement or putting a piece of sports equipment into a player's hands—are a critical and often overlooked part of the rehab process. In fact, both say that when they've added a sport-specific implement to the rehabilitation process, they have seen firsthand

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that the athlete's focus is then split.

"Anecdotally, there can't be any doubt that holding an implement and the changing focus to have to be able to catch a ball, or getting ready for a hit, or feeling the ground beneath them … that visual input and acuity are required," Macrina said. "It's unknown, but we're learning so much about it."

Lorenz believes elite athletes have a leg up in managing the distractions that go hand-in-hand with on-field play.

"Elite athletes have the ability to anticipate the move before the opponent even does," Lorenz said. "And they are able to prepare themselves ahead of time."

That preparation may allow the athlete to compensate for the unexpected move, but as Lorenz has noted in years of working with elite athletes, compensation often comes in the form of raw power. That power, he said, is what separates the elite athlete from the average athlete, and it allows those athletes to overcome potentially high-risk situations that the average human cannot.

"It's striking to me that the elite athletes I've had the ability and privilege to work with are able to overcome deficits with raw natural talent and ability," Lorenz said. "There is a paper[11] about what makes elite athletes different from others in their sport, and without question, in any sport, it came down to power. It had nothing to do with height, weight, bench press, etcetera. It was power."

Translational training

Of course, it's one thing to recognize sport-specific equipment handling as a potential injury risk factor, and it's another thing altogether to design effective interventions to reduce that risk. However, recent research does suggest training can help address the extent to which unanticipated movements contribute to the problem.

A German study of 24 active women published in March found a combination of perturbation training and plyometric training was associated with significantly reduced knee joint moments during lateral reactive jumps after four weeks.[12] And, in a Danish study published in September, a six-week balance training intervention was associated with significant reductions in knee abduction moment during perturbed cutting in 26 healthy men.[13]

As a way to help rehabilitate injured athletes who participate in equipment-handling sports, experts said it's important to put an athletic implement into an injured athlete's hand. Both Lorenz and Macrina said this can have positive mental and physical impacts on the rehabilitation process.

At first, the stick, ball, or glove can be used early in the rehabilitation process just as a way to give the athlete a reminder of what he or she is working toward.

"For me, when someone is going through ACL rehab, if you just put that stick in their hand, it just does so much for their psyche," Lorenz said. "It gives them a mental boost."

Later in the rehabilitation process, the clinician can observe how holding the implement changes the way the athlete's body moves—and how the athlete self-adjusts to the new feature.

"Anecdotally what I've seen is, 'Where are you carrying the implement? Close to your body? Far away? High up?'" Macrina said. "Even team handball players, they're getting the ball above the head, which changes the body's landing. It creates changes in the pelvic position, which influences the lumbar area, then the glutes, quads, and hamstrings. Are they now in a poor position to stabilize?

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You're influencing muscular positions because you've now changed your upper extremity position."

And that change in position circles right back to hard research about the effect of carrying a piece of equipment on the lower extremities.

"In rehab, you have to take it in stages," Chaudhari said. "I think it [holding equipment] should be a goal, that you shouldn't be done with rehab until you're able to increase strength/movement *with* your equipment and the same sorts of distractions as you'd have during a game."

Chaudhari is also a big believer in giving athletes the proper training early on.

"I've heard a lot of people say over the years, 'We teach kids how to catch and how to throw, but we don't teach them how to land,'" he said. "We should teach them how to catch *while* they land. Because they hurt themselves when they land, not so much when they catch and throw."

A 2012 Australian study[5] made similar recommendations, after finding that landing after making an overhead catch was associated with increased peak knee valgus moments, as well as altered lower extremity kinematics.

Theories related to this topic vary, but one thing academics and clinicians can agree on is this: Carrying a piece of sports equipment has an effect on biomechanics, but how those changes happen and the net result of those changes require more study.

"This is an area that is way under researched," Macrina said. "But it should be highly considered in the advanced phase of rehab and even earlier." (ler)

Jill R. Dorson is a freelance writer based in San Diego, CA.

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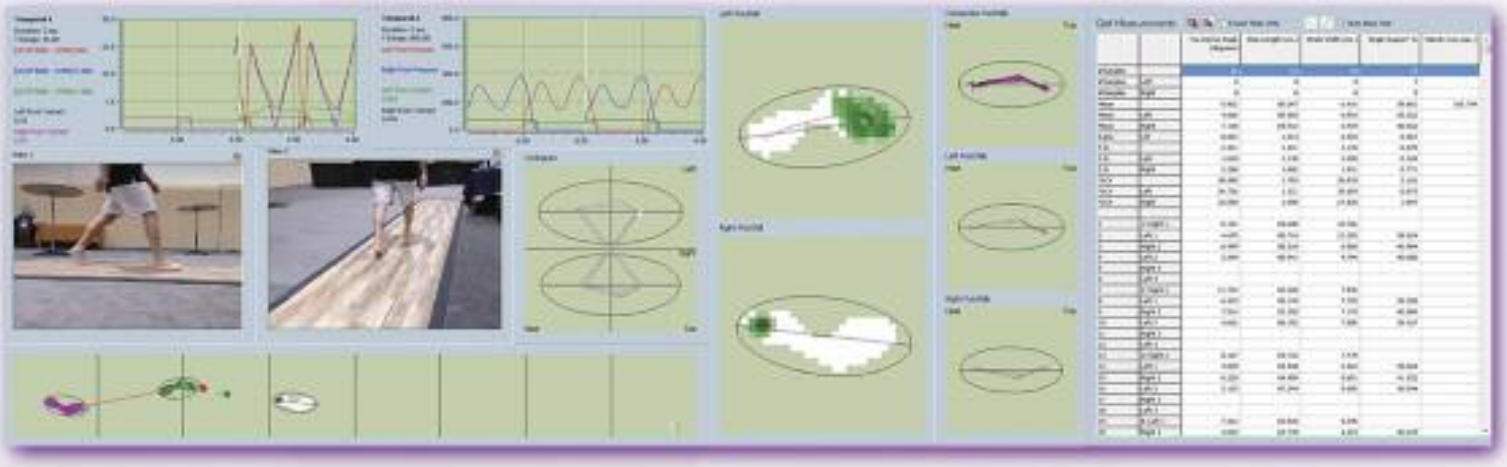

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Lower extremity clinicians absorb hurricanes' impact

Clinicians in areas affected by hurricanes Harvey and Irma were prepared for issues involving preexisting lower extremity concerns, but were surprised by the number of cases they saw in the storm's aftermath involving healthy people trying to function under extraordinary conditions.

By Nancy Shohet West

As government officials and residents alike in Houston, TX, prepared in late August for what was correctly predicted to be the most significant rainfall the region had ever known, hospitals took their own precautions. With Hurricane Harvey bearing down, planned surgeries were rescheduled, medical staff were urged to stay onsite at their hospital posts, and power generators were prepared in anticipation of power outages.

Meanwhile, medical personnel who treat patients for lower extremity problems worried about what it would all mean for their patients, such as those with diabetes and the skin ulcers and open wounds that often accompany the condition, those with decreased mobility due to injuries or degenerative diseases, and those with chronic problems like tendinitis.

Hurricane Harvey, which arrived in the US on August 25 near Rockport, TX, was responsible for more than 80 deaths and deluged the Houston area with more than 30 inches of rain. Less than two weeks later, another powerful Atlantic hurricane targeted Florida, making landfall in Naples on September 10, killing more than 70 in that state. Damage from Irma is estimated at $100 billion, and Harvey at $190 billion, which would make the storm that hit Texas the most expensive weather event in US history, according to accuweather.com. (The Atlantic storm-related destruction continued after this article was written, as Hurricane Maria pummeled Puerto Rico on September 20 and Hurricane Ophelia was approaching the coast of Ireland at press time.)

Nadim Islam, MD, an emergency medicine physician and director of emergency services at Houston Methodist St. John Hospital in Nassau Bay, just southeast of Houston, recounted that at his hospital, medical personnel who were in place on the morning of Saturday, August 26—when the storm first reached the Houston area—couldn't be relieved until sometime late Sunday, when doctors and nurses were transported to the hospital via government boat to cross an otherwise impassable flood zone.

Inside the emergency department (ED), things were relatively

> Storm survivors, focusing on what they view as more immediate concerns, may make poor shoe choices and ignore lower extremity symptoms until they are severe.

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quiet during that time, Islam said.

"During the storm, we didn't see a tremendous number of patients," Islam said, pointing out that local residents had plenty of warnings about either leaving the city or sheltering in place, and hardly anyone was taken by surprise when the storm hit.

However, he said, those who did show up in the emergency department generally had good reason.

"The patients we did see tended to be much more complicated, either because their symptoms were severe enough to require a hospital visit despite the conditions or simply due to the social circumstances that accompanied the storm," Islam said. "Maybe they couldn't get home after being discharged, or maybe they'd lost their home in the storm and they had nowhere else to go. Even some of the shelters were inaccessible by that point."

Pedro Cosculluela, MD, a foot and ankle orthopedic surgeon at Houston Methodist Hospital, said the initial storm preparation efforts there centered on how patients who had already been admitted to the hospital could be kept safe. The next level of preparedness focused on people who developed symptoms severe enough to warrant a trip to the hospital even in the direst of weather conditions: those with chest pains, breathing problems, or signs of a stroke.

"The hospital's efforts then go into putting those specialists in place: surgeons, ER doctors, ICU doctors," Cosculluela said. "By contrast, a lot of the problems we see as orthopedic specialists can wait."

And so while the facility's ED doctors attended to patients with heart attack or stroke symptoms, orthopedists and podiatrists were left to worry about their chronically ill patients whose conditions impacted their lower extremities even in the best of circumstances.

Patients with diabetes, for example, were of particular concern, given their propensity for ulcers, fungal infections, and bacterial infections in the legs and feet. Floodwaters, according to bulletins put out by the National Institutes of Health and other official agencies, are prone to contamination by sewage, thereby increasing the likelihood that they carry *E coli* bacteria, which can cause severe infections and illnesses.

But, for the most part—according to clinicians not only in Houston but also those in Florida, who dealt with horrific weather conditions of their own when Hurricane Irma struck—patients with serious preexisting conditions were fairly well prepared for the storm and had taken precautions that prevented their problems from growing any worse during the ensuing municipal emergencies. Most patients, or their caregivers, checked ahead to ensure they had enough of the insulin and other medications they would need, that they had a safe place to stay, and that they wouldn't be required to do more walking or other activity than their conditions safely allowed for.

"Early on in a severe weather event, the incidence of orthopedic trauma we see in the hospital is lower than usual," Cosculluela said. "When it's pouring, people don't go outside and are therefore less likely to fall."

By contrast, hospital personnel covering emergency departments during the storms, as well as specialists who saw patients in the days and weeks that followed, were surprised to find the biggest lower extremity issues they saw didn't involve patients with preexisting conditions but people who considered themselves in fine health. It was that very perception of strength and wellness that led many of them into careless behavior that resulted in injuries.

"With all the frantic movement as they rushed around trying to take care of their homes and belongings, people were twisting

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ankles. We even saw people who had climbed up to their attics for safety, not realizing the plywood floor couldn't hold them, and had fallen through, resulting in fractured ankles, broken legs, or broken hips, as well as scrapes and open cuts that led to infections," Islam said.

Cosculluela observed the same phenomenon.

"We saw a minor spike in ankle sprains and ankle fractures," he said. "In the midst of the floods, people were jumping into the water without knowing what was underneath. People who were carrying their belongings were dropping heavy objects, damaging their feet and toes. Rescue workers hurrying in and out of boats and reaching into difficult places incurred twists and sprains and breaks."

Once the storm ended, said Islam, hospital personnel started to see patients with infections.

"People had been working throughout the night as water levels crept up. They were frantically running around trying to keep water away from their homes, and often they did so in sandals or water shoes," he said. "As a result, they'd get cuts on their feet, which would then become infected in the dirty flood waters. We saw many infections that we had to treat like MRSA [methicillin-resistant *Staphylococcus aureus*] because we weren't sure what was causing them."

Maria Buitrago, DPM, of Podiatry Associates of Houston, also said she's seen a lot of patients with infections since the hurricane, including patients with open wounds related to diabetes or vascular problems, who may have picked up new infections during the flooding. Moreover, slogging through muddy, opaque, swirling floodwaters lends itself to scrapes and lacerations, another source of infection.

"I saw one lady with a fifth metatarsal fracture in one foot and infected sores on the opposite leg from the floodwaters," Buitrago said. "I also saw a lot of cellulitis, some of it caused by the rubbing and blistering incurred by people walking around in wet boots. But so far, all the infections I've seen in my patients could be successfully treated by antibiotics. I haven't seen any cases of necrotizing fasciitis, though I understand from news reports that it's out there."

The *Houston Chronicle* reported two Houston-area residents developed necrotizing fasciitis related to storm conditions. One, a woman aged 77 years, died on September 15; a former firefighter and medic who was involved in rescue efforts survived his bout with the infection.

"This is when infections can happen," agreed Jairo B. Cruz Jr, DPM, a podiatrist with Advanced Podiatry in Tampa, FL, whose practice closed for about a week following the destruction of Hurricane Irma in early September. "Any kind of increase in moisture in the foot can lead to infections from bacteria that thrive in water. And, sometimes people overlook the signs of bacterial infections in their feet. That's when they run into trouble by not treating it fast enough. The very young and elderly, with compromised immune systems, are particularly vulnerable to these infections."

Like his peers, Cruz was especially concerned about his patients with diabetes and vascular disease.

"Both of those diseases put patients at greater risk for amputation," he said. "But so far our patients have done OK."

And the orthopedic injuries resulting from the storms may well have yet to peak, Cosculluela said in late September.

"What we expect to see in the upcoming weeks is a large number of injuries caused by the work people do as they try to put their

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Hurricane relief: How you can help

A number of lower extremity organizations and businesses have already stepped up to donate resources and funds to victims of hurricanes Harvey and Irma. Rockford, MI-based Wolverine Worldwide, for example, partnered with the American Red Cross, United Way, and the footwear industry charity Two Ten Footwear Foundation to pledge more than $2.6 million to disaster relief efforts (see "Lower extremity orgs help hurricane victims," October 2017, page 61). More recently, Mequon, WI-based Dr. Comfort donated more than 500 pairs of shoes to the American Red Cross and Soles4Souls for hurricane relief (see "Dr Comfort donates shoes to storm victims," page 62).

A few ways others can help:

- *Soles4souls* is accepting donations of products including shoes, clothing, socks, underwear, and diapers, but they are also in need of monetary donations to help get the products to those who need them. Visit souls4soles.org for more information.
- *Donating blood* is always a critical need after a natural disaster. To find a blood drive near you, go to redcrossblood.org.
- *Insulin for Life* is collecting unexpired and unopened diabetes supplies (especially test strips and insulin) for those affected by hurricanes. For information, go to ifl-usa.org/what-we-need.

homes back together—falls from ladders, for example, that lead to heel and ankle and leg fractures," he said. "This same kind of spike happens around Christmastime, too, when people are up on ladders putting up lights and decorations."

More injuries to feet and legs may well have occurred during debris clean-up than during the storms themselves, Islam agreed.

"When amateurs attempt to do heavy lifting, the result is often cuts, sprains, and fractures," he said.

This was a factor leading up to the storm as well, as homeowners climbed on ladders to cut branches or put up shutters.

"It's a high-risk situation, and when you combine the nervousness and jitters and sense of urgency that people feel when a storm is coming, the probability of injury grows," Islam said. "So people shouldn't wait until the last minute to prepare for a storm, and when they do, they should exercise extra caution."

Buitrago noted some patients she had been treating for ongoing conditions exacerbated their existing problems by prioritizing clean-up efforts over good judgment.

"People with conditions such as tendinitis who normally give their feet a rest were on their feet all day cleaning up their yard or helping neighbors. Then they'd come see us in pain," she said. "I've seen a lot of stress fractures in the past couple of weeks also, and even blisters. Some of the patients are flood victims, and others are people who were just helping neighbors and friends."

Not only are patients with preexisting conditions spending too much time on their feet; they're also doing so in the wrong footwear, Buitrago said.

"People are wearing rain boots that don't have a lot of support as they spend hours working on their feet," she said. "This results in not only stress fractures and blisters, but also in overall pain."

Footwear that exposes a lot of skin is another culprit, several medical professionals said. Some flood victims donned sandals to walk through the floodwaters, exposing their feet to debris in the water and increasing the risk of cuts and abrasions. Others automatically reach for their oldest sneakers when it comes time to clean up the debris.

"Wear your newest sneakers for this job," Buitrago urged. "You'll need the support. Then just replace them when you're done."

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Making matters worse, Buitrago said, is that storm survivors focused on what they perceive as more immediate concerns sometimes will ignore pain and discomfort in their lower extremities.

"We treated one lady who had been on her feet for hours wearing heels. An x-ray revealed that a bone was dislocated and she would need surgery," she said. "After a crisis like this, some people run on adrenaline, not thinking about themselves or how they feel."

Of course, few people who endured hurricanes Harvey and Irma would dispute that hurricanes and other storms are increasingly becoming a fact of modern life, and medical personnel emphasize that, as with so many other things, prevention is the best cure when it comes to protecting feet, ankles, and legs. People with diabetes and others who are prone to ulcers or have unhealed wounds need to be particularly ready when flooding is a threat.

"You have no idea what's in that water," Cruz said. "Once an infection starts to grow, it becomes increasingly difficult to treat. To resolve it efficiently and effectively, treatment needs to begin almost immediately. High-risk patients, many of whom have comorbidities, can develop massive infections in the space of twelve hours."

And even while he was counseling his own patients about hurricane preparedness, Cruz was trying to learn from the experience and expertise of those who had been through the process many times.

"My eighty-year-old patients were giving me advice on how to prepare," he said.

Ultimately, clinicians say, most hurricane-related injuries come down to a lack of caution and awareness—whether patients were trimming branches ahead of a storm, wading through water during an evacuation, or dragging out debris afterwards. Even the best-intentioned activities require vigilance when the circumstances aren't normal, noted Buitrago, who counts many runners among her patients and is a marathon runner herself.

"I saw people out for a run after the rain ended, jumping over the puddles," she said. "Even that carries a risk of slipping. It's good to get out, but people should continue to be careful." ler

Nancy Shohet West is a freelance writer in the Boston area.

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Implications of high ankle sprains in college athletes

High ankle sprains in collegiate athletes differ from lateral or medial ankle sprains in multiple clinically relevant ways. These include loss of sports participation time, mechanism of injury, rates of injury during competition versus practices, and the possible long-term risk of osteoarthritis.

By Timothy C. Mauntel, PhD, ATC; and Zachary Y. Kerr, PhD, MPH

It is well known that ankle sprains are among the most common injuries experienced by collegiate athletes.[1-7] Broadly, ankle sprains can be categorized as lateral ligament complex (inversion) sprains, medial ligament complex (eversion/deltoid ligament) sprains, and distal tibiofibular joint (high ankle/syndesmosis) sprains.[4,5,7,8]

Lateral ligament complex ankle sprains are the most commonly reported ankle ligamentous injury (5 injuries per 10,000 athlete exposures)[4-7,9] but are typically rather minor injuries, resulting in a mean of 8.1 days of missed physical activity.[9] Medial ankle sprains are less common (.8 injuries per 10,000 athlete exposures) but result in slightly longer recovery times (10.7 days).[10] Meanwhile, high ankle sprains are slightly more common than medial ankle sprains (1 injury per 10,000 athlete exposures) and typically result in the longest recovery periods of any ankle sprain (13.9 days).[5,7,11]

Nearly half (47.1%) of all high ankle sprains result in more than one week of missed physical activity and one in six (15.8%) collegiate athletes will miss more than three weeks of physical activity following a high ankle sprain injury.[12] Understanding high ankle sprain epidemiology and etiology is essential to help develop prevention interventions aimed at reducing the incidence and severity of these injuries.

Distal tibiofibular anatomy

The distal tibiofibular joint is typically a rather stable joint as a result of its bony and ligamentous supports. The distal tibiofibular joint encompasses the distal tibia and fibula and superior surface of the talus; collectively, these bones form what is commonly referred to as the "ankle mortise." The ankle mortise is further supported by the anterior- and posterior-inferior tibiofibular ligaments, interosseous ligament, and a strong interosseous membrane that runs between the tibia and fibula.[13-15]

These many bony and strong soft tissue restraints make the distal tibiofibular joint resistant to many internally generated injurious forces. Thus, sprains to this ligamentous complex in athletes most often result from contact with another player.[12,16,17] Commonly,

Understanding high ankle sprain etiology and epidemiology is essential in developing prevention programs aimed at reducing the incidence and severity of these injuries.

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Tampa Bay Buccaneers linebacker Lavonte David (number 54) suffered a high ankle sprain on September 24. (Photo courtesy of nflhu.blog.hu.)

injury to the distal tibiofibular joint occurs when an individual jumps, steps, or otherwise lands on the foot of another individual, resulting in forced ankle dorsiflexion and foot external rotation.[16,17] A recent study of 25 National Collegiate Athletic Association sports found player contact accounted for 60.4% of high ankle sprain injuries, while noncontact (17.5%) and surface contact (16.9%) mechanisms accounted for much smaller percentages.[12] The findings of this study agree with previous studies that showed the majority of high ankle sprains result from contact with another player.[17]

The large percentage of high ankle sprain injuries resulting from player contact is unique to this injury, compared with either lateral or medial ligamentous ankle injuries.[9,10] That means high ankle sprain injury prevention strategies will need to differ to some degree from what has been shown to be effective in reducing lateral or medial ankle sprains.[12,18,19]

The intercollegiate sports with the highest rates of high ankle sprains are men's football, men's wrestling, and men's ice hockey.[12,17,20-22] This is not surprising, as intentional and unintentional player contact is common during these sports. Player contact can result in athletes stepping or landing on another player, which forces the foot into dorsiflexion and external rotation.[16,17]

Ankle dorsiflexion and foot external rotation (the most common biomechanical mechanism for high ankle sprain injuries) are required motions during many weightbearing activities, including normal gait.[23] When the ankle is dorsiflexed and the foot is externally rotated, the talus is repeatedly forced superiorly, separating the tibia and fibula,[16,17] which results in stress on the syndesmotic ligaments.[8] In an athlete with a high ankle sprain, these movements—even if performed during low-impact weightbearing activity—essentially replicate the mechanism of injury with each step or jump. Therefore, injured athletes should avoid weightbearing activity during the early stages of rehabilitation following a high ankle sprain. This extended period of nonweightbearing likely contributes to the significantly longer recovery periods for high ankle sprains relative to either lateral or medial ankle sprains.[8]

Understanding high ankle sprains' unique mechanism of injury and associated recommendations for a slow-progressing rehabilitation[8,16] will aid clinicians in the prevention and rehabilitation of these injuries.[12]

Frequency of high ankle sprain injuries

High ankle sprains occur at a rate of 1 injury per 10,000 athletic exposures. In a study that examined high ankle sprains across a variety of varsity collegiate sports, male athletes had higher rates of high ankle sprains than female athletes involved in comparable sports (rate ratio = 1.77; 95% CI: 1.28, 2.44).[12] However, this finding may be sport- and/or population-specific, because high ankle sprains are up to 5.36 (95% CI: 1.11, 25.79) times more likely to occur in elite female soccer players than in their male counterparts.[24] High ankle sprains are most frequently observed in men's football (2.4 injuries per 10,000 athlete exposures), men's wrestling (2.1 injuries per 10,000 athlete exposures), and men's ice hockey (1.1 injuries per 10,000 athlete exposures).[12] Furthermore, the proportion of high ankle sprains resulting in one week or more of restricted participation was higher in male athletes than female athletes.[12] However, differences in high ankle sprain severity between sexes have not been consistently reported across all studies.[7]

The majority of high ankle sprains occur during competitions (56.7% of all injuries), and there are substantially higher injury rates during competition than practice (rate ratio = 5.79; 95% CI: 4.83, 6.93), across all sports.[12] Within football specifically, this discrepancy is even more pronounced, and high ankle sprain injury rates are nearly 14 times (rate ratio = 13.9; 95% CI: 11.90-16.34) higher during competitions than practices.[25] The observation of higher injury rates and counts during competitions as opposed to practices appears unique to high ankle sprain injuries, given that previous work with collegiate athletes from multiple sports found higher injury rates during competitions but higher injury counts during practices.[26] Thus, these authors suggested practices may be the best time to incorporate injury prevention strategies (eg, programs targeting proprioception and balance).[9,10,27,28]

Proprioception- and balance-focused injury prevention programs have been successful in their own right and may help to mitigate the overall risk of musculoskeletal injuries, namely ankle sprains.[27,28] These programs, however, may not be the most effective means for reducing high ankle sprain risks for collegiate athletes.

Previous work has suggested integrating targeted injury prevention strategies into competitions will likely be more efficacious for reducing high ankle sprain injury risk than proprioception and balance training programs alone.[12] Examples of such potential prevention strategies include changes to game play rules that minimize player contact (the number-one mechanism of injury)[12,16,17] or implementing the use of mechanical interventions (eg, ankle braces).[12,18,19]

Mechanical interventions may reduce the available ranges of motion within the ankle joint and assist with limiting forced dorsiflexion and more likely eversion motions that commonly occur during player contact, thus reducing the risk for high ankle sprain injuries. Although investigations have found the use of mechanical interventions has reduced the incidence of ankle sprain among high school athletes, these studies did not differentiate ankle sprains by type (ie, lateral/medial/high ankle sprain).[18,19] Further research is required to identify the effectiveness of these suggested injury prevention strategies for mitigating high ankle sprain injury risk.

Although there is a need for longitudinal research comparing

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New York Giants wide receiver Odell Beckham Jr (13) suffered a high ankle sprain during a preseason game on August 21, but returned to competition at the start of the regular season. (Photo courtesy of newsasylum.com.)

pre- and postintervention injury rates to determine the effects of such injury prevention strategies, it is also important to incorporate cross-sectional comparisons among samples of student-athletes to understand which characteristics may be risk factors for injury and which may be protective. Descriptive epidemiology helps generate overall estimates of the incidence of high ankle sprain injuries, but a common limitation of such studies is that variability may exist that hasn't been examined. This variability can occur at the individual level (eg, conditioning level, general health history), team level (eg, types of practice drills and injury prevention programming used), and setting level (eg, mandates and policies per division/state). Thus, future research that further explores the characteristics of study populations at these levels may help to clarify potential positive and negative contributing factors.

Long-term implications

High ankle sprain injuries result in significant time loss from physical activity immediately following injury;[5,7,11,12] however, potentially significant long-term detriments to health following high ankle sprain injuries have also been well documented. Nearly one in 10 (9.8%) of high ankle sprains are recurrent injuries;[12] this is comparable to the recurrence rate of lateral ankle sprains (11.9%) in collegiate athletes.[10] It's not clear whether one sex is more likely to sustain a recurrent high ankle sprain injury than the other.[12,29,30] If differences in recurrence rates do exist between the sexes, it may be attributable to differences in injury recovery rates, rehabilitation programs, or sport-specific rules that differ between genders (eg, men's vs women's lacrosse). Additional work to fully elucidate the potential causes and risk mitigation strategies of high ankle sprain recurrence is warranted.

Furthermore, beyond the initial participation restriction time from sport and the likelihood for increased risk of recurrent injury, the long-term consequences of ankle injury can be debilitating. There is an increased risk of osteoarthritis and post-traumatic osteoarthritis (PTOA) following acute joint injuries,[31,32] and these findings hold true following ankle sprains, as well.[3] One study estimated 79.5% of individuals with ankle OA developed the condition following an acute injury, and specifically 10% of these individuals developed ankle PTOA following an ankle sprain.[33] It is likely that the risk of developing PTOA is even greater following high ankle sprains compared with lateral or medial ankle sprains.

High ankle sprains typically result from higher-energy mechanisms of injury (eg, player contact) than either lateral or medial ankle sprains.[9,10,12,16,17] Although this has yet to be elucidated, previous literature examining the rate of PTOA following high-energy ankle

Seattle Seahawks running back Thomas Rawls suffered a high ankle sprain in the team's preseason opener on August 13. He returned to competition on September 17. (Photo courtesy of sportspressnw.com.)

injuries (eg, combat-related injuries, plafond fractures) found the incidence of PTOA as high as 57% to 91% following these injuries).[32,34] The short- and long-term consequences of high ankle sprains further underscore the necessity for the development and implementation of targeted high ankle sprain injury prevention and rehabilitation strategies.

Conclusions and take-home points

High ankle sprain injuries result in significant lost sport participation time, with nearly half of collegiate athletes missing more than seven days of sports participation following a high ankle sprain injury. High ankle sprains most commonly occur following player contact[12,16,17] and occur more frequently during competitions than practices,[12] which are unusual findings compared with many other common injuries observed in collegiate athletics.[26] These findings likely require sports medicine professionals to adopt high ankle sprain injury prevention strategies that are different than other common injury prevention strategies and are unique to high ankle sprain prevention.[12] Unlike lateral and medial ankle sprain risks that can be mitigated through intervention programs targeting proprioception and balance,[9,10,27,28] high ankle sprain injury prevention strategies may require mechanical interventions[18,19] or changes to game play rules.[12]

The unique mechanisms and significant long- and short-term consequences of high ankle sprain injuries should make them a priority for sports medicine clinicians so that targeted primary injury prevention strategies and rehabilitation programs may be developed. In addition, as more epidemiological data are published regarding these injuries, clinicians need to advocate for further research that empirically examines associated risk and preventive factors and develops and evaluates current and forthcoming prevention programs. ler

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Orthotic management tactics for hallux limitus

Orthotic devices for hallux limitus are designed to limit first metatarsophalangeal joint motion while providing cushioning and plantar pressure distribution. A lack of quality research on conservative treatment of the disorder, however, forces clinicians to rely on their own experience.

By Hank Black

Hallux limitus is a painful, degenerative condition of the first metatarsophalangeal (MTP) joint characterized by restricted range of motion (ROM) at the great toe and progressive osteophyte formation. This restriction of the first ray is believed in most cases to be caused by trauma or multiple microtraumas that cause damage directly to the articular cartilage and restrict the windlass mechanism from functioning smoothly.[1]

Hallux limitus is the second most common condition of the first ray, after hallux valgus.[2] Two-thirds of hallux limitus patients have a family history of the disorder, and up to 79% have bilateral effects.[3]

Although there are several descriptions of functional hallux limitus, Laird defined it first as nonweightbearing dorsiflexion of greater than 50°, with less than 14° of dorsiflexion at terminal stance.[4] Patients typically present with pain and stiffness at the first MTP joint, plantar calluses, and enlargement of the joint.[5] In some patients, however, pain does not correlate with advancement of mechanical restriction of the joint even with radiologically confirmed joint space deterioration.[6]

Functional hallux limitus becomes structural hallux limitus as the stress of repetitive loading in gait makes the first MTP joint susceptible to developing osteoarthritis (OA).[7] The end-point of hallux limitus is near-total restriction of movement, which is called hallux rigidus.[8]

However, functional loss of hallux dorsiflexion at the first MTP joint may occur even when adequate dorsiflexion is available in a nonweightbearing condition.[9] And some patients will have a functional restriction and pain only on weightbearing, but no appreciable structural changes.[8]

Identified risk factors include an abnormally long or elevated metatarsal bone, other differences in foot anatomy, family history, increased age, traumatic injury to the big toe, and female sex.[7]

Failure of the first metatarsal to achieve sufficient plantar flexion prior to the propulsive phase of gait may prevent the posterior glide of the metatarsal head,[10,11] resulting in abnormal hallux dorsiflexion,

With or without orthotic treatment, hallux limitus may progress to hallux rigidus. But whether orthotic management can delay the progression of the disease is unclear.

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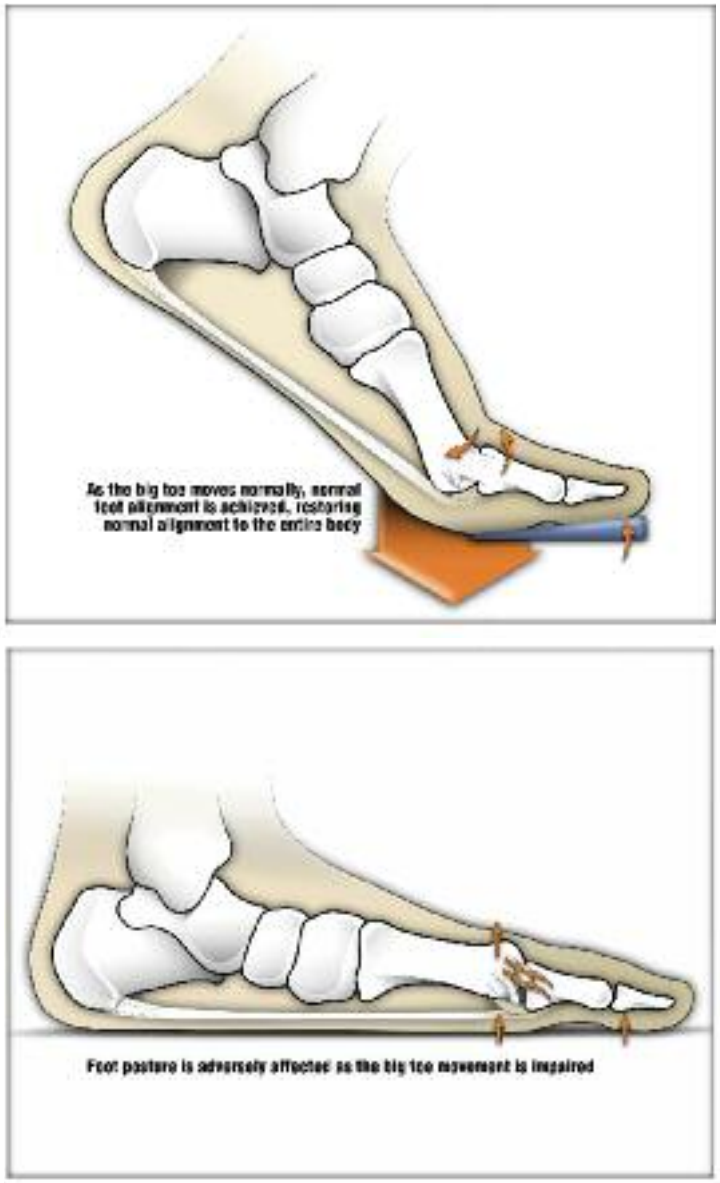

Figure 1. Illustrations depict normal great toe movement (top) and its impairment in a patient with hallux limitus (bottom). (Images courtesy of James Clough, DPM.)

with impingement of the first metatarsal and the proximal phalanx causing pain and inflammation.[12,13] In addition, altered foot and ankle kinematics associated with such pain may be a precursor to OA changes in the first MTP joint.[14,15]

"It's not a pathology but a mechanical action that takes place when the first ray doesn't plantar flex actively and there's a spur on the dorsal aspect of the first MTP joint," said Roger Marzano, LPO, CPed, vice president of clinical services for Yanke Bionics in Akron, OH. "The inability of the proximal phalanx to glide dorsally at the first met head is a component of either hypermobility of the first ray, forefoot varus, or both in combination."

Hallux limitus can result from lack of use of the joint, as well, as patients adopt avoidance strategies to compensate for pain.[16]

Footwear modifications and foot orthoses are widely used in clinical practice to treat this condition, but their effectiveness has not been rigorously evaluated.[17] Surgery may be performed during the course of hallux limitus to remove bone spurs to relieve pain, to add a synthetic "bumper" in the joint, and, if the disorder advances to hallux rigidus, to fuse the joint for pain relief.[18]

"What starts as a functional restriction of range of motion with no arthritis in the big toe joint progresses to the beginning of early arthritis with bone spurs limiting motion but the toe still able to function. Then progressive arthritis occurs with more and more limitation as the windlass mechanism fails to work and the great toe is completely locked up in hallux rigidus," said James G. Clough, DPM, who practices at the Foot and Ankle Clinic of Great Falls, MT.

The incidence of hallux limitus has increased in recent years, according to Georgeanne Botek, DPM, who practices at the Diabetic Foot Clinic of the Cleveland Clinic in Ohio. She attributes this largely to an aging but active population.

"Patients in the past would present in their mid-forties, but now we see increasing numbers in their sixties and seventies," Botek said. "With their increased physical activity and greater awareness of health issues, they present with more symptomatic and severe cases."

The condition affects one of every 45 middle-aged persons and 35% to 60% of the population older than 65 years, according to a 2017 review.[3]

Orthotic management

Orthotic devices for hallux limitus are designed to limit motion across the first MTP joint while providing cushioning and plantar pressure distribution. Many practitioners bemoan the paucity and quality of research on conservative treatment of this disorder, as it leaves them to find what works best in their individual view.

One recent review[19] found high-quality studies supporting orthoses, manipulation, and intra-articular injections. However, nonoperative management should still be offered prior to surgical management, the authors wrote.

A 2010 paper in the *Journal of Foot and Ankle Research*[9] noted most publications on orthotic management of hallux limitus were small case studies,[10,20,21] though a number of studies had looked at the effect of orthotic devices on first MTP joint function in healthy or asymptomatic individuals.[22-28]

But conservative care, including orthotic management, often leads to symptomatic relief. Grady et al, in a retrospective analysis of 772 patients with symptomatic hallux limitus, found 55% were treated successfully with conservative care.[29] Of those, 84% were given foot orthoses. Overall, 47% of the patients in the analysis were treated successfully with orthoses. Other conservative care in the study included corticosteroid injections and changes in footwear.

"In mild cases, the goal is to allow protected movement, and in more severe cases, to block movement of the first MTP joint," said Howard Kashefsky, DPM, FACFAS, director of podiatry services at the University of North Carolina Hospitals in Chapel Hill.

With or without orthotic treatment, hallux limitus may progress to hallux rigidus. Whether orthotic management can delay the progression of hallux limitus, however, is unclear.

"No orthotic will ever take away the progressive arthritic condition, and in the end, most people wind up coming back for surgery," said Samuel Adams, MD, assistant professor of orthopedic surgery and director of foot and ankle research at Duke University Medical Center in Durham, NC.

Kashefsky said he knows of no studies that suggest orthoses can help delay or stop progression. However, he said, "I do have a

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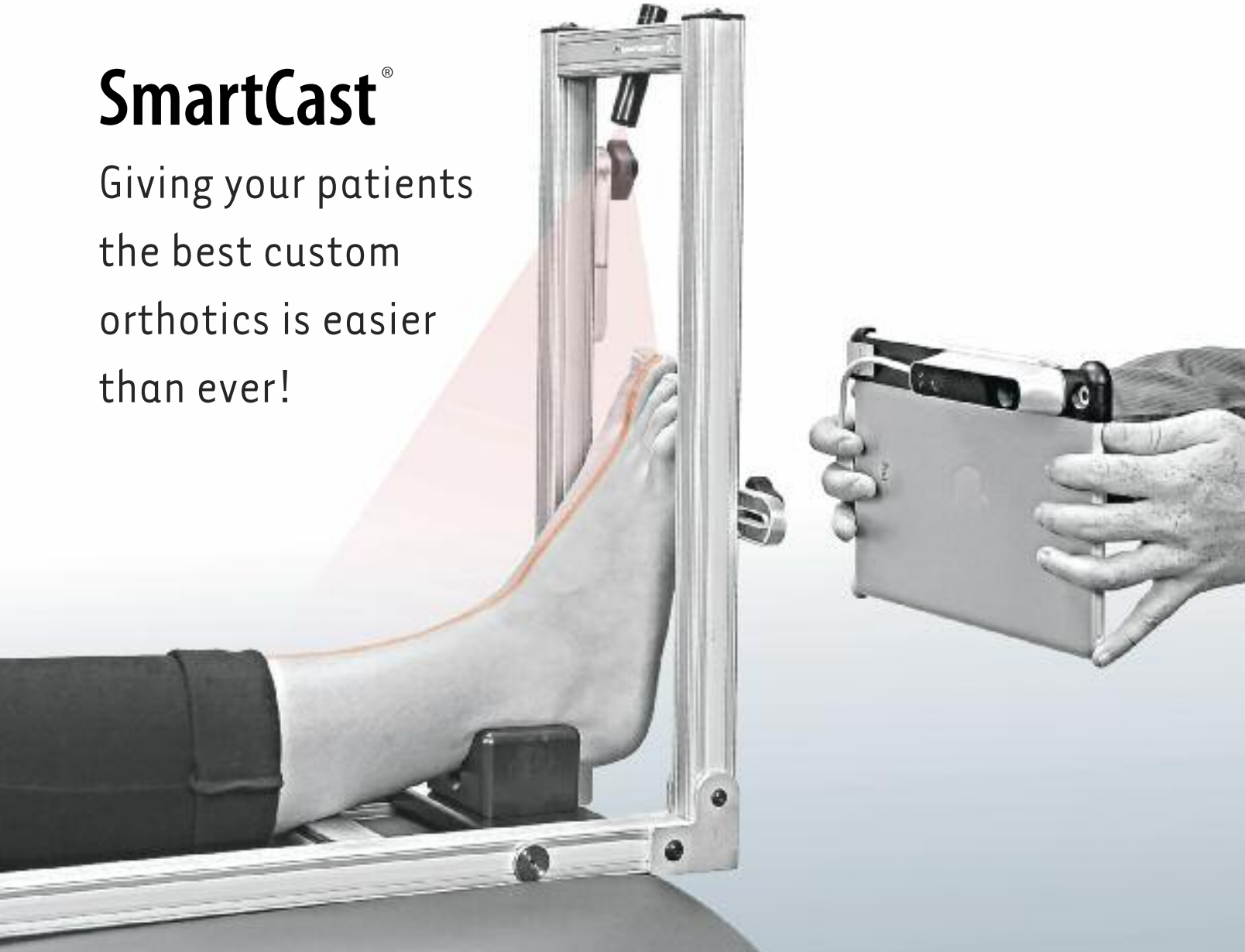

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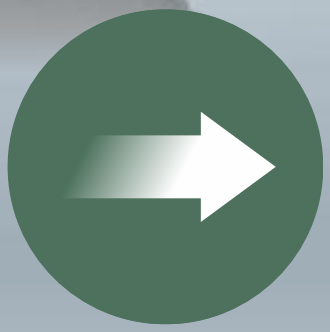

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Figure 2. Graphic depiction of hallux rigidus, the endpoint of hallux limitus progression. (Image courtesy of Roger Marzano, LPO, CPed.)

population that seems to respond well to orthotics and conservative care for years. Some can avoid surgery for their lifetime, based on their life stage, activities, and expectations."

Referring to orthoses and other conservative management strategies for hallux limitus, Clough said, "If it is found in an early stage with good range of motion, minimal spurring, and the ability to engage the windlass mechanism with adequate mobility of the big toe joint, I believe you can maintain mobility and prevent the deformity from progressing."

Increasing dorsiflexion at the first metatarsal joint, by reducing inflammation and implementing physical therapy, does produce symptomatic improvement, according to Paul R. Scherer, DPM, founder of ProLab Orthotics in Napa, CA, and a clinical professor at the Western University College of Podiatric Medicine in Pomona, CA.

"But what we do not know is whether that relates to physiologic change in the joint. Have you really prevented further physiologic damage down the road? For that you might need to gather forty patients and follow them for ten years to get enough data for a possible answer," Scherer said.

Device design

If patients are in early phase of the continuum with pain only at the end of their ROM, many practitioners start orthotic management with a flexible cork Morton's extension and a rocker added to the shoe. In later stages, as joint deterioration increases and movement becomes more painful throughout its range, more rigid orthotic materials such as fiberglass are employed, along with a stiffer shoe and a rocker sole.

Pain only with compression of the first MTP joint, also known as "grind testing," and pain during the middle of ROM may indicate advanced arthritis,[3] a prognosis Kashefsky said should be addressed with a stiffer orthotic device.

Adams said he would offer an orthotic device for relief of minor pain, usually either a Morton's extension by itself or with a full-length device.

"Our physical therapists might also put in a pad under the MTP joint to increase range of motion," he said.

Kashefsky said he checks the patient's family history for prognostic clues. He assesses passive and active ROM using a goniometer, gets weightbearing x-rays, and checks manually for the exact location of pain, including under the sesamoids and at the metatarsal-medial cuneiform joint. Sesamoid deformities, which can result from arthritis, trauma, or necrosis, can contribute to pain under the joint and warrant treatment with a stiffer orthosis, Kashefsky said.

A hypermobile first ray, he said, can contribute to abnormal first-ray elevation.[30] He also looks for the presence of bone fragments in the joint, gout, between-limb symmetry of any arthritis, and any changes suggestive of seropositive/seronegative arthritis or trauma.

Materials are chosen based on a patient's age, weight, activity level, and preferred type of activity.

"I prefer a Morton's extension with something soft like cork for hallux limitus and fiberglass for hallux rigidus," Kashefsky said.

The fiberglass extension is commonly used when large football players incur turf toe from trauma to the first MTP joint, he said. Marathon runners in his clinic typically run with cork extensions under the great toe.

"I encourage them to run at a high cadence and a short stride to avoid over-striding, and pair that with thickly cushioned, 'maximalist' running shoes," which, he said, helps runners tolerate low levels of first MTP pain over a long period.

Scherer uses principles he and others set out in a 1996 hypothesis,[31] for which they confirmed clinical applicability in 2006.[26] It rests on the idea that first-ray dorsiflexion increases ROM at the first metatarsal joint.

"I don't think you will find a practitioner today who wouldn't plantar flex the first ray when casting for orthotics and provide minimum fill, as well as use a reverse Morton's extension in an orthotic prescription for functional hallux limitus," he said. "There's not much evidence for anything else in this arena."

Plantar flexion is essential, Clough agreed, to eliminate any elevation of the metatarsal joint that could cause jamming of the motion and eliminate any forefoot supination.

To avoid eversion of the rearfoot, which has been reported to be associated with hallux dorsiflexion,[32] Clough doesn't use a first metatarsal head cut-out, because it would eliminate a rigid point of stability. But he always uses a slight wedge of about 4 mm under the hallux.

"That allows the hallux to dorsiflex unimpeded and the first metatarsal to plantar flex as the patient moves forward in propulsion," he said. "It helps reorient ligaments around the first MTP joint so they don't restrict mobility there. It also eliminates any forefoot supination."

Marzano recommends a first-ray cut-out.

"Some pocket or relief is given under the first metatarsal head to stimulate plantar flexion of the first ray at the heel-off phase of gait," he said.

A recent Spanish publication found a cut-out orthosis significantly increased declination of the metatarsal angle and demonstrated a positive effect on the affected joints.[33] The cut-out also significantly reduced adduction movement of first metatarsal bone in the transverse plane.

"If the cut-out alone does not resolve the symptoms, I utilize a medium density carbon fiber footplate contoured to the shoe," Marzano said. He explained that an orthosis might fail if a practitioner picks a flat foot plate for a shoe with a large heel rise and great toe spring.

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Figure 3. Radiographs of a patient with bilateral hallux limitus. (Images courtesy of Georgeanne Botek, DPM.)

Because people with hallux limitus often roll their foot laterally to avoid putting weight on the big toe, lateral wedging the full length of the orthosis may be employed, partly to address any subconscious, compensatory movements that might cause problems, Marzano said.

"Peroneal tendinitis can occur from rolling the foot laterally because it hurts to push off. That repetitive rob-Peter-to-pay-Paul mechanism can irritate the peroneal longus tendon, which is a significant plantar flexor of the first ray," he said.

Metatarsal pad utilization depends on the size and shape of the metatarsal heads, Botek said.

"You're probably off-loading the first, second, and third heads, or perhaps the entire MTP area, as opposed to just having a cut-out for the first ray," she said. "A metatarsal bar could be placed on the shoe, and some orthotics come with a built-up met bar to offload the entire metatarsal head region."

For Botek, an orthosis for most people with moderate to severe cases of hallux limitus starts with a thin carbon fiber insert fit to the proper shoe size.

"It extends just beyond the first metatarsal head, providing a little propulsive plate under an insole, and in my experience, helps some seventy percent of patients," she said.

Alex Kor, DPM, immediate past president of the American Academy of Podiatric Sports Medicine, said that though typically the cut-out in an orthosis will stop just proximal to the metatarsal head, the orthotists he works with will, at times, extend the rigid part of the device beyond the first metatarsal head to help facilitate push off.

But Kor, who practices at Froedtert & the Medical College of Wisconsin Health System in Milwaukee, noted there are always exceptions.

"I had a semiactive, weekend-warrior type of woman who couldn't tolerate the longer first ray Morton's extension, so we cut it back, and that eliminated her pain," he said. "Prescribing orthotics is an art and a science. There's no one size fits all."

Custom or over the counter?

Disagreements abound over whether to start orthotic management with custom or over-the-counter (OTC) devices.

Welsh et al conducted a case series of 32 patients with first MTP joint pain in which modified prefabricated foot orthoses were associated with significantly reduced pain at 24 weeks.[9] However, a control group was not included in that study.

Botek estimates about 80% of patients find an OTC option that helps.

"People are relying more on off-the-shelf orthotics now because the devices incorporate better technology," she said. "The most common accommodation for hallux limitus is a metatarsal pad to help offload the entire forefoot, and some OTC inserts and even some footwear come with that. So, I start with those, unless something is clearly out of line mechanically, and if pain relief is not adequate we may prescribe a custom device."

In Botek's experience, improvements in prefabricated orthotic technology have led to decreased use of anti-inflammatory medications; as an alternative, she recommends topical analgesics along the great toe.

Kashefsky agreed some off-the-shelf devices can be helpful, but said the inserts' shape must match the foot's architecture.

"If there's a mismatch, a custom device is indicated," he said.

Kor has a strong preference for custom orthoses, but acknowledges that isn't always practical.

"Orthotics are a work in progress, and that's why the best are custom-made. There's an art to this, and I want to work with an orthotist who's flexible enough to try different things," he said. "But off-the-shelf orthotics definitely can be tried. We have to deal with reality, as insurance isn't often covering orthotic adjustments. I tell patients to try the store-bought device and bring it to me after a couple of weeks' use so I can customize it to the foot."

Clarke Brown, PT, DPT, said customization is also a priority for his group, BrownStone Physical Therapy in Rochester, NY.

"Our group prefers custom orthoses, which allow you to add and subtract material for specific patient conditions," Brown said.

At least one visit to physical therapy is often prescribed for a range of treatments, including stretching, manipulation, ultrasound, and balance board, to achieve a strengthened foot with maximal ROM in the big toe joint and lack of tightness of the gastrocnemius-soleus unit, he said.

"Our takeaway is to use orthoses to maximize the physical therapy treatment," Brown said. "Make the orthosis the last, not first thing you do when treating hallux limitus or other foot problems."

Marzano also has personally observed that gastrocnemius-soleus contractures are often present in runners with symptomatic hallux rigidus and have limited dorsiflexion due to highly developed musculature, as well as in runners who spend too little time stretching.

"If you don't have range of motion at the ankle joint because of Achilles contracture, you're exacerbating the hallux rigidus symptoms due to a necessary increase in metatarsophalangeal extension, as compensation for the decreased ankle range of motion," he said.

Botek said in addition to orthotic treatment, she also instructs her patients to perform a prescribed series of toe-joint motion and distraction exercises with an emphasis on great toe ROM while both weightbearing and nonweightbearing.

Scherer said he refers patients for physical therapy, but typically

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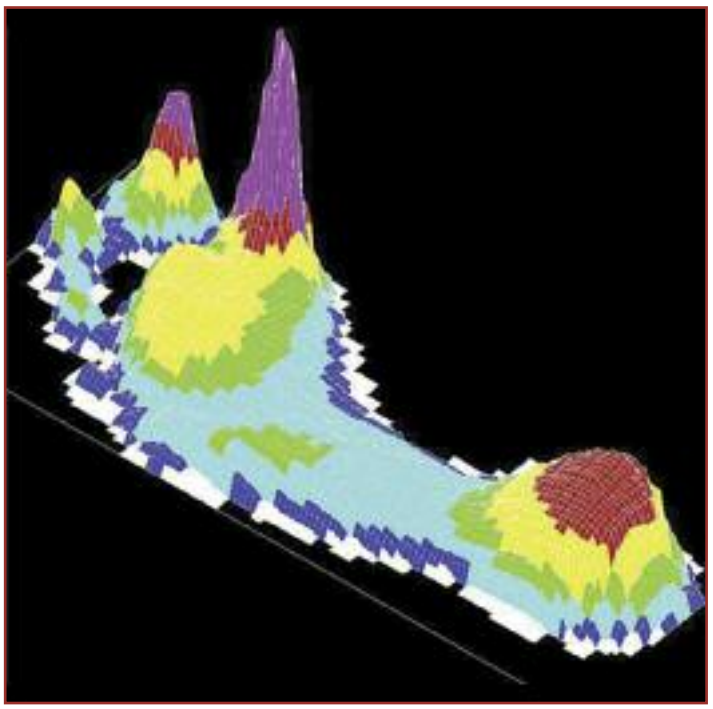

Figure 4. Elevated plantar pressures under the great toe in a patient with hallux limitus in shoegear. (Image courtesy of Georgeanne Botek, DPM.)

does so after orthotic fitting.

"I personally construct the orthotic first, but I don't think there's any literature to say which [order] is best," he said. "It's based on anecdotal, personal preference."

Footwear considerations

Shoe choice is critical to the success of orthotic treatment for hallux limitus, several practitioners said. Brown starts with a flat housing and a neutral shoe (no bias toward a curved or straight last), laces, sufficient width for the orthosis, and no wedge or roll bar.

"However, fashion preferences and workplace requirements may force you to deal with a different shoe," he said, a statement many others echoed.

Botek said she looks for a Vibram- or rubber-soled shoe with laces to hold the orthosis firmly in place. In particular, the shoe should accommodate the device's depth, which can be a challenge, she said. Some patients turn to steel-toed footwear for a toe box of adequate size. High and wide toe boxes may also help prevent compression of dorsal osteophytes.[3]

Kashefsky's ideal shoe to pair with orthoses should have a rocker sole, be stiff enough to protect the great toe joint, and allow for shock absorption. It also should have a removable liner or other means of making room for the device.

Marzano warned that many orthotic professionals construct devices well, "but then [patients] stuff them into shoes that may not have adequate volume."

Runners in particular, he said, don't understand that this is critical to the success of the orthosis.

"Some don't realize their feet have gotten longer and wider as they've aged," he said.

Many athletic shoe manufacturers offer both medium and wide widths, Marzano said, but depth can still be an issue relative to the dorsal prominences present in many runners with hallux limitus.

In patients with later stages of hallux limitus, with erosion at the

first metatarsal joint and arthritic changes occurring, Marzano said he moves aggressively in orthotic management. One of his patients, aged 72 years, wanted to continue playing doubles tennis three times weekly with only 5° of ROM at the first MTP joint. A cardiac condition made surgery untenable, so, "every year I take two pairs of his preferred tennis shoe and bury steel shanks in the bottom and add a mild rocker sole. That's something I wouldn't do for a forty-five-year-old," Marzano said.

The popularity of shoes that lack structure may contribute to first metatarsal joint issues, he said.

"People need to think of their shoes as a therapeutic device versus being just a piece of apparel. I think some MTP joint problems may come from wearing shoes you can bend in half with one hand and don't provide any structural integrity or any resistance at all to toe motion," Marzano said. "I see fewer leather-soled, rubber-heel shoes now, and no steel shanks, either."

In patients with early hallux limitus, a shoe should bend on the ball of the foot right behind the toes with nothing to impede great toe motion, Clough said.

"We want mobility and flexibility at first, to allow the toe to bend absolutely freely," Clough said. "In later stages, where there is structural limitation and not enough motion available to provide stability of the medial arch when the toe isn't actually dorsiflexed, we look to stiffer soles and rocker bottom shoes." ler

Hank Black is a freelance writer in Birmingham, AL.

References are available at lermagazine.com.

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Los Angeles Lakers star Kobe Bryant tore his Achilles tendon in 2013. (Photo by Keith Allison, licensed by Creative Commons.)

Return-to-play concerns following Achilles tears

Achilles tendon ruptures are severe injuries that are associated with a long recovery and significantly affect an athlete's ability to function at a high level. In devising strategies for rehabilitation and return to play, the goal of clinicians and athletes alike is to try to minimize this impact.

By J. Turner Vosseller, MD

Achilles tendon ruptures are common injuries that affect those at the pinnacle of athleticism, as well as those who only irregularly engage in physical activity. Generally, frequent athletic activity is a consistent risk factor for Achilles tendon rupture. Historically, the overwhelming majority of these injuries occurred in young (aged 20-30 years) active men. However, there is some evidence to suggest the mean age at which patients rupture their Achilles tendons has increased with time, as has the proportion of women sustaining these injuries.

While the optimal treatment of an Achilles tendon rupture has been and continues to be a subject of debate, a consistent truth is that, irrespective of how the rupture is treated, patients take a long time to return to preinjury levels of function.

Formal return-to-play (RTP) criteria have been developed for some orthopedic injuries, most notably anterior cruciate ligament (ACL) reconstruction, though many of these guidelines are still being developed.[3] However, objective criteria for RTP still do not exist for many other types of injuries, which can make decisions regarding RTP more difficult. The higher the level of sport, the higher the stakes can be, as well as the pressure on medical professionals to get athletes back to play as expeditiously as possible. In this review, we will look briefly at the current state of Achilles tendon rupture treatment and assess expected outcomes after Achilles rupture in athletes, as well as the data that exist with regard to RTP following these injuries.

In higher-level athletes, and certainly in professional athletes, the clinical bias continues to be toward surgical rather than nonsurgical treatment of these patients.[4] This is most likely because the tension of the tendon can be directly restored surgically and because most of these patients will be young and very healthy, which minimizes the risks associated with surgical treatment, namely wound healing issues. Moreover, high-level athletes are the patients most likely to have every facet of rehabilitation optimized postoperatively.

However, even professional athletes often require a long time

Identifying return-to-play benchmarks and risk factors for slow recovery are critical for developing effective rehabilitation protocols following Achilles tendon rupture in athletes.

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Robert Mathis of the Indianapolis Colts suffered a torn Achilles tendon in 2014. (Photo courtesy of Wikipedia.)

to return to preinjury function, if they are ever able to attain that level. This underscores the extent to which these injuries—in any patient—constitute a significant blow to functional capability that will necessitate a long period of functional recovery.

Treatment risks vs benefits

Discussion of Achilles rupture treatment has traditionally been framed by the balance between the risk of rerupture associated with nonoperative treatment versus the risk of wound issues associated with operative treatment.[5] For the purposes of this article, we will confine our discussion to Achilles rupture in athletes.

With regard to rerupture versus wound issues, operative treatment of Achilles rupture is most commonly chosen in athletes because, given the long recovery associated with these injuries, a rerupture would be a disaster for an athlete. Although it could be reasonably argued that a wound complication would be no less a disaster, the reality is that most athletes—and certainly most professional athletes—are in tip-top physiological health, potentially mitigating the risk of wound issues.

A second concept may be in play, as well. There is some evidence to suggest strength is better after surgical repair of an Achilles tendon rupture than after nonoperative treatment.

In perhaps the most influential recent article on Achilles rupture treatment, Willitts et al[5] promulgated nonoperative treatment, noting no significant difference in rerupture rate between operative and nonoperative treatment arms. However, these authors did note the surgical patients were significantly stronger than the nonoperative ones at final follow-up, though they deemed that difference not clinically significant. The assertion of a lack of clinical significance is perhaps true for some athletes, but it is certainly reasonable that the higher the skill level of the athlete, the more important even seemingly negligible strength differences may be. Other authors have noted this trend, as well,[6] though the literature suffers from inconsistency in reporting strength data during follow-up with these patients.

A final reason that may influence the frequency of surgical treatment of athletes after Achilles rupture is that there is an assumption among these patients that surgical treatment is most appropriate, and "better." It is no doubt the job of clinicians to educate the patient as to his or her options, but a patient who has decided on surgery will likely ultimately find a surgeon who will do it.

RTP outcomes

Many authors have looked at the effect of an Achilles tendon rupture on professional athletes in various sports. Parekh et al assessed the epidemiology and outcomes of Achilles ruptures in the National Football League (NFL), retrospectively reviewing 31 such injuries over a five-year period (1997-2002).[7] In this cohort, only 68% of athletes were able to return to the sport, and those that did generally returned at a lower level of efficacy compared with preinjury.

Another study used the NFL Orthopaedic Surgery Outcomes Database to assess all injuries, treated both surgically and nonsurgically, over a 10-year period (2003-2013).[8] Achilles tendon repair, along with patellar tendon repair, led to significantly fewer games played than other surgeries. Moreover, Achilles repair, along with ACL reconstruction, patellar tendon repair, and tibia intramedullary nailing, were associated with significant decreases in performance in the first year after injury, though the Achilles repair patients returned to preinjury performance levels in the second and third year postinjury.

Finally, Jack et al most recently and comprehensively assessed Achilles ruptures in the NFL using data on 95 players.[9] Seventy-one players were able to return to competition (72.4%); a player's ability to return to a certain level of performance depended in large part on the player's position.

Achilles ruptures have been assessed in other sports, as well. Amin et al assessed 18 players from the National Basketball Association (NBA) who had Achilles ruptures over a 23-year period (1988-2011).[10] The injuries had a profound negative impact on the athletes, as 39% were unable to return to competition, and those who did return had a significant decrease in both playing time and performance. Further data suggest Achilles tendon repair is associated with the lowest RTP rates among NBA players of any orthopedic surgical procedure.[11]

Other authors have assessed Achilles ruptures in Major League Baseball (MLB).[12] Given the nature of the sport, the incidence of Achilles rupture is significantly lower than in sports such as basketball and football, which require frequent eccentric contractures. However, only 62% of MLB position players who sustained Achilles tendon ruptures were able to return to play.

A few studies from Europe have assessed athletes from other sports. Maffulli et al compiled data on 17 elite athletes from sports as diverse as badminton and martial arts, though most were soccer players.[13] All athletes were able to return to competition after

Continued on page 54

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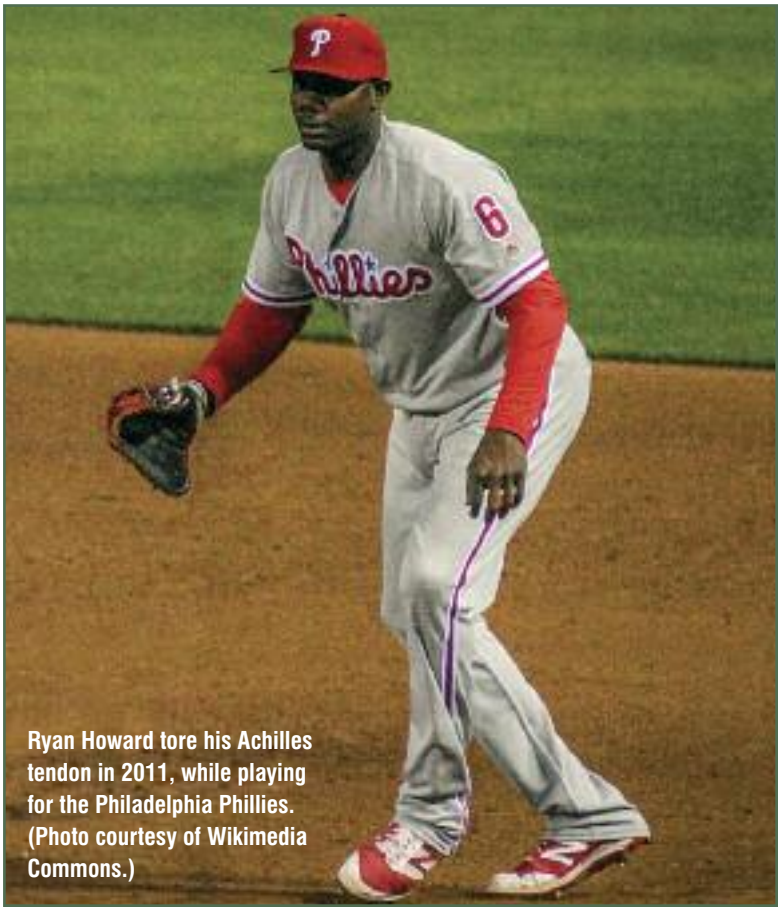
Achilles rupture, but one was not able to compete at the same level as before the injury. The authors did not assess performance capacity objectively; RTP was ultimately a binary variable. Additional research has found that Achilles ruptures are relatively uncommon in soccer, a somewhat unexpected finding, though there are limited data on postinjury performance in these patients.[14]

Synthesizing much of these data, Trofa et al assessed the major professional sports in the US for Achilles ruptures over a 24-year period.[15] Only established professional athletes were included, and control players were used to assess the injury's effect on the player's career trajectory. Only 70% of athletes were able to return to play; those who did return to play did so at a lower level than matched controls one year after injury, but their level of play normalized relative to controls two years after injury.

RTP strategies

Clearly, Achilles ruptures are severe injuries that significantly affect an athlete's ability to function at a high level. The goal of clinicians and athletes alike is to try to minimize this impact.

One aspect of treatment that appears to lower the rate of rerupture among patients with this injury, whether the patient is treated operatively or nonoperatively, is early functional rehabilitation. There are now reams of data showing early weight-bearing and early functional rehabilitation lead to both stronger new tendon formation and better ultimate functional outcomes.[8-10,16] Many treatment protocols do not differentiate much between operative and nonoperative treatment when it



Ryan Howard tore his Achilles tendon in 2011, while playing for the Philadelphia Phillies. (Photo courtesy of Wikimedia Commons.)

comes to the rehabilitation progression. As a gross simplification, rehabilitation focuses on motion for roughly the first two months and thereafter on strengthening.

Some authors have suggested optimal RTP protocols for Achilles rupture patients. Silbernagel and Crossley offered a possible starting point in their proposed program for noninsertional Achilles tendinopathy,[17] primarily just by codifying a protocol and a proposed progression. Of course, Achilles tendinopathy, though related and on the same continuum of disease, is not the same as an Achilles rupture. Any protocol, however, should include some ability to assess where a patient is in their recovery relative to where they should be.

Hansen et al noted that a patient's Achilles tendon Total Rupture Score (ATRS) at three months postinjury could predict their ability to return to sports at one year.[18] Establishing these objective benchmarks is a critical step toward being able to provide the most useful criteria for RTP.

Others have noted that men, patients with Achilles pain at rest three months after injury, and patients with lower physical functioning and calf endurance at six months all have delayed recovery of calf endurance at one year.[19] Although these data may be skewed slightly, given the relative infrequence of Achilles rupture in women, Achilles pain at rest at three months could help identify those patients at risk for slower recovery so that additional interventions could be made to try to fortify their recovery and to adjust their RTP expectations.

Explicit criteria and protocols for RTP after Achilles rupture, however, are generally lacking. Fanchini et al offered a case report of an Italian professional soccer player as an example of a potential protocol.[4] Indeed, this report mainly highlights the vast difference between the resources at the disposal of a pro athlete versus almost anyone else, as the attention paid to this one athlete—including hi-tech monitoring of training-load variables—is likely not possible for the overwhelming majority of the public or for most amateur athletes. Despite that, though, the case study does provide some sense of how the progression should work and what the stages of recovery are.

Summing up

There has been one systematic review with meta-analysis on this topic.[20] The mean RTP rate across all included studies was about 80%. However, the authors noted the studies that were more objective about how RTP was defined (vs a binary did/did not return to play, or studies that did not describe the metrics used) were generally associated with lower RTP rates. Perhaps unsurprisingly, the analysis also found that measures used to evaluate RTP are variable and inconsistent.

Achilles tendon ruptures can be devastating injuries for athletes who require a long recovery, and may not allow them to achieve the degree of athletic prowess they had before the injury. The understanding of RTP following these injuries is in its infancy; as this understanding expands, the negative impact of these injuries may be lessened. ler

J. Turner Vosseller, MD, is an assistant professor of orthopedic surgery specializing in orthopedic foot and ankle surgery at Columbia University Medical Center/New York Presbyterian Hospital in New York City.

References are available at lermagazine.com

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Free Flow AFO Sleeve

The new JAFO Free Flow ankle foot orthosis (AFO) sleeve uses a comfortable, 1/8" thick CoolFlex material to secure a prefabricated AFO. The zip-up sleeve design is intended to eliminate the chafing that can be caused by AFO straps, as well as enhance blood circulation, increase proprioception, reduce swelling, protect the AFO and limb from external forces, and allow the user to walk longer and faster in comfort and style. The sleeve comes in three heights, three calf circumferences, and multiple colors. It can also be used with many existing custom and prefabricated AFOs. The Free Flow retails for $79.99.

JAFO
347/525-0322
myjafo.com

Adjustable Knee Brace

Elite Orthopaedics introduces the Advantage Post Operative Adjustable Knee Brace, designed to provide controlled range of motion for patients recovering from knee surgery or those who have knee injuries or instabilities. The brace is comfortable, lightweight, and simple to apply. Designed as a universal brace to reduce inventory needs, it features trimmable straps and telescoping bars that are easily adjusted for a personalized fit. A hinge with quick-adjusting flexion and extension stops provides range of motion control, and quick clip buckles allow for easy brace application and removal. One size fits most patients.

Elite Orthopaedics
800/284-1688
elite-ortho.com

WalkOn Reaction Junior AFO

Ottobock launches WalkOn Reaction Junior ankle foot orthosis (AFO). Based on the WalkOn Reaction Plus, the WalkOn Reaction Junior is designed for children requiring greater support than traditional dorsiflexion-assist AFOs provide. It features highly dynamic properties and uses ground reaction force to promote a more stable physiological gait pattern. The lightweight carbon fiber prepreg material utilized in the pediatric AFO provides high energy return to support lifting of the foot during swing phase and toe clearance to reduce fall risk. The durable, one-piece design can be fit by trimming the sole with scissors.

Ottobock
800/328-4058
ottobockus.com

Hyperion II Footwear

Xelero has replaced its original best-selling pedorthic shoe, Hyperion, with the Hyperion II. This outdoor shoe, optimized for excursions in extreme conditions, is available as a women's low top and a men's low top and high top. Featuring a wider outsole than the company's Genesis XPS style, the Hyperion II features a similar propulsion element that promotes a quick forward motion during gait while providing stability and control. Midsole gel pads provide added shock absorption, and the insole is designed to help reduce plantar pressures. Aquamax technology makes the shoes waterproof and weather-resistant.

Xelero
866/969-3338
xeleroshoes.com

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KidSport Insoles

KidSport Cushioning Insoles are new, affordable full-length insoles from Powerstep that are specifically designed for children. KidSport is a fully cushioned, less aggressive option for children's footwear, which often lacks sufficient cushioning or support. The dual-layer foam offers full-foot comfort and shock absorption, and the contoured arch shape and heel cup provide slight support with a soft, supportive feel. The top fabric is heat and friction-reducing with antimicrobial qualities to help prevent odor. The new full-length insole is available in 12 sizes, ranging from size Toddler 9 to "big kid" size Youth 6.

Powerstep
888/237-3668
powersteps.com

Vertex Camera From Vicon

Academy Award-winning Vicon has announced the availability of a new compact camera, the Vertex. The Vertex camera boasts a small and flexible design, with wide angle fields of view, allowing it to capture significant volumes in very tight spaces. The 1.3-megapixel camera is equipped with a two-m flexible cable. The camera's unobtrusive design and infrared strobes mean that patients or study participants are less likely to be distracted by the camera and more likely to behave naturally. The Vertex is designed to integrate seamlessly with the company's existing cameras, Vantage and Vero.

Vicon
303/799-8686
vicon.com

Coral Daily Vitamin D3

Coral now offers Coral Daily Vitamin D3, designed to help maintain strong bones and good overall health in the millions of Americans who are deficient in vitamin D, even during the summer months when sun exposure promotes natural vitamin D production. Coral Daily Vitamin D3 provides 5000 IU of vitamin D3 and 100 mg of coral calcium per serving. The supplement includes 73 other trace minerals derived from above-sea, EcoSafe coral; these include chromium, copper, iodine, iron, magnesium, and potassium. Coral Daily Vitamin D3 is offered in a container of 100 easy-to-swallow vegetarian capsules for $18.95.

Coral
800/882-9577
coralcalcium.com

Decompression Foot Sleeve

New from ING Source, the OS1st DS6 Decompression Foot Sleeve simulates therapeutic taping, delivering six zones of compression to improve circulation and help relieve the painful symptoms of moderate to severe plantar fasciitis, heel pain, foot swelling, and other arch and heel conditions. Designed for use as resting or low activity therapy only, DS6 is a first-stage treatment. It is not intended for running or use during activity. The OS1st DS6 Decompression Foot Sleeve is engineered to be a comfortable, easy-to-use alternative to bulky and uncomfortable night splints or splint socks.

ING Source
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Game Changer Knee OA Brace

Ovation Medical has introduced the new Game Changer Premium Universal OA Knee Brace, designed to get knee osteoarthritis patients back to as much activity as possible. The brace should be worn for 30 to 60 minutes on the first day, and wear time should be gradually increased as comfortable each day thereafter. Every brace comes with printed instructions for use. The company also provides free step-by-step video instructions on its website. Although the best outcomes will be achieved when the Game Changer is worn directly against the skin, it can be effective when worn either under or over clothes.

Ovation Medical
800/403-6466
ovationmed.com

AeroSpring Brace Systems

Created as an alternative to heavy, difficult-to-secure walking boots, the new Richie AeroSpring Brace Systems have been designed to treat common conditions treated with walking boots. The AeroSpring "system approach" combines the therapeutic effects of a custom functional foot orthosis with the lower limb stabilizing effect of a dynamic ground reaction carbon fiber ankle foot orthosis. Depending upon the pathology being treated, the foot orthosis of the Richie AeroSpring is modified with specific features that address the specific foot and ankle condition to augment and optimize the effects of the device.

Richie Brace
877/359-0009
richiebrace.com

Thermal Vent Plantar DR

The Swede-O Thermal Vent Plantar DR is designed to help relieve pain and discomfort associated with plantar fasciitis, Achilles tendinitis, and other conditions. The device features a nonelastic strap that pulls the ankle into slight dorsiflexion and extends the toes gently to stretch the plantar fascia, while passively stretching the calf and Achilles tendon. The gentle stretch is intended to help reduce muscle contracture, inflammation, and associated pain. Other features of the Thermal Vent Plantar DR include a nonslip safety sole, a soft thermal lining, and a microventilated, breathable membrane.

Swede-O by Core Products International
800/365-3047
swedeo.com

SmartCast Scanning System

SmartCast is a new, all-inclusive system designed by Chris Smith, DPM, and Northwest Podiatric Laboratory to simplify and improve the process of prescribing custom orthotic devices. With patients comfortably seated in an exam chair, practitioners follow a simple positioning process using visual cues and an alignment laser to achieve the ideal foot position. Using the included iPad and 3D sensor, patients' feet are scanned, prescription information is entered into the HIPAA-compliant SmartCast app, and orders are submitted instantly over wi-fi for crafting by highly trained, experienced technicians.

Northwest Podiatric Laboratory
800/675-1766
nwpodiatric.com

market mechanics

By Emily Delzell

Ipsen data show CP spasticity undertreated

A presentation given by Basking Ridge, NJ-based Ipsen Biopharmaceuticals in September at the annual meeting of the American Academy of Cerebral Palsy and Developmental Medicine in Montreal, Canada, found more than 40% of children with cerebral palsy (CP) receive none of 10 common therapies for the motor disorder.

The retrospective study analyzed two years (2013-2015) of Medicaid data from a seven million-person database, identifying 3294 unique cases of children with CP; 42% of these children didn't receive any of 10 therapies identified by an expert panel as those most commonly used for spasticity management. The therapies are physical therapy, orthotic devices, oral baclofen, botulinum toxin, antispasm medication, casting, orthopedic surgery, baclofen injection, baclofen pumps, and rhizotomies.

The data also showed children with CP who were likely nonambulatory had average annual costs four times higher than those for children with CP who were likely ambulatory (ambulation status could not be obtained so researchers used an algorithm to estimate its likelihood). ler

Comau, Össur invest in Iuvo exoskeletons

Rekyavik, Iceland-based Össur and Italian automation company Comau in October announced their investment in Iuvo, a wearable technology company headquartered in Pisa, Italy, that's focused on developing robotic exoskeletons to enhance mobility.

Össur and Turin-based Comau hold a majority share of Iuvo, which was founded in 2015 as a spin-off company of The BioRobotics Institute of the Scuola Superiore Sant'Anna in Pontedera, Italy. Comau is the majority holder in the joint venture between Comau and Össur. ler

OrthoPediatrics closes $59.8M IPO

Warsaw, IN-based pediatric surgical system maker OrthoPediatrics on October 15 announced the closing of its initial public offering of 4.6 million shares of its common stock, including the full exercise by the underwriters of their option to purchase 600,000 additional shares, at a public offering price of $13 per share. OrthoPediatrics received $59.8 million in gross proceeds from the offering. The shares began trading on the NASDAQ Global Market on October 12 under the ticker symbol "KIDS." ler

NIH funds $1.3M post-traumatic OA study

The National Institutes of Health in July awarded a $1.3 million grant to an Indiana University-Purdue University Indianapolis mechanical engineer to evaluate a new method of strengthening damaged cartilage and preventing arthritic progression.

Diane Wagner, PhD, associate professor of mechanical engineering in the School of Engineering and Technology, will study a photo-initiated cross-linking treatment in which a combination of a chemical solution and a particular light wavelength is used to add bonds between collagen fibers within cartilage. The therapy can be delivered through arthroscopic surgery, according to a university release. ler

Ottobock acquires Freedom Innovations

Duderstadt, Germany-based Ottobock HealthCare GmbH has acquired Irvine, CA-based Freedom Innovations from its previous owner, private equity company Health Evolution Partners. The two parties signed a confidential purchase agreement on September 22.

Ottobock has taken over all company operations, but Freedom Innovations will keep its brand, according to a release from the German company.

Dave Reissfelder, who has headed the Ottobock subsidiary BionX in Boston, MA, was appointed as the new Freedom Innovation CEO.

"Together, Ottobock and Freedom Innovations—the number one and the number three [prosthetic companies] on the American market—will benefit from their combined sales power and portfolios," says Hans Georg Näder, president of Ottobock HealthCare GmbH.

"Users will benefit from an even broader spectrum of innovative systems in prosthetics and a full pipeline of new products. And our growth strategy will be bolstered by a great brand that will also further strengthen our presence in North America." ler

Mueller Sports is WFATT official supplier

Prairie du Sac, WI-based Mueller Sports Medicine in September cemented its relationship with the World Federation of Athletic Training and Therapy (WFATT), becoming their official supplier of sports medicine products.

WFATT is a coalition of national organizations of health care professionals in the fields of sports, exercise, injury/illness prevention, and treatment. As part of the partnership Mueller Sports will help educate athletic trainers and therapists on products and techniques for injury prevention and recovery. ler

NSF gives $500K for synthetic muscle work

The National Science Foundation (NSF) in September awarded a University of Houston (UH) engineer $500,000 to develop artificial muscle and tendons for prostheses.

Zheng Chen, PhD, the Bill D. Cook Assistant Professor of Mechanical Engineering and director of the Bio-inspired Robotics and Controls Lab at the UH Cullen College of Engineering, won an NSF Career award, granted to promising junior faculty, for his work on prostheses with dielectric elastomers. These smart materials have built-in actuation and sensing capabilities that let them mimic human muscles more closely than motorized metallic parts.

Chen and his colleagues have developed an artificial muscle and tendon prototype, and plan to use nanotechnology to refine the material's performance. ler

CMS shelves controversial O&P proposal

The US Centers for Medicare and Medicaid Services (CMS) in October withdrew a controversial proposal that would have restricted many physical therapists (PTs) from furnishing custom orthotic and prosthetic devices.

The proposed rule, issued in January, would have required PTs to be "licensed by the state [as a qualified provider of prosthetics and custom orthotics], or…certified by the American Board for Certification in Orthotics and Prosthetics…or by the Board for Orthotist/Prosthetist Certification." ler

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market mechanics

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Footmaxx fits fishmongers with orthoses

Roanoke, VA-based Footmaxx in September partnered with Seattle's Pike Place Fish Market to deliver its custom Voyager orthoses to its fishmongers, who are known for their fish-throwing flair.

"Voyager is one of our signature orthotics and contains technology we knew would benefit them," explained Lindsay Smith, Footmaxx marketing coordinator. "They're on their feet for twelve to sixteen hours each day on concrete floors. Many complained about soreness in their lower backs, knees, and hips. Voyager contains Poron cushioning technology in the midlayer to absorb punishing shock, while the SmartTech topcover contains Outlast to regulate temperature and keep the feet cool, Dri-Freeze to provide maximum moisture management, and Cleansport NXT to fight odor."

Footmaxx brought its 3Dmaxx scanners to the market to get volumetric data from the feet of all the market's 18 fishmongers and a few days later delivered the customized full-length carbon-edged semirigid Voyager orthoses. ler

Therafirm adds sizing, pattern options

Kansas City, KS-based Therafirm in September expanded sizing options for its Ease Opaque gradient compression knee highs.

Previously available only in long (accommodating knee-to-floor lengths of 16" or longer) and short (for lengths shorter than 16"), in small, medium, and large sizes, the knee highs are now offered in a petite length and an XL size.

Petite length knee highs fit individuals with a leg length shorter than 13", while the XL size fits those with an ankle and calf circumference up to 15" and 23", respectively. Ease knee highs are also available in a new pattern, a black microfiber material woven with red dots. ler

Dr. Comfort donates shoes to storm victims

Mequon, WI-based Dr. Comfort reported in September its donation of more than 500 pairs of its diabetic shoes to victims of hurricanes Harvey and Irma through the American Red Cross and Soles4Souls, a nonprofit based in Nashville, TN.

Soles4Souls gives shoes and clothing to people in need around the world and is accepting donations to fund its work for recent storm victims on its website at soles4souls.org. ler

BOC offers 3-year pharmacy accreditation

The Owings Mills, MD-based Board of Certification/Accreditation (BOC) announced in October that it's accepting applications for a new pharmacy compounding accreditation.

The accreditation will focus solely focus on nonsterile compounding and is only available in conjunction with BOC Retail or Retail + DMEPOS (durable medical equipment, prosthetics, orthotics, and supplies) accreditation. BOC's compounding three-year accreditation is based on the US Pharmacopeial Convention (USP) guidelines, federal regulations and third-party payer requirements, according to a BOC release.

Those interested in applying for the accreditation can visit bocusa.org/pharmacy to review the BOC Compounding Accreditation Standards, complete an application, and access other resources, including site survey checklists. ler

NWU promotes Fatone to professor

Northwestern University (NWU) in Chicago in September promoted Stefania Fatone, PhD, BPO(Hons), to professor of physical medicine and rehabilitation in the Feinberg School of Medicine.

Fatone, a member of *LER*'s board of advisors, is principal investigator for multiple research and development projects at the Northwestern University Prosthetics-Orthotics Center (NUPOC), where she also contributes to the Master of Prosthetics and Orthotics Program. She began her career at NWU in 2000 and was more recently research associate professor in the Department of Physical Medicine and Rehabilitation.

Fatone, who's a native of Australia and a graduate of its La Trobe University in Melbourne, developed the Northwestern University Flexible Sub-Ischial Vacuum Socket for transfemoral amputation. She leads research in the orthotic management of neuromuscular conditions, particularly stroke and cerebral palsy, and is evaluating partial foot amputation outcomes to facilitate shared decision-making. She's one of a small cadre of qualified prosthetists and orthotists with a doctorate, according to an NWU release.

She has published more than 65 peer-reviewed articles, editorials, and book chapters and mentored more than 60 graduate students, postdoctoral fellows, residents, and junior faculty.

The American Academy of Orthotists and Prosthetists recognized her contributions with honorary membership in 2007 and its Research Award in 2010. She's a long-standing member of the Clinical Content Committee for the American Academy of Orthotists and Prosthetists and a board member and chair of the Research Committee for the Orthotics and Prosthetics Education and Research Foundation. ler

Athletic training students win SWATA grants

The University of Arkansas in Fayetteville in September reported the Southwest Athletic Trainers' Association awarded scholarships and research grants to three students in its graduate athletic training program at the association's annual meeting in San Marcos, TX, where the regional group of Texas and Arkansas athletic trainers is based.

Among the winners was Mariellen Veach, who received the Texas Health Ben Hogan Sports Medicine Graduate Scholarship and an Entry-Level Master's Student Grant. Veach, who earned a bachelor's degree in kinesiology from the University of Illinois in Urbana-Champaign, plans to use the grant to study preseason vitamin D levels as a predictor of musculoskeletal injury in college athletes. ler

AOSSM, Aircast back return-to-play study

The Rosemont, IL-based American Orthopaedic Society for Sports Medicine (AOSSM) and The Aircast Foundation, headquartered in Naples, FL, announced in September that the groups are funding a new grant of up to $150,000 for a clinical research project investigating return to play after musculoskeletal injury.

The organizations are seeking collaborative multicenter research proposals for the grant. Applications are due November 15. For more information about the grant, which will be awarded in February 2018, go to the AOSSM website at sportsmed.org. ler

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