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LOWER EXTREMITY REVIEW
November 15 / volume 8 / number 11

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By Cary Groner

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out on a limb: Strike pattern revisited

The concept of foot-strike pattern during running—something rarely discussed a decade ago, even in research circles—is now pervasive among runners as well as biomechanics experts and lower extremity clinicians. But that's not necessarily a good thing.

To be sure, discussing the risks of running-related injuries in terms of foot-strike pattern is preferable to discussing those risks in terms of barefoot vs shod running. While many barefoot runners will swear that giving up footwear forever is the only true path to health and happiness, researchers have demonstrated that many of the impact-related benefits of barefoot running are related to the fact that runners are far less likely to use a heel-strike pattern while barefoot than while shod. And midfoot- or forefoot-strike patterns aren't exclusive to barefoot runners; they can be observed in plenty of shod runners too.

Shifting the discussion from barefoot-or-bust to the relative benefits of different foot-strike patterns has acknowledged some of the complexity involved and has made runners feel they have more options for reducing their injury risk. There's just one problem: It turns out that foot-strike pattern can be pretty difficult to determine. Research suggests even experienced runners can correctly identify their foot-strike pattern only about half the time. This may be, at least in part, because many runners, especially distance runners, vary their foot-strike patterns during the course of a run.

It also turns out that a noticeable change in foot-strike pattern isn't necessary to reduce injury risk factors in runners. Researchers from the Cleveland Clinic, for example, found that increasing step rate—which has previously been associated with reduced impact forces—only affected foot-strike pattern in a small percentage of runners (see "Step rate manipulation and foot-strike pattern," September, page 51). More recently, Australian researchers reported that running in minimalist footwear had no effect on foot-strike pattern for the study group overall, despite a significant shifting of work from the knee to the ankle.

Interestingly, although the interventions in these two studies were not associated with a change in foot-strike pattern, they were associated with significant changes in foot inclination angle. And it makes sense that, if the foot hits the ground at less of an angle, that can still have measurable effects even if the change isn't large enough to reclassify a heel striker to a midfoot striker. The Australian study also noted a significant shift in strike index (the location on the long axis of the foot of the runner's center of pressure at initial contact), which researchers sometimes use to define foot-strike pattern. Again, strike index didn't change enough to warrant foot-strike pattern reclassification, but did change enough to have made a difference in other ways.

> Runners and clinicians should focus less on foot-strike pattern and more on altering variables like step rate or step length.

These developments underscore the need for runners and the clinicians who treat them to focus less on foot-strike pattern as an outcome measure. Training goals based on variables like step rate or step length are easier to implement, and are likely to benefit a greater percentage of runners—even those who prefer to keep their shoes on.

Jordana Bieze Foster, *Editor*

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ITBS intrigue

Fatigue leads to decreased hip adduction

By Katie Bell

Women with iliotibial band syndrome (ITBS) independently modify their running gait when fatigued to decrease hip adduction, potentially as a result of pain, according to research from Rutgers University in Newark, NJ, that may have implications for gait retraining.

The findings underscore the complex relationship between ITBS and hip adduction; some studies have reported excessive hip adduction in runners with ITBS, while others have not (see "Iliotibial band syndrome and running mechanics," July 2015, page 35).

"I think the most important take-home message from these data is that there is no 'recipe' that can be given for gait retraining with a specific diagnosis," said first author Allison Brown, PT, PhD, an assistant professor in the Department of Rehabilitation and Movement Sciences at Rutgers Biomedical and Health Sciences. "Prior to implementing gait retraining as an intervention, clinicians should evaluate the patient's gait to see what gait impairments are present."

The study included 32 female runners, 12 with ITBS and 20 uninjured. Overground running data were collected before and after participants performed a treadmill run to fatigue. The variables of interest were focused on stance phase: peak hip adduction and internal rotation angles, peak hip abduction and external rotation moments, and frontal-sagittal plane hip and knee joint coupling.

In the runners with ITBS, fatigue was associated with a mean peak hip adduction angle that was 3° smaller than in the uninjured

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Step rate, length differentiate trained from untrained long distance runners

Trained long distance runners have a higher step rate and a shorter step length during running than untrained participants—characteristics that may represent adaptations to reduce injury and improve running economy, according to research from Spain.

Investigators from the University of the Basque Country in Vitoria-Gasteiz, Spain, analyzed 10 amateur runners with long-distance training experience and 10 healthy untrained participants during two treadmill runs: a submaximal run (between 9 and 15 km/h) and a graded exercise running test (from 6 km/h to exhaustion). All study participants were habitual rearfoot strikers.

The trained runners had a significantly higher step rate and shorter step length than the untrained runners at the same running speeds and at the same physiological intensities. In addition, running economy was about 7% more efficient in the trained group than in the untrained group. However, contact and flight times during running did not differ significantly between the groups.

The findings were epublished in October by the *Journal of Strength and Conditioning Research*. ler

–Jordana Bieze Foster

Source:
Gomez-Molina J, Ogueta-Alday A, Stickley C, et al. Differences in spatio-temporal parameters between trained runners and untrained participants. J Strength Cond Res 2016 Oct 6. [Epub ahead of print]

Runners with chronic ankle instability demonstrate altered kinetics in study

Chronic ankle instability (CAI) is associated with altered vertical ground reaction forces (vGRF) and loading rates during running, which may be related to altered landing patterns designed to protect the ankle joint, according to research from Indiana University in Bloomington.

Investigators assessed kinetics in 13 healthy young adults (six women) and 11 with self-reported CAI (six women), all of whom were experienced runners, as they ran on a treadmill at 3.3 m/s for five minutes.

Compared with the uninjured group, the CAI group had significantly higher impact peak forces and active peak forces, faster loading rate, and a shorter time to reach active peak force. Time to reach impact peak force did not differ significantly between groups. The findings were epublished in early November by the *Journal of Athletic Training*.

Although the study did not assess kinematics, the altered kinetic variables in the CAI group are consistent with previous findings that individuals with CAI run with a stiffer landing strategy than uninjured controls, possibly to protect the ankle. ler

–Jordana Bieze Foster

Source:
Bigouette J, Simon J, Liu K, Docherty CL. Altered vertical ground reaction forces in participants with chronic ankle instability while running. J Athl Train 2016 Nov 4. [Epub ahead of print]

Continued from page 13

runners, which translated to an 18.5% difference between the groups. There were no between-group differences with respect to hip adduction prior to the fatiguing protocol.

With respect to the remaining variables, fatigue did not affect injured runners differently than controls, and hip joint coupling did not differ between the groups during the loading or propulsive phases of stance. The findings were published in the November issue of *Clinical Biomechanics*.

Runners may minimize hip adduction to reduce pain by shortening the length of the iliotibial band, the authors hypothesized, noting that the other variables examined may not have been sensitive to such compensations.

Brown said that the participants had a mean pain level of .25 out of 10 on the Borg CR10 scale at the start of the run and finished with a mean pain level of 2.7, while two runners terminated their run due to their pain level reaching 6 out of 10.

"This pain may in fact be associated with the findings of the study, in that runners might have already adopted pathologic gait mechanics due to the pain. However, that would be speculation, as it was not tested," Brown added.

Although the study did not look at other factors that have been reported to be associated with ITBS, such as narrow step width and knee internal rotation, Brown suggested rearfoot angle at initial contact and the rate of pronation should be considered.

"Most certainly the 'endurance' of muscles, rather than just their gross strength, should be considered," she added.

Commenting on the study, Stacey A. Meardon, PT, PhD, an assistant professor in the Department of Physical Therapy at East Carolina University in Greenville, NC, said that it continues to be relevant to address excessive hip adduction, as it has been linked prospectively with ITBS and is positively associated with ITB strain rate.

Other factors that may be associated with ITBS under fatigue conditions include running-related characteristics, such as magnitude, frequency, duration, and intensity, Meardon noted.

"The specific relationship between prolonged running and potential for injury from a mechanistic viewpoint is likely related to stress accumulation without adequate recovery or adaptation," she added.

The Rutgers investigators concluded that, since runners with ITBS decrease their stance phase hip adduction angles as a result of fatigue, management of this population should include screening for increased hip adduction prior to initiating gait retraining interventions.

However, stance phase hip internal rotation, coupling of hip adduction and hip internal rotation, and coupling of hip adduction and knee internal rotation are less likely to be associated with fatigue-related symptoms and therefore do not warrant a clinician's focus when rehabilitating runners with ITBS. ler

Source:

Brown AM, Zifchock RA, Hillstrom HJ, et al. The effects of fatigue on lower extremity kinematics, kinetics and joint coupling in symptomatic female runners with iliotibial band syndrome. Clin Biomech 2016;39:84-90.

Sex and BFR

Too many studies exclude young women

By Cary Groner

The problematic trend of physiological studies in which young women are underrepresented now extends to research on blood flow restriction (BFR) training, according to a paper epublished in October by *Clinical Physiology and Functional Imaging*.

BFR training, which involves partially occluding blood flow to the limbs in combination with low-load resistance exercise, is experiencing a recent surge in popularity (see "Blood Flow Restriction Training: The slow-flow movement is fast becoming rehab's hottest trend," July 2016, page 20).

The authors of the new paper reported, for example, that in Japan, where the technique originated and is most widespread, 55% of those using BFR are women, but that of existing BFR research, only 29% and 17% of short- and longer-term studies, respectively, included young women.

"This issue isn't exclusive to blood flow restriction; it's rampant in physiology studies," said Jeremy Loenneke, PhD, one of the paper's authors and an assistant professor of exercise science at the University of Mississippi in Oxford. "People will do a study only in men, then extrapolate it to the whole population. But you really shouldn't do that, and it's a problem given that women represent about half the world."

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Foot-specific training in older adults helps improve strength and balance

Foot-focused progressive resistance training helps improve toe flexor strength and balance in older adults, which may help reduce the risk of falls, according to research from the University of Wollongong in Australia.

Investigators randomized 85 community-dwelling older adults to 12 weeks of either a home-based general exercise program or a progressive, supervised resistance training program focused on the foot muscles. Another 32 individuals made up a control group.

Follow-up assessment was performed in 68 participants from the two exercise groups. Flexor strength in the hallux and lesser toes was significantly greater (by up to 36%) compared with baseline in the foot-focused training group but not in the home-exercise or control groups. In the foot-focused training group, increased toe flexor strength was associated with significant improvements in perceived general foot health (based on the Foot Health Status Questionnaire) and single-leg balance time.

The findings were epublished in October by *Clinical Biomechanics*. The authors recommended further trials to determine if the foot-focused training is associated with a reduced risk of falls.

–Jordana Bieze Foster

Source:

Mickle KJ, Caputi P, Potter JM, Steele JR. Efficacy of a progressive resistance exercise program to increase toe flexor strength in older people. Clin Biomech 2016 Oct 7. [Epub ahead of print]

Foam rolling outperforms stretching for quadriceps, hamstring flexibility

Foam rolling is associated with greater acute improvement in quadriceps and hamstrings flexibility compared with static or dynamic stretching, according to research from Taiwan.

In 30 college students (15 women), investigators from Kaohsiung Medical University assessed quadriceps and hamstrings flexibility, along with isokinetic peak torque during knee flexion and extension, before and after three warm-up interventions: foam rolling, static stretching, and dynamic stretching. All participants performed all three interventions on three days, in random order, with 48 to 72 hours between test sessions.

Compared with baseline, improvement in flexibility was significantly greater after foam rolling than after either of the two stretching interventions. Foam rolling and dynamic stretching were both associated with significant improvements in knee extension peak torque; none of the interventions were associated with significant changes in knee flexion strength.

The findings, epublished in October by the *Journal of Sport Rehabilitation*, support the use of foam rolling as part of a warm-up to improve flexibility without adversely affecting strength, the authors concluded.

–Jordana Bieze Foster

Source:

Su H, Chang N-J, Wu W-L, et al. Acute effects of foam rolling, static stretching, and dynamic stretching during warm-ups on muscular flexibility and strength in young adults. J Sport Rehabil 2016 Oct 13. [Epub ahead of print]

Continued from page 15

Loenneke and his coauthors considered the possible reasons for the discrepancy and eliminated one—namely, that women have more fatty tissue than men, thus complicating surface electromyography (EMG) signals.

"Women do have more adipose tissue in general, but many men have a lot of it as well," Loenneke said. "If you normalize the EMG signal to itself, you address that problem."

The researchers noted a curious aspect of the issue: namely, that older women are represented in studies just as often as older men. As *LER* reported, for example, BFR shows promise for leg strengthening in female patients with osteoarthritis. The most likely reason young women are excluded, then, is that researchers don't want to deal with the metabolic variables introduced by the menstrual cycle. But, according to Loenneke, this is a poor reason to leave women out.

"Studies don't usually last a week; they typically last two to three months," he said. "So the women would be training across both the follicular and luteal phases of their cycles; they don't train half the month and then take the other half off. Mechanistically speaking, the distinction between BFR's effects in different parts of the cycle might be interesting, but pragmatically, for muscle size and strength, it probably wouldn't matter."

Loenneke suggested that practical solutions to the problem would strengthen research rather than compromise it.

"The ideal would be to have the same number of each sex and then see if there was any difference between them in the end," he said. "But we understand that sometimes that's not possible. You may be unbalanced in your study population and end up with more men than women. One thing you could do in that situation is run the group results and get the mean—do traditional stats the way we always do, in other words—but then plot the individual responses to see if there's a similar pattern in men and women. That would be something to investigate."

Loenneke and his colleagues have recruited women for their own BFR studies and have seen them respond to the technique, so they admit to frustration with the slow rate of change across the field.

"Once in a while you hear researchers say that we need more women in the studies, but then nothing ever comes of it," he said. "If there's something you need to control for in the menstrual cycle, consider it when you plan the study, but at least try to include them. And if for some reason you don't, explain why and acknowledge that it's a limitation in your study." ler

Source:

Counts BR, Rossow LM, Mattocks KT, et al. Let's talk about sex: Where are all the young females in blood flow restriction research? Clin Physiol Funct Imaging 2016 Oct 11. [Epub ahead of print]

Segal NA, Williams GN, Davis MC, et al. Efficacy of blood flow-restricted, low-load resistance training in women with risk factors for symptomatic knee osteoarthritis. PM R 2015;7(4):376-384.

Bryk FF, Dos Reis AC, Fingerhut D, et al. Exercises with partial vascular occlusion in patients with knee osteoarthritis: a randomized clinical trial. Knee Surg Sports Traumatol Arthrosc 2016;24(5):1580-1586.

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MOUTHGUARD MYSTERIES:

Can wearing one really improve athletic performance?

By Cary Groner

Multiple studies suggest that mouthguards, designed to protect athletes from dental injuries during contact sports, may also help improve muscle force and power. But plenty of other studies have found no such benefits, and even the experts aren't sure what to believe.

Chew on this: Research suggests that what your jaw is doing may have repercussions throughout your body, from brain activity to speed and strength.[1]

Chomping on something has a long history in stress mitigation, of course. Long before National Football League coach Pete Carroll started chewing gum on the sidelines, gnawing a piece of leather to fight through pain was common practice in the terrifying pre-anesthesia world—a soldier screaming his way through a battlefield amputation or a woman suffering the agonies of childbirth.

In recent, more humane decades, chewing is usually unnecessary for pain control, but even so, studies have shown it increases blood flow to areas of the brain associated with memory, attention, motor control, and planning.[2,3] Mastication also destimulates the amygdala, which is associated with emotional reactions;[4] activates brain serotonin action; and reduces anxiety while improving alertness.[5,6] It improves mental performance and reaction time, too, and appears to help dissipate physiological stress.[1]

Athletes who wear mouthguards often chew on them, of course. The devices are designed primarily to prevent dental injuries in contact sports—such as football, ice hockey, and lacrosse—by keeping the upper and lower teeth at a courteous distance from each other. But some researchers have suggested there may be performance benefits associated with wearing them, as well. It's a baffling field full of contradictory claims that have left experts scratching their heads, and though a few

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recent papers are shedding light on what may be going on, much speculation remains.

The pros

Courtenay Dunn-Lewis, PhD, a visiting assistant professor in health and sports medicine at the University of Pittsburgh in Pennsylvania, and colleagues compared neuromuscular force and power production in athletes wearing a customized mouthguard, an over-the-counter (boil-and-bite) guard, or no guard.[1] She reported that bench throw power and force were significantly higher with the custom guard than the other conditions in both men and women, and that a plyo press power quotient (3PQ) was higher in terms of both power and force production in men. Similarly, men using the custom guard had a higher rate of power development in the vertical jump, but the researchers found no differences in flexibility, balance, visual reaction time, or sprint time. They concluded that the custom mouthguard improved the performance of upper-body loaded power exercises in both sexes, and lower-body power exercises in men, without compromising other performance measures.

"It may have been that the custom mouthguard helped people stabilize their head and neck by clenching their jaw," Dunn-Lewis told *LER*. "That particular guard placed a space between the subjects' back teeth that they could clench against, and this may activate the muscles a little more, in contrast with slimmer versions primarily used for protection that don't change the position of the mandible. My impression is that when you do something that requires a burst of effort, and you just clench down and go, that specific guard tends to work. It wouldn't necessarily have an impact on the rest of the body unless the individual was actively clenching against it."

As to why women didn't seem the same lower-body benefits as men, Dunn-Lewis suspected physiological differences between the sexes.

"Women are generally more flexible than men, so it may just be that plasticity of muscle," she said.

She also speculated about what, more specifically, might cause the effects reported.

"I think the idea of stress attenuation is interesting, that you can just focus all your tension right into the jaw," she said. "If you want to perform better, you want your core to resist movement, and stabilizing the jaw could theoretically help with that. It's an interesting question, and I hope that in the future we'll get more clarity around it."

Other studies have reported similar findings. For example, in 2008 researchers at Marquette University in Milwaukee found that when study participants exerted maximal clenching on a mouthguard during a countermovement jump, the rate of force development was 19.5% greater than when they didn't wear the guard.[7] Time to peak force was 20.2% lower with the guard, as well, though there were no significant differences in overall peak force between the conditions.

The next year, a study of taekwondo athletes found that custom mouthguards were associated with significant improvement in peak and average power in a Wingate anaerobic test, as well as hamstring isokinetic peak torque.[8] Other measures, however—sprint times, jumping tests, isometric leg strength—weren't affected.

A 2013 paper suggested that, in pro golfers, the gap the guard creates between the teeth may affect performance.[9] In that study, golfers performed four trials of 10 driver swings while using a mouthguard, a dental stabilization splint, or nothing. Club speeds and driving distances were significantly increased with the guards or splints, but this advantage decreased when the devices were adjusted to result in molar occlusion.

A 2016 paper found that teeth clenching increased the soleus H-reflex regardless of the degree of muscle fatigue.[10] One study found that using devices to create unbalanced dental occlusion increased knee muscular performance,[11] though another showed the opposite effect.[12] The reasons for the disparity, as well as the mechanism itself, remain unclear.

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The cons

If such positive press has you thinking it might be worthwhile to wear a mouthguard on your next walk in the park, think again. There's just as much bad news as good.

A 2006 French study found that neither boil-and-bite nor custom mouthguards had a significant effect on a variety of parameters studied, including visual reaction time, explosive power, and ventilation at rest or during exercise.[13] Two years later, Swiss researchers reported that a custom mouthguard had no effect on maximal exercise capacity or cardiopulmonary parameters.[14] In 2014, investigators at the University of Mississippi in Oxford tested a noncustom

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mouthpiece (which was designed for bite alignment rather than to prevent injury) and found no significant effects on countermovement jumps or bench presses.[15] Finally, a 2016 study from Germany[16] reported that specially fitted dental splints had no effect on Wingate anaerobic tests—a finding consistent with those of Dunn-Lewis and others, who've reported that mouthguards don't seem to influence anaerobic tasks such as sprinting.

It's worth noting that all these studies have been carried out in different countries, with a variety of mouthguard designs and widely disparate outcome measures. It's a bit like trying to draw conclusions about the biomechanical effects of footwear from studies that include running shoes, ballet slippers, and steel-toed boots, and that evaluate everything from the metatarsals to the hips. Under such conditions, generalizations tend to prove elusive.

"Are there real effects or are there placebo effects?" asked Alison Brooks, MD, MPH, an associate professor in the Department of Orthopedics and Sports Medicine at the University of Wisconsin in Madison. "When athletes wear or do something that they perceive as positive for their performance, it usually is—but not necessarily for any physiologic reason. We always have to account for that."

Brooks is aware of theories that correlate correct jaw alignment with effects down the kinetic chain,[17] but considers much of the research deficient in design and execution.

"Often the number of people in the studies is quite small, or there's no control group," she explained. "Every mouthguard company makes anecdotal claims to sell their product, but I don't put much stock in those. You might find that there's a statistical difference between people wearing the mouthguard and those who aren't, but if it's four one-thousandths of a second, it's not likely to be clinically meaningful for the average recreational athlete. Though

if you're talking about athletes at the highest level of sports, maybe those minute differences matter."

A study published this past May in the *Journal of Strength and Conditioning Research* further supports the notion that mouthguards may not exert significant effects.[18] Investigators tested several strength and endurance measures in 10 college football players wearing custom-made, boil-and-bite, or no mouthguards in a crossover study. The custom guards showed no advantage over the other conditions, though, as other research has shown, they didn't limit performance either.

Lead author Scott Drum, PhD, an associate professor of exercise physiology at Northern Michigan University in Marquette, told *LER* that the theory being tested had to do with the temporomandibular joint (TMJ).

"The idea is that if you're relaxing that joint, positioning the jaw to reduce the fight or flight response by inhibiting teeth clenching, and you're more physically relaxed, then that should enhance performance," Drum said. "It's supposed to put you into a state of proper stress—good stress, so you're not over-amped. It's an interesting strategy, but we found no difference."

One telling issue here, however, is that researchers who've found performance benefits from mouthguards, such as Dunn-Lewis et al, specifically cited the effects of teeth clenching as potentially contributing to those benefits. So a device (or instructions to the wearer) to reduce clenching might naturally eliminate that effect.

"That's a really good point, but I think we're talking about aspects of the same thing," Drum said. "If somebody isn't aroused enough to perform well, clenching on a mouthguard may signal just enough stress to get their head into the game. But you want to be on top of that bell curve of stress, without too much or too little, and everybody's different. If you can identify a given individual who may benefit from more jaw-clenching, then the mouthguard might clue them in to proper alignment and help them be optimal with their stress arousal."

As Drum points out in his paper, moreover, results like those of Dunn-Lewis aren't due to clenching per se, but to the space the mouthguard introduces between the teeth so that they're not occluded by the clench. This invokes the aforementioned study in golfers, in which the advantages associated with the mouthguards disappeared when they were adjusted to eliminate that space.

Drum suspects some of the wide discrepancies in the research may have to do with the heterogeneity of study populations.

"Some individuals are undertrained," he said. "I could see that in a highly stressful competitive situation with elite athletes, eking out a half percent of relaxation could be a viable difference. Even if the benefits are the result of a placebo effect, by all means wear the mouthguard, because the placebo effect is well-studied and real, and the mouthguard isn't going to do any harm. I just think it's a red flag when manufacturers make blanket statements about improving strength, endurance, agility, skill, and balance."

Both sides now

Few researchers are better positioned to look at both sides of the issue than Shawn Arent, PhD, director of the IFNH (Institute for Food, Nutrition, and Health) Center for Health & Human Performance, and of the Graduate Program in Kinesiology & Applied Physiology at Rutgers University in New Brunswick, NJ. Some of Arent's research has shown performance benefits associated with mouthguards, but not all of it has.

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For example, in a 2010 paper, Arent and his colleagues compared the effects of a neuromuscular dentistry-based mouthguard—which emphasizes alignment of the TMJ—to a standard boil-and-bite guard in 22 high-level male athletes who performed vertical jumps, bench presses, and variations of a Wingate anaerobic test.[19] When the participants wore the dentistry-based mouthguard, they had significantly better performance in peak power output and repeated maximal efforts than when they wore the boil-and-bite device.

By contrast, in a 2015 paper studying four conditions—a custom-fitted jaw-repositioning mouthguard, a boil-and-bite guard, a placebo guard, and no guard—Arent and his coauthors reported no significant differences between the mouthguards in terms of muscular strength or power, dynamic balance, or agility.[20]

"In the first study, the custom guard involved a forty-five minute fitting process that included hooking the subject up to a TENS [transcutaneous electrical nerve stimulation] unit to relax the jaw, ideally into its true resting alignment," Arent said. "They took the bite impression at that point, and I think that process was associated with a lot of the expense of those guards, which cost fifteen hundred to two thousand dollars."

Arent said that in the second study, that fitting process wasn't used.

"Those guards were just trying to create occlusal space, and we didn't see any significant effects, which leads me to wonder if there was something important about that fitting process in the earlier study." (Arent said the mouthguard company in question eventually abandoned the process and sold its technology, in any case.)

Like the other experts *LER* spoke with, Arent felt that even when the guards seemed to work, the associated mechanism of action remained unexplained. He thought it might have something to do with the TMJ and its effect on the cranial nerves that pass nearby.

"The idea is that if the TMJ is not in an optimal position—if it impinges on anything—it may affect the descending cranial nerve," he said.

Unfortunately, there isn't much research that would shed light on this possibility, one way or another. A 2012 literature review in the *Journal of Oral Rehabilitation* found no evidence for a predictable relationship between occlusal and postural features, and found that TMJ pain wasn't associated with postural abnormalities;[21] but of course, posture and performance, while often related, aren't the same thing. Later, a 2016 study reported that patients with lower-limb disease who used a TMJ exerciser experienced gait improvements;[22] however, it was a small study and results were inconsistent across the 11 participants.

"This may just be one area where you get what you pay for," Arent said. "As ridiculous as it seems, we didn't see the same effects with cheaper mouthguards as we did with those that cost fifteen hundred dollars and involved the more extensive fitting process. Can we replicate that? After [the company] stopped doing it, we never had the opportunity to."

Arent agreed with Alison Brooks that an athlete's degree of training may affect the relative effects of a mouthguard on performance, however.

"My guess is that in highly trained athletes, even a small adjustment can make a difference," he said. "When you're talking about races won or lost by hundredths of a second, you might not need a big effect from the mouthguard to see benefits. Then it becomes a question of cost versus utility—is it just part of the arsenal?"

Arent emphasized that the current state of the evidence does address a few important issues, however.

"One is whether athletes in noncontact sports should wear mouthguards, and I don't think anything supports that at this point," he said. "But would it hurt? No; for me, one of the most important things to come out of these studies is that none of the mouthguards interfered with performance. And if you have an athlete in a sport for which a mouthguard is recommended, the logic for refusing isn't good. They protect from injury, and some research shows performance benefits even if the reasons aren't well established from a mechanistic standpoint. Again—for an elite athlete, even a modest effect could be beneficial; it's just part of the whole equation of your preparation and training."

Cary Groner is a freelance writer in the San Francisco Bay Area.

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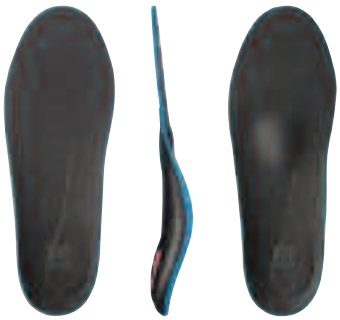

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Peroneal tendinopathy management in tennis

By Patricia Pande, MClScPT, CSCS, CPed

Although not as common as Achilles tendinitis, peroneal tendinitis is seen in a certain group of patients with chronic ankle instability or with a cavovarus foot.[1] Peroneal tendinitis presents as lateral foot pain and may also be of unknown etiology or associated with an acute inversion injury.[2,3] Some authors have noted an association with impingement at the site of the fibular head in pes plano valgus and as a causative factor in peroneal tendon tear in the absence of instability of the ankle.[4,5] For the purposes of this article, peroneal or fibular tendinopathy will be defined as any form of peroneal involvement, including tenosynovitis and tendon trauma.

Widely considered a rare injury, it is frequently missed as a source of pain after a sprain or with overuse. Some researchers estimate that peroneal tendon injuries are missed up to 40% of the time on initial evaluation of ankle pain.[6] Tears of the fibularis tendon in cadavers have ranged between 11.3% and 37%[7] with higher incidence increased in those with lateral ankle instability.[8] Although chronic degenerative peroneal tendinopathy may be associated with anatomical variants[2] there is disagreement about which anomalies are causal.[9]

The peroneal muscles stabilize the foot in weightbearing. The peroneus brevis everts, abducts, and plantar flexes while the peroneus longus is a primary evertor with a secondary role of plantar flexion. The peroneus longus plantar flexes the first ray and stabilizes the medial column while reinforcing ankle ligaments.[10]

Assessment

Differential diagnosis of fibular tendinopathy includes tests to exclude ankle sprain, fracture, os trigonum syndrome, and flexor hallucis longus tendinopathy. Since ankle sprain and instability often coexist with peroneal tendinopathy, tests for ligamentous instability, syndesmotic injury, and posterior tibialis tendon involvement should be performed. Balance testing forms a baseline for treatment strategies and should be done in all patients.

Patients with peroneal tendinopathy have associated pain and tenderness on palpation of the peroneus longus or brevis, along with weakness on resisted movement. They may experience pain with overpressure into inversion, adduction, and dorsiflexion.[11] Longitudinal edema along the length of the peroneal tendon typically accompanies intrasheath swelling from an acute injury.[12] The block test may be administered in a patient with a cavovarus foot type and a flexible deformity.[13,14]

Risk factors in tennis players

Tennis is a hugely popular global sport played by people of all ages. Ankle sprains remain the most frequent injury in tennis players.[15,16] Because fibularis tendon damage may occur in conjunction with ankle sprains, we can assume a risk of tendon damage during lateral movements, sudden stopping,[16] or the backhand ground stroke.[17,18] Recently Fong et al[19] observed ankle inversion and internal rotation in side cutting as a finding concomitant with ankle injuries in tennis players.

Since the mechanism of injury may differ for the peroneus brevis versus the peroneus longus, different causative factors must be studied.[18] For example, the orientation of front foot relative to the net in the tennis backhand stroke is associated with risk of ankle inversion.[19]

Footwear and orthoses

Footwear for peroneal or fibularis tendinopathy should be wide enough for lateral support while reducing tensile forces on the peroneal tendon.[20] The prevention and treatment of foot and ankle injuries with shoe modifications has not been substantiated in the literature, however. Intuitively, medially posted footwear should be avoided in the presence of an uncompensated pes cavovarus foot.

The use of heel lifts may reduce stress on the fibularis tendon, according to Michael Gross, PT, PHD, FAPTA, a professor in the Division of Physical Therapy at the University of North Carolina at Chapel Hill.[21] However, since plantar flexion may result in inversion forces associated with sprains and acute peroneal tendinopathy,[12] heel lifts should be used judiciously. In tennis and other players who cut laterally, it is important to evaluate balance (both static and dynamic) in footwear rather than barefoot. Videotaping the tennis player can provide valuable information on the effects of footwear modifications.

Orthoses with lateral wedges have been prescribed for patients with recurrent ankle instability or with peroneal tendinopathy. Orthotic modification to prevent inversion sprain remains controversial and there is a paucity of data in tennis and other cutting sports.

Baur et al reported that, in 99 runners, foot orthoses were associated with enhanced peroneus longus activation during preactivation, and suggested this finding indicates an alteration in preprogrammed activity that could lead to better ankle stability.[22] Orthoses with a lateral bar decreased the peak amplitude of the peroneus longus during mid to terminal stance during walking.[23]

Because tennis players vary greatly with regard to age and comorbidities, a multifactorial approach to orthotic management is advised. Studies suggesting that lateral wedged orthoses reduce knee

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moments only in conjunction with increased ankle inversion and a greater eversion moment may have relevance for athletes with both peroneal tendinopathy and knee osteoarthritis.[24,25] Gross advises the use of a lateral wedge when the rearfoot has enough motion to adapt to the modification.[21]

Theoretically a plantar flexed first ray should cause a supinatory force at the ankle. Thus, orthotic modification for a rigid plantar flexed first ray includes either a cut out or a kinetic wedge. In the case of hallux limitus, this should include control of the lateral foot with a flange or lateral post or a deep heel cup.[26] Caution must be taken to not overload medial structures.[27]

Peroneal tendon subluxation

Peroneal tendon subluxation may occur acutely and may coexist with fibularis tendinopathy;[4] it has also been associated with chronic ankle instability.[28] The most common causes are cutting and twisting movements involved in sports such as tennis and skiing. In my observation, the condition exists more often with hypermobility, and it may be associated with a shallow fibular head groove.[29]

Patients with peroneal subluxation may describe popping or snapping of the peroneal tendon while actively moving the foot into dorsiflexion and eversion. The patient may also experience pain and swelling, and subluxation of the tendon anterior to the lateral malleolus may be visible. Biomechanical foot problems may include a pes cavus foot, an uncompensated rearfoot varus, or an uncompensated rearfoot varus combined with a tibial varus.[30] This condition is often misdiagnosed as an ankle sprain, but computed tomography, ultrasound, and other imaging modalities can be used to verify the condition.


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Conservative treatment includes ice, rest or activity modification, and stretching. Although early return to full activity has been reported when cryotherapy is applied within 36 hours of injury,[31] utilization of this modality remains surprisingly low. Tape or bracing has also been used with varying results.[27] Treatment incorporating strength, proprioceptive, and balance training is introduced after the early stages of healing. Proprioceptive training is believed to increase activation of the peroneus longus[32] and was associated with reduced ankle sprain recurrence in Italian basketball players.[33] The Italian authors suggested that improved proprioceptive control may enhance reflex contraction of protective muscles at the ankle, reducing deleterious supination of the foot.[33] Their study does support the need for continued, measured analysis of the effects of proprioceptive training in ankle injuries.

Orthoses and peroneal subluxation

Research on chronic ankle instability demonstrates that orthosis use can improve balance and center of pressure;[34-36] these findings can be extrapolated to the treatment plan for peroneal subluxation.[34] Orthoses can be used to reduce postural sway in asymptomatic individuals and postinjury.[35-39] Proprioceptive input from total contact of the orthoses may enhance stability[40] and should be studied further.

Dingenen et al found increased preactivation of the peroneal muscles associated with orthoses,[40] suggesting they could be used in addition to or as a substitute for bracing. The additive effect of orthoses (custom or standard) along with footwear altered the temporal characteristics of firing for the peroneus longus. Early activation during the transition from single- to double-leg stance is suspected to confer a protective effect for lateral ankle sprains.[40] A lateral wedge can be used if some of the biomechanical rearfoot problems allow a degree of correction.[21,24,30]

Footwear and peroneal subluxation

Footwear must be wide and have torsional stability. The shoe must fit properly and be high enough to contain the foot up to the malleoli but not rub the tendons. Spacers can lift the foot, or a gel horseshoe can be placed near the tendon to offload it.

In a study of ankle kinematics and kinetics in 13 child tennis players, a decrease in shoe drop was associated with decreased impact forces during open-stance forehand shots.[41] The findings cannot reliably be generalized to injuries other than those that are impact-related, but lower-drop footwear was related to an earlier onset of muscle activation of the peroneus longus, which may have some protective effect in players with recurrent ankle sprains; I have seen evidence of this effect clinically.

Summary

A balanced approach and continued research are key to current and future success in managing the perplexing conditions of peroneal tendinopathy and subluxation. Orthoses must be adaptable to the changing needs of the athlete and not worsen the problem. Gradual modification and ongoing measurement of the effect on tennis biomechanics is of paramount importance. Shoes and orthoses must complement each other to avoid increasing the risk of ankle instability. Lateral posts must be used judiciously in players with sufficient rearfoot motion and appropriate responses to the rearfoot motion. Modifiable inserts with various degrees of posting, along with a deep heel cup and flanges, should be considered; these may provide a new paradigm for a challenging problem.

Patricia Pande, MCIScPT, CSCS, CPed, is a physical therapist, pedorthist, and strength and conditioning specialist based in San Diego. She is the founder of FootCentric, an online continuing education company dedicated to comprehensive multidisciplinary foot treatment.

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AFO stiffness can help optimize patient function

Decisions related to the stiffness of an ankle foot orthosis (AFO)—whether they involve device design or the materials from which it's fabricated—can help lower extremity clinicians customize stability, biomechanics, and muscle function to meet individual patients' needs.

By Lori Roniger

While practitioners and researchers have proposed devices, algorithms, and methods for determining the appropriate ankle foot orthosis (AFO) and stiffness for individual patients,[1,2] choosing the right AFO stiffness remains more art than science than many in the field would prefer.

LER spoke with researchers and clinicians to learn more about how the stiffness of an AFO affects its function in different patient populations and ways to determine the most appropriate AFO stiffness for each patient.

The importance of stiffness

Practitioners and researchers concurred that AFO stiffness has been getting more attention in recent years and that they are trying to better quantify stiffness so that AFOs can be prescribed more accurately.

Elisa S. Arch, PhD, a research assistant professor of kinesiology and applied physiology at the University of Delaware in Newark, researches AFO stiffness and believes there is now a better understanding of how it influences gait.

Her research suggests AFO stiffness can replace lost ankle muscle function and provide functional gains.[3] In the study, two patients who had experienced stroke wore a passive-dynamic AFO designed to be worn without a shoe, with bending stiffness personalized for their level of plantar flexor deficit. At the baseline visit, 3D landmarks on each patient's lower leg were digitized and used to customize their AFO's fit. Compared with walking while wearing shoes only, wearing the customized AFO was associated with increases in net peak plantar flexion moment and natural ankle pseudostiffness (the amount of joint resistance when a moment is applied); in addition, the AFO's bending stiffness added to but did not substitute for existing plantar flexor function. The AFO also helped to improve the patients' paretic knee and hip joint kinematics during mid and late stance but excessively reduced dorsiflexion excursions.

"The key question now is how do we customize the level of AFO stiffness to optimize each individual's function," Arch said.

Goals related to stability or improved gait can present a trade-off for lower extremity clinicians in determining the appropriate AFO stiffness for a particular patient.

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Photo courtesy of Otto Bock.

Choosing the right stiffness

The patient's plantar flexion strength is important to consider when determining AFO stiffness, according to David G. Wilson, MPO, CPO, LPO, instructor in the Prosthetics-Orthotics Program at University of Texas Southwestern School of Health Professions in Dallas. He pointed to the example of drop foot.

"It doesn't take much force to hold up someone's foot in the air," said Wilson, who spends most of his time with patients who have neuromuscular issues—such as multiple sclerosis, Parkinson disease, stroke, or peripheral neuropathy. "It takes more to hold up body weight."

So, one brace may be more appropriate for an older person using it at home or in the office, while another may be more suited to someone with a very high activity level who is running and jumping.

A patient's height is also another key factor, Wilson said.

"Things need to be a bit stiffer if the leg is longer," he said. "But we're not trying to lock people up in ski boots."

He explained that clinicians want to ensure the patient has a normal range of motion but at least have the ability to provide some limit, restriction, or soft stop if needed without causing any other gait abnormalities.

"The key is understanding the gait cycle," he said. "If the only issue is foot drop, for example, then I'm treating a swing phase condition primarily. Thus the AFO only needs to be stiff enough to maintain the foot in a neutral position during swing, and should have limited effect on the foot and leg during stance, besides providing a more controlled foot flat at loading response to prevent foot slap."

Factors like strength, range of motion, and spasticity can vary significantly between patients with the same condition and affect stiffness requirements, practitioners and researchers said.

"You have to look at each patient as an individual," Wilson said.

A patient's gait deviations, weight, activity level, joint range of motion, and level of spasticity are factors that Denise Nathan, BPO, senior orthotist at OAPL (Orthopedic Appliances Propriety Limited) in Melbourne, Australia, considers in determining an AFO prescription.

A patient with spasticity may require a very stiff ankle or footplate to prevent toe walking, Nathan explained, while one with a partial foot amputation may require a stiff footplate to extend their foot lever to normalize the point of application of the ground reaction force. Spina bifida patients require a high degree of AFO stiffness at the ankle, as they tend toward crouch gait, but require flexibility at the toe break point to allow propulsion, she said. On the other hand, patients who need to be able to walk up or down stairs often require less stiffness.

"The material choice may be determined by patient weight, but often we need to look at where the stress points are likely to be and consider reinforcing or allowing flexibility where applicable," Nathan said. "Using dynamic strut designs to shift yield points in AFOs has allowed me to reduce failures in some patients' AFOs."

Stability before gait?

Goals related to stability or improved gait can present a trade-off for clinicians in determining the appropriate AFO stiffness for a given patient. Efficiency in gait might be preferable for a patient who is more active, whereas stability would be a greater concern if a patient has poor balance and a history of falls, Wilson said.

"AFO stiffness can often help to provide control across joints and influence more proximal joints but can equally be problematic if the stiffness is too great for some patients," Nathan said. "A very stiff AFO may, for some patients, allow very stable standing but hinder their ability to progress their limb. This is where manipulation of materials, joints, and their stiffness needs to sometimes compromise for the best outcome."

If gait efficiency is the goal, device stiffness may need only to provide stability during stance, rather than the entire gait cycle, she said.

"If we can provide improved propulsion then we gain greater efficiency," Nathan said. "Stiffness may be required to provide stance phase stability but may not be required in late stance."

Stroke and stiffness

Toshiki Kobayashi, PhD, RPO, professor of prosthetics and orthotics at Hokkaido University of Science in Sapporo, Japan, has conducted research on AFOs for poststroke patients for around 10 years.

"The effects of AFOs, particularly their mechanical properties,

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ie, stiffness and alignment, on gait are still poorly understood and underestimated in the clinical setting," Kobayashi said. "We want to raise more awareness that design and mechanical properties of AFOs matter."

An advantage of articulated AFOs, he said, is that the mechanical properties within the joint can be adjusted without affecting other parts of the AFO. Changing the properties of a nonarticulated AFO often requires the adjustment of trimlines, which is irreversible. However, articulated AFO joints tend to be bulky and may not be suitable for many patients, especially women and children.

"Articulated AFOs that can adjust their stiffness are ideal, but a lot of work needs to be done to make them compact enough to be acceptable in most of the patient populations," Kobayashi said.

He emphasized the importance of AFO stiffness in these patients, even though other mechanical characteristics, such as alignment, trimlines, and articulated versus nonarticulated design, are also key.

"Our recent work[4] clearly suggested that, by appropriately tuning the plantar flexion resistance of an AFO, AFOs could reduce knee moments that lead to hyperextension of the knee," Kobayashi said.

Kobayashi and colleagues performed gait analysis on six stroke patients with genu recurvatum using an articulated AFO with adjustable plantar flexion resistance. Other recent research Kobayashi has conducted used gait analysis with poststroke patients wearing an articulated AFO and found that changing the plantar flexion resistance of the AFO affected both ankle and knee joint angles and moments.[6]

He is now investigating the effect of plantar flexion resistance and dorsiflexion resistance and alignment of AFOs in the same population.

A pilot study conducted at Becker Orthopedic in Troy, MI, investigated the effects of AFO stiffness and alignment on lower extremity kinematics in two stroke patients and one multiple sclerosis patient.[5] Two patients wore a custom acrylic composite AFO with therapeutic sandals, and one patient wore a customized double upright AFO with a walking shoe. Both AFOs featured an ankle joint with high stiffness in the coronal and transverse planes and adjustable alignment. During each trial, one of three ankle joint settings (plantar flexion resist, dorsiflexion resist, or alignment) was changed while the other two were held at their optimal values.

Ankle adjustments had varying effects on kinematics. In quiet standing, the ankle alignment setting had a smaller influence on knee angle in patients with greater spasticity. During walking, the ankle alignment setting affected ankle and knee kinematics throughout the gait cycle. Gastrocnemius length and spasticity may have influenced the effect of alignment and plantar flexion resist on ankle-knee coupling in stance and late swing.

Device designs that allow for more flexibility around the ankle may necessitate more stiffness in the rest of the AFO, said Nicholas LeCursi, CO, chief technology officer at Becker.

"The design of an AFO involves control of three fundamental attributes: shape, material stiffness, and compressibility of interface materials both intrinsic and extrinsic to the AFO," LeCursi said. "This compressibility also includes the stiffness of the shoe sole. We recommend using more rigid materials and higher stiffness interface materials for the AFO and shoe, then using an adjustable ankle joint to tune the stiffness and alignment of the AFO."

Shoes and stiffness

Kobayashi is investigating the effects of the mechanical properties of shoes on AFO-shoe combinations. He explained that shoe design can significantly affect AFO function by influencing stiffness as well as alignment.

"Shoes are used in combination with AFOs, but their influence is often neglected or underestimated," he said.

Elaine Owen, MSc, MCSP, a pediatric physical therapist at the Child Development Center in Bangor, North Wales, UK, has worked for decades with children, many of whom have cerebral palsy. Her center has a gait lab and custom makes AFOs, and she has published algorithms for the design and tuning of AFO-footwear combinations (AFOFCs) based on shank kinematics.[2]

"You apply that to every patient, as it is independent of diagnosis but dependent on the gait pattern and clinical presentation." she said.

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Patients who have normal shank kinematics in stance phase but a swing phase/initial contact problem may be prescribed a posterior leaf spring or hinged AFOFC, while those with abnormal shank kinematics in stance receive various types of fixed-ankle AFOFCs, depending on factors including insufficient or excessive incline in midstance, terminal stance, or both.

The amount of AFO stiffness required of a fixed-ankle AFO can differ depending on gait type and patient size. Patients typically receive fixed ankle polypropylene AFOs with varying designs.

"If they're bigger with very severe crouch gait, then it's going to be a much stiffer AFO," Owen said.

Some patients will require fixed metatarsophalangeal joints and a stiff-soled shoe, Owen said.

"People sometimes fail to control crouch gait if they use a fixed ankle AFO but not the right footwear," she said.

The materials used, trimlines, depth at the ankle, and use of corrugation can affect stiffness.

She noted that working with children who are growing and typically have a congenital neurological disability can be completely different from working with adults, like stroke patients, with an acquired disability.

Adults with acquired disability typically have a normal mature skeleton and foot, she explained, whereas typical skeletal development may not occur in children with congenital disability due to neuromuscular and biomechanical effects. Orthotic devices can protect against these abnormal forces and help the skeleton—particularly in the feet—develop normally, she said, and optimizing device stiffness can be an important part of that process.

How to customize

A number of researchers and companies are investigating the best way to customize AFO characteristics for each patient.

"My ultimate goal is to develop objective prescription models that, based on any individual's impairment profile, determine what characteristics, such as stiffness level, the AFO should have and


Photo courtesy of Richie Brace.

the design needed to achieve those characteristics," Arch said.

Some patients do not need stiffness in both dorsiflexion and plantar flexion, so knowing the stiffness of a brace in each direction would help the clinician to tailor an intervention and produce a greater benefit, Nathan said.

Michael Orendurff, PhD, director of the Motion and Sports Performance Laboratory at Lucile Packard Children's Hospital Stanford in Palo Alto, CA, has collaborated on some of Kobayashi's research on stroke patients. He spoke of the importance of collecting and providing objective data for clinicians.

"Some of these patients don't have very good feedback or sensation and have a hard time saying what feels good," Orendurff said. "What you'd like to do is come into a realm that's close to their right prescription."

A patient may respond in a stair-step manner until reaching a plateau at which gait is smoother, but adjusting beyond that doesn't have any effect; the goal should be for clinicians to identify when small adjustments can make a difference, Orendurff said. This could involve an instrumented device that can measure and make these adjustments and, together with feedback from the patient, pick the optimized setting, he said.

Material world

The types of materials used to fabricate AFOs, in combination with device design, significantly affect AFO stiffness.

Arch designs and conducts research on passive-dynamic AFOs, in which stiffness is largely determined by the strut that goes up the back of the leg and connects the cuff and footplate; both the thickness of the strut and the material the strut is made of affect stiffness.

She currently uses AFOs made of polycarbonate or a carbon fiber composite. For both of these materials, the thicker the strut, the stiffer the AFO. For the carbon fiber composite, other design features, such as the fiber orientation, also influence stiffness level.

Varying stiffnesses can also be achieved with plastic. Although generally thicker plastic and more circumferential trimlines will produce a stiffer AFO, some will use very thin plastics, often only 2 mm thick, in a bivalve circumferential design to gain stiffness without increasing bulk, Nathan explained.

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"Clinicians need to know the properties of materials so they can manipulate them for their relative properties. Trimlines can always be trimmed back to make an orthosis more flexible, but you will need to remake the orthosis if it is not stiff enough," she said. "Sometimes we need to fail to succeed and try different combinations to find the right stiffness."


Photo courtesy of Insightful Products.

Wilson has been doing bench testing and material properties investigations, with future plans to include patients, on the use of carbon fiber and prepreg materials for AFOs and how to fine-tune them to maximize efficiency, effectiveness, and durability. He is hopeful about the promise of 3D printing and its potential for being able to offer more standardization in AFO stiffness.

"You can get to the same brace design ten different ways," he said. "It's a bit secretive. Everyone has a secret sauce that no one exactly knows. We're trying to standardize some of that: the thickness and how to cut back the trimlines."

He also recommended working closely with a physical therapist.

"It's not that the AFO itself is magic and solves every problem," he said. "It's how to use it so the patient can reach his potential."

Back in the lab

Fan Gao, PhD, associate professor of health care sciences and Wilson's colleague at UT Southwestern, is bench testing AFOs while manipulating the designs, materials, and construction to evaluate mechanical properties.

A study Gao and colleagues published this year used a motorized device with an inline torque sensor and optical encoder to cycle an AFO through dorsiflexion and plantar flexion. The researchers found that a posterior leaf spring AFO fabricated with nine-ply carbon-infused polypropylene composites demonstrated more dynamic mechanical properties (indicated by increased stiffness and decreased index of hysteresis) than standard homopolymer polypropylene orthoses.[7] This decreased energy loss and provided a rigid toe lever at preswing.

"Though many things (eg, stiffness) could be quantified in the research lab, it is hard to transfer this knowledge directly to clinical practice," Gao wrote in an email. "The mechanical properties are not only related to thickness/construct/design. They are also altered throughout the fabricating procedure [eg, thermoforming]."

Kobayashi thinks it's important to characterize the properties of AFOs, in research as well as in the clinic. He said many studies still compare orthoses without characterizing their properties, including stiffness.

"It is difficult to generalize outcomes of AFO studies without knowing the properties of the AFOs," he said.

Lori Roniger is a freelance writer based in San Francisco, CA.

References are available at lermagazine.com.

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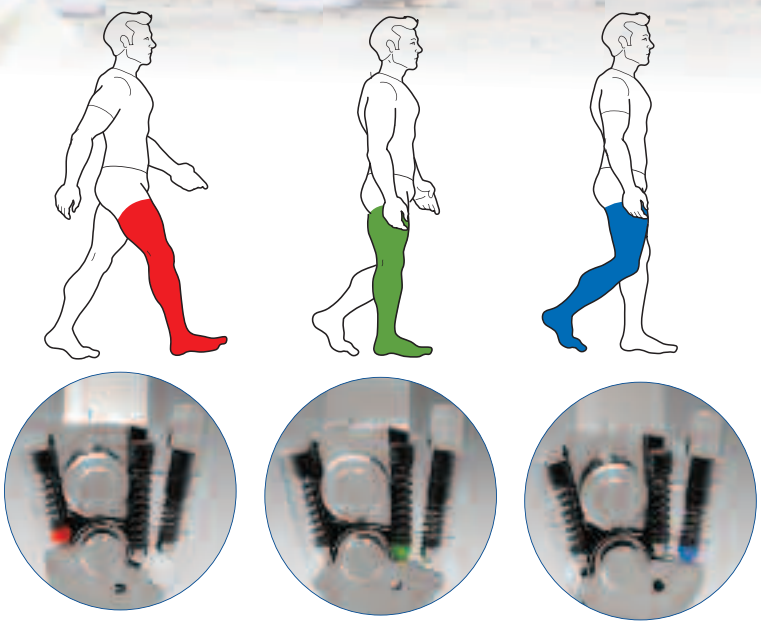

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Michael Crabtree. (Photo courtesy of miamisportsgeneration.com)

How foot and ankle injury trends reflect today's NFL

Professional football players are enduring higher levels of force than ever, and foot and ankle injury rates are increasing as a result. Advances in surgery and rehabilitation have helped get players back on the field more quickly, but injury prevention remains a significant challenge.

By Will Carroll

There are two injury-related trends that are noticeable right now in the National Football League (NFL). The number of foot and ankle injuries—Achilles tendon tears, ankle sprains, and various maladies of the foot, especially the midfoot—have increased greatly over the last decade. And the amount of research the NFL is putting into solving this problem remains troublingly flat.

As with most sports, the NFL players themselves have gotten bigger, stronger, and faster, in combination rather than isolation. A bigger man running faster has greater forces that he must dissipate. Even as the muscles higher up the kinetic chain are getting bigger, feet and ankles are essentially left with the anatomic gifts of a player's genetics. And, while advances in the design of shoes and cleats have led to exponentially better performance, it's clear that one thing the expensive shoes aren't doing is reducing foot and ankle injury rates.

Achilles tears

One of the highest-profile injuries in the NFL is the Achilles tendon tear, due in part to the length of time required for recovery and for the player to return to pre-injury performance levels. One of the highest-profile studies on NFL performance after Achilles tear was done in 2009,[1] led by Selene Parekh, MD, MBA, who is now an associate professor of orthopaedic surgery at Duke Health in Durham, NC. The study looked at a relatively small number (31) of Achilles ruptures in NFL players between 1998 and 2002. About two-thirds of injured players (64%) returned to NFL play after an average of about 11 months, and their performance in the three years after their return tended to be significantly lower than preinjury levels.

That study is limited not only by the number of athletes studied, but as surgical and rehabilitation techniques have advanced, the study's relevance to today's NFL has also changed. New surgical methods and tools have helped improve player outcomes, but a change in rehab protocols appears to have made even more of a difference.

Foot and ankle injury trends suggest an opportunity for customization within the framework of existing shoe designs, such as orthotic devices, to help reduce risk.

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One current NFL team physician (NFL medical personnel are not authorized to speak on the record to the media) says quicker weightbearing and an emphasis on active mobilization after surgical Achilles repair (see "Battles of Achilles II: How the debate is informing clinical practice," November 2015, page 20) have increased success rates while simultaneously reducing return times.

"Terrell Suggs is the one that stands out," the physician explained, noting a speedy linebacker from the Baltimore Ravens who returned from a 2012 Achilles rupture in just six months. "When [the Ravens] announced that he was playing, I thought he was just a decoy. Instead, he was quick. There was a play where he was pushing his blocker, stopped, and made a quick jump to bat down a pass. That was an athletic play that showed complete confidence in his leg."

Suggs, now 33, tore his contralateral Achilles tendon in September 2015 and returned to start the 2016 season after a more conventional recovery period. But other players have been posting shorter recovery times: After San Francisco 49ers wide receiver Michael Crabtree tore his Achilles in 2013, for example, he made headlines, not just for returning to play in six months but also for racking up more than 100 receiving yards in two of his first six postinjury games.

David Chao, MD, a former NFL team physician in practice in San Diego, believes the changes in foot and ankle injury patterns—both positive and negative—are inherent in the player, not the surgery or rehab.

Dez Bryant. (Photo courtesy of Wikimedia Commons.)

"People have gotten braver, more willing to be aggressive in rehab, but the technique remains the same for the repair," Chao explained. "Twenty years ago, Dan Marino came back from [an Achilles tear] and he was pretty immobile. Today, they come back and are back to explosive movements."

In the National Basketball Association (NBA), the oft-cited Achilles case is Kobe Bryant. The future Hall of Famer ruptured his Achilles in 2013, near the end of his career, but after a repair, had no issues for the next two seasons. While he did have other injuries and Father Time was making his presence known, the Achilles held up, despite reports of extensive workouts to keep Bryant competitive. Indeed, analysis from SportVu, the tracking system used by the NBA, shows no real change to Bryant's in-game speed from year to year in his final three seasons (unfortunately the only seasons for which these data are available).

A 2016 study of return rates after various orthopedic procedures in the NFL offers a partial snapshot of the positive Achilles rehab trend.[2] The study found Achilles tendon repair, along with other procedures, was associated with a decrease in number of games played and decreased performance in the first year after surgery, but not the second or third years.

Accelerated rehab

Almost every physician and physical therapist I spoke with pointed to one technique that has altered recovery most: earlier rehab, largely driven by antigravity treadmill use. The ability to get rehabbing athletes back on their feet and into motion with some weightbearing early in rehab is seeing huge gains in terms of results. Several physicians and therapists I spoke with also pointed to techniques such as platelet-rich plasma and stem cell injections as positives.

Adam Bitterman, DO, an orthopedic surgeon with Northwell Partners in Huntington, NY, who specializes in Achilles reconstructions, noted that minimally invasive surgical techniques have helped make accelerated rehab possible.

"Because of advances in surgical technique, wounds are smaller and the procedures are less invasive, thereby allowing patients to begin physical therapy and weightbearing exercises at an earlier time frame then in the past," Bitterman said.

Lenny Macrina, MSPT, SCS, CSCS, the director of physical therapy at Champions Physical Therapy in Boston, said new and advanced rehab techniques include low-level laser therapy to help with tissue recovery and healing, dry needling to potentially prevent excessive tightness in the muscle belly and maintain a proper length-tension relationship, and blood flow restriction training (BFR; see "Blood flow restriction training: The slow flow movement is fast becoming rehab's hottest trend," July 2016, page 20) in the acutely injured or postsurgical patient.

"BFR seems to help aid in gaining muscle mass back quicker than any modality out there, but we still need further research on all of these to figure out the exact mechanisms and long-term ramifications," Macrina said. "Good old-fashioned strengthening and manual therapy will always be the mainstay in treatment, but these modalities offer promise for future treatments."

Improvements in both the treatment and the rehabilitation for athletes with Achilles damage have made the return both faster and better, but there's been little progress on prevention or reducing injury severity. And, given the increased forces associated with elite-level sports today, that lack of progress seems likely to continue. The balance is clearly off.

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Ken Jung, MD, of the Kerlan-Jobe Orthopedic Clinic in Los Angeles and the team physician for the Los Angeles Lakers and other teams, is seeing a rapid increase in incidence among athletes—and not just those one would expect.

"It used to be a middle-aged couch potato injury," Jung said, "but now it's elite players. It's young, in-shape college guys, pros, and everyone."

Jung believes part of the reason behind the increase is a lack of rest.

"Players are year-round now, especially the younger ones," he said. "Even with cross-training, I don't think that there's enough rest time for tissue to heal."

Foot injuries

Beyond Achilles ruptures, sports is also seeing a major increase in midfoot sprains and dislocations. The Lisfranc fracture is now a common part of the fan's lexicon, just a few years after it was an absolute unknown. The anatomical complexity of the area only increases the issue, but it is also poorly understood by strength and conditioning. As with most sports, there's more of a focus on narrow improvements rather than holistic and systemic factors.

"It's hard to fix feet in the weight room," explained one NFL athletic trainer I spoke with.

Among NFL medical staff, there are a number of theories about what is leading to the increase in incidence of foot and ankle injuries. The focus is on the increased forces or the "bigger-stronger-faster factor." With shoes getting lighter (and often less stable) while experiencing higher levels of traction and friction thanks to evolutions in playing surface technology, the forces acting on the foot and ankle complex are simply too high to survive, both on a traumatic and a chronic basis.

One injury in which this is apparent is Jones fractures. Several star NFL players, including three named Jones, have had this specific kind of fracture. The injury has happened almost exclusively to receivers and to defensive backs, which indicates it's an issue of function. The hard cuts necessary to the positions are generating too much force for the fifth metatarsal to hold up. Again, this likely has a chronic component with repetitive stress from these maneuvers, followed by a straw-that-broke-the-camel's-back trauma forcing the fracture.

In addition, there is a significant re-injury risk with Jones fractures. Even after surgery to install an intermedullary screw, many have needed a revision of this operation or a secondary operation to use a bone graft to further stabilize the bone. Changes in the treatment, such as going immediately to the bone graft, have not shown a decrease in the incidence of setbacks.

While Jones fractures are still relatively rare, it does appear the incidence rate is increasing at all levels. The increase in incidence at elite levels indicates strongly that the "bigger-stronger-faster" is a key component in this; NFL athletes are usually all three, while equipment and physical demands are roughly the same at every level from high school up.

In fact, the size-speed combination appears to be predictive. Elite receivers like Julio Jones and Dez Bryant—both of whom have suffered Jones fractures—combine height, size, and speed, which translates into force on the hard cuts. In most situations (but not all), the players have artificial turf in their home fields and almost all of them were playing on them when injured.

Researchers from OrthoCarolina Foot & Ankle Institute in Charlotte, NC, performed a recent study analyzing 34 Jones fractures in the NFL between 2004 and 2014.[3] The return rate was high and predictable (all returned to play, and 80% were still playing when the study was published), but first author Craig Lareau, MD, who is now a foot and ankle surgeon with New England Orthopedic Surgeons in Springfield, MA, said the recurrence rate is the biggest issue. Twelve percent of athletes needed a repeat of the surgical procedure, the study found, which raises questions about the efficacy of current techniques in high-level, high-impact athletes.

Chao questioned the use of the surgical screw itself and wonders whether its shape could be improved.

"I've altered the technique slightly and seen results in a small sample," he said.

There is very little in the way of research on Jones fractures or even related conditions in American football players. But, if we look across the ocean at the wealth of research on European soccer players, there's a lot that can translate, despite the differing physical demands of the two sports. For example, a 2013 Swedish study[4] of fifth metatarsal fractures in 64 elite European soccer teams found—as Lareau's NFL study did—that the injury was particularly common in the youngest players. Interestingly, the Swedish study also found that 45% of injuries were associated with a prodromal period, which suggests an opportunity for early intervention that NFL teams might find worth exploring.

Opportunities

The climate of acceptance of scientific research and sports science is significantly higher in European soccer than it is in American football. Even the less-popular Major League Soccer (MLS) league is demonstrating more acceptance of both sports medicine and sports science than the NFL, including an emphasis on injury prevention. For the MLS, the relative youth of the league and the relatively high average age of its star players has created a need for quick results, so we haven't seen a major increase in published research, but I've heard that inside the clubs there's been quite a bit of work, as well as collaboration with larger clubs in Europe.

However, the specifics of the foot and ankle complex injuries involve unique issues that could affect injury prevention efforts. It's impossible to upgrade the basic human anatomy, and it would be difficult to make wholesale changes to currently popular footwear designs. But that would suggest an opportunity for customization within the framework of the shoe, such as orthotic devices and other interventions that augment what is available.

There are great opportunities for advancement, but only if the right studies and experiments are done, then transferred to practice. The NFL, and American professional sports organizations in general, tend to be well behind the curve in research. And, when individual leagues or teams do their own research, there is little sharing, which increases the risk that any findings will be applied inconsistently or inappropriately.

The crisis of Achilles and other foot/ankle complex injuries is not being addressed from a preventive basis by stakeholders like the NFL. A clear opportunity exists for further research that is both focused and funded. (ler)

Will Carroll is a writer in Indianapolis who specializes in covering injuries in professional sports.

References are available at lermagazine.com.

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Adjacent-joint arthritis after ankle arthrodesis

Altered biomechanics after ankle arthrodesis often increase stress on the adjacent joints in the foot, which can cause or exacerbate osteoarthritic degeneration in those joints. Clinicians and researchers are working to better understand this process and how to minimize patients' risk.

By Cary Groner

People who develop osteoarthritis (OA) of the ankle joint, whether due to traumatic injury or the effects of age, have traditionally faced limited therapeutic options.[1] Surgical procedures including ankle fusion (arthrodesis) or replacement (arthroplasty) are typically deployed when less invasive approaches fail, but both have drawbacks.

Fusion limits the multiplanar motions of the ankle joint and leads to deficits in function.[2] Moreover, some of that lost motion and its associated stress is transferred to the adjacent joints in the foot, particularly the subtalar joint, and this may cause or exacerbate arthritic changes in those joints.[3]

Ankle joint replacements, though retaining ankle motion, have implant longevity limitations that make them less practical as an alternative to arthrodesis in younger patients.[4] As a result, clinicians and researchers are striving to better understand adjacent-joint OA and discover ways to alleviate it. Surgeons are refining arthrodesis techniques, and medical device companies are working to make ankle joint implants function better and last longer. Eventually, those in the field hope to be able to minimize or eliminate adjacent-joint OA, but there's much work to be done.

The nature of the beast

A study published in 2001 in the *Journal of Bone and Joint Surgery* suggested the long-term scope of the problem. Patients who'd had arthrodesis to treat post-traumatic ankle OA were followed for a mean of 22 years.[5] The authors reported that OA of the ipsilateral subtalar, talonavicular, calcaneocuboid, naviculocuneiform, tarsometatarsal, and first metatarsophalangeal joints was consistently more severe than the OA in those joints on the nonarthrodesis side. The leg that received ankle fusion was also significantly worse in terms of activity limitation, pain, and disability.

A 2015 paper analyzed the long-term results of two different arthrodesis techniques—isolated tibiotalar fusion and combined tibiotalar and subtalar fusion—and found each had drawbacks.[6] The

> The foot's flexible adaptation to a restricted ankle joint allows compensations that make gait more functional, but can also lead to degeneration in other joints over time.

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former was associated with severe arthritic degeneration at the subtalar joint, and the latter was associated with arthritis at the talonavicular and Lisfranc joints.

Another recent article has questioned such results, however. A systematic review analyzed 24 studies and reported that, though most found altered biomechanics in the fused ankle, it remained unclear whether the fusion caused OA in the adjacent joints.[7]

The literature is one thing, though, and the exam room is another. All of the clinicians *LER* spoke with for this article were concerned about adjacent-joint OA related to arthrodesis, though they had different ideas about addressing it.

"The fused ankle joint doesn't move, and the resulting altered gait stresses the adjacent joints," said David Thordarson, MD, a professor of orthopedics at Cedars Sinai Hospital in Los Angeles. "Twenty years after an ankle fusion, you'll start to see arthritic changes in the hindfoot joints caused by the altered biomechanics of the foot. This can be particularly exacerbated if the fusion isn't done in proper alignment."[8]

The talonavicular and subtalar joints are the adjacent joints that are most at risk, said Jeffrey Johnson, MD, professor of orthopedic surgery and chief of the Foot and Ankle Service at Barnes Jewish Hospital at Washington University Medical Center in St. Louis, and current president of the American Orthopaedic Foot and Ankle Society.

"After arthrodesis, the ankle joint is constrained, so those adjacent joints need to function as inverters, everters, dorsiflexors, and plantar flexors," Johnson said. "They are asked to perform functions that they were never designed to do."

According to Matthew Sorenson, DPM, FACFAS, an attending surgeon at the Weil Foot and Ankle Institute in Des Plaines, IL, when motion is taken away from one joint, the associated forces will inevitably travel somewhere else.

"Ideally we're not fusing joints if we don't have to, but it's important to remember that arthritis in the ankle limits its motion too, and that motion is going to the surrounding joints, which then tend to wear out more quickly," Sorenson said. "The patients have a subconscious compensation in response to pain, and the global degeneration is the body's response to the arthritis."

Patients who restrict activity after arthrodesis rather than finding other ways to maintain function often end up with fewer adjacent-joint issues, noted Smita Rao, PT, PhD, an associate professor of physical therapy at New York University.

"The most mobile joints may be the ones that compensate and end up at risk for OA," Rao said.

Surgery and its effects

Research has helped clarify the nature of the adjacent joint adaptations. For example, one study compared patients who had undergone ankle arthrodesis to a control group who had not; the former's cadence and stride length were negatively affected, and there was significantly decreased sagittal, coronal, and transverse range of motion of the hindfoot and midfoot.[9] Another study suggested that pressure increases in the talonavicular and calcaneocuboid joints may be responsible for the secondary tarsal joint degeneration associated with ankle arthrodesis.[10]

One paper reported that arthrodesis tended to relocate force and pressure from the lateral column to the medial column of the

foot, significantly increasing force and peak pressure on the talonavicular joint.[11] A 2009 article in *Foot & Ankle International (FAI)* found a 10.8% combined compensatory increase in motion in the subtalar joint and medial column after arthrodesis—a hypermobility that likely contributes both to functional gait and later development of arthritis.[12] Finally, a 2015 paper found that substantial ankle malalignment, primarily varus deformity, is common in ankles with end-stage OA, and that the subtalar joint often compensates for the malaligned ankle in static weightbearing.[13]

In other words, the foot's flexible adaptation to a restricted ankle joint—whether due to arthritis or arthrodesis—is a double-edged sword; it allows compensations that make gait more functional but that lead to other degenerative changes over time. And, if a patient's initial arthritis isn't limited to the ankle joint, but may already be present to some degree in adjacent foot joints, one question is whether fusion accelerates that arthritic process. Many clinicians suspect that it does, but the situation is complex.

"In late-stage ankle osteoarthritis, the patient often adapts their gait to alleviate pain, and that causes more strain on the surrounding joints, whether the subtalar or the talonavicular," said Eric Barp, DPM, FACFAS, a foot and ankle surgeon at the Iowa Clinic in West Des Moines. "A correctly aligned ankle fusion should decelerate that adjacent osteoarthritis, but one that's improperly aligned could cause more problems."

James DeOrio, MD, a professor of orthopedic surgery and codirector of the Foot and Ankle Fellowship at Duke University in Durham, NC, acknowledged that many patients who present with ankle arthritis already have it in adjacent joints, particularly the subtalar joint.[7]

"When we do an ankle fusion, we prefer not to do additional fusions because we'd like to allow some motion in the hindfoot," DeOrio said, adding that the risk of adjacent joint OA after ankle fusion is strongly affected by the patient's activity level. "If people do too much, they're headed for subtalar arthrosis for sure. When you walk enough miles you're going to take off that remaining cartilage."

DeOrio considers proper surgical technique crucial in ankle arthrodesis, and is bluntly critical of surgeons who remove the fibula as part of the procedure.

"If you have a young patient—say, a rock climber who's fallen—and you choose arthrodesis over joint replacement because the implant won't last long enough, it's imperative to leave the fibula," he said. "If you don't, you can't do an ankle replacement later. I just had a patient that this happened to; his heel was sliding toward the lateral side where the fibula would have blocked and protected it, so I had to put his subtalar joint back together. You need the fibula to support the ankle arthrodesis and to permit the patient to have an ankle replacement later if they need one."

DeOrio and his colleagues prefer a two-plate fusion technique that, according to their research, is stiffer and improves fusion rate, especially in patients with suboptimal bone quality.[14]

Of course, when it comes to arthritis, what appears on an x-ray may not be obviously related to what the patient reports. Johnson said that the common disconnect between radiographic findings and arthritis symptoms has influenced his clinical decisions.

"In the old days, if we had a patient with ankle arthritis who already had hindfoot arthritis, we would probably have fused both the ankle and the subtalar joint, because we knew that if we did just the ankle, the subtalar joint would start being painful, and then

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they'd have two surgeries instead of one," he explained. "Now we're more accepting of arthritis at the subtalar joint and the talonavicular joint unless it's very painful, or there's a deformity there we need to correct."

Johnson acknowledged that it's challenging to predict which patients will have problems with adjacent-joint OA, but he particularly worries about those with hypermobility in the joints.

"Those joints go through a much greater range of motion than they normally should, and it stretches out the capsules and wears them out," he said.

Some research suggests subtalar fusion is more likely to fail in patients who've had a previous ankle arthrodesis; if the foot is relying on the subtalar joint for much of its flexibility, after all, that joint will experience more of the forces that can undo a fusion attempt. For example, a 2015 study in *FAI* reported that in subtalar fusions without previous ankle arthrodesis, 91.3% were successful; by contrast, in patients who'd had ankle arthrodesis, subtalar fusions succeeded only 61.5% of the time.[15]

Replacement vs fusion

For a long time, most surgeons considered total ankle replacement (TAR) a poor stepchild to arthrodesis.[16] There were good reasons for this, and some of those reasons remain valid.

"How confident do you feel that you can perform a successful arthroplasty in a given patient, considering their bone stock, their expectations, whether there is deformity?" asked Johnson. "If I have a patient who says he wants just one operation and never wants to address this again, I have a hard time ignoring the literature that says that the average patient that has an ankle replacement is going to have more operations in the coming years than the one who has arthrodesis."

One such study, for example, reported TAR survival rates of 81% at 10 years;[4] this contrasts with a reported fusion success rate of 91%.3 Another paper found that 11% of patients who had arthrodesis required major revision surgery within five years, versus 23% of those with a TAR. (Ankle replacement, however, was associated with a reduced risk of subsequent subtalar joint fusion—.7% vs 2.8%, respectively).[17]

"Knees and hips are classic joint replacements that now last twenty-plus years," said David Thordarson. "Those are bigger bones [than in the foot and ankle], so it's easier to dissipate the stress, and with a bigger prosthesis there's more bearing surface, so it takes longer for them to wear out. The alternative—a knee or hip fusion—is a god-awful operation that drastically affects your ability to walk. But on the other hand, if all you have is an isolated ankle fusion, six months afterward ninety percent of patients can walk in a regular flat shoe with no detectable limp. Fusion is a good operation, and ankle arthritis is much rarer than hip or knee arthritis,[18] so ankle arthroplasty will probably never be done in the same numbers as knees and hips. Even so, five or six years ago I was doing three fusions for every replacement, and now I'm doing two replacements for every fusion."

Improvements in replacement devices and surgical techniques are influencing many clinicians' decisions, as it happens. Thordarson said patient profiling is a crucial part of the process.

"If someone is age fifty or fifty-five, they're too young, the replacement will fail, and then it's going to be a much bigger problem to fuse," he said. "For people over fifty-five without significant varus or valgus deformity, I'll discuss it."

But in certain cases, younger patients may be candidates for TAR, according to Thordarson.

"If somebody already has significant pre-existing arthritis in the foot, or has already had other foot joints fused, to fuse the ankle joint is a very different beast," he said. "They'll walk with a limp for the rest of their life, so in a case like that, an ankle replacement, even in a relatively young person, may be a good idea. You may get only ten or twenty years out of the replacement, but at least you postpone throwing their gait off."

Surgical technique, as always, plays an important role.

"The current consensus," Rao said, "is that anatomic alignment is critical to the longevity of ankle arthroplasty.[19] I could see it being a choice in a younger patient of maybe fifty, with good alignment—someone who has ankle OA secondary to a post-traumatic intra-articular mechanism, with no deformity or residual instability."

According to Johnson, postreplacement revisions, including fusion, still present challenges.

"That isn't an easy fusion because there's bone loss related to the arthroplasty," he said. "I may have to fuse both the ankle and the subtalar joint, and once you do that, the patient has a tibiotalocalcaneal fusion, which is much more rigid and less functional than an isolated ankle fusion."

Johnson also pointed out that surgeons shouldn't be cavalier about subjecting their patients to repeated procedures.

"Your skin envelope is not a zipper," he said. "When you go in a second time, there's scar tissue, and things become more problematic."

Thordarson agreed, particularly in the context of replacing a TAR with another one.

"When the polyethylene in the prosthesis wears, the body does not like it," he said. "Histocytes and macrophages attack the adjacent bone, then the metal–bone interface loosens and you have cystic changes.[20] In patients with well-fixed metal components, you can just go in and replace the plastic parts, but there are not many of those patients so far. You could say that we'll fuse the ankle ten years down the line, but when you do a primary fusion you've got two well-matched, well-vascularized surfaces. When you have a failed ankle replacement, you've got a big hole that you've got to fill with graft, and that vastly increases the complexity of the operation."

James DeOrio believes the evolution of components has nevertheless made replacement a more attractive option. He now takes a computed tomography (CT) scan of the patient's ankle and sends it to the component manufacturers. They use the scan to fabricate plastic molds that facilitate alignment and streamline the surgical process. The technique has been described in the literature by others,[21] and DeOrio and his colleagues plan to publish a paper about it this fall. He and his team also have a new ankle replacement coming out that they've designed themselves.

As for outcomes, research suggests that TAR and arthrodesis are associated with roughly equivalent levels of postsurgical sports participation.[22] Some research supports the position that patient satisfaction scores are similar for both procedures, though TAR more often meets patient expectations.[23] And in 2015, Idaho clinicians presented a paper at the annual meeting of the American Academy of Orthopaedic Surgeons indicating that TAR patients do better than arthrodesis patients in activities where more natural-feeling ankle motion is important, such as walking on uneven surfaces such as hills or stairs.[24]

Bracing and footwear

Of course, not everyone wants surgery or is a candidate for it. According to the clinicians *LER* spoke with, patients with high body mass indices, diabetes, neuropathy, or other conditions likely to inhibit healing or overstress implants may be better served by arthrodesis than arthroplasty. They may also benefit from more conservative approaches such as foot orthoses, bracing, or specialized footwear before electing either procedure.

"We want to do everything we can conservatively before we choose surgery," said Eric Barp. "If the patient has had longstanding ankle arthritis—particularly if it's also in the talonavicular or subtalar joints—an ankle foot orthosis [AFO] can limit the motion, which limits the pain."

Jeffrey Johnson, too, encourages patients to buy time with bracing.

"AFOs can affect arthritis by limiting joint motion, which may let patients delay their index ankle arthroplasty to later in life, so they only need to have one," he explained.

Such interventions may also be helpful postsurgically.

"You can put a patient with an ankle fusion in a shoe with a rocker sole, which makes it easier to roll over the stiff foot," added David Thordarson. "That may also help if they've had their hindfoot fused."

If the patient has a residual deformity after surgery, or a foot fused in poor alignment, he added, an in-shoe orthosis can better distribute the stress across the foot and help alleviate symptoms.

Research supports these positions. One study concluded that rocker-bottom shoes significantly improved the total motion of ankle arthrodesis patients, versus walking barefoot.[25] Another reported that interventions including shoe adjustment and orthoses may help reduce forces across the midfoot and prevent ankle arthritis, particularly in patients who already have midfoot arthritis.[26]

A recent study from the San Antonio Military Medical Center in Texas looked at the effect of a custom orthosis and rehabilitation program on outcomes following ankle and subtalar fusions in soldiers whose ankles had been damaged by traumatic battlefield injuries.[27] Patients did rehab in two phases; four weeks without a brace, then four in an Intrepid Dynamic Exoskeleton Orthosis (IDEO). One group had ankle fusions alone or with subtalar fusions; the other had subtalar fusions only. Neither group saw significant improvements until the IDEO was added; then both groups had significant improvements in physical performance, and those with subtalar fusions alone also demonstrated improvements in patient-derived outcome measures.

Down the road

Although orthotic and bracing strategies, alone or in combination with arthrodesis, continue to address ankle and foot arthritis in many patients, trends suggest that as ankle replacements become more durable they will eventually be the treatment of choice—not only for preserving more natural motion but for sparing the adjacent joints from the additional stresses associated with ankle fusion. How soon that future will arrive isn't certain, but it's clearly on the way.

Cary Groner is a freelance writer in the San Francisco Bay Area.

References are available at lermagazine.com.

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Psychological aspects of ACL rehabilitation

The ability to identify and treat patients at risk for mental health issues after anterior cruciate ligament (ACL) injury may help improve psychological readiness for reconstructive surgery, attitudes toward postoperative rehabilitation, and successful surgical and rehabilitation outcomes.

By John Reaume, MD, MHSA; Dana Reaume, PsyD; and Melissa A. Christino, MD

Anterior cruciate ligament (ACL) injuries are among the most common orthopedic sports injuries, occurring almost 300,000 times annually.[1] The athlete's response to an ACL injury extends from the time of the initial injury, through rehabilitation, and ultimately to return to activity. As the rate of youth and adolescent athletes participating in sports continues to grow, the number of injuries is also expected to rise. Rehabilitation following an ACL reconstruction (ACLR) is challenging, with return to sport contingent on both physical and psychological factors.

Michael Jordan, who many consider the best basketball player of all time, once said, "My body could stand the crutches, but my mind couldn't stand the sidelines."[2] Although Jordan wasn't sidelined by an ACL injury, his personal perspective on the psychological impact of a significant injury speaks volumes about the emotional paralysis, sense of loss, and uncertainty that is often associated with a physical injury.

Emotional reactions to injury are normal. Mind, body, and sports clinicians agree the emotional responses to injury can include sadness, irritation, feelings of isolation, disengagement, lack of motivation, anger, frustration, changes in appetite, and even sleep disturbance.[3] Problematic reactions are defined as those that do not resolve, and may worsen, over time. Such excessive reactions will impact recovery and may ultimately lead to performance failure. While in most cases ACL injury rehabilitation leads to a successful return to preinjury status, in some patients the injury may unmask or trigger more serious mental health or emotional issues. In particular, athletic injuries associated with excessive time loss from sport may result in ongoing physical and emotional suffering and may benefit from psychological intervention.[3]

Behavioral strategies directed at improving an athlete's sense of self-efficacy may increase compliance with treatment and help create a smoother path to recovery.

Psychological aspects of ACLR

Injury is both a physical and psychological process. The ability to return to preinjury status following ACLR is a critical component of

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successful postsurgical outcomes. An understanding of the inherent distress associated with injury can positively impact the recovery process. Psychological factors that have been associated with recovering from ACL surgery include self-efficacy, fear of reinjury, psychological distress, and locus of control.

Self-efficacy refers to an individual's belief that he or she possesses the skill set necessary for success. Thomeé et al used the knee self-efficacy scale (K-SES) to evaluate 38 patients who had undergone ACLR to predict patient outcomes in physical activity, knee symptoms, and muscle function one year postoperatively.[4] The study concluded perceived preoperative self-efficacy of knee function has predictive value for return to acceptable levels of physical activity, symptoms, and muscle function one year after ACL reconstruction.

Fear of reinjury, which may be referred to as kinesiophobia, has been linked to suboptimal outcomes after ACL reconstruction in multiple studies. Psychological distress refers to a range of symptoms and experiences of a person's internal life that are commonly held to be troubling, confusing, or out of the ordinary, and can manifest in suboptimal performance. A study of competitive versus recreational athletes who have undergone ACLR found competitive athletes experienced greater mood disturbance and had a prolonged rate of psychological recovery compared with their recreational counterparts.[5]

Locus of control refers to the degree to which an individual believes they have control of the outcomes of their lives as opposed to control being dictated by external forces. The Multidimensional Health Locus of Control (HLOC) scale was used along with validated knee, sport, and health outcome surveys to identify the relationship between perceived locus of control and outcomes in 198 patients who had undergone ACLR at a mean 5.1 +/- 2.9 years postoperatively.[6] The authors concluded patients with high internal HLOC scores were more satisfied with their knee function.

When an injury occurs, the athlete must be able to process the medical information provided by the interdisciplinary team, both cognitively and emotionally. The response to injury is not necessarily predictable. Injuries can be devastating to individuals who have established a strong personal identification with being an athlete.

Psychology and ACLR outcomes

In their study on self-protective changes in athletic identity following ALCR that included 24 months of follow-up, Brewer et al prospectively followed 72 men and 36 women undergoing ACLR using preoperative and postoperative athletic identity measures (based on the Athletic Identity Measurement Scale [AIMS]).[7] Ninety-six percent of study participants identified as athletes (49% as competitive athletes, 47% as recreational athletes). The study found a significant decrease in mean AIMS score, indicating a decrease in athletic identity, across the 24-month period following surgery; the greatest reductions in athletic identity were seen in the participants who had the slowest physical rehabilitation progress between six and 12 months after surgery. The study suggested the reduced athletic identification in these participants was a self-protective effort against a perceived threat to their positive self-image. It is not uncommon for injured athletes to feel social isolation from their team and teammates, which can negatively affect self-image.

Despite the high success rates of ACL reconstructions for restoring knee stability,[8] many athletes do not regain their preinjury ability, which may lead to decreased performance and sports-related satisfaction. A recent study found only 31% of athletes returned to their preinjury level of sport at 12 months postoperatively and that psychological factors may play an important role in determining outcomes.[9]

Christino et al also found psychological factors were significantly associated with patient perceptions and functional outcomes after ACLR.[10] The authors performed a cross-sectional study of 27 young (mean age 25.7 years) mostly athletic (89%) individuals who underwent ACLR performed by a single surgeon. The authors used physical and psychological outcome measures. Sixty-five percent of the self-described athletes reported returning to sports at a competitive level. Those who returned to sports had significantly higher self-esteem and Knee Injury and Osteoarthritis Outcome Score – Quality of Life Subscale (KOOS-QOL) scores than those who did not. Functional hop-test performance and validated outcome measures were associated with higher levels of self-esteem and locus of control. Interestingly, objective knee stability was not significantly different between those who returned to competitive sports and those who did not.

Continued on page 54

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An expectation of return to preinjury levels of function can be one of the most important aspects of the physical and psychological adaptations to ACLR and rehabilitation. A cohort study of 122 competitive and recreational athletes who had not returned to their preinjury level of sport one year after ACLR helps illustrate this point.[11] Patients were given a questionnaire regarding return to sport, sports participation, and psychological responses at one and two years postoperatively. Additionally, a physical therapist evaluated physical function at the one-year mark.

The study found that two years after ACLR, 66% returned to playing sports, but only 41% returned to their preinjury level of sport. Psychological factors, such as decreased readiness to return to sport and mood disturbance, negatively impacted the athletes' return to preinjury levels of function. Physical factors, such as previous ACLR and poor hop-test symmetry, were also found to be predictive of not returning to preinjury levels of function. The authors concluded that return to sport after ACLR is multifactorial and that psychological factors may play an important role.

Another major factor in the post-ACLR recovery process is fear of reinjury. A recent meta-analysis, which included 48 studies involving 5770 athletes who had undergone ACLR with an average 41.5-month follow-up, looked at the factors influencing return to sport.[10] The authors found 90% of participants achieved normal to near-normal physical knee functioning in terms of knee range of motion, strength, and ligamentous stability. While 82% returned to some degree of sports participation, only 44% returned to a competitive level at final follow-up. Of the multiple factors that can influence an athlete's ability to return to competitive sport, fear of reinjury was the most common reason cited for inability to function at preinjury levels.

It is essential to assess how the athlete feels about his or her potential for recovery and how he or she is dealing with the ACL injury and the recovery from an emotional standpoint. Equally important is determining the athlete's level of social connectedness and his or her sense of control over the rehabilitation process. Ongoing appraisals of the athlete's mental and physical coping skills needed to recover are imperative components of a thorough clinical evaluation.

Focusing on the athlete rather than the injury may prove helpful in encouraging an open discussion of feelings and emotions.

Intervention

Interventions to optimize self-efficacy, the belief in one's ability to overcome obstacles and to succeed, hold great potential for symptom management. An athlete's preoperative assessment of expectations may be indicative of self-efficacy, self-esteem, and HLOC. Behavioral strategies directed at improving his or her sense of self-efficacy may increase compliance with treatment tasks, and may help to create a more favorable path of recovery.[12]

While not specific to ACL injuries, an integrated model of psychological response to injury and rehabilitation targets three responses to injury that, in turn, will determine the patient's approach and adherence to the rehabilitation process.[13] All three responses are mediated by both personal (personality, motivation, self-belief, perception of control, resilience, history of injury) and situational factors (social support, resources available, life stressors, requirements of the sport). The three responses are:

Cognitive appraisal: what we think about the injury and its relationship to our lives and goals;

Emotional response: how we feel about the injury, our future,

and how mood and energy are affected; and

Behavioral response: what we do in response to injury and functional loss, ie, planning and execution.

Of the three, cognitive appraisal plays a central role. As mind-body clinicians have surmised, it's primarily mind over matter.

The consequences of being sidelined may negatively impact an athlete's ability to cope with the stress of injury and rehabilitation and may result in catastrophic thinking. Catastrophizing can be defined as predicting the worst-case scenarios, and often generates increased feelings of helplessness, rumination, and magnification of symptoms, leading to increased emotional disturbance, avoidance of painful or threatening activities, and increased perceived disability. Stress inoculation and resiliency training are cognitive behavioral interventions that involve empowering the individual to reduce the stress associated with the injury and to develop enhanced coping strategies for overcoming the obstacles associated with rehabilitation.

The intensity of symptoms experienced by individuals undergoing ACLR rehabilitation may be reduced by enhancing coping strategies. Guided imagery and relaxation training have been associated with improved psychological coping and reduced reinjury anxiety.[14] These strategies involve using the senses to create mental images focused on having the desired outcome. Other psychological techniques have also been described that effectively help athletes recover from injury. Acceptance and commitment therapy and written disclosure have demonstrated effectiveness in reducing negative psychological consequences, improving psychological coping, and reducing reinjury anxiety.[15,16] These psychological techniques involve realistic goal setting and adherence to and compliance with the multifaceted rehabilitation protocol.

Conclusions

The literature suggests a significant need to develop and implement interventions that target improvement of postinjury psychological outcomes to help injured athletes recover successfully from ACL injury and surgery. Educating athletes about the mental health risks associated with injury may prove instrumental in optimizing performance and return to play. Establishing interdisciplinary teams that integrate mental healthcare providers, such as sports and health psychologists, working alongside lower extremity clinicians—including orthopedic surgeons, sports medicine physicians, physical therapists, and athletic trainers—could go a long way toward demystifying the psychological factors and mental health issues associated with ACL injury.

The ability to identify and treat patients at risk for mental health issues after ACL reconstruction may help improve psychological readiness for surgery, attitudes toward postoperative rehabilitation, and successful surgical and rehabilitation outcomes. Future research should focus on intervention studies designed to increase compliance with treatment, enhance surgical outcomes, and improve return to sport. ler

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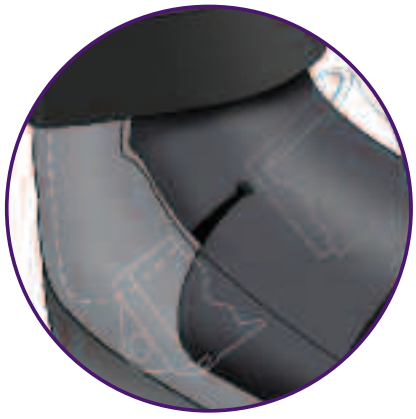

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Darco Pro Term Walker

Darco International announces the addition of the Body Armor Pro Term Walker to its product line. The Pro Term Walker is an interim orthosis for conservative follow-up treatment following Chopart and Lisfranc amputations, among other indications. The walker, which can be worn on either the left or right foot, is designed to allow the foot to completely heal before transitioning to a more traditional walker or custom footwear. It features a wide opening, secure closure system, EVA (ethylene vinyl acetate) and Plastazote insoles, and an air compression bladder for a customized fit. Suggested L-code is 4360.

Darco International
800/999-8866
darcointernational.com

Pain Posters From OPTP

OPTP has partnered with Adriaan Louw, PT, PhD, CSMT, to create a new set of posters focused on neuroscience pain education. The Pain Neuroscience Posters are now available as a set of four 17.75" x 24" posters suitable for display in therapy clinics or rehabilitation centers. Featuring the content and recognizable illustrations of Louw's patient education books, the posters explain the foundational principles behind the neuroscience of pain. They are designed to help patients better understand why they hurt and to complement Louw's other neuroscience resources, also published by the company.

OPTP
800/367-7393
optp.com

Össur Pro-Flex Prosthetic Foot

Össur has launched Pro-Flex, a new foot designed to help reduce joint pain among amputees who engage in low-to-moderate impact activities. Pro-Flex is designed to address many comorbidities often found in lower limb amputees, including altered gait dynamics that can increase load on the remaining joints. Its three-blade design features levers and pivots, plus a foot blade with a full, effective toe lever and a more anatomical split toe. These generate mechanical power and a fluid, natural progression from heel strike to toe-off. Pro-Flex is compatible with the company's Unity sleeveless vacuum system.

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Footmaxx MyFit Orthoses

The vast majority of Footmaxx orthotic devices are custom, carefully crafted based on a patient's unique prescription. Now Footmaxx also offers the MyFit line of nonprescription foot orthoses as an economical solution to foot, arch, and heel pain. MyFit Control orthoses feature longitudinal arch support and a heel cup for stability. The low-profile, flexible MyFit Support orthoses include self-adhesive metatarsal pads for customized correction. MyFit Heat-molded orthoses allow for additional customization. All MyFit orthotic devices feature an antibacterial topcover designed to help cool the feet and reduce friction.

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Little Feet For Children

TRS has responded to requests from the O&P profession by introducing two new sizes (14 cm and 15 cm) of its Little Feet for infants and young children. Little Feet are functional, economical prosthetic feet in sizes now ranging in 1-cm increments from 10 cm to 15 cm. The 14-cm and 15-cm models utilize internal keels for stability, and come in both standard and Syme versions. Little Feet are made of high-performance polyurethane polymers, not foam, which helps facilitate energy storage and energy return. Designed to be anatomically realistic, they come in three colors representing different flesh tones.

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Orfitrans Medium Soft

Orfit Industries introduces Orfitrans Medium Soft, made of a stronger thermoplastic material for optimal patient comfort. Orfitrans Medium Soft can be used for transtibial check sockets as well as for lower limb orthoses. The new version can be submitted to pressures of approximately 75 MPa and is designed to retain its shape over time. Orfitrans Medium Soft is available in a range of thicknesses (5/16", 3/8", 1/2", 19/32") and sheet sizes. The material is designed to be strong and rigid enough to provide control, flexible enough to allow for range of motion, and smooth enough for easy donning and doffing.

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Swede-O Ankle Foot Stabilizer

Swede-O announces the launch of the Ankle Foot Stabilizer (AFS), the newest addition to the MVT2 (Micro Ventilated Thermal) Technology line of products. The AFS includes medial and lateral stabilizers, an adjustable closure strap for greater support, and a nonslip safety sole to help prevent slipping. The AFS provides heat therapy and gentle compression to increase blood flow to help reduce pain. A moisture-wicking, breathable membrane keeps the skin dry and comfortable to improve compliance. Available in sizes S-XL (fits men's shoe sizes 5.5-14 and women's 6.5-15). HCPCS coding verified L1902.

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Paceline introduces the new customizable Tensitube Blue Shrinker, an elastic postoperative residual limb shrinker that applies controlled compression to help provide pain relief and reduce hypertrophic scarring and edema in lower extremity amputees. Prosthetic facilities can now customize the Tensitube Blue Shrinker by having their company logo placed on the product, giving them the ability to promote their facility to doctors and rehabilitation professionals. The Tensitube Blue Shrinker is available in white, beige, and silver antimicrobial versions. It is sized in 2"-6" widths and 18", 24", and 30" lengths.

Paceline
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paceline.com

AF7 Ankle Bracing Sleeve

New from Allied OSI Labs is the AF7 Ankle Bracing Sleeve, a flexible two-in-one ankle brace for treating acute ankle sprains and Achilles tendinitis or peroneal tendinopathy. The AF7 combines elements of a compression sleeve and an ankle brace, designed to stabilize the ankle without immobilizing. The AF7 Ankle Bracing Sleeve provides medial and lateral stabilization and support for the ankle, the Achilles, the arch, and the overall foot structure. Its thin profile allows patients to wear it easily under socks and in shoes. The AF7 can also be worn with the Richie Brace, which is also available from Allied OSI Labs.

Allied OSI Labs
800/444-3632
alliedosilabs.com

RevoFit Lanyard

Click Medical introduces the RevoFit Lanyard, a simple-to-use system that allows amputees to easily draw and lock their residual limb into a prosthetic socket. Unlike traditional lanyards, the RevoFit Lanyard can be used with suction and seal-in systems. The device is suitable for patients with range of motion limitations because the Boa reel can be positioned anywhere on the device for easy patient access and control, which also allows amputees to don a socket while seated. It is safe for use in water or harsh elements, and there is no dangling cord to store because everything is contained in the Boa dial.

Click Medical
970/670-7012
revofitlanyard.com

ProTech Control Met Orthosis

Powerstep's new ProTech Control Met orthosis offers the stability, support, and comfort of its ProTech Control Full Length, but has the added benefit of a built-in metatarsal pad. The Poron met pad helps to spread and cushion the metatarsal heads to reduce pain associated with metatarsalgia and Morton neuroma. The polypropylene arch provides firm support, and the 2° medial heel post and heel cup offer rearfoot positioning and stability. Dual-layer Poron/EVA (ethylene vinyl acetate) cushioning provides comfort and protection. A heat- and friction-reducing top fabric also features antimicrobial qualities.

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Tread Labs Stride Insoles

Tread Labs introduces Stride orthotic insoles. The two-part system features a molded polypropylene arch support and a replaceable topcover, which attaches to the arch support with low-profile Velcro to make replacement or modification fast and easy. Arch supports are molded polypropylene and have a 12-mm heel cup. They are semiflexible for firm but dynamic support. The antimicrobial topcovers feature silver ions and 4-mm open cell polyurethane foam, which resists compression set and provides long-term resiliency. All Tread Labs insoles for men and women come in 21 sizes and four arch heights.

Tread Labs
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Arizona Mezzo Brace

Arizona AFO introduces the Arizona Mezzo brace. Developed by Wisconsin-based Wilson Janisse Group, the Arizona Mezzo is a happy medium between a UCBL (University of California Biomechanics Laboratory) orthosis and the original Arizona AFO (ankle foot orthosis). The custom-fabricated Arizona Mezzo is designed for management of a variety of midfoot and hindfoot conditions requiring superior longitudinal arch support. The device's low-profile design and soft leather lining allow for easy shoe fit and comfort to help improve patient compliance. A Partial Foot Arizona Mezzo brace is also available.

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Spenco
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Dalco Premium Air Walker

Dalco International's new Premium Air Walker, the company's most advanced walker, immobilizes and protects the leg and foot following injury or surgery. Similar to Dalco's traditional Air Walker, the boot utilizes an inflatable bladder to ensure compression and fit. Additionally, the boot protects the toe and shin with a lightweight shell that encompasses the walker. A rocker sole helps promote a natural gait, and a shock-absorbing insole helps reduce heel-strike impacts. The Premium Air Walker is available in three sizes and high and low versions. All options sell for $55 with no minimum purchase required.

Dalco International
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dalcointernational.com

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market mechanics

By Emily Delzell

Hanger foundation funds 2016 grants

The Austin, TX-based Hanger Charitable Foundation in October awarded $17,500 to four grant recipients, concluding its third round of 2016 grants.

The organizations and award amounts are: $2500 to the Spina Bifida Association of Arizona, Children's Rehab Support, to help fund weekly clinics to support children with spina bifida and their families; $2500 to Project H.O.P.E. of Cleveland, Foot Care Health Education and Clinical Care, to support a free monthly foot care clinic for the community; $5000 to the Wisconsin Amateur Hockey Association, Coulee Region Sled Hockey, to purchase adaptive sleds and protective equipment for the sled hockey program; and $7500 to Children's Healthcare of Atlanta, No Limb-itations Leadership Academy, for its program that helps teens with limb loss develop life skills and build community.

The foundation has awarded more than $199,000 to 20 organizations in 2016 thus far, and more than $450,000 to 30-plus organizations since its first grant award in May 2015, according to a foundation release.

The application deadline for the next round of funding is January 31, 2017.

Visit hanger.com for more information. ler

biodesigns socket ups walking distance

Westlake Village, CA-based biodesigns in November reported a recent 13-patient study showed its alternative transfemoral socket outperformed a standard-of-care socket in improving amputees' balance confidence and walking capacity.

The retrospective cohort study compared results from the Activity-Specific Balance Confidence Scale (ABC) and the two-minute walk test (2MWT) in transfemoral amputees aged 26 to 58 years (two women) who had first received an ischial/ramus containment (IRC) socket (worn for at least 30 days) followed by the biodesigns socket after rejection or failure of the IRC socket. Three patients functioned at the K4 activity level; all others functioned at the K3 level.

Mean ABC scores were significantly higher with the HiFi socket than the IRC socket; the HiFi socket also was associated with significantly greater walking distance, though the difference between conditions didn't reach the minimum detectable change threshold.

Technology and Innovation published the study in its September issue.

Randall Alley, BSc, CP, LP, biodesigns' CEO and chief prosthetist, created the HiFI socket, which has less cumbersome walls and subischial trimlines than conventional sockets, according to a company release. ler

Spenco sends shoes to disaster victims

Waco, TX-based Spenco Footwear donated 1000 pairs of shoes, sandals, and slippers to Haitian victims of Hurricane Matthew, which devastated the island nation in early October.

"When we see a tragedy causing suffering to the degree we've seen in Haiti, most of us wonder if there is anything we can do to help," said Jeff Antonioli, Spenco sales and marketing VP. "Hurricane victims need shoes, and if we can help one thousand of those victims, we are happy to provide them some relief."

Nashville, TN-based Soles4Souls is a nonprofit global social enterprise committed to fighting poverty through the collection and distribution of shoes and clothing.

Visit soles4souls.org to donate or learn more. ler

NBA, AT orgs join to grow youth access

The New York, NY-based National Basketball Strength and Conditioning Coaches Association (NBSCA) in October announced it would form a scientific advisory panel of four experts from various fields within the strength and conditioning community to provide continuing education and sharing of best practices to its members.

They are: physical therapy expert Mike Clark, DPT, founder, chair, and CEO of Alpharetta, GA-based Fusionetics, a performance healthcare system company that helps athletes understand, monitor, and improve performance; research expert Darin A. Padua, PhD, ATC, professor and chair of the Department of Exercise and Sport Science at the University of North Carolina at Chapel Hill; coaching science expert Nick Winkelman, PhD, CSCS, head of Athletic Performance & Science for the Irish Rugby Football Union in Dublin; and recovery expert Barnett S. Frank, MA, a resident sports medicine consultant for the University of North Carolina at Chapel Hill.

Visit thenbsca.com for more information. ler

Össur users sweep medals in Cybathlon

Reykjavik, Iceland-based Össur reported in October that amputees wearing its technologies dominated the lower limb competition at the inaugural Cybathlon games in Zurich, Switzerland, claiming all three medals in the leg prosthesis race. The Cybathlon is the first global competition designed to pit users of different assistive technologies in contests assessing their ability to address real-life obstacles.

Above-knee amputee Helgi Sveinsson won the gold medal in the leg prosthesis race, wearing his Össur Rheo Knee XC. Teammates Billy Costello, using an Össur running leg, and David Jonsson, using an Össur Power Knee, took silver and bronze, respectively. The fourth member of Össur's Cybathlon team, Lukas Kalemba, claimed ninth place.

An estimated 4600 people cheered the runners, who completed six designated challenges, including sitting and rising from an upholstered chair, side-stepping over barriers of varying heights, climbing and descending ramps, and balancing food items on plates while traversing up and down stairs. ler

Curbell names Airlite vendor of the year

Orchard Park, NY-based Curbell Plastics in October named Airlite Plastics its 2015 Vendor of the Year. Omaha, NE-based Airlite makes plastic packaging as well as a variety of extruded plastic sheet materials for the O&P industry.

Each year, Curbell recognizes an industry partner for its quality products, exemplary work, and service. Airlite, a long-time Curbell partner, was noted for its responsiveness, focus on providing technical assistance, quality products, and ability to work with Curbell to develop new products, according to a Curbell release. ler

Phoenix launches to sell molded devices

Lake Placid, FL-based Phoenix Molded Shoes, Inserts, and Braces opened its doors on September 12.

The manufacturer is emphasizing communication with its practitioner customers about its services and lower extremity custom devices, which include accommodative and functional orthoses.

Email keithb@phoenixsib.com or call 863/658-2616 for more information about Phoenix. ler

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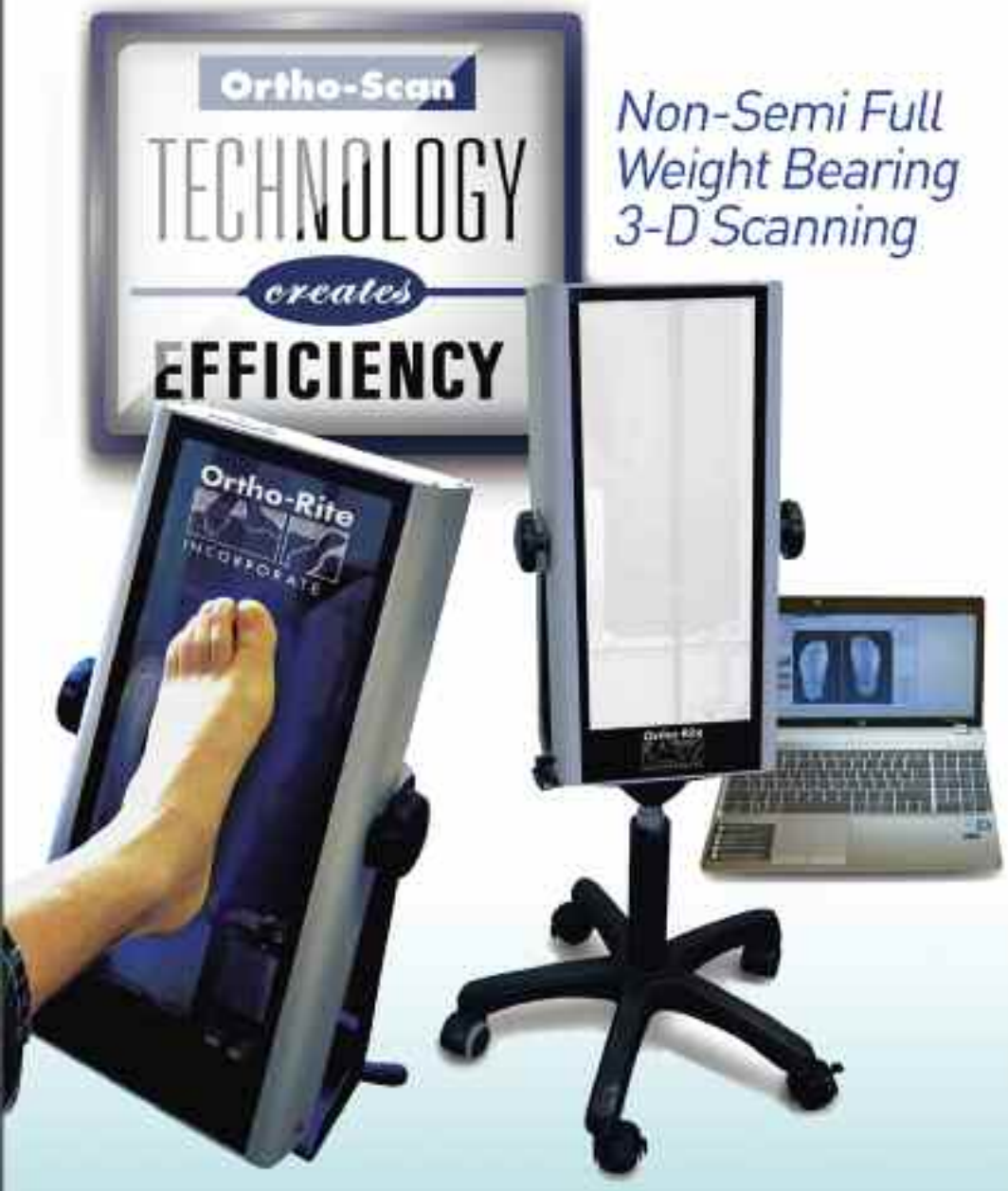

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