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LOWER EXTREMITY REVIEW
August 15 / volume 7 / number 8

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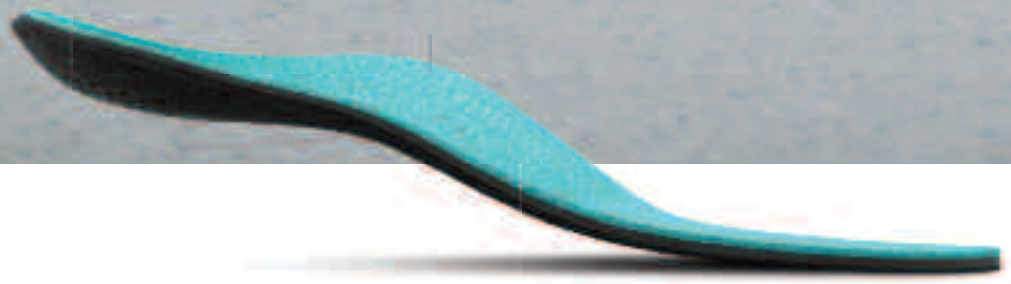

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Publisher
Richard Dubin | rich@lermagazine.com

Editor
Jordana Bieze Foster | jordana@lermagazine.com

Senior editor
Emily Delzell | emily@lermagazine.com

Associate editor
P.K. Daniel | pk@lermagazine.com

Operations coordinator
Melissa Rosenthal-Dubin | melissa@lermagazine.com

Social media consultant
Kaleb S. Dubin | kaleb@lermagazine.com

New products editor
Rikki Lee Travolta | rikki@lermagazine.com

Graphic design & production
Christine Silva | MoonlightDesignsNC.com

Website development
Anthony Palmeri | PopStart Web Dev
webmaster@lermagazine.com

Circulation
Christopher Wees | Media Automation, Inc

Editorial advisors
Craig R. Bottoni, MD, Jonathan L. Chang, MD,
Sarah Curran, PhD, FCPodMed, Stefania Fatone, PhD, BPO,
Timothy E. Hewett, PhD, Robert S. Lin, CPO,
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Erin D. Ward, DPM, Bruce E. Williams, DPM

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

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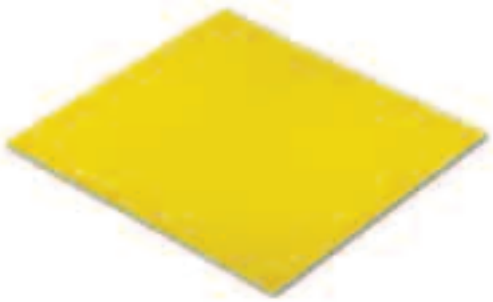

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out on a limb: Hands-free therapy

My former company launched a publication called *Telehealth* in 1998. Nearly two decades later, that magazine no longer exists, and telemedicine hasn't revolutionized healthcare the way some thought it would. But advances are being made, and researchers are demonstrating that the potential applications for remote healthcare include disciplines that have always been considered "hands on."

The publishing group that launched *Telehealth* had its roots in the world of radiology—a specialty for which working remotely makes all kinds of sense. With the right transmission and viewing equipment, most diagnostic images can be interpreted from anywhere in the world, and few patients are expecting to have face time with their radiologist. So, it's not surprising that radiology remains a telemedicine trailblazer today, with some radiology practices now based entirely on remote image interpretations.

It's not a huge leap from the remote assessment of radiographs, magnetic resonance images, and computed tomography scans to the remote assessment of diabetic wounds (see "Telemedicine: Bringing diabetic foot care to the small screen," January 2015, page 14). Not only can telehealth technology minimize the need for patients with diabetic ulcers—who shouldn't be ambulating more than necessary and definitely shouldn't be driving—to make an in-person clinic visit just to check the status of a wound, clinicians can provide informational and motivational consultations via cellphone, Skype, or other cyber-modalities.

Physical therapy and telemedicine, however, would seem to be mutually exclusive. Few clinicians have historically been more hands-on than physical therapists. How effective could a virtual physical therapist possibly be? Surprisingly effective, as it turns out.

In a recent Canadian study, two-month functional outcomes were similar for total knee replacement surgery patients who received either remote physical therapy or in-person therapy sessions (see "Telerehabilitation after TKA," page 15). But the two experiences differed in significant ways. Unable to perform hands-on adjustments or manipulations on patients, the remote therapists had to be able to effectively explain how to do exercises correctly and how patients could perform basic versions of therapies like massage on themselves. The remote therapists also had to master the technical aspects of the video system, including panning, tilting, zooming, and using an on-screen goniometer.

It's a somewhat different skill set than that required for conventional physical therapy. Not every clinician will excel at both versions of their job, and not every patient will respond equally to both types of treatment. It will take a lot more research to determine which conditions and which patients are the best candidates for telerehabilitation. And then, of course, there are reimbursement issues to be hammered out.

> Without the ability to be hands-on, how effective could a remote physical therapist be? Surprisingly effective, as it turns out.

But the possibilities are exciting. Not only does telerehabilitation have the potential to make therapy more accessible to patients, it also has the potential to make careers in physical therapy and rehabilitation medicine more accessible to individuals with disabilities who aren't physically able to provide hands-on treatment.

Lower extremity clinicians won't be as quick to embrace telemedicine as radiologists have been, and for good reasons. But now that the telehealth trail has been blazed, smart practitioners will be thinking about where that path might ultimately lead them.

Jordana Bieze Foster, *Editor*

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By Barbara Boughton and Jordana Bieze Foster

Healing hamstrings

Sport-specific factors affect return to play

A new study of more than 500 hamstring injuries sustained by collegiate soccer players provides evidence that return to participation after these strains is influenced by factors other than an athlete's strength and flexibility.

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In the study, published in the *Journal of Athletic Training* in July, researchers from the University of Virginia (UVA) in Charlottesville found that the time needed to return to full participation was not affected by player gender. Yet other factors did make a difference—including the point in the season when the injury occurred, the level of competition, and the player's position. The data in the study, regarding hamstring injuries sustained between 2004 and 2009, were derived from the National Collegiate Athletic Association Injury Surveillance system.

"We had evidence from a previous study that there was a difference between men and women collegiate soccer players in the occurrence of hamstring injuries—with more men than women affected by these strains," said Kevin Cross, PhD, PT, ATC, a staff physical therapist and research coordinator at UVA-HealthSouth Rehabilitation Hospital and lead author of the study. "Yet we didn't know what extrinsic factors affected return-to-play time among players."

Continued on page 12

Self-reported information helps predict knee injury risk in female soccer players

Two self-reported measures are significantly associated with risk of knee injury in adolescent female soccer players, according to a Danish study that could have implications for screening.

In 326 adolescent female soccer players who were uninjured at the start of a season, researchers from Copenhagen University Hospital in Denmark assessed self-reported history of knee injury and scores on the Knee Injury and Osteoarthritis Outcome Score (KOOS) function questionnaire.

During the season that followed, players who suffered knee injuries that resulted in a loss of participation time were significantly more likely to have reported a history of injury at baseline than those who did not miss time with a knee injury. Risk of time-loss injury was also significantly associated with low baseline scores (less than 80 points) on three KOOS subscales: activities of daily living, sport/recreational, and quality of life.

The findings, which were epublished in July by the *Scandinavian Journal of Medicine & Science in Sports*, suggest that such inexpensive, easily administered outcome measures could be used for preliminary screening in this patient population. ler *—JBF*

Source:

Clausen MB, Tang L, Zebis MK, et al. Self-reported previous knee injury and low knee function increase knee injury risk in adolescent female football. Scand J Med Sci Sports 2015 Jul 15. [Epub ahead of print]

Baseball season takes toll on hip strength and range of motion in collegiate pitchers

Hip range of motion (ROM) and strength in collegiate baseball pitchers decrease significantly over the course of a competitive season, but these changes are not associated with pitching workload, according to research from the University of Florida in Gainesville.

In 14 collegiate baseball pitchers, investigators assessed bilateral hip rotation ROM and hip isometric strength before and after a single competitive season. They found that postseason measures of external rotation, total rotational ROM, and hip abduction strength were significantly lower than preseason measures in both the trail and lead hips. Internal rotation ROM and hip extension strength did not change significantly between preseason and postseason.

The findings, which were published in the August issue of the *International Journal of Sports Physical Therapy*, could have implications for in-season training strategies to maintain pitching effectiveness and reduce injury risk. The authors were surprised to find, however, that pitching workload (defined as the number of pitches thrown over the course of a season) was not significantly associated with any of the significant changes in ROM or strength measures. ler *—JBF*

Source:

Zeppieri G, Lentz TA, Moser MW, Farmer KW. Changes in hip range of motion and strength in collegiate baseball players over the course of a competitive season: A pilot study. Int J Sports Phys Ther 2015;10(4):505-510.

Continued from page 11

The results indicated that when return-to-play time was compared between male and female soccer players with either first-time or recurrent hamstring strains, there were no significant differences. Yet male players with first-time hamstring strains took longer to return when the strain occurred during competition (vs practice) or in-season/post-season (vs preseason), or if the player was a Division I athlete (vs Division II or III).

Male players with recurrent hamstring strains took longer to return if the injury was sustained during the season or the post-season rather than in the pre-season. Among women with recurrent strains, more days were missed by forwards than by midfielders or defenders. There were no significant differences for return-to-play time among women with first-time hamstring injuries, even when injury timing, position, and level of competition were considered.

"The findings suggest that athletes are more likely to need a longer time to return to play when they are injured while playing in an open environment and not restricting their activity—during competition, for instance, as opposed to practice, which is more regimented," Cross said.

Athletes who tend to run at higher intensities during play and are therefore more likely to fatigue during games—such as Division I male athletes and female forwards—were also more likely to need longer recovery times, he added.

Clinically, the findings suggest that training should be not only sport-specific, but also specific for a player's position and style of play, Cross said. Training athletes for whom competition involves high intensity sprints should also aim to aerobically and anaerobically challenge athletes during practices and minimize fatigue before competition. These goals can be best accomplished with longer sprints (about 40 m) and an exercise-to-rest ratio of 1:6, Cross added.

Athletes should also be given sufficient time to recover after a hamstring injury and should be able to function well during high intensity sprinting before returning to play, Cross said. One test that's particularly useful in assessing whether an athlete is ready to return to play is the Yo-Yo intermittent recovery test level 2, which consists of two timed 20-m runs, he added.

"It's very useful to have this information, because it gives us some data when we try to project return-to-play time," said Jimmy Smuda, MA, LAT, CSCS, a Tampa, FL-based athletic trainer with the United States Soccer Federation. "It also points out the importance of fatigue in these injuries, so training should really taper off as you near competition. Although you want to ensure that the athlete has the appropriate level of training, you also don't want to tax them too much prior to competition." ler *–BB*

Source:
Cross KM, Saliba SA, Conaway M, et al. Days to return to participation after a hamstrings strain among American collegiate soccer players. J Athl Train 2015;50(7):733-741.

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By John C. Hayes and Jordana Bieze Foster

Telerehabilitation after TKA

Remote PT matches in-person outcomes

In a randomized trial said by its authors to be the largest of its kind, patients receiving in-home therapy after total knee arthroplasty had equivalent outcomes whether they saw a therapist face-to-face or via a video- and sound-connected "visit" from a remote location.

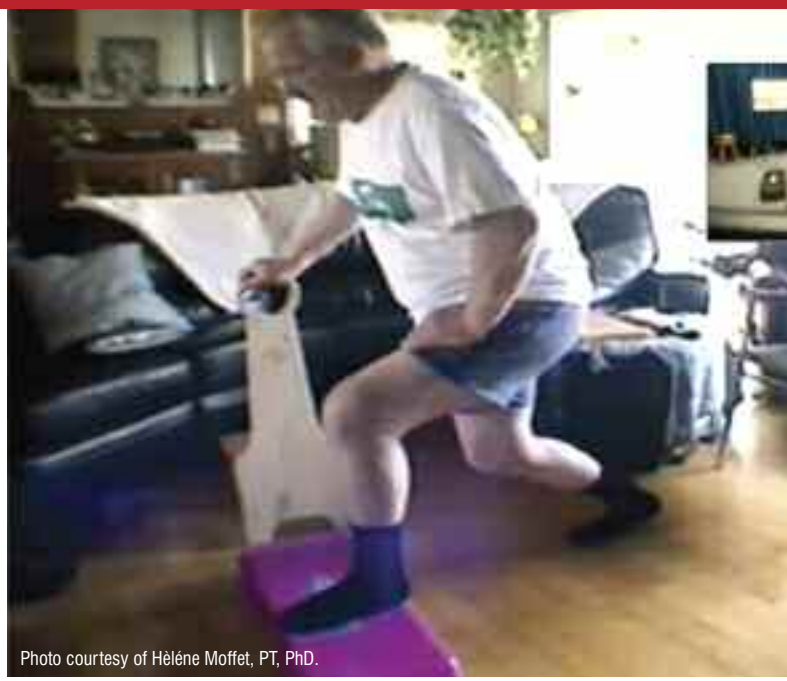


Photo courtesy of Hèléne Moffet, PT, PhD.

The trial conducted in Quebec, Canada, included data from 101 patients in the standard care arm and 98 patients in the "telerehabilitation" arm. Patients from eight hospitals participated. The study was published in July by the *Journal of Bone & Joint Surgery*.

The therapy was a relatively strenuous, hour-long, 16-session, two-month course, said lead author Hèléne Moffet, PT, PhD, a professor in the Department of Rehabilitation at the Université Laval in Quebec City.

Using the Western Ontario and McMaster Universities Osteoarthritis Index, the researchers found that the gains for telehealth and standard care groups for post-therapy outcomes were equivalent for measures of pain, stiffness, and function. Outcomes were also equivalent in a secondary test, the Knee Injury and Osteoarthritis Outcome Score.

Moffet said she was most impressed that there was a comparable rate of adverse events in both groups (two related to the therapy in the standard group and none in the telehealth group) and that there

Continued on page 16

Muscle force changes vary after gait modification to reduce knee moment

A single gait modification to reduce knee adduction moment in patients with knee osteoarthritis (OA) is associated with muscle force pattern changes that vary from one patient to another, according to research from Shanghai, China.

Investigators from Shanghai Jiao Tong University analyzed 10 individuals with self-reported knee pain and radiographic medial compartment knee OA as they walked using their customary gait and a toe-in gait modification. They then used muscle-actuated dynamic simulations to determine muscle force patterns for each gait condition.

Foot progression angle during the toe-in gait averaged 7° less than during customary gait, and the kinematic change was accompanied by a 20% mean decrease in knee adduction moment. However, although the researchers observed changes in muscle force patterns associated with the gait modification within individuals, these muscle force pattern changes were not consistent across the patient population.

The findings, which were epublished in July by the *Journal of Biomechanics*, suggest clinicians may want to consider muscle forces in addition to kinematics when implementing gait retraining in patients with knee OA. ler *–JBF*

Source:

Shull PB, Huang Y, Schlotman T, Reinbolt JA. Muscle force modification strategies are not consistent for gait retraining to reduce the knee adduction moment in individuals with knee osteoarthritis. J Biomech 2015 Jul 17. [Epub ahead of print]

OA treatment outperforms usual care with regard to pain but not sensitization

The mechanism by which an integrated nonsurgical treatment program reduces pain in patients with knee osteoarthritis (OA) does not appear to involve pain sensitization, according to research from Denmark.

Investigators from Aalborg University in Aalborg randomized 100 patients with knee OA to receive usual care (two educational leaflets and treatment advice) or a three-month treatment program including neuromuscular exercise, education, diet, insoles, and pain medication.

At three months, patients in the intervention group had greater improvements from baseline than those in the usual care group for peak pain intensity, pain after 30 minutes of walking, and number of body sites with pain. However, sensitization improved in both groups compared with baseline, and the change in sensitization did not differ significantly between the groups.

The findings, which were epublished on August 1 by *Osteoarthritis & Cartilage*, suggest that mechanisms other than pain sensitization contributed to the patients' perceived pain. However, the authors hypothesized that pain sensitization might play a larger role in patients with more severe disease or in other subgroups of patients. ler *–JBF*

Source:

Skou ST, Roos EM, Simonsen O, et al. The efficacy of non-surgical treatment on pain and sensitization in patients with knee osteoarthritis: a pre-defined ancillary analysis from a randomized controlled trial. Osteoarthritis Cartilage 2015 Aug 1. [Epub ahead of print]

Continued from page 15

were relatively few personal visits in the telehealth group. Although 22 of the telehealth patients required home visits during the study period, most of those were for technical reasons involving the telehealth equipment. The actual number of personal visits comprised less than 3% of the telehealth total, she said.

"The data show that we can do a lot at distance and that telehealth can be very useful, even in a big city, because you save a lot of time not traveling," Moffet said.

The physical therapists were trained on identical protocols for the in-person and telehealth visits. For the telehealth visits, even tasks that might have been performed by a therapist, such as massage of the surgery scar or moving the patella to improve motion, were left to the patients based on instructions from the physical therapist.

The exercises focused on balance, weight transfer, mobility, endurance, flexibility, and strengthening of the quadriceps, hamstrings, calf muscles, and upper limbs. Patients were given charts to monitor their progress as they performed the exercises between visits.

Because the telehealth therapists were not physically present during the sessions, there was a greater focus on safety, Moffet said. Techniques were developed to ensure patients listened and followed directions carefully. They had a chair or walker on hand for stability.

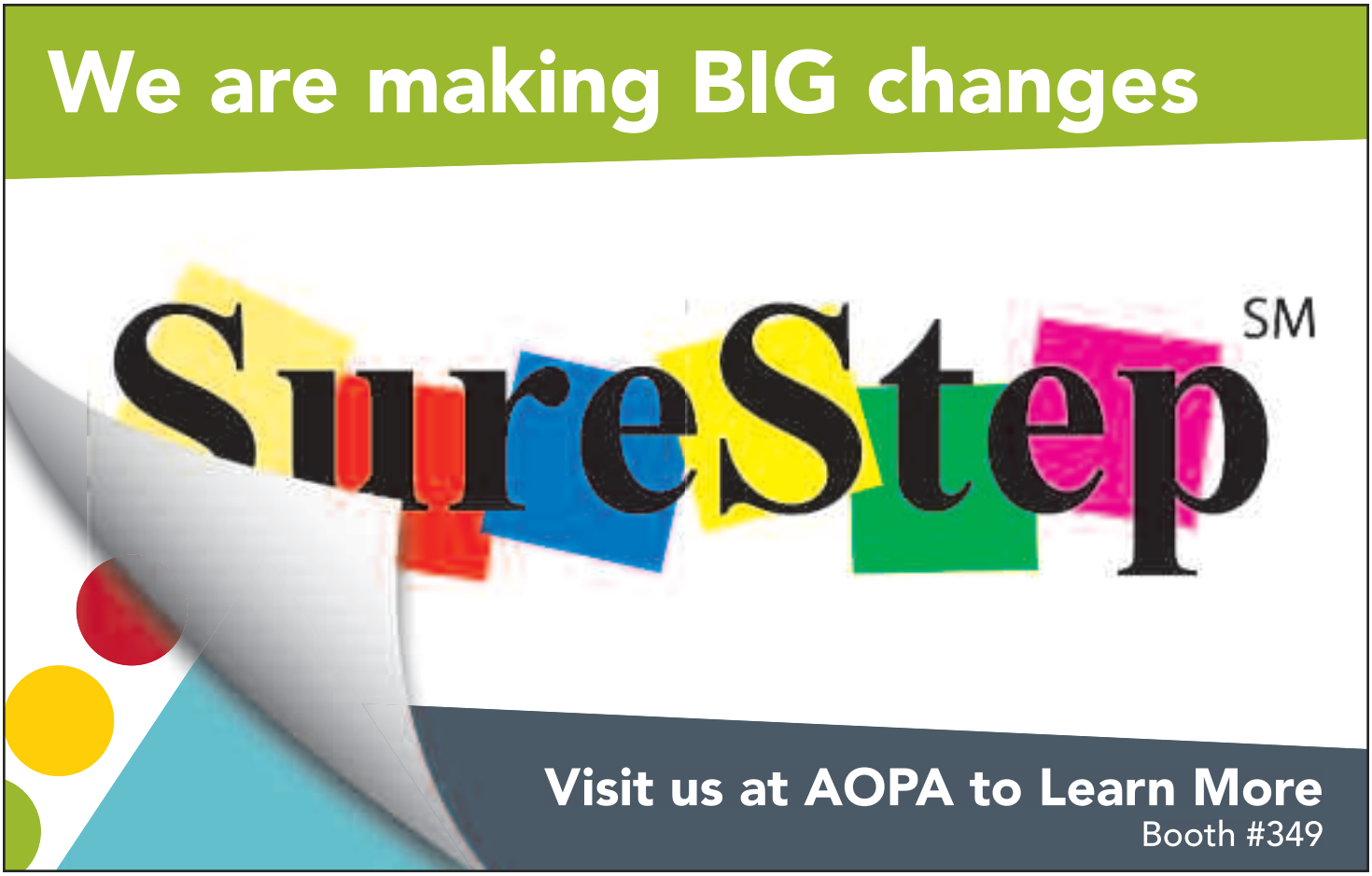
The telehealth equipment included clinician-controlled pan, tilt, and zoom cameras and dedicated software allowing real-time two-way video and audio communication. A therapist did the initial installation to provide a proper setup, adequate space for exercises, and an opportunity to meet the patient. Therapists used an on-screen goniometer to assess range of motion and a zoom feature to check the condition of the scar or measure the knee for swelling. Monitoring the status of the knee also relied on patient assessments of factors, such as its warmth and answers to general questions that might signal an infection.

"You really have to learn how to treat differently," Moffet said. "There is more time in explanation and education of the patient."

There is a growing interest in telehealth in the physical rehabilitation community, but it is a step away from the hands-on approach most physical therapists are familiar with, said Alan Chong W. Lee, PT, PhD, an associate professor in the Doctor of Physical Therapy Program at Mount Saint Mary's University in Los Angeles, and an observer of telehealth for the past decade.

"We're a hands-on field. We want to put our hands on them and make the patient-provider relationship happen," Lee said. "It may not be one or the other, but a hybrid, where the connection begins face-to-face but continues through technology." *–JCH*

Source:
Moffet H, Tousignant M, Nadeau S, et al. In-home telerehabilitation compared with face-to-face rehabilitation after total knee arthroplasty. J Bone Joint Surg Am 2015;97(14):1129-1141.



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Managing Finger and Toe Wounds

The closing and healing of all wounds involves establishing and maintaining optimal wound healing conditions. Managing wounds on fingers and toes can be difficult due to the need to reduce edema without a good way to accomplish the goal. Additionally, a caregiver is often required to apply dressings in a way that limits the digit's range of motion, further interfering with the healing process. Dressings applied to the finger or toe often need to be changed frequently because they slip off due to movement. In patients with vascular or diabetic co-morbidities, digit wounds can be especially slow to heal and often require multiple medical interventions.

A recent poster,[1] highlighting four patients with digit wounds on either the hand or foot, demonstrated the use of Ferris Mfg. Corp.'s latest product, the PolyMem® Finger/Toe dressing. The dressing was developed to be easily applied and removed and contains the same formulation of all PolyMem dressings, helping ensure less pain and more healing.

Patient 1 was a 78-year-old diabetic male with a below-the-knee right leg amputation. He bumped his left foot during a transfer from his wheelchair to the toilet. The trauma resulted in three blood-filled blisters on the second toe of the left foot and swelling of his left lower extremity became a healing obstacle. Due to increased susceptibility to infection, the silver version of the PolyMem Finger/Toe dressing was applied to the blisters. His wife performed the dressing changes and his blisters dried under the dressings in less than two weeks, using only two dressings.

The Silver Finger/Toe dressing was easily applied.

Patient 2 was a 71-year-old diabetic male with a history of poor vascular perfusion, below-the-knee amputation of the right leg, and venous stasis ulcers. The hook-and-loop fastener of a post-operative shoe created a friction wound on the top of the toe on his remaining foot. The periwound skin became edematous and macerated. Using the PolyMem Finger/Toe dressing, he was able to do his own dressing changes and the periwound maceration, swelling and weeping decreased. The wound, which originally measured 0.5 cm x 0.7 cm x 0.1 cm, was closed in 14 days. Only two PolyMem dressings were used to close this wound.

Patient 3 was a 56-year-old paraplegic female whose shoe came off when her foot fell from the wheelchair footrest, resulting in an avulsion of the second toenail of the left foot. The periwound skin became slightly erythemic and edematous. Her dressing changes were performed by home health and the wound closed in only three days.

Patient 4 was a 56-year-old male who suffered an amputation at the proximal joint of the first finger of his right hand while operating a hydraulic log-splitter. A surgical flap was attempted, but it was unsuccessful. The periwound skin was swollen, macerated and warm to the touch. He received whirlpool baths to the wound twice weekly by physical therapy. He changed his own dressings when required and when no whirlpool treatments were scheduled. The macerated periwound skin resulting from the whirlpools was managed with a barrier cream. The pain during the whirlpool treatments was managed with oral analgesia. All these wounds healed rapidly using PolyMem Finger/Toe dressings.

PolyMem is a multifunctional polymeric membrane dressing and contains components that draw and concentrate the body's natural healing substances into the wound bed to promote rapid healing. PolyMem Silver has all the unique properties of the standard pink PolyMem dressings with the additional antimicrobial properties provided by elemental silver.

The Finger/Toe dressings, like all PolyMem products, help to reduce edema, bruising, pain and inflammation when applied to either open or closed injuries. The dressings help relieve both persistent and procedural pain that is associated with injury and are effective throughout all stages of the healing process. The dressings fit securely over the finger or toe while allowing freedom of movement; encouraging range of motion; helping reduce pain, swelling, bruising and inflammation; and providing cushioning protection.

After application of PolyMem dressings, all these patients experienced significant swelling reduction in the affected digits and saw rapid resolution of any previously present periwound skin complications. Nurses, patients and caregivers found the dressings easy and convenient to use. Finger/Toe dressings were shown to be cost effective when compared to other approaches as the number of dressings used was significantly decreased, the time needed for dressing changes was minimal and the home health nurses made fewer visits. PolyMem dressings provided optimal healing environments, which resulted in rapid wound resolutions.

The entire dressing was applied to cover the the knuckle as well as the wound in order to help reduce the swelling faster.

Reference:

1. Harrison J. Successful Healing of Digit Wounds with One Dressing. Poster 6130. Wound Ostomy and Continence Nurses Association (WOCN). June 9-13, 2012. Charlotte, NC, USA.

Sports compression garments:

The expectations vs the evidence

Research suggests that compression garments can be effective for improving muscle recovery after fatiguing exercise, but has found little to indicate an athletic performance benefit.

By P.K. Daniel

A World Cup soccer player, a National Basketball Association point guard, a National Football League wide receiver, an Olympic gold-medal-winning short-track speed skater, a mixed martial artist, a professional wake boarder. These are examples of elite-level athletes who wear compression garments with expectations of enhanced performance or muscle recovery.

These expectations are driven by compression gear companies who target professional and recreational athletes alike with website messages advising that the products will "take their sports performance and recovery to the next level," as one site puts it. Published studies of compression garments, however, don't fully support these claims.

In theory, sports compression garments improve performance during exercise and speed recovery afterward by improving vascular circulation, thus increasing oxygen delivery to muscles and removal of metabolic waste products such as lactic acid.

Research does indicate that compression can be effective for improving muscle recovery after fatiguing exercise, such as running a marathon. But, although multiple studies have looked at the effect of compression garments on sports performance, they have found little evidence of a performance benefit. And some researchers have found that the advantages of the garments primarily have to do with the wearer's perception—raising the possibility of a placebo effect.

The degree to which marketing impacts the wearing of compression garments cannot be underestimated, according to Australian researchers in human movement science.

"There is little doubt that sports compression garments exploded on the scene and the 'trend' grew much faster than the scientific evidence," said Peter Clothier, PhD, a lecturer in the School of Science & Health at the University of Western Sydney in Australia.

"As with many trends in sports performance, the onus on the usage of devices such as compression garments is an individual one."

Focusing on fit

The question of fit, or more specifically, the degree of compression provided by compression garments, is a common issue that has been raised in the peer review process and literature regarding the variable results. Specifically, a large majority of studies have not measured the exact amount of compression participants are receiving.

Experts say the fit is fundamental: If compression is not optimized, then the garment can't do what it is proposed to do, regardless of whether that compression can actually make any physiological difference to an athlete.

"It is possible that there may be an optimal degree of pressure that elicits beneficial or better effects," Clothier said. "However, there is a lack of a valid and reliable scientific method to measure the pressure at the garment-skin interface. Several studies report attempts to quantify the degree of compression. However, these studies often fail to report the reliability of these measurements. Attempts to measure compression have occurred at a small number of easily accessible sites that are not representative of the net compression over the entire limb."

Amitabh Gupta, PhD, a lecturer in Allied Health at the University of Western Sydney in Australia who coauthored a study on compression garments with Clothier, said a valid and reliable system would need to be developed to accurately measure total limb compression.

"To date, there are no such systems available," Gupta said. "Therefore, the approach in our study[1] was to follow manufacturer guidelines, which are the only method a consumer has to purchase an appropriately fitting garment."

Jessica Hill is a PhD candidate studying recovery from muscle damage in endurance exercise and a sport and exercise physiology senior lecturer in the School of Sport, Health and Applied Science at St. Mary's University in Twickenham, UK. She was the lead author

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Photo courtesy of Knit-Rite.

on another compression garment study that appeared earlier this year in *International Sports Engineering Association*.[2] The study addressed the variation in pressures exerted by commercially available compression garments.

"...there was large variability in the way that the compression garment fits an individual," Hill said. "They will not all be getting the same amount of compression. For me the biggest issue surrounding compression is whether the garment fits, and unfortunately, unless an athlete goes bespoke, it is going to be difficult to know if the garment fits properly. The fit of the garment is likely to be an important factor in how effective the garments are."

Assessing performance

Clothier and his colleagues studied the effect of compression garments on motor performance parameters and leg mechanical characteristics during rapid and repeated loading of a limb to exhaustion—a lower limb dynamic rapid loading task that utilized the stretch-shortening cycle.[1]

They assessed 38 recreationally active male participants with a mean age of 22 years who performed single-leg, on-the-spot hopping at a frequency of 2.2 Hz for up to three minutes or to volitional exhaustion. Biomechanical measures included total duration of hopping time and individual hop cycle characteristics, including spatiotemporal variables and leg mechanics.

Each participant was tested under three conditions—garment, sham garment, and no garment—with the order of conditions randomized. The sham garment was designed to look and feel like the compression garment but did not actually provide compression.

Flight phase and contact phase duration, vertical displacement of the center of mass during the flight phase, and normalized vertical leg stiffness all were significantly different at the end of the hopping trial than at the start. However, there were no significant differences between conditions for any of the variables measured. The researchers concluded that commercially available compression garments, when fitted to manufacturer guidelines, did not enhance performance in a controlled, relatively short duration hopping task to exhaustion, compared with no garment and the sham garment.[1]

"There was also no influence of [the compression garment condition] on performance of a number of biomechanical measures as described by spatiotemporal characteristics and vertical stiffness," Gupta said.

While compression garments did not improve performance, they also did not detrimentally affect performance, the researchers noted. Therefore, they said, the choice to use compression garments must be made based on the perceived cost-to-benefit ratio.

"The perceived benefits, such as comfort, may still sway the choice of whether to use a compression garment or not during their performance," Gupta said. "This study did not demonstrate a change in leg mechanical characteristics, and interestingly did not demonstrate an increase in the duration of hopping. Although not surprising, it does add to the view that compression garments may not directly improve motor performance, however, and plausibly,

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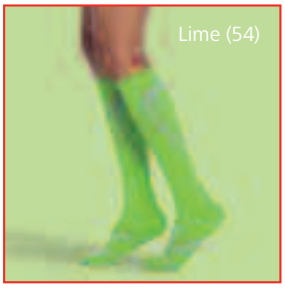

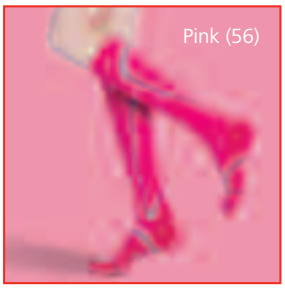

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they may play a role in comfort and recovery."

Despite the lack of research supporting compression garments as performance enhancers, their popularity has been likened to the widespread appeal of kinesiology tape among athletes.

"The use of compression garments during sport is similar to the fashion of Kinesio tape," said Stuart Armstrong, MD, a sports and exercise physician with Anglesea Sports Medicine in Hamilton, New Zealand, alluding to the fact that manufacturer claims about the physiological effects of elastic therapeutic tape also have proved difficult to substantiate (see "Elastic therapeutic tape: The search for evidence," March 2015, page 37).

Possible placebo effects

Armstrong, like others who have studied the sports application of compression garments, said that any performance benefit is an imagined one.

"It will have a placebo effect if [athletes] believe it is helping their game, but there is no clinical evidence above and beyond this," he said.

Scientists have said the challenge of blinding participants makes conducting studies on compression garments difficult, if not impossible. This leaves open the possibility of a placebo effect when measuring variables like subjective responses (eg, perception of muscle soreness) or subsequent exercise performance.

"That said, if evident, a positive effect is a positive effect," said researcher Braid MacRae, MSc, who published a study on compression garments and exercise in *Sports Medicine* in 2011 while with the University of Otago in Dunedin, New Zealand.[3] MacRae, who is currently with the Swiss Federal Laboratories for Materials Science and Technology (Empa) in St. Gallen, Switzerland, said the placebo effect should not be discounted.

"I think it would be foolish to overlook a placebo effect as an effect," MacRae said. "If what you're after is getting out the door for your next training session, and wearing compression garments helps do that, then I don't see anything wrong with that. My advice for athletes would be quite practical. I believe you shouldn't underestimate personal experience."

Researchers in the US and abroad expressed similar positions.

"While it doesn't appear that there are quantifiable physiologic changes when you wear [compression] garments, anecdotally, people do feel better and more confident when they wear them," said Samuel R. Ward, PT, PhD, who is a professor in the departments of radiology, orthopaedic surgery, and bioengineering at the University of California, San Diego in La Jolla. "They feel like they have more support around something that was either injured or they feel as though it's predisposed to injury. I think many people downplay the second part of that, which is not right. There's a significant component of performance that is between your ears—the better people feel, the better they're going to perform."

Photo courtesy of Sigvaris.

Evidence for muscle recovery

Despite the lack of evidence for performance enhancement, the research has generated some evidence of beneficial effect in terms of muscle recovery. Armstrong, in fact, was the lead author of a randomized controlled trial of compression socks and their effects on functional recovery following marathon running that appeared last year in the *Journal of Strength and Conditioning Research (JSCR)*.[4]

The compression garments came up to the knee and had a moderately strong compression gradient. They were fitted to 33 uninjured experienced marathon runners based on shoe size and calf girth.[4]

"Essentially, my research showed that there is a benefit in the use of compression garments for recovery after an exhaustive sporting event," he said. "Crucially, the compression garments weren't worn during activity, but were worn following the completion of activity."

The aim of the study was to show whether compression socks worn for 48 hours after running a marathon could improve functional recovery 14 days later. The runners were measured by a timed treadmill test to exhaustion two weeks prior and two weeks following each marathon. The group wearing the compression socks, which were designed to give a compressive value between 35 and 45 mm Hg when fitted per the manufacturer's instructions, increased runners' time to exhaustion by 2.6%. The placebo group, wearing the sham garment—a no-seam diabetic sock designed to be in the 4- to 5-mm Hg range (enough compression to keep the sock up)—decreased their time by 3.4%.[4]

"I was surprised I was actually able to show a difference in running performance two weeks following a marathon in the compression group versus the noncompression group," said Armstrong, who noted that compression garments need to be medical grade rather than fashion-accessory grade. He recommended a level between 35 and 45 mm Hg for athletes. He also noted the importance of fit.

"Fit of the garments is incredibly important, and I know from the study I did, even though the compression socks were fitted to the participants, they were off the shelf and there was a wide variety of actual compressive values obtained in the athletes," he said.

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Another study investigating the effects of compression on recovery following marathon running indicated perceived lower levels of muscle soreness. Hill was the lead author on the study that appeared last year in *JSCR*.[5]

"Compression garments appear to reduce the severity of symptoms associated with muscle damage and have been indicated to accelerate recovery of muscle function," she said.

Twenty-four runners were divided into two groups. One group wore lower limb compression tights for 72 hours after completing a marathon. The other group received one 15-minute treatment of sham ultrasound after the marathon. Perceived muscle soreness, maximal voluntary isometric contraction (MVIC), and serum levels of markers for muscle damage (creatine kinase [CK] and C-reactive protein [C-RP]) were assessed at various points. Perceived muscle soreness was significantly lower in the compression group than the sham group 24 hours after the marathon. There were no significant group effects for MVIC, CK, and C-RP.[5]

The study concluded that, while the use of a lower limb compression garment improved subjective perceptions of recovery, there was neither a significant improvement in muscular strength nor a significant attenuation in markers of exercise-induced muscle damage and inflammation.[5] The other factor Hill said should be noted is that the individuals who took part in this study were experienced runners completing high weekly training volumes. Therefore, they were unlikely to experience very high levels of muscle damage, even after a marathon, and were likely to recover more quickly than less intense runners.

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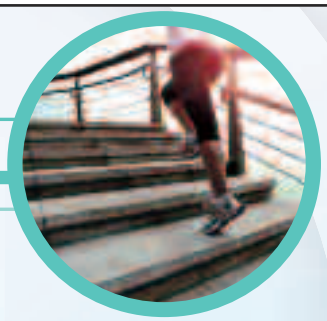

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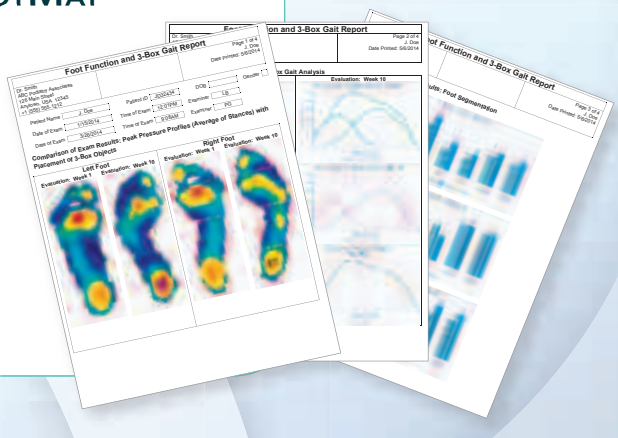

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"If we had used a more inexperienced group of individuals we may have found different results," Hill said. "We conducted a systematic review and meta-analysis of studies investigating the efficacy of compression and identified that the use of compression appears to reduce the severity of symptoms associated with exercise-induced muscle damage following strenuous exercise."

That meta-analysis was published in the September 2014 issue of the *British Journal of Sports Medicine*.[6] Hill and her researchers used an electronic search of the literature, ending in August 2012. They used three online databases (MEDLINE/PubMed, SportDiscus, and ISI Web of Knowledge) using combination of terms.


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Caveats and considerations

While sports compression garments aren't a magic bullet and likely won't help an athlete run faster or jump higher, they may enhance performance through perceived benefit and they may help in recovery.

"As a general rule in medicine, particularly in orthopedics, when people have pain or instability, compression provides some improvement in symptoms," Ward said.

Additionally, Clothier and Gupta pointed out that, while their study concluded compression garments did not promote performance in a controlled short-duration hopping task, their findings did not necessarily translate into a lack of efficacy.

"In no way do we suggest that the wearing of commercially available [compression garments] could not enhance sporting performance, especially in relation to other movements, sporting activities or from a thermoregulatory, neuromuscular, physiological, or psychological perspective," Clothier said.

He added that, because it's possible that garments may affect other parameters than those measured, it is also plausible that the reported benefits of garments involve aspects of motor performance that do not directly relate to biomechanics. ler

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Good shoe!

London exhibit puts footwear in the $

'Parakeet' shoes, by Caroline Groves, England, 2014. Photography by Dan Lowe.

Desert boots, light brown suede, by Clarks, 1994. © Victoria and Albert Museum, London.

Wedding toe-knob paduka, silver and gold over wood, India, 1800s.

POTLIGHT

By Shalmali Pal

It may seem a bit odd that Clarks would sponsor an exhibit called "Shoes: Pleasure and Pain" at the Victoria and Albert Museum in London, UK. After all, the company is known for producing very practical footwear, including the Desert Boot, which would seem out of step with the exhibit's declaration that it highlights the "impractical, un-functional and overly decorated."

But "Shoes: Pleasure and Pain," which runs through the end of January 2016, is ultimately a celebration of the artistry and engineering that go into footwear, and any shoe manufacturer can support that. (An interesting aside: London is a particularly fitting place for the show, for some obvious reasons and some that are less familiar. Sure, it's a global fashion capital, but it also happens to be the burial place, at Highgate Cemetery, of Issachar Zacharie, chiropodist/podiatrist to Abraham Lincoln!)

The exhibit is divided into two parts: The main show offers a history of shoes, with many examples of the aforementioned impractical and overly decorated. There's a pair of 19th century wedding sandals from India, rendered with intricately inlaid silver and gold, and Roger Vivier for Christian Dior heels from the mid-20th century that are equally ornate.

The exhibit then takes the viewer through the ages with examples of footwear that are similarly beautiful, but also potentially hazardous to one's foot health, like stilettos festooned with feathers, metal spikes, leather fringe, or crystals. Featured high-end designers include Christian Louboutin, Jimmy Choo, and, of course, Manolo Blahnik of "Sex & the City" fame.

Then there's the pain element: The sky-high heels are obvious in their crimes against lower extremity biomechanics. But some of the featured flats are equally treacherous, with zero arch support and narrow toe boxes (check out the gilded and marbled leather English oxfords circa 1925), along with platforms that are so tall, they look as if they have to summited rather than donned, such as Vivienne Westwood's 12-inch "mock-crocs".

It's in the pain arena that the exhibit falls a bit short: It would have been interesting to have some discussion or description of how shoes affect the feet, whether it's excess pressures on the forefoot from a pair of pumps or the complete lack of support from barely there strappy sandals.

The second part of the exhibit offers computer modeling of how shoes are designed and constructed, from last to laces. There's also an area devoted to a number of private shoe collections—these are folks who amass shoes as artwork.

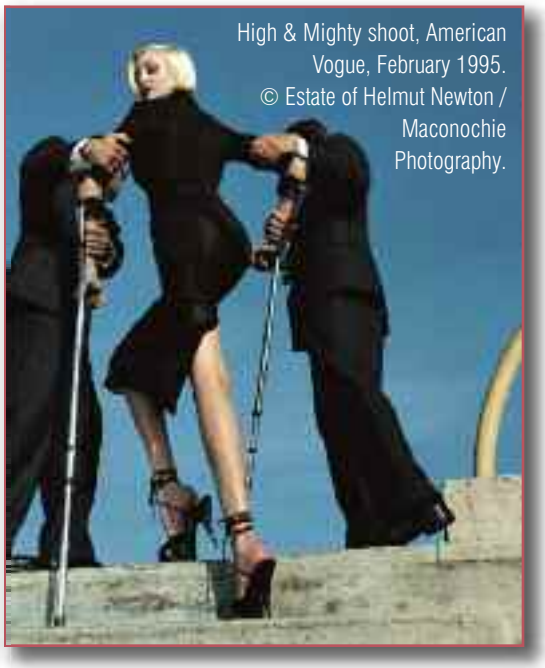
My favorite section was on the "future shoe"—footwear created and customized with 3D printing. If these shoes come to fruition on a mass market level, would it be the ultimate boon to lower extremity professionals whose patients currently refuse to comply with their prescribed footwear? Foot cosmesis could be a thing of the past if patients could easily obtain customized shoes that met their sartorial preferences as well as their clinical needs.

"Shoes: Pleasure and Pain," is open until January 31, 2016, at the Victoria and Albert Museum. For more information, visit vam.ac.uk.

Shalmali Pal is a freelance writer based in Tucson, AZ.

Mens' shoes, gilded and marbled leather, Northamptonshire, England, 1925. © Victoria and Albert Museum, London.

Evening shoe, beaded silk and leather, France, 1958-1960. Made by Roger Vivier for Christian Dior. © Victoria and Albert Museum, London.



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Running modifications to alter PFJ contact force

Patellofemoral pain interventions have increasingly focused on running technique and training approaches—such as utilization of a forefoot strike pattern, a shortened step length, and manipulations to training pace—to reduce patellofemoral joint loading parameters.

By Collin D. Bowersock, BS, and John D. Willson, PT, PhD

Running is a very popular mode of exercise among people of all ages, with nearly 30 million Americans participating regularly. However, the high incidence of musculoskeletal injury associated with running represents a barrier to lifelong participation in this activity. Patellofemoral pain (PFP), which is among the most common of these running-related musculoskeletal injuries, typically requires treatment because patellofemoral joint (PFJ) symptoms do not naturally abate permanently.[1] The importance of effective treatment for runners with PFJ symptoms is underscored by the reported finding that 24% to 30% of individuals with a musculoskeletal injury permanently stop participation in their exercise program.[2]

Although the etiology of PFJ pain among runners is believed to be multifactorial, a universally accepted causative factor is the rapid and repetitive microtrauma of elevated PFJ contact forces experienced while running. Indeed, the PFJ experiences a cumulative impulse of several hundred body weights per kilometer run.[3] As such, interventions have increasingly focused on running technique and training approaches—such as utilization of a forefoot strike pattern, a shortened step length, and manipulations to training pace—that may reduce these PFJ loading parameters. Although limited evidence currently exists to support the effectiveness of such interventions in the prevention or treatment of PFJ pain, clinicians and runners alike tend to find these interventions appealing because they promote continued participation in running. Each of these conservative options has potential benefits and limitations from a biomechanical perspective, and the decision of which option, if any, to implement should be made on a case-by-case basis, with particular consideration of the runner's short- and long-term goals.

Researchers have demonstrated effects of running modifications on PFJ kinetics, but have not yet conducted studies to determine whether there are effects on PFJ symptoms.

Step length

A reduction in step length during running appears to have favorable effects on PFJ kinetics. In laboratory environments, interventions to increase step rate while holding running speed constant are used to decrease step length. In the field, reductions in step length may

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be accomplished using mobile feedback devices to monitor both step rate and running speed.[4] Increasing step rate without changing running speed (decreasing step length) by 10% has been reported to decrease peak PFJ contact force by 17% and peak PFJ stress by 10% to 15% per step compared with a runner's preferred step length.[3,5] Further, while running with a greater step rate, runners experience this force for less time with each step. Thus, runners may expect a 20% reduction in PFJ impulse (force multiplied by time) as a consequence of a 10% decrease in step length.[3] Kinematic and kinetic changes that contribute to this reduction in PFJ impulse while running with a shortened step length include making initial contact closer to the runner's center of mass (COM), decreased COM vertical excursion, decreased peak knee flexion during stance phase, and decreased braking ground reaction force.[6]

Over the course of a training run, these relatively large reductions in PFJ kinetics per step associated with reduced step length become less substantial due to the inverse relationship between step length and the number of steps required to run a given distance. For example, a 10% reduction in step length was found to decrease total PFJ impulse by 6% to 12% over the course of a kilometer.[3,5] Although the increased number of steps partially mitigates the reduction in PFJ kinetics experienced with each step, the reduction in cumulative impulse may still have therapeutic effects. Running with a 10% reduction in step length is estimated to shield the PFJ from 21.5 body weights for each kilometer run.[3] For a 150-lb runner, this equals a reduction of more than 16,000 lbs experienced by the PFJ for each 5-km run, compared with running at a preferred step length. Whether this reduction in cumulative joint contact force contributes to clinically relevant improvement in

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treatment outcomes for patellofemoral pain is a worthwhile area of future study.

Running with a shortened step length may also have other beneficial effects for individuals with PFJ symptoms. A 10% reduction from preferred step length has been found to result in a significant decrease in peak hip adduction moment and peak hip adduction angle,[6] which are typically increased among individuals with PFP.[7,8] Reducing step length may also increase preparatory gluteus medius activation prior to initial contact during running.[9] This may help to address the delayed gluteus medius activation prior to initial contact during running experienced by runners with PFP, a delay that may be associated with increased hip adduction excursion during stance phase.[10] The fact that reducing step length positively affects both PFJ kinetics and lower extremity alignment during running makes this gait modification an attractive rehabilitation option.

Reducing step length may be accompanied by unfavorable natural performance consequences, however. Runners tend to utilize a preferred stride length that minimizes metabolic cost, so reducing step length may decrease running efficiency, particularly among experienced runners.[11,12] Self-reported perceived exertion also increases with a 10% reduction in step length, at least in the short term, which may reflect the additional metabolic demand as well as the novelty of the task.[6] However, it is expected that the novelty and perceived difficulty of the task will decrease with practice. Previous gait modification interventions report significant improvement in both ratings of perceived effort and naturalness over as few as eight practice sessions.[13] As such, runners with PFJ symptoms may be willing to accept a modestly increased metabolic demand, provided a reduction in symptoms accompanies their efforts—especially if the alternative is to decrease participation in running or discontinue it altogether.

Foot strike pattern

While running in traditional footwear with a cushioned heel, runners predominantly demonstrate a rearfoot strike pattern during training runs and endurance events.[14] Two characteristics of running with a rearfoot strike pattern are that the foot is generally dorsiflexed relative to the running surface and that the ground reaction force vector acts at a point very close to the ankle joint. Together, these two characteristics put the ankle plantar flexors at a disadvantage for supporting the runner's mass against gravity following initial contact with the ground. This, in turn, places greater demand on the quadriceps to stiffen the leg while running with a rearfoot strike pattern than if the runner's foot made initial contact more anteriorly. Because the patella is a sesamoid bone within the quadriceps tendon, increased quadriceps force will increase PFJ contact force.

Several authors recently tested the hypothesis that using a mid- or forefoot strike pattern reduces PFJ contact force during running. Kulmala et al observed that female runners who habitually run using a forefoot strike pattern experienced 16% lower peak PFJ stress than those who run with rearfoot strike pattern.[15] Vannatta and Kernozek[16] and Willson et al[3] also observed 27% and 11% reductions in peak PFJ stress while running with a forefoot strike pattern, respectively. Further, it was reported that cumulative stress per step (stress-time integral) was reduced by 11% to 12% during the forefoot strike condition.[3,16] Although experimental evidence is lacking at this time, such decreases in peak stress and cumulative

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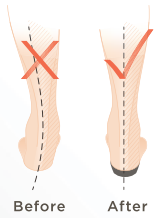

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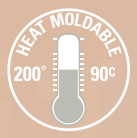

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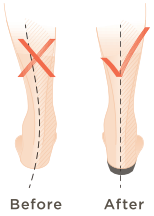

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stress per step may assist with rehabilitation efforts for runners with PFP who wish to continue their preferred mode of exercise.

Some interaction appears to exist between step length and typical foot strike pattern during running. Some runners who utilize a rearfoot strike pattern while running in conventional footwear may adopt a forefoot strike pattern in response to a reduction in step length. A shorter step length has been associated with a more horizontal foot at initial contact and also decreased frequency of the vertical ground reaction force impact transients typically observed among runners with a rearfoot strike pattern.[6] However, these changes were not ubiquitous among participants, and some runners continue to demonstrate a rearfoot strike pattern following instruction to run with a shortened step length.

Although interventions to reduce step length may affect foot strike pattern, changing foot strike pattern does not appear to affect step length. Interestingly, this appears to be true regardless of a runner's experience with a forefoot strike technique. For example, Vannatta and Kernozek[16] did not find an acute difference in step length among runners who preferred a rearfoot strike pattern when they were asked to run with a forefoot strike pattern. Almonroeder et al did not observe a difference in step length among runners who adopted a forefoot strike pattern following a two-week introduction to minimalist footwear.[17] Finally, step length among experienced runners who habitually train with a forefoot strike pattern was similar to runners who habitually train with a rearfoot strike pattern.[15,18] If adopting a forefoot strike pattern does not affect step length, the number of steps required to run a given distance is not expected to increase. Consequently, the magnitude of the potentially beneficial reductions in PFJ impulse observed during each step when switching from a rearfoot strike pattern to a forefoot strike pattern will be equivalent to the magnitude of the decrease in cumulative PFJ impulse for any given distance run. This is in contrast to running with a shortened step length, where the increase in the number of steps required to run a given distance reduces (but does not eliminate) these effects over the course of a mile.

Runners and clinicians considering a conversion to a forefoot strike pattern should be mindful that running with a mid- or forefoot strike pattern will introduce novel forces to the lower extremity, including an increased braking force impact peak and loading rate,[19] increased metatarsal force,[20] and increased Achilles tendon force.[15,17] For example, the Achilles tendon is reported to experience an additional 48 body weights of force for each mile run with a forefoot strike pattern relative to a rearfoot strike pattern.[17] Increased plantar flexor force contributes to increased distal tibia contact force while running with a forefoot strike pattern.[21] And, because the gastrocnemius, which acts nearly parallel to the long axis of the tibia, crosses both the ankle and knee, increased tibiofemoral joint contact force may also be expected.

Despite the potentially adverse effects of adopting a mid- or forefoot strike pattern to reduce PFJ kinetics, to date, there is no experimental evidence of increased foot or lower leg injury incidence in response to this technique modification while running in conventional footwear. Regardless, rapid conversion to a forefoot strike pattern among people accustomed to running with a rearfoot strike pattern, without allowing sufficient time for tissue adaptation to these novel stresses, should be avoided. A systematic and progressive approach to this technique change that considers running frequency, duration, and intensity with adequate rest intervals for tissue adaptation is recommended.

Running speed

PFJ injury prevention and rehabilitation efforts may benefit from manipulations to training pace. Running speed is a product of step rate and step length. As such, increasing running speed may be accomplished by increasing step length or step rate. However, it has been observed that, during submaximal effort running, increases in step length tend to outpace increases in step rate as runners increase speed.[18,22,23] Taking longer steps to increase speed requires a longer flight phase and shorter stance time, which is accomplished by generating larger lower extremity joint moments to increase vertical ground reaction force during the stance phase. The contribution of the ankle plantar flexors to the increased vertical ground reaction force at higher running speeds appears to be disproportionately large.[23] Peak knee extension joint moment also increases per stride as running speed increases up to roughly 7 m/s, but to a lesser extent.[24,25]

Because quadriceps force is a primary contributor to knee ex-

tension moment, increased peak PFJ contact force during each step is a natural consequence of increased running speed. Further, the decreased stance time associated with increased running speed suggests these forces are applied at a higher rate. To the extent that repetitive exposure to greater peak PFJ contact force and loading rate exacerbates PFJ symptoms, it may be advisable for runners with PFP to avoid high-speed running.

Conversely, however, increased running speed may have beneficial effects for treatment or prevention of PFJ symptoms despite increased peak PFJ force and loading rate. This is possible due to two effects associated with running at higher velocity: decreased contact time with the ground and increased step length. Although, as described above, the magnitude of the peak PFJ contact force increases with increased running speed, the joint experiences this force for less time. Thus, the PFJ impulse per step changes very little as velocity increases. Increased step length while running at a higher velocity results in fewer steps per unit distance; therefore, the cumulative PFJ impulse per mile run may decrease with increased running velocity.

This premise is supported by the findings of Petersen et al,[24] who reported no change in knee extension angular impulse per step and an 80% decrease in cumulative angular impulse per kilometer as running speed increased from 2.23 m/s to 4.38 m/s. That suggests that, to the extent that decreased cumulative PFJ impulse affects patellofemoral joint symptoms, increased running speed may be advisable in runners with PFP. However, as noted earlier, increasing running speed requires greater muscular effort per step and therefore may still exacerbate any existing PFJ injury.

Increasing running speed to reduce cumulative PFJ impulse per kilometer run will also have metabolic consequences that limit prolonged training runs at increased speed. Interval training techniques that incorporate rest periods between high speed bouts, however, can be easily integrated into a runner's usual routine. Such routines provide energy expenditure that is similar to prolonged continuous bouts of running, with comparable short- and long-term health benefits.[26,27]

Despite the recent interest in these modifications to running technique and training routines as they relate to PFJ kinetics, it is worthwhile to note that none of these interventions have yet been demonstrated to reduce PFJ symptoms. This is not to say they are not effective. Rather, it is unknown if they are effective because they have not been tested using rigorous experimental research designs. Future studies to delineate the PFJ loading characteristics most significantly associated with PFJ injury and the effectiveness of interventions such as these are necessary and relevant for conservative prevention and treatment efforts. ler

Collin Bowersock, BS, is a graduate student in the Biomechanics Laboratory within the Department of Kinesiology at East Carolina University in Greenville, NC. John D. Willson, PT, PhD, is an associate professor working in the Human Movement Analysis Laboratory within the Department of Physical Therapy at East Carolina University.

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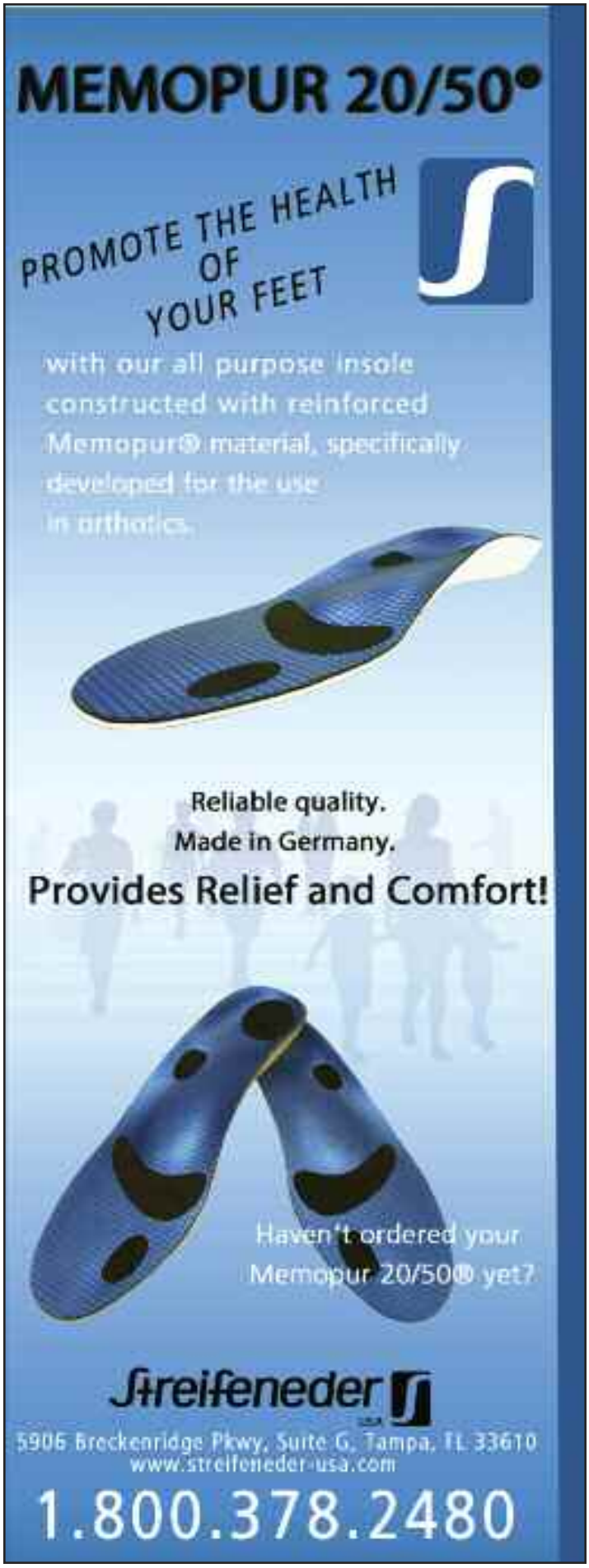

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Researchers inch toward understanding of PTTD

In recent years, studies have elucidated aspects of the biomechanical effects of posterior tibial tendon dysfunction that may ultimately lead to improvements in treatment. But it isn't always clear which factors contribute to PTTD and which develop in response.

By Cary Groner

Posterior tibial tendon dysfunction (PTTD), often known as adult acquired flatfoot deformity, remains a therapeutic challenge, particularly if patients and their clinicians wish to avoid surgical intervention.

The condition, which most often afflicts overweight women during or after menopause, occurs in about 3.3% of women older than 40 years, according to a UK study,[1] but often goes undiagnosed. PTTD may also occur as an acute overuse syndrome in young athletes,[2] however, and whether this predisposes these patients to the chronic condition later in life is unclear.

In recent years researchers have begun to unravel some of PTTD's mysteries, including poorly understood aspects of its etiology, biomechanical complexities, and response to treatment. Much more remains to be discovered, but clinicians agree that any progress is welcome.

Definitions

PTTD is typically defined as a progressive, degenerative musculoskeletal process that ranges from a localized tenosynovitis to a rigid foot, ankle deformity, or both.[3,4] The condition leads to the elongation of the posterior tibialis tendon, which is the primary dynamic stabilizer of the foot's medial longitudinal arch (MLA).[3] The posterior tibialis muscle, to which the tendon attaches, also serves as an ankle plantar flexor and invertor of the subtalar joint.[5] Researchers are investigating the role of the muscle in PTTD, but it remains unclear.

Elongation of the tendon is associated with increased pronation and subsequent functional imbalances, including lowering or collapse of the MLA, valgus calcaneal alignment, forefoot abduction, and related problems such as Achilles tendon contracture.[4,6] These imbalances are also associated with stress on important foot ligaments, including the plantar calcaneonavicular (spring), talocalcaneal interosseous, and deltoid ligaments, though it remains unclear whether ligament problems precede or follow muscle

> Clinicians increasingly are seeking to combine stretching, strengthening, and physical therapy with bracing to achieve optimal outcomes in patients with PTTD.

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Photo courtesy of South West Orthopedic Designs.

weaknesses.[3] Regardless, add it all together and you have impaired foot biomechanics and pain.

PTTD is typically described as having four stages.[4,7,8] In Stage I, patients have posterior tibial tenosynovitis or tendinosis without structural deformity. Stage II disease often involves pain medially along the tendon early on, with later subfibular impingement and sinus tarsi pain; there is also a flatfoot deformity that remains flexible, as well as attenuation or rupture of the tendon. By Stage III, patients usually have a fixed nonreducible deformity with marked calcaneal valgus and midfoot abduction. In Stage IV, there is a flatfoot deformity with associated ankle involvement, including a valgus talar tilt due to deltoid ligament failure.

Even staging is more complex than it sounds, however.

"We have this concept that PTTD progresses from stage one to stage four, but actually it seems that stage one conditions are almost unique to athletes and younger people, whereas stage two is almost exclusively experienced by older, sedentary people," said Jeff Houck, PT, PhD, director of research in the Department of Physical Therapy at George Fox University in Newburg, OR. "A lot of these patients have flat feet as a risk factor, but the progression is not that well established."

Research: Hit and miss

As noted, in recent years some research has elucidated aspects of the biomechanical effects of PTTD that may ultimately lead to improvements in treatment.

For example, Canadian investigators compared differences in arch height, ankle muscle strength, and biomechanical factors in 24 runners, 12 of whom were healthy and 12 of whom had Stage I PTTD.[9] The authors reported that runners with PTTD had lower arch height as well as greater and more prolonged peak rearfoot eversion during gait than those who were healthy, suggesting that increased pronation may put more strain on the posterior tibial muscle. In another study, the same research group used an exercise fatigue protocol to reduce the force of the same muscle; the protocol disrupted typical shank and foot joint coupling patterns and increased coupling variability.[10]

But, as already noted, one problem with studying and managing PTTD is that it isn't always clear what affects what.

"Some people argue that the ligament is damaged first, then the tendons," Houck said. "But it's not easy to tell. A student of mine did a study that looked at PTTD patients—who was strong, who was weak, what their foot motion was.[11] They were markedly different, suggesting that either the strength protected their foot posture and ligaments, or that the ligaments helped them stay stronger. We don't know which it was; it's just as common for weakness to be a response to a problem as the cause of it."

PTTD's prevalence in perimenopausal women has long provoked suspicion that the disease may be associated with metabolic or hormonal issues. But Penn State researchers in State College, PA, sampled tendon tissue from diseased tendons belonging to eight patients with PTTD requiring surgery (five women, mean age 52 years), then compared the tissue to samples from healthy tendons. There was no difference in estrogen receptor expression in the samples regardless of whether they were taken from normal or diseased tendons, or from male or female participants, undercutting (though probably not eliminating) speculation that hormonal changes in older women are a risk factor.[12]

Little if any research has been conducted on women's shoes as a potential risk factor for the disease, even though male-female footwear differences—particularly high-heel wear—are increasingly suspect in other problems such as the gender disparity in rates of knee osteoarthritis.[13] Of course, the biomechanics associated with high heels and OA are in some ways opposite to those found in PTTD; the former may be exacerbated by the shoes' interference with pronation through the gait cycle, whereas the latter is worsened by excessive pronation. Researchers are skeptical, in any case, and a recent PubMed search found no published papers addressing the topic.

"The gender difference is puzzling, but it doesn't seem to have to do with footwear," Houck said. "The evidence for that is very weak."


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However, Michael Pinzur, MD, a professor of orthopedic surgery and rehabilitation at Loyola University Medical Center in Maywood, IL, noted that shoes may affect symptoms even if they don't cause PTTD-related deformities.

"Generally, women's shoes are not as supportive as men's," he said. "Just as many men have flat feet as women do, but they wear better shoes and tend to be less symptomatic."

Various studies have looked at the relationship between PTTD and the kinetic chain. For example, researchers at the University of Southern California (USC) in Los Angeles reported that 17 middle-aged women with PTTD had decreased bilateral ankle and hip muscle performance—including being able to do fewer single-leg heel raises and leg lifts, and having lower endurance in the hip abductors and extensors—as well as worse performance and a significant increase in pain during a six-minute walk test, versus age-matched controls.[14] The findings again bring up the chicken-and-egg conundrum that's part of PTTD research, however: Did the women with PTTD walk slower because they were in more pain, and has slower walking contributed to their muscle weakness? Or did preexisting weakness slow down their walking?

"We found that patients were weaker on both sides even though [the PTTD] was a unilateral problem," said Stephen Reischl, PT, PhD, one of that paper's coauthors. Reischl, an adjunct associate professor of clinical physical therapy at USC, described the implications of this in terms of a possible biomechanical cascade.

"As the posterior tibialis fails, there may be more stress on the plantar fascia, which may fail," he said. "Some of the deltoid spring ligament complex may fail; then the pull of the peroneus longus becomes a deformer of the foot rather than helping to stabilize the arch."

Reischl noted that unilateral problems often have bilateral effects, as the USC team's research showed.

"When a problem occurs on one side, something changes in the nervous system," he said. "They walk slower, so the stimulus to the muscle decreases, and that happens in the entire lower extremity."

One of Reischl's colleagues, Eugene Chang, PT, PhD, who this summer completed his doctorate at USC, told *LER* that his dissertation examined just this issue—how local musculoskeletal disorders affect the control system, including the central nervous system (CNS).[15]

"It's an adaptation on multiple levels to a localized disorder," he said. "If the tendon is more compliant, the muscle has to work harder to compensate for the mechanical deficit. The CNS has to work harder to drive the muscle to compensate for the deficits."

In unpublished research into patients with Achilles tendinosis, for example, Chang found that, even when the tendon problems were unilateral, patients tended toward biomechanical symmetry during bipedal activities.

"We had them run and looked at the kinematics—how they flexed their knees, ankles, and hips," he said. "We saw a similar pattern on both sides; it looks like the uninvolved side tries to mimic the involved side. That has to be caused by the central nervous system, whether in Achilles tendinosis or PTTD."

Neal Blitz, DPM, FACFAS, who is in private practice in New York City, also emphasized the importance of kinetic chain factors.

"If you internally rotate and have flat feet, that generally causes instability in the arch and unlocks the midfoot, and that causes the posterior tibial tendon to work harder to try to straighten up the arch," Blitz said. "You get a tug-of-war between where the bones want to go and where the muscles are, and that's where you get into trouble."

Tibial internal rotation has been identified as a risk factor for PTTD, and in a 2011 article in this magazine, Christopher Neville PT, PhD, an assistant professor of physical therapy at SUNY Upstate Medical University in Syracuse, NY, said that such rotation was associated with several likely components of PTTD, including hindfoot eversion, lowering of the MLA, and forefoot abduction.[16]

Evaluation critical

Thorough patient evaluation is the first step in treatment, according to clinicians.

"To assess foot kinematics in the clinic, I tend to use the simplest tests—navicular drop, foot posture index, subtalar neutral," said Houck, who added that he sees mostly older patients with Stage II PTTD. "I assess stability in the talonavicular and calcaneal-cuboid joints, and I think controlling the foot's interaction with the tibia is important; it's good to include functional retraining of the whole lower extremity when you're working on the foot."

Houck said most of his patients with PTTD have bilateral pronation or flatfoot, but that the mechanical issues are worse on the side with the tendinopathy.

"I tend to think of things like muscle volume and muscle strength as associated with the cascading effect of the problem, not

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Continued on page 44

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as much the cause of it," he said.

Neal Blitz said that evaluation is crucial, and can be challenging for clinicians who are not familiar with PTTD.

"One reason it's often missed by primary physicians is that it has a wide variety of presentations," he said. "Younger, athletic patients could have some swelling in the tendon that is self-limiting and goes away. But that tenosynovitis can also become chronic; there's an inflammatory process that, with continued stress, can lead to tendon rupture and attenuation."

When the clinician suspects a rupture, an evaluation with magnetic resonance imaging (MRI) is indicated.

"A longitudinal tendon split is a game changer," Blitz said. "Those patients have to have some form of immobilization to allow the tendon to heal."

Treatment options

Although patients with advanced (Stage III-IV) PTTD often resort to surgery, several therapeutic approaches are available for those with less severe disease, or those who are poor candidates for surgical intervention. The standard strategy includes anti-inflammatory medication, in-shoe foot orthoses or ankle foot orthoses (AFOs), stretching and strengthening exercises, and physical therapy.[4] The appropriateness of each modality is determined by clinician and patient preference, disease stage, the patient's pathomechanics, and related issues.

"I tend to treat stage one patients with anti-inflammatories, rest, ice, and bracing, which can include simple ACE wraps or ankle straps," Blitz said. "Sometimes, if it's really tender, I'll put them in a walking boot for anywhere from two to six weeks, assuming their muscle power is good."

If patients have suspiciously high pain levels or weak muscles, Blitz may order an MRI to rule out tendon splits.

"There's a bit of an art to PTTD treatment," he continued. "You really have to be concerned about someone with a tendon split and flatfoot; their structure isn't good and they're putting a lot of stress on the tendon. An injured tendon heals as scar tissue, and if that happens repeatedly you've got problems. In those cases I may talk to them about surgery."

Selene Parekh, MD, an associate professor of orthopedics at Duke University in Durham, NC, told *LER* he uses orthotic intervention and physical therapy in less severe cases.

"If patients have a weak posterior tibial tendon without a lot of malalignment issues, we can get them better by strengthening the tendon," he said. "In those patients I'll use a medial heel wedge orthotic, or sometimes a supramalleolar orthotic or an AFO. Most stage one patients will be successful with that, along with physical therapy and topical anti-inflammatories. I may treat stage two patients the same way, depending on their pain levels, or I may add an Arizona brace. If they fail therapy and bracing, they may end up in the operating room, as will those with significant malalignment, such as stage three and four patients."

Strategies for orthotic intervention vary. For acute Stages I and II PTTD, the goal is to prevent the development of abnormal kinematics; patients may have the foot immobilized for three to six weeks in a cast or controlled ankle motion (CAM) boot, along with a foot orthosis inside the boot to control hindfoot eversion.[8] For chronic PTTD Stages II to IV, possible approaches include UCBL (University of California Biomechanics Laboratory) and other foot orthoses, supramalleolar orthoses, and various types of AFOs.[8]

The literature generally supports the use of AFOs for treating chronic PTTD. In a 1996 study, investigators reported that 67% of patients with Stage I and II PTTD showed improvement in pain, function, and ambulation distance with a custom-molded AFO or medial-posted shoe insert.[17] In 2008, researchers at Rush University Medical Center in Chicago reported results from a long-term study of 32 Stage II patients treated with a double-upright AFO. After an average follow-up of 8.6 years, 70% of patients were brace-free and had avoided surgery.[18] In 2012, investigators from SUNY Upstate Medical University reported that custom articulated AFOs provided the greatest correction of flatfoot deformity while maintaining ankle motion and push-off function in 15 patients with Stage II PTTD.[19]

Jeff Houck agreed with those findings.

"Those patients don't need to have the ankle fixed," he said. "They just need arch support and hindfoot control. Long term, a solid-ankle AFO leads to calf-muscle atrophy and dependence on the device."

AFOs are helpful by themselves but they can't do everything. Correcting mechanical defaults will ideally affect the tendons and ligaments that support the foot, but some foot postures—forefoot abduction, for example—are harder to influence than others.[20] As a result, clinicians increasingly seek to combine stretching, strengthening,


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Continued on page 46

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and physical therapy with bracing to achieve optimal outcomes.

In one study, researchers treated 47 patients with Stage I and II PTTD using a short, articulated AFO or a foot orthosis as well as a physical therapy regimen that included a variety of strengthening exercises and stretches. After an average of 10 sessions over four months, 83% of patients had successful subjective and functional outcomes.[21]

In a 2009 study, USC researchers reported that Stage I and II patients improved the most with a combination of foot orthoses, stretching, and an eccentric exercise regimen focused on the posterior tibial tendon.[22]

This June, in a literature review presented at the World Congress of the International Society for Prosthetics and Orthotics in Lyon, France, researchers analyzed 10 studies and concluded that the most effective treatment for treating Stage I and II PTTD was a custom foot orthosis in conjunction with an exercise program that included stretches and eccentric strengthening. The protocols prevented progression and decreased the need for surgery.[23]

In a just-published randomized controlled trial, Houck and colleagues compared the effects of augmenting orthosis treatment with either stretching (n=17) or a combination of stretching and strengthening (n=19) in Stage II PTTD patients. Although both groups showed significant improvements in pain and function over the 12-week trial, the added interventions were minimally effective in augmenting orthosis wear alone.[24]

"That approach didn't show a strong benefit," Houck said.

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"I think it's more important, for PTTD, to have an aggressive global program that really targets the tendon."

Others have arrived at similar conclusions. According to Patrick McKeon, PhD, ATC, it's crucial to look at systems, not just isolated aspects of them.

"We have always looked at PTTD as a dysfunction within the tendon," said McKeon, who is an assistant professor and clinical education coordinator for the athletic training program at Ithaca College in New York State. "But it's really a dysfunction in the system, and the tendon is caught in the middle. If you use orthotics alone, how will you encourage the tendon to adapt positively? We need to think about how to use orthotics and rehabilitation exercises together so eventually we can wean people off orthotics."

McKeon and several colleagues have developed a program that focuses on strengthening the intrinsic muscles of the foot to improve lower extremity injury prevention and rehabilitation for conditions including PTTD.[25,26]

"We often see that PTTD occurs when something else isn't doing what it's supposed to do," he said. "We've started to look into the role of the intrinsic foot muscles in helping to stabilize the arch. If we can rely more on those muscles, it should decrease stress on the posterior tibial tendon and help ensure that tissue breakdown doesn't exceed the ability of the body to remodel it. Bahram Jam [a physical therapist at York University in Toronto] has published a model regarding PTTD and the role of the plantar intrinsics,[27] and we hope these approaches may end up creating a more robust system that can cope with change."

Looking forward

This "Foot Core System," as Jam's model is called, has yet to be tested extensively, but it represents a growing acceptance of the need for PTTD management to go beyond the status quo, given that the current nonsurgical therapeutic arsenal mainly manages the disease rather than curing it. Ideally, as researchers and clinicians continue to clarify the causes of PTTD and develop strategies to combat them, patients may find increasing relief from this vexing and complex condition. ler

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

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Vitamin D deficiency and risk of fracture in football players

Many US football players have lower than adequate serum vitamin D levels, but questions remain about the potential benefits of proactive treatment with supplementation to address vitamin D deficiency and reduce the risk of fracture in this patient population.

By Mark A. Duca, MD; Christina M. Mathyssek, PhD; Jeffrey W. Bost, PA-C; and Joseph C. Maroon, MD

Vitamin D deficiency is an epidemic, with more than 77% of the general population considered to have inadequate vitamin D levels.[1] The general adverse health effects of low vitamin D levels involve every organ system. The most noted effects involve bone health, but low vitamin D levels have also been associated with increased rates of depression,[2] suicide,[3] autoimmune diseases, including type 1 diabetes,[4] multiple sclerosis,[5-7] rheumatoid arthritis,[8] and greater rates of mortality and morbidity related to cardiac disease and colon, prostate, and breast cancers.

The consequences of vitamin D deficiency with respect to bone health and muscle function are widely recognized in the elderly. However studies involving younger adults—including military personnel, athletes, and certain ethnic populations—have recently identified other at-risk groups. In 2006, Ruohola et al[9] reported that male Finnish military recruits (n = 756, mean age 19 years) with vitamin D levels below 30.3 ng/mL had a 3.6 times higher risk of stress fracture than those with higher vitamin D levels. In a double-blinded randomized controlled trial involving female US Navy recruits (n = 3700, median age 19 years), the group that took 2000 mg calcium and 800 IU vitamin D per day had a significantly lower incidence of daily stress fractures than the placebo supplementation group.[10]

As in the military, the relevance of vitamin D for bone and muscle health is also of particular importance to athletes who require optimal musculoskeletal functioning due to the increased demands of sports on the musculoskeletal system. Despite this, vitamin D level and its associations with bone health and performance have only recently been researched in athletes who participate in high-impact sports, such as US football players.

> Indoor athletes, as well as those who play football during the winter months at higher latitudes, may be at higher risk for vitamin D deficiency due to limited sun exposure.

Mechanism of vitamin D in bone health

Aside from exposure to ultraviolet B (UVB) rays, humans obtain vitamin D from their diet, including dietary supplementation. Few foods naturally contain vitamin D, and the vitamin is not abundant

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even in those that do. One exception to this is fish liver oils, which naturally contain relatively high levels of vitamin D. Several food items are commonly fortified with vitamin D, including milk, margarine, and ready-to-eat cereal.[11,12]

After the conversion of vitamin D to 25-hydroxyvitamin D (25(OH)D) in the liver, it will further convert to its active form, $1,25(OH)_2D$, in the kidneys or in other tissues such as the breasts, colon, prostate gland, and immune cells. While the production of $1,25(OH)_2D$ in local tissue regulates cell growth, controls immune function, and affects gene expression, the production of $1,25(OH)_2D$ in the kidneys is used for calcium and phosphorus metabolism. Both calcium and phosphorus are of particular importance for optimal bone and muscle health.[12]

The mechanism underlying the effect of vitamin D on bone health is relatively well understood: adequate calcium and phosphorus levels promote bone mineralization, which is necessary for strong bones. The interaction of $1,25(OH)_2D$ with vitamin D receptors (VDR) markedly increases intestinal absorption of calcium and phosphorus. Without vitamin D, only up to 15% of the dietary calcium intake and 60% of phosphorus intake is absorbed in the intestines; with adequate vitamin D levels (at least 30 ng/mL), calcium absorption increases to 30% and phosphorus absorption is also markedly increased.[13]

A parallel mechanism has to do with the association between vitamin D and parathyroid hormone (PTH), and is based on the body's efforts to maintain optimal blood serum calcium levels. Lower vitamin D levels are associated with increased levels of PTH. PTH employs several mechanisms to regulate and achieve optimal blood calcium levels, including the activation of osteoblasts, which stimulate transformation of preosteoclasts to osteoclasts. Osteoclasts dissolve the mineralized collagen matrix in the bone (bone resorption), mobilizing calcium from the bone and into the blood, and thereby preventing hypocalcemia but weakening the bone structure and increasing risk for fractures.

Mechanism of vitamin D in muscle health

The mechanism through which vitamin D affects skeletal muscle performance is not well understood,[14] but several pathways seem to contribute. Multiple studies[15,16] showed that low vitamin D negatively affects handling, binding, and storage of calcium in the muscle sarcoplasmic reticulum. Therefore, one proposed action of vitamin D is to increase calcium accumulation in the muscle fiber's sarcoplasmic reticulum, which plays a key role in muscle contraction and, hence, muscle performance. Furthermore, phosphate deficiency, which can be induced by vitamin D deficiency, was shown to cause muscle weakness that can be reversed with vitamin D supplementation.[17] Lastly, there is evidence of a direct effect of vitamin D on the muscle cells via the membrane-bound VDR that induces new protein synthesis and subsequent muscle growth.[14] In adults with low vitamin D levels, biopsies of skeletal muscles showed signs of muscle atrophy, especially in fast-twitch fibers.[18,19]

Optimal serum vitamin D levels

There is currently no consensus on the ideal level of vitamin D in humans as measured by serum level of 25(OH)D,[20] neither for the general public nor for athletes specifically. A scientifically supported and commonly used categorization defines vitamin D deficiency as 25(OH)D levels below 20 ng/mL, vitamin D insufficiency as 25(OH)D levels between 20 and 32 ng/mL, and adequate vitamin D levels as greater than 32 ng/mL.[20,21] Studies show that 25(OH)D is inversely associated with levels of PTH, which promotes bone loss until 25(OH)D reaches levels between 30 and 40 ng/mL. Furthermore, intestinal calcium transport increases steeply between 20 and 32 ng/mL.[12,22-24] Risk factors for vitamin D deficiency and insufficiency include limited dietary intake of vitamin D and diminished sun exposure and absorption of UVB radiation (wavelengths 290-315 nm), which can be due to living in northern latitudes (above 35°), having darker skin pigmentation, consistently covering the body when outside, or consistently using UVB ray blocking sunscreen.[25-27]

Research in athletes

Vitamin D deficiencies have been well documented in children, the elderly, the obese, and those with dark skin or reduced sunlight exposure. More recently, studies have indicated that young adult athletes also have an increased incidence of vitamin D deficiency.[13,28,29] In a cross-sectional survey of 18 Australian female elite gymnasts (aged 10-17 years), Lovell et al[29] found that 83% of the gymnasts who primarily trained indoors had vitamin D levels below adequate, and that these gymnasts had a higher incidence of bony stress injuries in the year prior to the testing than those with adequate vitamin D levels. Ward et al[30] studied vitamin D levels in 99 girls aged between 12 and 14 years to investigate the relationship between serum vitamin D levels and muscle power and force, measured using jumping mechanography. They found a positive relationship

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between vitamin D levels and muscle power and force. Close et al[31] conducted a randomized double-blind placebo-controlled study in 10 professional male athletes (70% had insufficient or deficient vitamin D levels at baseline). They found that vitamin D supplementation of 5000 IU D_3 over eight weeks significantly increased total serum 25(OH)D (mean ± standard deviation increase from 11.6 ± 10 ng/mL to 41.2 ± 10 ng/mL) and significantly improved athletes' 10-m sprint and vertical jump performance compared with their own baseline measures. The placebo group did not show significant serum vitamin D or performance changes.

However, not all studies found an association between vitamin D levels and muscle performance. For example, in a different but similar study among 30 young athletes, Close et al[32] failed to find improvements in muscle performance after 12 weeks of supplementation. The authors hypothesized that higher serum vitamin D levels may have been necessary to see improvement.

A study conducted in 2011 by Hamilton et al[33] investigated a multiracial sample (n = 342) of professional male soccer players in Qatar and found a high rate of vitamin D deficiency/insufficiency (84% had vitamin D levels <30 ng/mL and 12% had levels <10 ng/mL, indicating severe deficiency); yet, they found no unique association between vitamin D levels and isokinetic lower limb peak torque. Interestingly, in a previous study by Hamilton et al[34] from 2010, the researchers found a very high rate of vitamin D deficiency in athletes in Qatar, which prompted them to instigate a nationwide education and supplementation program for team staff and players. The players who still had severely deficient vitamin D levels in 2011 may have been noncompliant with this program, raising questions as to whether they are representative of the general population of athletes. Furthermore, the group that was severely deficient in vitamin D differed from the insufficient and adequate groups in total and lean body mass, but not in height or body fat percentage. This could indicate a different body type that, in turn, may be associated with a difference in racial composition between vitamin D groups.

The researchers found significant differences in vitamin D levels between the racial groups, but did not provide information about the racial composition of each vitamin D level group. This information could aid in interpretation of their findings, as recent research indicates that different races may have a different bioavailability of vitamin D (ie, African Americans typically show low serum vitamin D levels when measured with the standard tools, yet, paradoxically, have higher bone density than whites).[35]

Vitamin D levels in football players

In professional US football players, who regularly endure high-impact hits and put great demand on their musculoskeletal system, vitamin D levels and associated health and performance outcomes have only recently received research attention. Two cross-sectional studies, one unpublished and one published, have looked at the association between vitamin D levels and musculoskeletal health and performance.

Shindle et al[36] measured serum vitamin D levels of all 89 players on a single National Football League team and looked for associations between vitamin D level and occurrence of muscle injury during the previous season. They found that only 19.1% of the players had adequate vitamin D levels, 50.6% had insufficient levels of vitamin D, and 30.3% had deficient levels. The mean vitamin D level in non-African American players was 30.3 ng/mL, compared with 20.4 ng/mL in African American players ($p < .001$). In addition, they found that players who had at least one muscle injury (defined as a strain, tear, or pull that led to at least one missed practice or game) during the prior season had significantly lower vitamin D levels than players with no muscle injury during the same time frame (19.9 ng/mL vs 24.7 ng/mL, $p < .05$).

We recently published our research findings on vitamin D levels in a different team of 80 NFL players (mean age 26.5 ± 3.7 years, 84% African American) in the *American Journal of Sports Medicine*.[37] In this study, we measured serum vitamin D levels during the 2011 offseason and evaluated associations between vitamin D levels and bone fracture history during the 2011-2012 and 2012-2013 seasons, as well as ability to obtain contracted employment, which may be a proxy for performance.

We found that only 31.3% of the players had adequate vitamin D levels, 42.5% had insufficient levels of vitamin D, and 26.3% had deficient levels. Mean vitamin D level was 27.4 ± 11.7 ng/mL, with significantly lower levels in African Americans (25.6 ± 11.3 ng/mL) than in whites (37.4 ± 8.6 ng/mL; $F(1,78) = 13$, $p = .001$). Interestingly, all athletes who were vitamin D deficient were African American.

Furthermore, when controlling for number of professional years played, vitamin D levels were significantly lower in those with at least one bone fracture during their football career compared with no bone fracture ($F(2,77) = 7.75$, $p = .001$). Players who were released during the 2012 preseason had significantly lower vitamin D levels than players who played in the regular 2012-2013 season ($F(1,64) = 27.60$, $p < .001$).

Implications and future directions

Our findings, along with those of Shindle et al, raise questions about the role of prevention and proactive treatment with vitamin D supplementation to obtain and maintain recommended serum vitamin D levels. An important first step, however, is to establish a causal relationship between vitamin D levels and bone fractures. By design, our cross-sectional study on US football players cannot be used to draw any causal inferences regarding bone fractures and serum vitamin D levels in athletes. However, there are only a limited number of other studies that have used randomized controlled designs reporting evidence of fracture prevention using vitamin D supplements in a similar age group. For example, the previously described study in military personnel of similar age and physical conditioning found that vitamin D supplementation benefited bone health by reducing stress fracture rates.[10]

When considering the potential benefits of vitamin D supplementation in athletes, it is important to consider the vitamin D source and the specific physiologic requirements of this group, as well as fracture prevention. A recent review study of vitamin D with regard to bone health and athletic performance reported that perhaps the most important risk factor for deficient and insufficient vitamin D levels was time spent outside, rather than nutrition or skin pigmentation.[38] Indoor athletes such as gymnasts and possibly NFL players during the winter months at higher latitudes (which applies to both of the teams that have been studied thus far) may be particularly at higher risk for low vitamin D levels due to limited sun exposure. Research is needed to clarify whether increased outdoor training time could be used to sufficiently increase vitamin D levels to adequate levels.

According to a 2010 report from the Institute of Medicine,[39]

the typical young adult vitamin D daily requirement is 400 IU and the recommended dietary allowance is 600 IU (maximum of 4000 IU), while the Endocrine Society recommends double to triple that amount of supplementation.[40] It has been suggested that certain subgroups, such as older adults, require increased intake of vitamin D due to increased physiological demands. The literature thus far does not indicate that athletes require a higher vitamin D intake than the general population to obtain adequate serum vitamin D levels.

The bone health benefits of raising vitamin D levels appear limited to increasing deficient and insufficient levels to adequate levels (usually defined as levels greater than 30 to 32 ng/mL). Vitamin D levels that are higher than adequate have not shown additional bone health benefits in the general population. In fact, vitamin D supplementation as a health benefit demonstrates a U-shaped relationship, with elevated risks associated with both hypo- and hypervitaminosis.[38] Some preliminary findings on athletic performance indicate that athletes may benefit from higher than adequate serum vitamin D levels specifically to optimize muscle function and performance, while others state there is no evidence that athletes would benefit from elevated serum vitamin D levels.[38] Little research has been conducted on this matter, however.

Lastly, while several trials in athletes have shown beneficial effects of vitamin D supplementation on bone density, they did not provide convincing evidence for fracture prevention, since total bone strength is only partly defined by bone density.[38] Future research needs to address other contributing factors, such as protein and calcium intake and their interactions, for fracture prevention. ler

Mark A. Duca, MD, is a clinical assistant professor of medicine at the University of Pittsburgh School of Medicine in Pennsylvania, and serves as a team physician for the Pittsburgh Steelers Football Club. Christina M. Mathyssek, PhD, received her PhD in psychology in 2014 from the Erasmus University Rotterdam in the Netherlands and currently works as senior research principal at the University of Pittsburgh Medical Center. Jeffrey W. Bost, PA-C, is a research director and clinical instructor at the University of Pittsburgh Medical Center. Joseph C. Maroon, MD, is professor and vice chair of the Department of Neurological Surgery and Heindl Scholar in Neuroscience at the University of Pittsburgh Medical Center and team neurosurgeon for the Pittsburgh Steelers.

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Contributors to pediatric ACL surgery outcomes

Different factors influence outcomes after anterior cruciate ligament reconstruction in younger and older pediatric patients, but regardless of age, a delay to surgery is correlated with more severe additional injuries and the need for additional surgical procedures.

By Justin T. Newman, MD

The anterior cruciate ligament (ACL) has been a focus of sports medicine and orthopedic surgery over the past decades. Entering those three words into the PubMed search engine returns nearly 15,000 peer-reviewed articles on the topic. This segment of the literature continues to expand, with several articles published in the prominent orthopedic sports journals each month.

The ACL consists of two distinct bundles that originate from deep within the lateral notch of the femur and course to the anterior aspect of the tibial plateau. The primary function of this ligament is to provide stability at the knee with regard to anterior translation and rotation of the tibia underneath the femur.

Although adult ACL injuries and their treatment are well recognized and routinely addressed, the management of pediatric ACL injuries continues to be defined. The pediatric patient with growth remaining still has growth plates, known as open physes. These physes are found in the femur and tibia just above and below the joint line. Damaging a physis could cause disturbances to the growth of the leg, resulting in a shorter limb or malalignment from a disproportionate amount of growth in the normal, uninjured part of the physis. In addition, pediatric ACL injury was historically thought to be a rare occurrence, with the tibial spine avulsion fracture thought to be the more common version of this injury in the younger population.[1]

Several factors have led to an increased interest in pediatric ACL injuries. ACL injury in the pediatric population has been diagnosed more frequently, likely due to an increased appreciation for this injury by younger athletes (and their parents) and increased education of the providers who treat these patients on a routine basis. There has also been a dramatic increase in the amount and intensity of the activities in which pediatric athletes participate. Children are now involved at a higher level of competition at a younger age, they participate in year-round sports leagues, and there is an increased focus on a single sport at a younger age. All of these factors have resulted in younger athletes, with a different set of muscle control

> The pediatric ACL reconstruction patient is not a smaller version of the adult patient, and a different approach is required to avoid a different set of complications.

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and balance profiles than in the past, being exposed to more frequent opportunities for ACL injury.[1,2]

These factors have prompted increased interest in the diagnosis and treatment of pediatric ACL injuries. This has correlated with an uptick in the volume of peer-reviewed literature on this topic and in the development and popularization of new or modified surgical techniques. The pediatric patient is not a smaller version of the adult, and a different approach is required to avoid a different set of complications and to both prevent and rehabilitate the injury patterns seen in this cohort.

Pediatric surgical techniques

Broadly speaking, the surgical techniques that have been created to address the special circumstance of the pediatric ACL injury aim to decrease the possibility of damage to the growth plates while restoring the anatomical or functional role of the ACL. These techniques either do not cross the physis of the tibia or femur, cross it with a deliberately minimal footprint, or modify the type of graft fixation to minimally impact the patient's remaining growth. Long-term studies on many of these techniques have not been performed, but the early outcomes are promising.[3]

Historically, patients with remaining growth were recommended to delay reconstruction of the torn ACL until little or no growth potential remained. While this treatment approach mitigates the potential for disturbance of the growth plate, the stability that is provided by an intact ACL remains absent. This raises the concerning possibility that the residual instability may allow abnormal joint motion, which can cause additional damage to the meniscus or cartilage.

Studies have shown that in adult knees, a delay to surgery for the ACL or a premature return to activities that require a functioning ACL can cause additional injuries. It is relatively common for a knee that has sufficient trauma to create an ACL rupture to also cause damage to other structures within the joint, with lateral meniscal injuries being reported in up to 50% of adult ACL injuries.[4] Meniscal tears and cartilage damage associated with ACL injury can lead to a need for further surgery and can cause damage that significantly decreases the long-term health of the knee joint.[5-7]

Our research

To evaluate the extent to which other injuries occur in conjunction with ACL injury in pediatric patients, my colleagues and I undertook a study at The Children's Hospital Colorado in Aurora.[8] Specifically, we investigated the factors that caused further damage to the knee in pediatric patients with an ACL tear. Earlier studies had shown that a delay (typically more than three months) in ACL surgery in pediatric patients could in general increase the likelihood of additional injuries in the knee.[9,10] However, we know that a pediatric patient is not just a smaller version of an adult patient, and pediatric patients vary in terms of their physical maturation. What had not been investigated in the past was the difference between older and younger groups of pediatric patients.

Specifically, our study aimed to compare the prevalence, severity, and management of such additional knee injuries among patients with remaining growth potential (younger than 14 years) versus skeletally mature patients (older than 14 years). We anticipated that concomitant injuries would be more prevalent in older patients. We also hypothesized that a delay to surgery would be a significant predictor of additional injuries that required additional surgical procedures in both groups.

We retrospectively reviewed the cases of 66 patients younger than 14 years and 165 patients aged 14 to 19 years. In addition to investigating the time from injury to surgery, we looked at the additional injuries these patients sustained. We not only reported on the injuries that were present, but went a step further and reported on the additional procedures that were required to treat these injuries.

Differences were found between the two groups. The older pediatric patients needed significantly more additional surgical procedures (65%) than the younger group (49%). This means that these patients needed procedures to fix or remove torn menisci or to treat injuries to the cartilage. Patients older than 14 years were doing more extensive damage to their knees by waiting for surgery.

Delays are detrimental

Even more interesting was that, in those younger than 14 years, we found that a delayed surgery was the strongest predictor of other ipsilateral knee injuries severe enough to need additional surgery. When looking at all factors (final multivariate analysis) for this age group, a delay in surgery was the only significant predictor of the presence of a concomitant knee injury requiring additional operative procedures. Patients who had surgery more than three months from the time of injury were 4.75 times more likely to need additional surgical procedures for injuries to cartilage or meniscus than those who had surgery within three months of the initial ACL injury. In univariate analysis, a return to activities or sport prior to surgery

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showed some correlation with the presence of concomitant injuries. There was no significant correlation with obesity, patient gender, or the sensation of instability prior to surgery or at any point after the initial injury.

In the older group, surgery delayed by more than three months was also significantly related to the presence of additional injuries. However, multivariate analysis revealed that obesity and a return to athletic activities before surgery were the most important and statistically significant factors in predicting additional knee joint injuries. These older patients were 3.86 times more likely to need additional surgical procedures if they returned to activity or sports before surgery. They were also 2.59 times more likely to need additional surgical procedures if they were obese, defined as a body mass index (BMI) above the 95th percentile for their age and gender.

In both groups, meniscal tear severity was worse when surgery was delayed. The longer the wait, the lower the probability that the meniscus tear could be repaired. The meniscus plays a vital role in the health of the cartilage, and if a tear is not able to be repaired, there is a much worse outlook for the knee over time.[11]

In the younger patients, a longer wait for surgery was also associated with greater severity of cartilage injuries. We did not find any association between delayed surgery and cartilage injury severity in the older group.

These results suggest that chondral injuries in younger patients are the result of progressive damage to the articular surface of the knee. In contrast, older patients may sustain more severe damage at the time of the initial injury. Adult studies also report that increased age and a longer time from injury to ACL surgery are associated with a higher risk for more severe cartilage injuries seen at the time of surgery.[7,12,13] Whether these apparent differences in injury patterns among adults and younger and older pediatric patients are due to increased patient awareness or the patient's age-related stability, body control, or proprioceptive differences remains to be determined.

We suspect that differences in activity level and compliance with activity restrictions may explain the injury patterns in the two pediatric populations we studied. Younger patients may be less compliant with activity restrictions and more likely to engage in activities outside of organized sports that can result in subsequent knee injuries. In older patients, subsequent knee injuries were more likely to occur after a return to organized sports, sport-related activities, or both, especially among heavier individuals. However, based on the data collected in the current study, it is not possible to draw definitive conclusions regarding the differences in risk factors between the two populations.

This study demonstrated that a delay to surgery was correlated with more severe additional injuries and the need for additional surgical procedures to treat these injuries. Similar findings have also been demonstrated in other studies on pediatric patients, as mentioned previously, as well as in the adult literature. This led us to question why these patients continue to present for surgery in this delayed fashion. If the risk factors for the delay in surgery could be identified, we might be able to treat these patients in a more effective manner, which in turn would potentially improve patients' ability to not only return to play, but to have a healthier joint for their lifetime.

Socioeconomic factors

To investigate these questions, we undertook a sister study using the same patient population to investigate if socioeconomic factors played a role.[14] From our anecdotal experience, we believed that socioeconomic factors do play a role in how quickly patients are able to present for evaluation and treatment of their ACL injuries. We hypothesized that socioeconomic and demographic factors would be significantly related to ACL surgery timing.

To study this, we looked back at all 272 patients who were included in the original study. Demographic variables of interest included age at injury, race, ethnicity, sex, height, and BMI. Obesity was defined as a BMI greater than the 95th percentile for age and gender. Socioeconomic variables included household income and insurance type. Household income was estimated based on the median income associated with each patient's home ZIP code.

We found that patients with commercial insurance underwent surgery an average of 1.5 months after injury, whereas patients who were government-assisted or uninsured had surgery after an average of three months. Patients younger than 14 years averaged 2.6 months from injury to surgery, compared to 1.7 months for patients 14 years or older. Patients whose household income was estimated

to be higher than the 75th percentile averaged 1.2 months to surgery, while patients in lower-income households averaged 2.2 months to surgery.

The risk of delayed ACL surgery was significantly higher among pediatric and adolescent patients who were younger, less affluent, and covered by a noncommercial insurance plan. There was a 67% chance that a patient with commercial insurance had undergone ACL surgery sooner than a patient with a noncommercial insurance plan.

After controlling for the other factors, we still found that a lack of commercial insurance made patients twice as likely to be delayed in undergoing surgery. Also, for every one-year increase in patient age, surgery occurred 1.2 times faster. None of the other factors we looked at had a statistically significant impact.

Sources of delays

There are many steps required to get patients from the knee injury to the operating room. We probed further to see where the delays might be occurring to see if there was one area in which intervention could potentially improve these findings.

We found that, when time to ACL surgery was divided into more specific treatment-related time periods, noncommercial insurance coverage was associated with a significantly higher risk of delayed care than commercial insurance coverage during the time from initial injury to MRI evaluation, from initial injury to orthopedic evaluation, and from orthopedic evaluation to surgery. This suggests the source of the delay among patients with noncommercial insurance was not related to one specific component of the postinjury treatment process. Instead, the delay was consistent across all treatment phases.

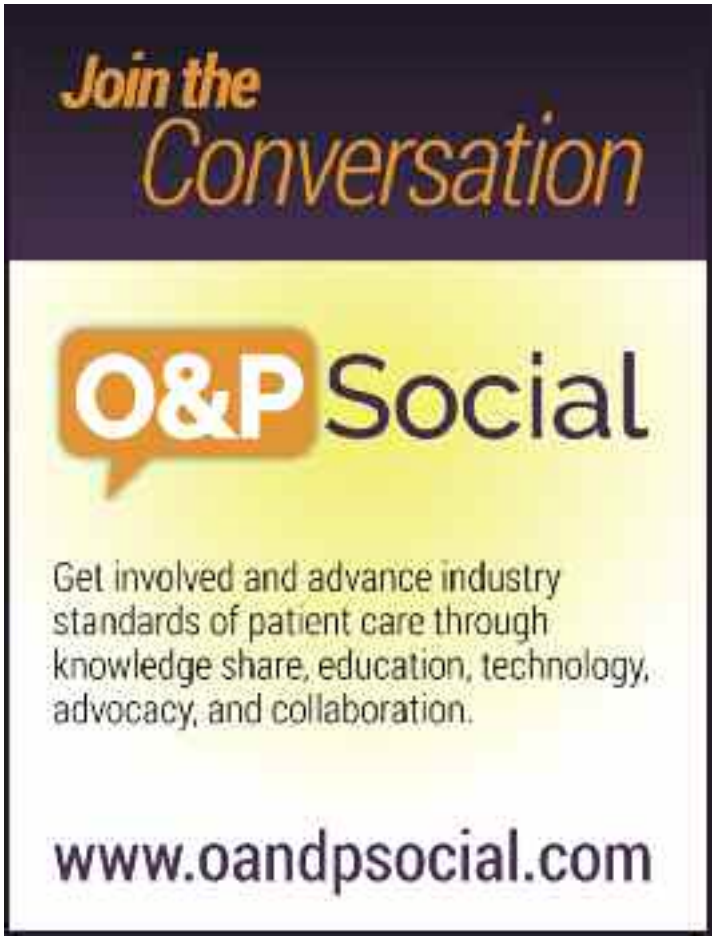
This study was performed at a tertiary referral pediatric hospital that, to our knowledge, has no policies of discrimination, screening, or access restrictions related to insurance, age, or affluence. These delays persisted despite no block from the medical providers, who understand the findings as presented above and would like nothing more than to see these patients in a timely manner.

It is important to appreciate that navigating the diagnostic, operative, and postsurgical appointments associated with the surgical management of an ACL injury places substantial burden on the patient and his or her family. The process can be expensive and time consuming, and progressing from one step to the next, from understanding the initial injury to the postoperative rehabilitation, can be a difficult process to navigate. This may be one of many confounding reasons for a delay in care for these young athletes.

It is our hope that this study, as well as an increased understanding of the injury and increased recognition by athletic trainers, staff, primary and emergency department physicians, and the medical team as a whole, can help to improve care for these patients. ler

Justin T. Newman, MD, is an orthopedic surgeon whose practice focuses on sports medicine and sports related injuries. He practices in Parker and Denver, CO.

References are available at lermagazine.com, or by scanning the QR or tag codes at left.



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ler new p

Two-toned Quikiks

Quikiks Hands-Free Shoes are now available in new contemporary two-tone styles. Created in response to customer feedback, the new color combinations include a white and navy upper with a black outsole and an all-black leather upper with a white outsole. Quikiks Hands-Free Shoes are designed to allow people with physical or cognitive challenges to easily step into the shoes, which securely fasten without the need for wearers to bend over or use their hands. Getting out of Quikiks shoes is easy too: Simply strike the heel on the ground, and the back of the shoe will pop open, allowing the foot to slide out.

Hands-Free
888/656-2751
quikiks.com

Soft Opaque Hose in Pecan

Sigvaris's Soft Opaque hosiery line is created for women who want the look and feel of designer hosiery and the medical benefit of graduated compression. Now Soft Opaque garments come in a new pecan shade designed to look natural against the skin while helping to disguise varicose veins, spider veins, and bruising. The pecan shade of Soft Opaque is available in 15-20 mm Hg, 20-30 mm Hg and 30-40 mm Hg compression levels and in closed-toe knee-high, thigh-high, and pantyhose styles. Other Soft Opaque colors include midnight blue, espresso, graphite, black, and nude; some also come in open-toe styles.

Sigvaris
770/631-1778
sigvarisusa.com

Heel Lift Ankle Sock

G&W Heel Lift now offers the Heel Lift Ankle Sock. This new ankle sock has a therapy pocket concealed inside the sock to hold heel lifts for secure placement while wearing sandals or flip-flops. Because the sock does not cover the entire foot, it can be used for dance, yoga, walking on the beach, or other activities that typically are performed while barefoot. It also can be worn with many types of footwear that do not easily accommodate a conventional heel lift. The Heel Lift Ankle Sock comes in black, and in three sizes (S = 8-9", M = 9-10", L = 10-11") based on the limb's circumference just above the talus.

G&W Heel Lift
800/235-4387
gwheellift.com

Synxsole Foot Orthoses

Designed by Australian podiatrists with more than 22 years of combined experience, Synxsole foot orthoses are slim, shock absorbing, and affordable. Synxsoles' design delivers increased stability across the forefoot and midfoot, providing a more durable device that can hold up better to adjustments. Being neutral at the rearfoot, the orthoses can be fully customized for pronation and supination. Because they can be trimmed to fit and cut to a half-length, an orthotic inventory of only four adult sizes and three children's sizes can be used to treat patients with shoe sizes ranging from US kids' 9 to US men's 14.

Synxsole
synxsole.com

roducts

Purple Gel Foot Pads

Dr. Jill's Foot Pads introduces Purple Gel Pads, distinctively colored to be more easily visible than a clear gel pad if accidentally dropped. Purple Gel Pads come in five shapes: ball foot cushions (in 1/8" or 1/4" thickness), U-shaped callus pads (1/8" thick), oval callus pads (1/8" thick), arch pads (1/8" or 1/4" thick), and dancer's pads (1/8" or 1/4" thick and available for right or left foot). The reusable pads are latex free and nonadhesive, but are self-sticking and regain their stickiness after each wash. Purple Gel Pads are sold by the pair, and each pad is designed to last four to six weeks before replacement is needed.

Dr. Jill's Foot Pads
866/FOOTPAD (366-8723)
drjillsfootpads.com

Plantar Fasciitis Sleeve

Three of the most commonly prescribed methods for plantar fasciitis relief include taping, stretching, and compression therapy. The new Nice Stretch Plantar Fasciitis Sleeve from Brownmed combines all three treatment protocols into one unique sleeve that is comfortable enough to wear all day. The Nice Stretch Plantar Fasciitis Sleeve provides balanced compression and support to the ankle, arch, and heel. The Plantar Fasciitis Sleeve is enhanced with X-Stretch technology, which helps distribute pressure evenly across the foot, and Bamboo Charcoal Fiber, which has antibacterial and deodorizing properties.

Brownmed
800/843-4395
brownmed.com

I-Runner Pro Athletic Shoes

I-Runner Shoes announces the addition of two new Medicare-approved athletic shoes, both with highly slip-resistant outsoles. The I-Runner Pro models are all black, one in mesh and the other leather. They feature a deep, wide forefoot and a narrower, doubly padded heel counter that resists slippage. I-Runner shoes are lightweight, and the construction of the shoe and its wide outsole produce a stable platform. A mild forefoot rocker to enhance toe off and a cushioned heel make them appropriate for walking the mall or jogging. I-Runner shoes are available in three widths and half sizes.

I-Runner Shoes
516/242-8070
i-runner.org

Queen Cobra Foot Orthosis

Footmaxx introduces the new Queen Cobra Orthotic, a cobra-cut custom foot orthosis designed to fit in the slimmest, tightest-fitting shoes. Handcrafted, Queen Cobra is a sulcus-length orthotic device with a vinyl top cover for comfort and durability. Because of its narrow and thin design, Queen Cobra is also extremely lightweight. For added control, Queen Cobra features a 3-mm polypropylene heel cup that is also fully customizable. Queen Cobra also includes a heel-to-metatarsal soft arch fill, a 1/16" forefoot extension for metatarsal cushioning, and a vinyl half-bottom reinforcement to help prevent slipping.

Footmaxx
800/779-3668
footmaxx.com

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ler new products

Elite Ortho Knee Braces

New from Elite Orthopaedics are three knee braces: the Range of Motion Hinged Knee Wrap, the Post Operative Range of Motion Knee Brace Light, and the Post Operative Range of Motion Knee Brace Standard. The hinged knee wrap is intended for most ligamentous instabilities, sprains, and strains. It is available in four sizes (S-XL) and will fit the left or right leg. Both postoperative braces provide immobilization with range of motion (ROM) control. They feature a steel ROM hinge that is designed not to degrade with use, a simple-to-use drop lock, and trimmable buckle straps. Both have easily adjusted strut lengths of 17-28".

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

Run 2.0 Women's Sock

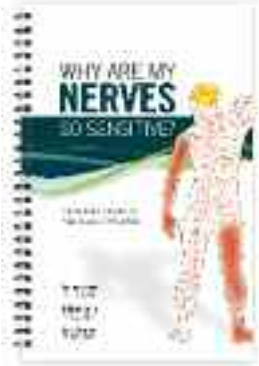
Injinji is a sock company dedicated to the health and performance of feet. The company now introduces the Women's Run 2.0 sock. The Women's Specific Run 2.0 features material with increased two-way stretch to provide better arch coverage and, in turn, provide more effective compression throughout the foot. This performance toe-sock allows toes to align and splay naturally for a more comfortable fit, and the individual toe-sleeves have been redesigned for a snugger fit throughout the toes without any excess material. A light and breathable mesh top maximizes ventilation and helps keep feet cool.

Injinji
858/270-3811
injinji.com

TurboToe Overshoe

The TurboToe safety overshoe is designed to protect the forefoot from accidental impact. The TurboToe is now available in a new XXS size with a purple toe cover, which fits North American men's sizes 2-4 and women's sizes 4-5. TurboToe is also available in XS (grey), S (white), M (yellow), L (red), XL (blue), XXL (green), and XXXL (black). The product is recommended for use in any industry, especially construction and heavy work environments that carry a risk of toe damage or have a steel toe cap requirement. The waterproof product is made of stretchy, pliable PVC and built to resist hardening, stiffening, or cracking.

Impacto Protective Products
888/232-0031
impacto.ca



Book for Patients With Chronic Pain

Patients with complex regional pain syndrome (CRPS) now have a new tool to begin a path to recovery. *Why Are My Nerves So Sensitive?* is written by three physical therapists affiliated with the International Spine & Pain Institute in Story City, IA: Adriaan Louw, PT, PhD, CSMT; Colleen Louw, PT, MEd, CSMT; and Kory Zimney, PT, DPT, CSMT. Using images, metaphors, and clear, approachable language, the book starts by teaching patients with CRPS that their chronic pain is more likely due to an extra-sensitive nervous system than to injured tissues, which may be why many tissue-based treatments fall short.

OPTP
800/367-7393
optp.com

market mechanics

By Emily Delzell

NAAOP moves to block Medicare policy that 'would return amputees to 70s care'

The National Association for the Advancement of Orthotics & Prosthetics (NAAOP) in August created a petition calling for the White House to rescind Medicare's recently published draft policy for Local Coverage Determination for Lower Limb Prosthetics.

NAAOP reported that, if implemented, the policy would install new barriers that would limit and potentially deny access to appropriate prosthetic care. The policy eliminates coverage for certain prosthetic devices and precludes amputees from reimbursement for a prosthesis if they fail to meet the subjective standard of "the appearance of natural gait" while using the prosthesis.

The draft policy was released on July 16 by the four Durable Medical Equipment Medicare Administrative Contractors (DME MACs) and, once official, will govern Medicare coverage of lower limb prostheses.

At *LER*'s press time in mid-August the petition was within 24,000 signatures of reaching its needed August 30 goal of 100,000 petitioners. To sign, go to wh.gov/iIloi. ler

AOPA names lifetime achievement winner

The Washington, DC-based American Orthotic & Prosthetic Association (AOPA) reported in July plans to honor Thomas V. DiBello, CO, with its Lifetime Achievement Award at the 2015 AOPA National Assembly in San Antonio, TX.

DiBello, former five-time AOPA board member and two-term past president, for 18 years headed Houston, TX-based Dynamic Orthotics and Prosthetics, which he merged in 2010 with Austin, TX-based Hanger Clinic. He is now Hanger's Gulf Coast regional director. DiBello is also clinical assistant professor at Baylor College of Medicine in Texas, honorary adjunct faculty at Texas Women's University in Denton, and chair of the Advisory Committee of the Baylor College of Medicine's Masters Program on Orthotics and Prosthetics.

DiBello will receive with the Lifetime Achievement Award at the 2015 AOPA National Assembly in San Antonio at the General Session on Saturday, October 9. ler

Converse revamps classic shoe for comfort

Boston-based Converse in August launched a new version of its classic Chuck Taylor sneaker, reporting the new shoe is redesigned for comfort with technology from its parent company Nike, headquartered in Beaverton, OR.

The Chuck II resembles its original version, sporting the iconic Converse All Star emblem, and is built with Nike's lightweight Lunarlon foam and arch support. The Chuck II retails for $75, while the classic version, which remains on the market, sells for $55. ler

DJO launches wireless stimulation device

DJO Global in July received Food and Drug Administration (FDA) approval to begin sales of the San Diego-based company's wireless electric muscle stimulation device.

The Compex Wireless USA, according to the company, sends electronic pulses to nerve fibers through small wearables to create involuntary muscle contractions and maximize muscular effort.

The device sells for $1149 at compexusa.com and select retailers. ler

IOC calls for world conference proposals

The International Olympic Committee (IOC) in July called for proposals for its 2017 IOC World Conference on Prevention of Injury & Illness in Sport.

The committee also announced a new location and dates for the 2017 world conference, which is scheduled for March 16-18 in Monaco.

The three-day program will include keynote lectures, symposia, debates, and other events focusing on sports injury prevention for different sports and different injury types, including studies on intervention methods, epidemiology, risk factors, and injury mechanisms.

Proposals for keynote lectures, symposia, head-to-head debates, and workshops are due by November 2.

For more information on the instructions for submitting proposals, or on the conference, go to ioc-preventionconference.org. ler

AOFAS releases plantar fasciitis guide

The American Orthopaedic Foot & Ankle Society (AOFAS) teamed up with *Consumer Reports Health* to produce a patient handout that it released in July focusing on conservative treatment of plantar fasciitis (PF).

The PF handout follows a 2014 AOFAS educational effort, part of the ABIM (American Board of Internal Medicine) Foundation's Choosing Wisely campaign, including its advice to try six month of conservative care before moving to surgery. The handout is available at footcaremd.org and at consumerhealthchoices.org. ler

ETH Zürich announces 'Cybathlon' event

Swiss university ETH (Eidgenössische Technische Hochschule) Zürich will hold in October 2016 a new championship event for individuals who use advanced assistive devices.

The Cybathlon will provide a platform for the development of novel assistive technologies useful for daily life and aims to remove barriers between the public, people with disabilities, and science, according to ETH Zürich.

Go to cybathlon.ethz.ch to learn more about the games and for registration information. ler

Rogers renames elastomeric division

Woodbury, CT-based Rogers Corporation on July 29 changed the name of its High Performance Foams Division to Elastomeric Material Solutions to better reflect its growing range of high-performance engineered materials solutions and capabilities to meet customer needs.

Rogers Elastomeric Material Solutions produces a variety of elastomeric products, including Poron foams, Bisco silicones, and the recently acquired Arolon silicones. ler

Alliqua markets graft for tendon repair

Langhorne, PA-based Alliqua Biomedical in July reported that its exclusive licensing agreement with Summit, NJ-based Celgene Cellular Therapeutics now includes the right to market an advanced wound care product for podiatric and orthopedic applications.

Biovance is a decellularized, dehydrated, human amniotic membrane allograft indicated for management of uninfected partial- and full-thickness wounds, and now, for repair of tendon, nerve, and bone in the foot and ankle. ler

Continued on page 66

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Ortho devices report predicts $940M rise

London, UK-based health industry research firm GlobalData reported on July 30 that the global orthopedic braces and orthotics market will rise from $2.56 billion in 2014 to reach just under $3.5 billion by 2021, largely driven by an aging population and patient preference for braces and supports as noninvasive treatment options.

The company reported this increase represents a moderate compound annual growth rate of 4.6%. The US will continue to dominate the orthotics space, retaining more than 50% of the market share throughout the forecast period.

While the global orthotics market is fragmented and composed of many smaller players, major companies hold large shares, said GlobalData medical device analyst Jennifer Ryan.

Key opinion leaders interviewed by GlobalData, however, noted there is a lack of brand loyalty in orthotics and that opportunities remain for new players. ler

Therafirm sponsors Kenyan runner

Kansas City, KA-based Therafirm and Auburn, ME-based Bedard Pharmacy and Medical Supplies are supporting Kenyan runner Moninda Marube on a cross-country run he began July 1 to raise awareness of human trafficking.

Marube came to the US in 2010 to train, but fell victim to a running manager, who kept his winnings. In 2012, Marube ran the Santa Barbara International Marathon, breaking the course record with a time of 2:22:28. The marathon's technical director, Dan Campbell, helped him relocate to Auburn.

In November he will end his run in California (see updates at monindamovement.com) by again competing in the Santa Barbara marathon.

Therafirm and Bedard will donate of proceeds of sales from the hosiery company's new sport compression line, which will launch September 1. CoreSport and CoreSpun products sold through March 31, 2016, on Bedard's website, bedarddirect.com, will benefit the cause. ler

POI names Bach new editor in chief

The International Society for Prosthetics and Orthotics in July named Australian biomechanist Timothy Bach, PhD, editor in chief of its flagship journal, *Prosthetics and Orthotics International (POI)*.

Bach, who recently retired from La Trobe University in Melbourne, where he remains honorary associate professor, replaces Sarah Curran, PhD, podiatry program director at Cardiff Metropolitan University in the UK. ler

Nike launches easy-don Flyease high-tops

Beaverton, OR-based Nike on July 18 began selling its new Flyease athletic shoe, designed for quick no-lace donning by people with disabilities, in limited quantities on nike.com.

The shoes, which are sold as part of the LeBron James Nike series, were inspired by Matthew Walzer, a high school student with cerebral palsy who was tired of asking friends to tie his shoes. He wrote to Nike in 2012, a move that resulted in the release of a basketball high-top designed for rear entry and easy closure. ler

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