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LOWER EXTREMITY REVIEW

March 17 / volume 9 / number 3

KNEE OA IN AMPUTEES:

Biomechanical and technological considerations

PLUS:

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FOOT POSTURE, ORTHOSES, AND PATELLOFEMORAL PAIN

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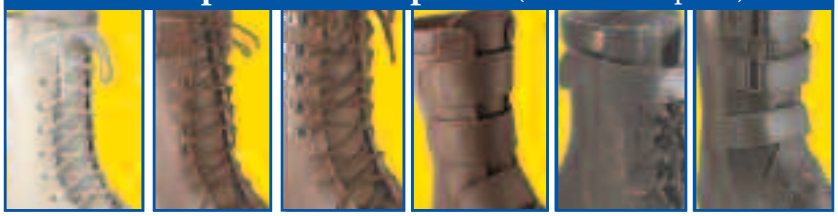

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out on a limb: In search of symmetry

Researchers and clinicians who work with unilateral lower limb amputees are increasingly exploring the effects of prosthetic devices on gait asymmetries and joint loading. What's less well known is that prostheses designed for use above the waist can also have positive effects on gait.

As *LER* senior editor Emily Delzell details in this issue's cover story (see "Knee OA in amputees: Biomechanical and technological considerations," page 18), gait asymmetries related to unilateral lower limb amputation can increase the risk of knee osteoarthritis in the intact limb, but improving prosthetic fit and function can help reduce that risk by making gait more symmetrical.

Losing an arm or a breast doesn't have the same direct effect on lower extremity function, but it makes sense that the asymmetries associated with those procedures could adversely affect balance and gait, and a handful of studies in the literature seem to support this.

In a 1996 study, German researchers reported that upper extremity amputees compensated by shifting the trunk toward the affected side and increasing gluteus medius activity on the affected side, potentially increasing stress on the hip. In 2012, another German group found similar compensations during gait in patients who had undergone shoulder disarticulation—but also found that wearing an arm prosthesis with a mobile shoulder joint helped to improve posture and reduce knee loading in the affected limb during gait.

Most recently, in a study epublished in early March by *Breast Cancer Research and Treatment*, Polish investigators found that static weightbearing differed significantly between limbs in women who had undergone unilateral mastectomy without reconstruction five to six years previously. They also found that foot shape differed significantly between limbs, which the authors suggested could represent the cumulative effect of the weightbearing imbalance over time.

In that study, about half of the 128 women said they used an external breast prosthesis during the daytime; another 37.5% said they used one only occasionally. However, the study did not analyze the extent to which the weightbearing and foot-shape asymmetries they found in the group overall might have been related to external prosthesis use.

The authors also did not specify whether the prostheses used were weighted silicone devices, designed to approximate breast tissue, or the soft, lightweight forms that are typically used immediately after surgery but sometimes are used in the longer term, especially while exercising or in hot weather. These different types of prostheses presumably would have different effects on biomechanical symmetry, despite having similar cosmetic effects when worn under clothing.

> Like lower extremity prosthetic devices, those designed for use above the waist can also have positive effects on gait symmetry.

This month's cover story points out that gait-related challenges in amputees—including knee pain and degeneration—often take a back seat to issues related to residual limb pain, phantom pain, and skin breakdown.

I suspect that in patients who have experienced breast or upper limb losses, gait asymmetries tend to be even less of a priority than in lower limb amputees. But, with patients living much longer after such procedures and rates of lower limb joint degeneration on the rise, I also suspect those priorities will need to change.

Jordana Bieze Foster, *Editor*

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Injury risk gets clinical

Studies support value of inexpensive tests

By Jordana Bieze Foster

Clinicians don't often have expensive biomechanical testing equipment to improve their assessment of injury risk in athletes, but a growing body of research—including several studies presented in February at the American Physical Therapy Association's Combined Sections meeting in San Antonio, TX—suggests standard clinical tests can help fill that void.

Aspects of the triple hop for distance test, for example, are significant factors differentiating young athletes at high risk of a second anterior cruciate ligament (ACL) injury from those at low risk, according to research from Cincinnati Children's Hospital in Ohio presented at the meeting.

In 120 athletes (105 girls; mean age 16.7 years) who had undergone functional testing when they were cleared to return to sports after an initial ACL injury and reconstruction, the investigators found those who went on to suffer a second ACL injury within two years typically matched one of two high-risk profiles.

Both high-risk profiles included age younger than 19 years. Those who fit the first profile had a triple hop distance on the involved limb between 1.34 and 1.9 times their height and triple hop limb symmetry of less than 98.5%. Those who fit the second profile were

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Among high school girls, specialization makes playing sports more hazardous

High school girls who specialize in one sport are more than twice as likely to suffer a moderate to severe injury as their multisport counterparts, according to research from San Diego State University in California.

Investigators surveyed 335 female high school athletes at baseline, then prospectively tracked the injuries sustained by those athletes during the next three sports seasons.

Athletes who specialize—which was defined as competing only in a single main sport or training for more than eight months per year in a single sport—made up 63.6% of the study population. Gymnastics, lacrosse, tennis, soccer, and swimming participants were most likely to specialize.

Moderate to severe injuries occurred 2.3 times more often in specialized athletes than nonspecialized, a statistically significant difference.

"We need to look more at number of athletic exposures and also their reasons for specialization," said Mitchell J. Rauh, BSPT, PhD, professor and director of the Doctor of Physical Therapy program at the university, who presented the findings in February at the American Physical Therapy Association's Combined Sections Meeting in San Antonio, TX.

Source:

Rauh MJ, Dillon AK, Paterno MV, et al. Relationship between sport specialization and musculoskeletal injury among competitive female high school athletes. J Orthop Sports Phys Ther 2017; 47(suppl 1):A49.

Runners with PFP experience symptom improvement after gait modifications

Running gait modifications designed to reduce patellofemoral loading also have immediate symptomatic benefits in patients with patellofemoral pain, according to research from Laval University in Quebec City, Canada.

In 32 rearfoot-striking runners with patellofemoral pain, investigators assessed the effects of three modifications: forefoot-strike running, increasing step rate by 10%, and running "softer."

As expected, all modifications were associated with reduced patellofemoral joint force during running, compared with the participants' normal running gait. But the modifications were also associated with immediate symptom improvement of at least one point out of 10; 62.5% of runners in the study experienced a positive symptomatic response to at least one of the gait modifications.

"Interventions that immediately induce a decrease in symptoms can really help with obtaining patients' trust," said Jean-Francois Esculier, BScPT, MSc, a doctoral student in the department of physical therapy at the university, who presented the findings in February at the American Physical Therapy Association's Combined Sections Meeting in San Antonio, TX.

Source:

Esculier J-F, Bouyer LJ, Roy J-S. Immediate effects of gait retraining on symptoms and running mechanics of runners with patellofemoral pain. J Orthop Sports Phys Ther 2017;47(suppl 1):A9.

Continued from page 13

female and had a triple hop distance more than 1.34 times their height, triple hop symmetry greater than 98.5%, and high knee-related confidence.

In another 43 athletes analyzed separately for validation, those with high-risk profiles were 5.14 times more likely to sustain a second ACL injury than the low-risk group.

"Standard clinical measures may be able to be used to identify patients at high risk for a second ACL injury," said Mark V. Paterno, PT, PhD, MBA, SCS, ATC, acting scientific director of orthopedic and sports physical therapy at Cincinnati Children's, who presented the findings in San Antonio.

In a second presentation, researchers from the University of Florida in Gainesville found that preseason weightbearing asymmetry during a drop vertical jump was significantly associated with risk of a lower extremity injury during the subsequent sports season in 137 collegiate football, volleyball, and basketball players. Asymmetry greater than 23.1% of body weight was associated with a positive likelihood ratio of 1.47 and a negative likelihood ratio of .88.

Weightbearing asymmetry during an overhead squat or a single-leg forward land, however, were not associated with injury risk, said Debi Jones, DPT, OCS, SCS, a member of the sports physical therapy faculty in the university's Department of Orthopaedics and Rehabilitation, who presented the findings.

"These findings may tell us that asymmetries are present in all athletic tasks, but only those related to the drop jump task may be predictive of injury," Jones said.

In a third presentation, researchers from George Fox University in Newberg, OR, found that preseason scores for standing long jump and single-leg hop for distance were associated with lower quadrant injury risk in 80 female collegiate volleyball players.

Those who jumped less than 70% of their height were 12.2 times more likely to have a lower quadrant injury than their counterparts; those who jumped less than 80% of their height and hopped less than 70% of their height were 5.7 times more likely to have a foot or ankle injury.

Preseason testing can help clinicians efficiently target athletes who may need additional preventive training to avoid injury, said Jason Brumitt, PT, PhD, ATC, an assistant professor of physical therapy at the university, who presented the findings in San Antonio.

"You often don't have a lot of time to get athletes ready, especially for fall sports," Brumitt said. ler

Sources:

Paterno MV, Huang B, Thomas S, et al. Clinical factors predict second ACL injury after ACL reconstruction and return to sport: Development of a clinical decision rule. J Orthop Sports Phys Ther 2017;47(suppl 1):A47-A48.

Jones D, Tillman SM, Moser M, et al. Preseason weight-bearing symmetries differ in athletes sustaining lower extremity injury during the competitive season. J Orthop Sports Phys Ther 2017;47(suppl 1):A41.

Brumitt J, Mattocks A, Lentz P, et al. Lower-quadrant time-loss injury rates and preseason performance risk factors in female collegiate volleyball players. J Orthop Sports Phys Ther 2017;47(suppl 1):A33.

Slip scores fall short

Testers take winter footwear to task

By Catherine M. Koetters

Although slip-resistant footwear can play a key role in preventing accidents related to wintry conditions, most styles don't do the job, according to researchers from the Toronto Rehabilitation Institute in Canada who have set out to change the situation.

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In a study published in the May 2016 issue of *Ergonomics*, Geoff Fernie, PhD, and his team showed that testing slip resistance using their Maximum Achievable Angle (MAA) method resulted in a more consistent and accurate evaluation of winter shoes and boots than the industry standard, mechanical bench testing, which does not involve human participants or realistic outdoor conditions.

"Other testing methods used tend to get variable results," said Fernie, a senior scientist and director of the research institute. "You get different results in different labs at different times. We seem to get rather consistent results."

For the Toronto study, eight participants of similar age, height, and weight tested six styles of men's winter footwear on wet ice, dry ice, and dry ice after walking over soft snow. Using Toronto Rehab's state-of-the-art WinterLab facility, researchers tipped the floor one degree at a time until each participant was unable to initiate gait or both feet slipped simultaneously midslope. Testers wore harnesses to prevent slip-related injury.

MAA ranged from 4° to 10° on dry ice and up to 13° on wet ice; the bench testing values were the equivalent of MAAs from 2° to 8°

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Early PT after hindfoot fracture surgery may help patients better address anxiety

Patients who undergo surgery for hindfoot fracture can safely start physical therapy two weeks later, which could provide an opportunity to improve outcomes, according to research from Utah presented at the American Physical Therapy Association's Combined Sections Meeting.

Investigators randomized 50 patients to undergo 10 physical therapy sessions either two or eight weeks after open reduction internal fixation of the calcaneus or talus.

Scores on two outcomes questionnaires did not differ significantly between groups at three, six, or 12 months after surgery. There was also no difference in adverse events. For the study population overall, self-reported anxiety at baseline was significantly associated with Lower Extremity Functional Scale score at six and 12 months.

"There is no downside to initiating PT early. By doing that, we may be able to better address some of the psychosocial factors that can affect outcomes," said Stephanie Albin, DPT, a physical therapist with Intermountain Healthcare in Salt Lake City, UT, who presented the findings in February at the meeting, which was held in San Antonio, TX. ler

–Jordana Bieze Foster

Source:

Albin S, Koppenhaver S, Fritz J, et al. Timing of supervised physical therapy after hindfoot fractures: A randomized controlled trial. J Orthop Sports Phys Ther 2017;47(suppl 1):A2.

In diabetic neuropathy cases, pedal bone health declines along with renal function

In patients with diabetic peripheral neuropathy, pedal bone health declines progressively in conjunction with worsening renal function, according to research from Washington University School of Medicine in St. Louis, MO.

The investigators assessed calcaneal bone mineral density (BMD) in 112 patients (43% women) with diabetic neuropathy, and categorized each patient's renal status based on five stages of chronic kidney disease (CKD), with stage 5 being the most severe. Thirty individuals were classified as stage 1, 35 as stage 2, 31 as stage 3, and 16 as stage 4 or 5.

Mean calcaneal BMD decreased significantly as CKD severity increased; the percentage of participants' feet classified as osteoporotic increased progressively from 17% of those in stage 1 to 56% of those in stages 4 and 5.

The findings support the need to monitor BMD in this population, said David R. Sinacore, PT, PhD, a professor of physical therapy and director of the Applied Kinesiology Laboratory at the university, who presented the findings in February at the American Physical Therapy Association's Combined Sections Meeting in San Antonio, TX. ler

–Jordana Bieze Foster

Source:

Sinacore DR, Bohnert KL, Bittel DC, Bittel AJ. Pedal bone density in progressive stages of CKD-MBD. J Orthop Sports Phys Ther 2017;47(suppl 1):A26.

Continued from page 15

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on wet ice and up to 14° on dry ice. There was even less agreement between MAA and bench testing for the snow-plus-ice condition (4° to 8° for MAA vs the equivalent of 10° to 25° for bench testing).

The researchers also studied the participants' gait as they walked across various surfaces. They found that step length and width, gait speed, foot angle at heel strike, and upper body flexion all adapted to changing conditions. According to the study's authors, this finding underscores the importance of using human participants when testing the slip resistance of footwear.

Fernie and his team have already put their MAA method to practical use. They tested the slip resistance of 98 new winter boots and published the results in November on a website they created, ratemytreads.com.

Fernie was surprised at how badly the footwear performed overall. One pair of expensive boots advertised the wearer's ability to "walk to the arctic." Yet a student tester could not walk up a 2° ice slope while wearing those boots, he said.

Boots received a rating of one, two, or three snowflakes. If testers could successfully negotiate the 7° angle—similar to the slope of many street curb ramps—under wet ice and dry ice conditions, the shoe got one snowflake. Only 10 boots out of 98 were awarded a single snowflake. The rest got zero.

The researchers found the shoes that performed best used either Green Diamond or Arctic Grip sole technologies. Green Diamond soles have a rough surface, resembling a scattering of little diamonds, that scratches at the ice, Fernie said. Arctic Grip soles feature fibers that penetrate the molecular layer of water on the ice's surface and stick to the frozen part underneath.

"People think the tread is most important, but when you're on a hard patch of ice, or really packed snow, or a sheet of black ice, the tread doesn't really penetrate," Fernie noted. "It's the material that matters. It's the material that interacts with the surface, which increases the friction, that matters."

Jeff Jacobs, CPed, owner of Foot Dynamics comfort shoe store in Boise, ID, is grateful for the research.

"Every bit of Information that can be brought forward to help us do our job is much appreciated," Jacobs said. "As the shoe industry can embrace this information and create better products, we all benefit."

Interest in the Rate My Treads website has been tremendous, Fernie said. The site received more than 250,000 hits in its first six weeks, and the researchers got phone calls from consumers frustrated that every boot with a one-snowflake rating was sold out before Christmas.

Fernie said retailers are now asking his group to test boots they're looking to carry next winter to ensure they will sell well. A few manufacturers also want the research team's help making better boots. The group has already tested one company's prototype that Fernie thinks may get a two-snowflake rating next year—that would mean the wearer could successfully negotiate an 11° slope. When testing next season's boots, the researchers will also perform wear studies to determine how long the better-rated footwear continues to perform well.

Fernie believes that in two to three years, winter footwear will achieve higher ratings as more manufacturers look to science, not fashion, when striving for truly slip-resistant winter footwear. ler

Source:
Hsu J, Shaw R, Novak A, et al. Slip resistance of winter footwear on snow and ice measured using maximum achievable incline. Ergonomics 2016; 59(5):717-728.

Sensory-enhancing insoles improve agility performance in recreational athletes

Insoles with sensory-enhancing technology, previously demonstrated to help address balance and proprioceptive deficits, can also improve agility in athletes, according to research from Harvard University in Cambridge, MA.

Subthreshold stochastic resonance (SR) sensory-enhancing insoles have been shown to improve balance and proprioception in the elderly and in patients with diabetic neuropathy or stroke (see "Using subsensory noise to improve balance, gait," May 2016, page 37). But balance and proprioception are also important for athletic performance, including agility, or changes of direction.

To test the effects of SR on agility in athletes, the Harvard investigators assessed 20 recreational athletes (eight women) as they performed a hexagonal agility drill commonly used by coaches and in sports medicine research. The athletes wore prototype SR insoles for all agility trials, but the stimulation was randomly turned on or off. Participants wore their own footwear, with the SR insoles in place of the existing insoles.

For the agility task, the researchers used tape to mark a hexagon (60 cm per side) on the floor, as well as seven smaller rectangular targets—one 18 cm outside each side of the hexagon, and one in the center. Each participant started in the center of the hexagon, then jumped to the first outside target, back to the center, then to the second outside target, and so on until a full circuit had been completed three times. Participants were

instructed to jump with the feet together and land on the targets with the forefeet, and to perform the task as quickly and accurately as possible.

The athletes completed the agility task more quickly with the SR turned on than with it off, decreasing their times by .12 s on average; 14 of the 20 participants were faster with the SR on than off. This improvement was not associated with any decrease in accuracy; in fact, 11 athletes had less accumulated error (the sum of the distance by which each target was missed) with the SR on than when it was turned off. The findings were published in the May 2016 issue of the *Journal of Biomechanics*.

"We observed no correlation between the performance in either completion time or accumulated error during the SR-off condition and the change with the SR on," said Danny Miranda, PhD, staff research scientist at the university's Wyss Institute and first author of the study. "This means that the outcomes during the SR-off condition did not influence the changes observed when SR was on. This suggests that SR stimulation has the potential to improve performance outcomes independent of their baseline values."

The .12 s improvement on the agility task in the study is consistent with an improvement of 10% to 20% in percentile ranking for NCAA Division I athletes, according to normative values published in 2006. A difference of .13 seconds on a different agility drill used at the 2015 National Football League Combine separated the top-ranked player from the eighth-ranked player. However, additional work is needed to determine if the benefits of SR stimulation in highly competitive athletes—who may have higher levels of both proprioception and agility to begin with—are similar to those experienced by the recreational athletes in the study, Miranda said.

He also noted that, along with the potential benefits, SR insoles also have some limitations.

"In regard to the pros and cons, I think the pros are pretty straightforward [sensory enhancement, balance improvement, proprioceptive improvement, and form factor to standard insoles]," Miranda said. "The cons would be charging, battery life, and vibration."

Robert Conenello, DPM, a past president of the American Academy of Podiatric Sports Medicine and a clinical advisor for Special Olympics International, is bullish on the future of SR insole technology.

"I do believe that there is something to be said for those insoles," Conenello said. "It is a hot topic that I don't think we have a grasp on. I think the pros outweigh the cons. I think that the future is bright and you are going to see athletes using them more and more. People of all ages should be able to benefit from SR insoles." ler

–Chris Klingenberg

Source:

Miranda DL, Hsu W-H, Gravelle DC, et al. Sensory enhancing insoles improve athletic performance during a hexagonal agility task. J Biomech 2016;49(7):1058-1063.

Hoffman J. Norms for fitness, performance, and health. *1st ed. Champaign, IL: Human Kinetics; 2006.*

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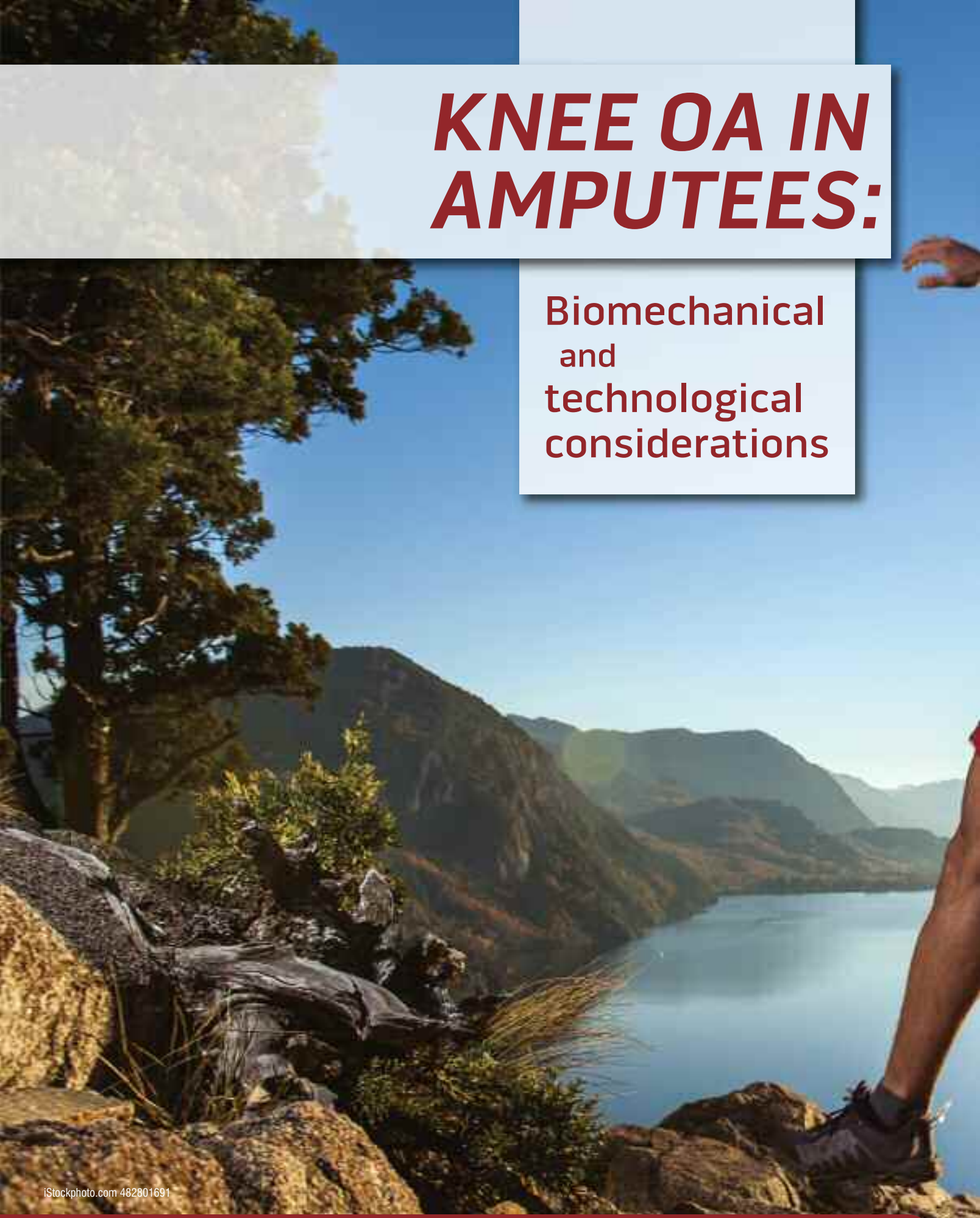
Biomechanical and technological considerations



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The risk of knee osteoarthritis in the intact limb of longtime unilateral amputees is much higher than in non-amputees, and the range of potential contributing factors is even more complex. Optimizing prosthetic fit and function, in addition to more conventional OA interventions, can help address gait issues that contribute to knee joint degeneration.

By Emily Delzell

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Unilateral amputees are at high risk for knee osteoarthritis (OA) in their intact limbs. Most experts think the increased risk comes from asymmetric force distribution caused by gait asymmetry and problematic compensations, poor prosthetic fit or alignment, and other factors, though not all researchers believe current evidence provides a definitive etiological answer.

Whatever its causes, knee OA is a significant concern for all unilateral amputees, particularly for the approximately 20% of individuals who lose a lower limb at a relatively young age to trauma, cancer, or congenital disease[1] but remain active, potentially subjecting the intact knee to increased loading for 40, 50, or more years.

"Not only are musculoskeletal conditions like knee OA prevalent among amputees, they can compound disability. I think that only recently have they begun to receive the study they deserve, and I'm not sure if, across the board on the clinical side, it's been recognized as much as it should be," said David Morgenroth, MD, assistant professor in the Department of Rehabilitation Medicine at the University of Washington and a staff physician and associate program director for the Amputation Rehabilitation Fellowship at the VA Puget Sound Health Care System (VAPSHCS), both in Seattle.

Among amputees, knee OA and other musculoskeletal conditions may be taking a back seat to more traditional concerns such as residual and phantom limb pain, said Morgenroth, who is also a research investigator in the VA Rehabilitation Research & Development Center of Excellence for Limb Loss Prevention and Prosthetic Engineering in Seattle.

"Those are two of the biggies, and are both quite important, but I think if clinicians are not asking their amputee patients about intact limb knee pain then they're potentially doing limited service; I think we need to be really thinking hard about prevention and treatment strategies," he said.

Prevalence

Studies have reported knee OA rates from 10 to 17 times higher in unilateral lower extremity amputees who are longtime prosthesis users than in age-matched nonamputees.[1-8] Knee OA is more prevalent among those with higher amputations.[1,2,4,7] Hungerford and Cockin were the first authors to note this higher incidence, reporting in 1975 that 41% of veterans with transtibial amputation (TTA) and 63% of those with a transfemoral amputation (TFA) had significant patellofemoral osteoarthritis compared with 22% of nonamputee veterans.[2] Later studies, mostly done in veterans, found similar incidence.[1,3-8]

Knee pain, often the first symptom of knee OA, is also common. Data show intact limb knee pain is twice as common in unilateral lower extremity amputees as in able-bodied individuals[5] and is the primary complaint among longtime prosthesis users (average prosthesis wear time of 24 years).[6] Pain is also more common among those with higher amputations; one study by Mussman et al found 46% of transtibial amputees had knee pain versus 75% of people with transfemoral amputation.[6]

Some have speculated higher body weight resulting from a more sedentary lifestyle after amputation could explain some of the increased risk of knee OA in this population,[7] but researchers controlling for body mass have also found higher rates of knee pain and OA among unilateral amputees than controls.

Norvell et al in 2005 investigated self-reported OA symptoms in 63 prosthesis-wearing male veterans with traumatic unilateral amputation, controlling for body weight at ages 18 and 30 years.[7] After the authors adjusted for age and body weight, those with TTA were three times and those with TFA were five times more likely to have knee pain on the intact side than nonamputee controls. Investigators concluded the loads experienced by the intact limbs of people with unilateral amputation are a potential cause of the increased risk of knee OA, a conclusion supported by Mussman et al, who found that 64% of longtime prosthesis-wearing lower extremity amputees said they depended more on their intact limb than their prosthetic side during activities.[6]

Causes

"The unaffected leg of people with a unilateral leg amputation typically experiences higher loading than the legs of nonamputees," said Alena Grabowski, PhD, an assistant professor in the Department of Integrative Physiology at the University of Colorado Boulder. "These higher forces, combined with the moment arm about the knee, increase torque on the unaffected knee, which likely contributes to the greater incidence of osteoarthritis in the unaffected knee of persons with unilateral leg amputation compared with nonamputees."

Some literature supports this hypothesis, Morgenroth said.

"Research looking at ground reaction forces in the intact limb compared with the prosthetic limb shows amputees do tend to load the intact limb more,"[2] he said. "Ground reaction forces are nonspecific, though, and can be distributed throughout different joints. A few studies have looked at knee adduction moment, which is more specific to knee OA, and those bear out an asymmetry of loading between the intact limb and the prosthetic limb."[9-11]

These findings, said Morgenroth, coincide with the literature showing that unilateral amputees have a higher risk of knee OA in the intact limb compared with matched controls and that they develop knee OA less commonly in the prosthetic side than the intact side. In their investigation of symptomatic knee OA and knee pain, Norvell et al, for example, found unilateral amputees are five times less likely to develop knee pain in the amputated limb than in the sound limb.[7]

"If you have an asymmetric gait, not only do you expose yourself to excessive wear and tear on your sound side, you also have a propensity to end up with knee and low back pain," said Mike Corcoran, CPO, cofounder of the Medical Center Orthotics and Prosthetics (MCOP) in Silver Spring, MD. "We see a lot of above knee amputees develop Trendelenburg gait, for example, where they lean over the affected side because their muscles aren't strong enough to support them as they advance through on their sound side, changing their gait symmetry so they land on the sound side with greater force."

Morgenroth noted these associations make sense, but pointed to a missing piece of the puzzle.

"If increased knee loading in the intact limb during walking is really responsible for this increased prevalence, then in these studies we should see an increase in knee loading of the intact limb compared to the control population, not just compared to the prosthetic side," he said. "This is where the literature hits a bit of a rough patch."

A 2014 study comparing young, active transtibial amputees with nonamputees found that the intact limb in individuals with TTA

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wasn't associated with greater peak external knee adduction moment (EKAM) or EKAM impulses across a range of walking speeds, though those with TTA had increased peak external knee flexor moment, peak vertical force, and loading rate as speed increased.[12] Investigators concluded the amputees' sound limb displayed few biomechanical risk factors for knee OA during walking compared with able-bodied individuals.[12]

A 2015 study from the same group found that young, active transfemoral amputees don't have greater sound-limb peak EKAM while walking at a self-selected speed than able-bodied controls, although they did find higher maximal loading rates in the amputees.[13] Surprisingly, the investigators also found that peak EKAM and impulses relative to body mass were lower among those with TFA than controls.

"I think the theory is still a very good theory, and I think there is some evidence pointing in that direction, but I also think we need larger, methodologically sound studies that provide more definitive evidence," Morgenroth said.

So, what else could be contributing?

Hopping, which is associated with high forces at the knee, may be a factor.

"We used to teach people how to get up and hop around the bedroom in the morning and hop into the shower," said Robert S. Gailey, PhD, PT, professor of physical therapy at the University of Miami Miller School of Medicine in Florida. "Now we're saying, 'Hey, put on your prosthesis, and don't hop unless you absolutely have to.'"

Clinically, Morgenroth has observed that transfemoral amputees tend to hop more frequently than transtibial amputees.

"Getting a transfemoral prosthesis on takes quite a bit more work typically than getting a transtibial prosthesis on. So maybe they wake up to urinate, and they just hop into the bathroom," he said. "As you can imagine, the forces on the intact limb during hopping may be even higher than those during walking. This hasn't really been studied in the literature, so at this stage it's more of a clinical hypothesis."

Tasks such as rising from a chair may be hard on the knees on unilateral amputees, Gailey said.

"There's not much hard evidence, currently, though people are working on it, but when a person gets in and out of the chair they primarily rely on the sound limb to do that, so that puts greater wear on the knee," he said.

In a 2016 study, Gailey and colleagues calculated the symmetry of weight distribution between lower limbs as 12 transtibial amputees and 12 age-matched nonamputees did a sit-to-stand activity.[14] Amputees showed an asymmetrical weight distribution pattern and a tendency to transfer weight to the intact limb during the activity, findings not seen in the nonamputees.

Morgenroth thinks sit-to-stand tasks could potentially contribute to OA risk, particularly in younger, more active amputees.

"I think rising to a standing position from a seated position, especially if you're in a low chair or on a low bed or couch, increases the patellofemoral forces rather than the tibiofemoral forces," he said. "This brings up another good point: When we talk about knee osteoarthritis there's three compartments, the medial tibiofemoral compartment, the lateral tibiofemoral compartment, and the patellofemoral compartment. At least in the general population it's known the medial tibiofemoral compartment is affected much more

commonly than the lateral, but the patellofemoral is also affected commonly.[15] So, I think another important aspect of future research is trying to correlate forces in specific places that are associated with degeneration in those specific places. So, if you're thinking about sit to stand as a potential reason, it might be important to look at the related patellofemoral forces."

Ascending and descending stairs, and even simple standing can also be problematic for amputees, Gailey said.

"When they go up and down stairs they will often skip a step, so all the work is done on the sound limb. When they come down, they put as little weight on the prosthetic limb as possible, and so three to four times body weight comes down on the sound limb. While standing, they tend to shift the weight to the sound limb," he said. "All these things accumulate year in and year out. You're sitting, standing, climbing stairs, and walking with increased effort, and the biomechanics of that limb are altered. The result is the knee breaks down a heck of a lot sooner than it should."

Device fit and physical therapy

Prosthetic fit is crucial for gait symmetry and to lower the risk of knee joint degeneration and OA, Corcoran said.

"If that socket is uncomfortable, you're going to spend more time on the sound side," he said. "As a prosthetist, you want to make the person comfortable, as all the technology in the world doesn't mitigate a poor-fitting socket."

All the experts interviewed for this article agreed.

"The first thing I advise people is to find a prosthetist who they like, who they believe is listening to their needs," Gailey noted. "Because, first, you need a well-fitting socket that allows you to use the muscles in the hip—or, for a below-knee amputee, about the knee—and to use them rapidly enough to bounce over the prosthesis. If you don't have that, you're never going to trust the limb, you're never going to be able to balance on it, and you're going to have additional forces."

Optimizing fit will help mitigate asymmetrical loading, said Morgenroth, who noted it also has a significant effect on functional mobility, comfort, and satisfaction.

"It's really tempting to look at high-tech solutions and think they will solve all problems, but if you have a poor fit, there's no prosthetic foot that will help you," he said.

Corcoran said his group is using total surface-bearing sockets with a silicone liner or silicone or gel interface.

"With these sockets, every part of the limb bears weight, and that increases comfort," he said. "Sockets also need to be aligned correctly to allow a normalized gait, and then there's the importance of physical therapy that focuses on gait symmetry to mitigate the risk of OA. You've got to use the prosthetic properly and keep in the back of your mind not just how much you're walking, but how well you're walking."

Physical therapy can help amputees walk, rise from chairs, and do other tasks with greater symmetry, Gailey said.

"I spend a lot of time working on posture, teaching them how to shift their weight when they're standing—sometimes on the sound limb, sometimes on the prosthetic limb—as an able-bodied person would do," he said. "I also advise them to spend the time to use their prosthesis properly because it will pay off over time; those that do can routinely incorporate those motor patterns into their everyday life and preserve the limb."

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Morgenroth would like to see physicians who work with amputees gain more experience with the population and the current literature.

"We have a lot of physicians treating amputees who don't have extensive training in it. That's very different than in the prosthetics community, where clinical prosthetists do have a lot more training, although from a different perspective," he said. "One of the key things is for clinicians to read the research with a critical eye and incorporate it into a thoughtful approach in the clinical setting that includes not only their reading of the literature, but their clinical experience as well."

Prostheses and push-off

Newer research on the effects of different prosthetic device types has changed Morgenroth's preventive strategies and treatments, he said.

"Typical prosthetic feet are associated with reduced push-off on the trailing limb [compared with intact foot push-off], which is associated with higher loading in the intact knee," he said.

Morgenroth and colleagues hypothesized greater prosthetic push-off would reduce loading of the entire intact limb and thereby reduce knee loading, and in 2011 reported on the effects of an experimental foot.[16] They studied seven unilateral transtibial amputees who walked with different three prosthetic feet with varying amounts of push-off: a controlled energy and storage return (CESR) prototype that increases push-off, a conventional foot, and the participants' currently prescribed foot.

The CESR foot on average produced 68% and 137% more push-off, respectively, than the prescribed foot and the conventional foot. The prosthetic foot condition with the least push-off demonstrated the largest EKAM, which was reduced by 26% with the prosthetic foot producing the most push-off. Trailing prosthetic limb push-off impulse was also negatively correlated with loading impulse in the intact leading limb.

However, research with commercially available feet that increase push-off on the prosthetic side have had mixed results.

Alena Grabowski and her coinvestigator in 2013 analyzed ground reaction forces and knee joint kinetics in seven transtibial amputees and seven age-, weight- and height-matched nonamputees who walked at five speeds over level ground under two conditions: with a commercial powered ankle-foot, which provided net positive mechanical work and powered ankle flexion during late stance, and with the patient's own passive-elastic prosthesis.[17]

Compared with the passive device, using a powered prosthesis reduced the force and knee adduction moment in the unaffected leg during level walking, significantly decreased unaffected leg peak resultant forces by 2% to 11% at speeds of .75 m/s to 1.5 m/s, and significantly decreased first peak EKAM moments by 21% and 12% at 1.5 m/s and 1.75 m/s, respectively.

"In addition to decreasing the risk of osteoarthritis in the unaffected leg, we have also found that use of a powered prosthesis normalizes walking biomechanics, metabolic costs, and preferred speeds.[18] Further, use of a powered compared to a passive prosthesis may improve the regulation of balance via the regulation of angular momentum in people with unilateral transtibial amputation,"[19] Grabowski said.

Loading rates in Grabowski's 2013 study were not significantly different between prosthetic feet.

"Loading rate may not be a risk factor for osteoarthritis," she said. "Further, the loading rates had a large range of variability across subjects, suggesting there are many different loading rate strategies utilized by people without and with an amputation."

In a 2014 *Clinical Biomechanics* study, Esposito and Wilken recruited 10 transtibial amputees and 10 able-bodied controls to compare limb loading between passive and powered prostheses, loading in the sound and amputated limbs, and loading in amputees and controls. Participants underwent gait analysis at three speeds.[12]

The powered prosthesis wasn't associated with a decrease in the sound limb's peak EKAM or impulse, but was associated with lower external knee flexor moment, peak vertical force, and loading rate as speed increased compared with the passive foot, and a slower loading rate compared with controls.

"The nice thing about the idea of increasing prosthetic push-off is there are other potential benefits, including improved gait symmetry and gait efficiency," Morgenroth said. "I think it's a concept that patients like and that feels good to them."

Traditional interventions

Practitioners are also using more traditional knee OA interventions, such as braces and insoles for the intact limb.

"I always look at the sound limb and the foot and often recommend off-the-shelf insoles," Gailey said. "Even if someone has good arches, there's a good chance they'll lose the arch; I base that anecdotally on the number of people that I've seen come through my clinic. Those who have been amputees for ten or more years have lost the arch or complain of knee pain, plantar fasciitis, or they have other kinds of ankle pain or a pronated foot."

If sound-side knee pain develops, Gailey is likely to prescribe an unloader brace for use during high physical activity.

Morgenroth noted that patient tolerance of bulky unloader braces can be a problem, and said he is cautious in his use of wedged insoles.

"It's really only helpful in potentially treating medial tibiofemoral OA and depends on a patient's foot and ankle mobility," he said. "If you have a patient with a lot of hindfoot motion, for instance, if you crank on their calcaneus relative to their tibia you see quite a bit of motion. You can imagine that might sort of soak up the wedging of the insole and won't necessarily be translated up to the knee. That said, when you have a really rigid foot in the frontal plane, even though those forces may be translated up to the knee, it may be quite uncomfortable depending on the wedge angle. So, again, it has to be patient-specific."

Corcoran emphasizes to his patients the need to maintain a healthy weight to keep load off the knee joint, as well as paying attention to changes in prosthetic fit.

"I stress the importance of sock management as the residual limb shrinks throughout the day—or if they gain weight and they're growing out of their socket," he said.

He also thinks consulting with a physical therapist every few years is a good idea.

"We see veterans that got hurt fifteen years ago coming back for prosthetic care who haven't had PT for ten or twelve years, and we definitely see a real deterioration in their gait," Corcoran said. "You need the complete package to reduce the risk of degenerative changes—a well-fitting, well-aligned prosthesis, an emphasis on gait quality, and an involved, educated patient."

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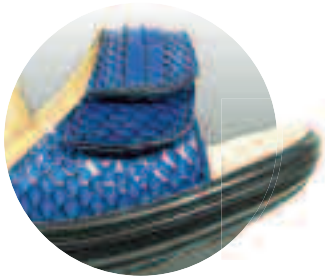

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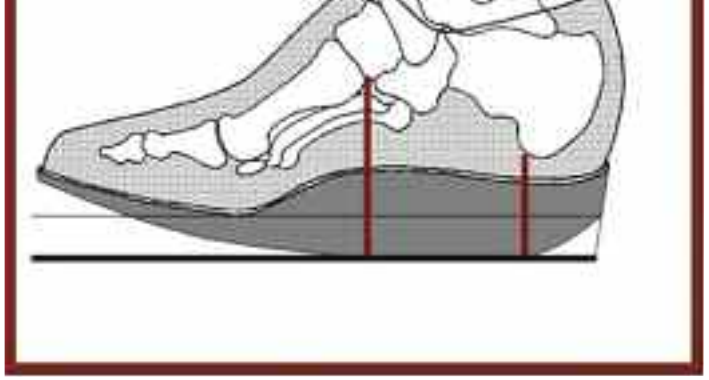

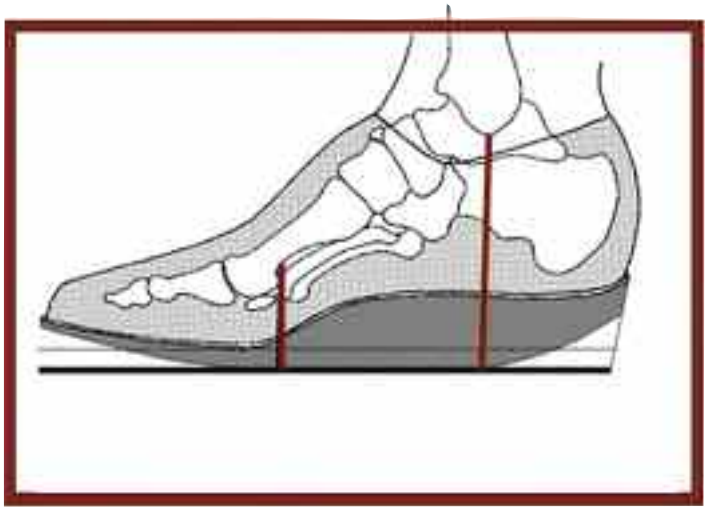

Rocker-bottom footwear: effects on balance, gait

Footwear with rocker soles are best known for helping to redistribute plantar pressures during gait in patients with diabetes, but research suggests they also have clinically relevant effects on balance and gait that can be beneficial for some populations but potentially dangerous for others.

By Greg Gargiulo

Although shoes were once used exclusively to protect the foot, they are now often used to improve the function of the feet and lower limbs as well.[1] To this end, there has been an upswing of interest in various methods to modify locomotion to address specific patient needs related to load modification, rehabilitation, and injury prevention.[2]

Rocker bottom soles, with added thickness and other design features intended to change gait mechanics, have been used to accomplish these goals for decades, and are currently the most commonly prescribed external therapeutic shoe modification.[3-6]

"Next to foot orthotic devices, rocker bottom soles are the proverbial 'aspirin' to chronic and temporary foot problems," said Arnie Davis, CPed, founder and owner of Davis Foot Comfort Center in San Francisco, who specializes in rocker soles. "Like foot orthotics, rocker bottoms can offer a number of mechanical remedies, such as inhibiting excessive or painful joint motion, preventing unwanted compensation for immobile joints, diffusing and reducing ground reactive forces, and aiding in the harmony of movement when weight flows through the foot during gait."

Potential applications for shoes with rocker sole designs have become wide-ranging, and the biomechanics of how they impact gait has been well researched.[1,3,7,8] Several studies also suggest rockers can be effective for managing gait issues associated with numerous conditions, including Achilles tendinopathy,[9-11] knee osteoarthritis (OA),[12,13] claudication,[14] hemiplegia,[15,16] plantar fasciitis,[17] chronic low back pain,[18] first metatarsophalangeal (MTP) joint OA,[19] and following ankle arthrodesis.[20]

But walking—and running—in rocker-soled shoes also comes with drawbacks and risks, which are primarily related to the way they alter balance. Some studies suggest rocker soles can negatively affect wearers' balance and in some may even increase the risk for falls and injury.[9,21,22]

Lower extremity clinicians may not agree on all aspects of rocker-sole utilization, but they do agree that the devices should be prescribed on a case-by-case basis.

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Figure 1. A boot with a rocker sole. (Photo courtesy of Arnie Davis, CPed.)

Situational instability

Intentionally interfering with balance was the core concept behind Masai Barefoot Technology (MBT) shoes, which were designed to transform flat, hard surfaces into unstable surfaces to enhance functional performance and address gait-related issues.[1] MBTs and similarly designed "toning shoes" experienced a surge in popularity in the late 2000s, but several models did not live up to their claims, and attention surrounding them has waned.[4,23,24]

On the whole, though, the existing data have not yet reached a clear conclusion on the basic effects of rocker bottom shoes on walking performance. Although rockers appear beneficial for certain applications, the jury is still out for others, and prescribing them must therefore be done cautiously and on a case-by-case basis.[8]

"Rocker-sole footwear produces significant changes in lower limb biomechanics and has the potential to alter function in both a beneficial and detrimental manner," said Hylton Menz, PhD, a senior research fellow and professor in the College of Science, Health and Engineering at La Trobe University in Melbourne, Australia. "When used appropriately, such footwear may be a useful adjunct treatment for some musculoskeletal disorders. However, rocker-sole footwear is not suitable for everyone, so their selection needs to be carefully considered."

Biomechanical factors

Research on the therapeutic use of rocker soles dates to at least 1950,[25] and a 1991 Schaff and Cavanagh study found rocker soles reduced peak plantar pressures by 30% in the medial forefoot, central forefoot, and toe regions compared with a conventional extra-depth shoe, suggesting rockers may help reduce the risk of ulceration in these foot regions.[26]

This can be especially beneficial for patients with diabetic peripheral neuropathy in danger of developing ulcers. In this context, a sole with a forefoot rocker pattern is used to functionally relocate the apex of the forefoot rocker posterior to the metatarsal heads, which reduces pressure on the met heads and promotes the transition from midstance to toe-off during gait.[4,5,27,28]

But reducing ulceration risk is far from the only function rocker soles can serve, and the forefoot rocker is just one of many variations in their design.

"It is important to understand that rocker shoes can be used to alter the biomechanics of walking and running in a number of different ways," said Steve Preece, PhD, deputy director of the Centre for Health Science Research and research fellow at the University of Salford in the UK. "While in people with diabetes, the objective is to reduce plantar pressures, the aim in other patient populations will often be to reduce or alter other biomechanical parameters, such as altering joint moments or changing muscle activation patterns."

According to Chapman et al,[29] rocker soles have three key design features: apex angle, apex position, and rocker angle. By tweaking and modifying these features, a variety of designs can be created and further customized, each with its own biomechanical goal.[29] In addition to the forefoot rocker—also known as the metatarsal head rocker, which Davis said is "the most common, and sort of the general rocker bottom"—other designs include the metatarsophalangeal joint rocker (or toe-only rocker), negative heel rocker, double sole rocker, Lisfranc rocker, and ankle joint rocker.[3,30]

"I prescribe them for patients with hallux rigidus, hallux limitus, osteoarthritis, rheumatoid arthritis, and those with an amputation from the forefoot or midfoot, among other conditions, and the beauty of the rocker sole is that you can control some of the pressures exerted on the foot by using different designs," said Rob Sobel, CPed, past president of the Pedorthic Footcare Association and previous owner of Sobel Orthotics & Shoes in New Paltz, NY. "They are also a good idea any time someone is in an ankle foot orthosis [AFO]."

Design tradeoffs

A 2004 Brown et al study[28] identified unique tradeoffs with three rocker sole designs in healthy individuals (see "For those about to rock, we caution you," December 2009, page 18). The toe-only rocker gave the best forefoot relief but increased pressure on the midfoot, while the double rocker sole was effective for individuals with a prominent fifth metatarsal base or a rocker-bottom foot deformity, and the negative rocker functioned similarly to the toe-only rocker, but with slightly more reported stability.[28]

This is not the only evidence of tradeoffs in rocker-sole use.

A 2017 Sobhani et al study,[9] which was associated with two earlier studies,[10,11] evaluated the effect of rockers on running mechanics in endurance runners with Achilles tendinopathy. They compared a standard running shoe with a modified version of the same shoe with a stiffened rocker placed 53% proximal to the metatarsal region. They found the rockers were associated with reduced positive and negative work, as well as internal plantar flexion moment, at the ankle; however, they also were associated with increased mechanical work at the knee joint. The findings suggest this type of rocker may help to decrease the load on the Achilles tendon, but may also increase the risk of overuse injuries at the knee joint.[9]

"Knee load was higher when running with the rocker shoes compared with the neutral shoes, which is a warning sign people should be aware of," said lead author Sobhan Sobhani, PT, PhD, an assistant professor of physiotherapy and research coordinator in the Faculty of Rehabilitation Sciences at Shiraz University of Medical Sciences in Iran. "We never recommended rocker shoes to be used as a permanent running shoe, and have always suggested wearing them as an adjunct load management option, especially at the beginning phase of Achilles tendon rehabilitation. We still need additional clinical trials to check the clinical efficacy of rocker shoes in the management of Achilles tendinopathy."

Other research has shown that combining rockers with orthoses or integrating them into orthotic designs may elicit benefits, as well.

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In a 2012 study by Fong et al, the combination of toe-only rocker shoes and a custom-made foot orthosis was associated with a significantly lower visual analog scale pain score than either of the two modifications alone in patients with unilateral plantar fasciitis.[17] Two separate 2016 Farmani et al studies investigated the impact of rockers on the gait of hemiplegic stroke patients, with one evaluating AFOs when paired with either a standard or rocker-soled shoe,[15] and the other comparing solid AFOs to rocker AFOs.[16] Both found rockers were associated with positive effects, including improved gait abilities and functional mobility and decreased energy expenditure.

In a similarly designed 2015 randomized controlled trial (RCT) Menz and colleagues compared the effectiveness of prefabricated foot orthoses to rocker shoes for first metatarsophalangeal joint OA.[19]

"Our trial essentially found no difference between the two interventions in regard to foot pain, as both groups improved to a similar degree," Menz said. "Where the two interventions most differed was in relation to adherence, as many participants had difficulty incorporating rocker-sole shoes into their normal workplace attire. And though our trial suggests rockers are effective, a previous randomized trial[23] did not demonstrate any benefits of them over flat-sole shoes in managing low back pain."

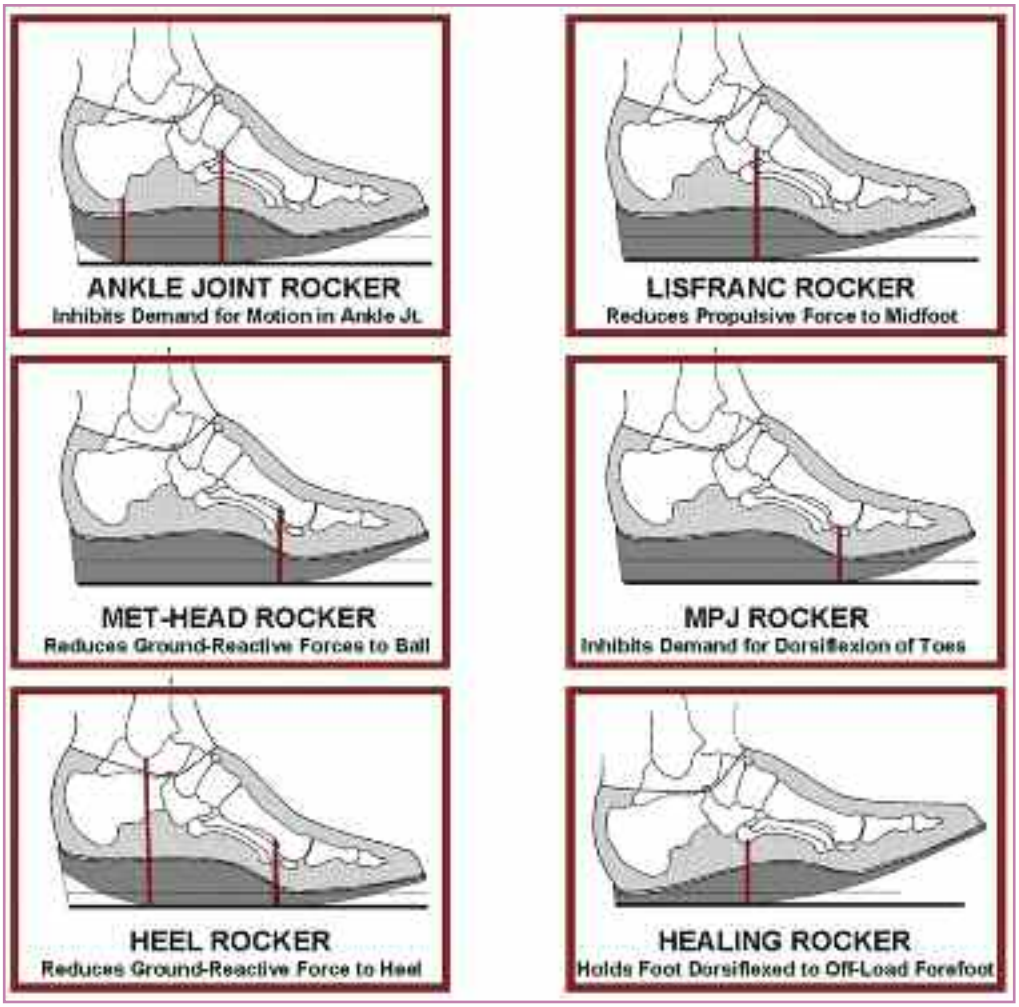

Figure 2. Images illustrate different types of rockers, with fulcrum locations indicated by vertical red lines. (Images courtesy of Arnie Davis, CPed.)

Beyond fitness

The MTP OA study and the low back pain study both used MBT shoes for their rocker-sole interventions, which has become a rather common practice in the recent literature.[2,8,12,13,22,31,32] MBT shoes originated in Switzerland in 1996 and debuted in North America in 2003. The shoe has a rounded sole in the anterior-posterior direction and a cushioned sensor under the heel area that creates a natural degree of instability to activate, strengthen, and condition neglected extrinsic foot muscles and provide benefits that are similar to those of barefoot locomotion (see "Unstable shoe designs: Functional implications," March 2011, page 31).

"There have been a number of studies on unstable shoes, mostly on walking activities, and the literature suggests that they generally have similar biomechanics to heel-to-toe rocker-profile shoes," Sobhani said. "Because of their unstable feature, they are believed to increase energy expenditure and are thus recommended as a good physical fitness and balance training tool, but the evidence is controversial."

Although MacRae et al found MBTs were no more beneficial than flat sole shoes in affecting disability and pain in people with chronic low back pain,[23] in a 2014 RCT wearing the unstable shoes for six weeks was associated with significantly decreased chronic low back pain but had no significant effect on quality of life and disability scores.[18]

A 2013 study conducted by Buchecker et al found that using the unstable shoes during level walking decreased mechanical demands on the lower body due to diminished joint moments and powers.[31] The authors suggested this may help reduce the risk of hip and/or knee OA, but comes at the expense of less mechanical input to the biological structures of locomotion.[31]

Two other studies looked specifically into using MBT shoes as a potential management intervention for knee OA. Tateuchi et al found they reduced knee flexion moment during walking without increasing compensatory trunk lean,[13] while Madden et al found peak knee adduction moment was lower in MBT shoes than non-rocker shoes, but still higher than during barefoot walking.[12]

Helping or hurting?

Despite the potential for reducing joint loads, researchers have stressed the need for additional studies on balance before recommending these shoes to older adults.

"The downside of MBTs, and indeed any rocker-sole shoe, is that some individuals may have difficulty habituating to the altered gait pattern induced by the shoe, and some will experience impaired balance. This is of particular concern for older people," Menz said.

This inherent risk with rockers has been pointed out in other trials, as well. Kimel Scott et al analyzed the use of forefoot rocker

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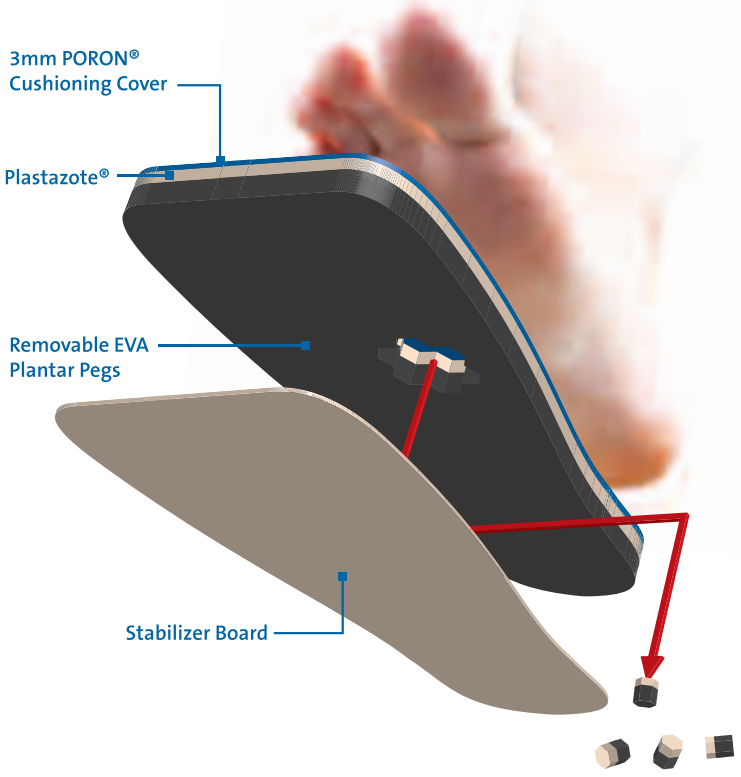

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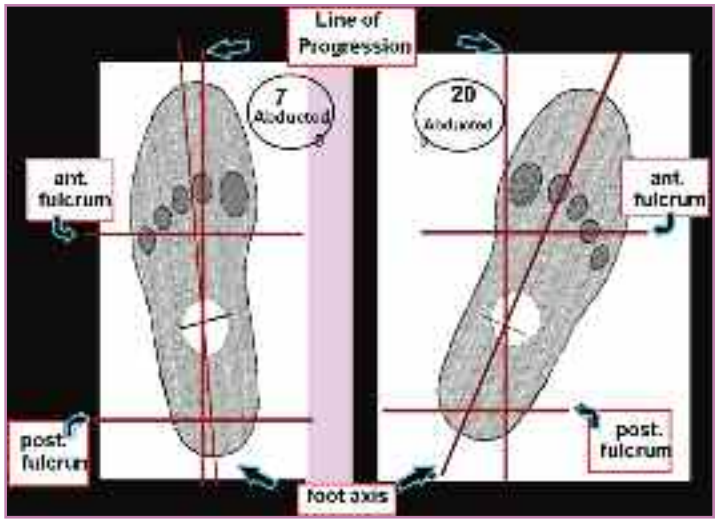

Figure 3. Rocker-bottom soles must consider the angle and base of gait. To be effective, fulcrums must be perpendicular to the line of progression. (Image courtesy of Arnie Davis, CPed.)

bottom soles in younger and older adults, and found them to be destabilizing to both groups, but even more significantly in the older group.[21] A 2009 study by Albright et al yielded similar outcomes, as rockers had a destabilizing effect on perturbed stance in young healthy adults.[4]

"The MBT is a fine, decent-made shoe, but my issue is that although they were fine for let's say a twenty-something-year-old whose proprioception and balance were really good, they were a disaster for anyone with any kind of gait abnormality, like a fractured hip waiting to happen," Sobel said.

Davis echoed this sentiment.

MBT-type shoes "force wearers to use certain muscles more than usual, which is their health therapeutic component. But do they help people with foot problems and pronation? I think it's going to hurt them before it helps them," he said. "So, although I know they can be beneficial for some, I generally don't recommend MBTs or similar types of shoes as a rehab method for people with foot issues. But I do have a pedorthist friend in New York who loves them and has recommended them to many of his patients."

Davis' friend is Robert Schwartz, CPed, past president of the Pedorthic Footcare Association and current president and CEO of Eneslow Pedorthic Enterprise in New York, NY.

"We have been carrying them in our shops for almost twenty years and commonly recommend them for plantar fasciitis, posterior tibial tendon dysfunction, and hallux limitus and rigidus, especially for people with the right foot size and shape to find comfort in them," Schwartz said. "Many people come back again and again, and I've found that they are great for improving balance, alignment, posture, and gait. I also wear them personally and have found them to be instrumental in accomplishing those goals."

But, while clinicians may not agree on all aspects of rocker-sole utilization, they do seem to universally value the importance of evaluating each patient to determine if they are a good fit and giving them ample time to adapt to any type of rocker-soled shoe.

"I think all clinicians should do a gait evaluation on patients

and look at their shoes beforehand to see where they're putting excessive pressure so you know what you need to do to give them the maximum benefit, while also being cautious to make sure [a rocker shoe] is stable enough so they don't fall on their face," Sobel said. "You should also do some gait training with patients [once they are given rocker shoes] and help them get used to it before sending them on their way, because the rocker is different than what they were using before."

Schwartz said he and his colleagues encourage patients to transition to rocker shoes slowly.

"Most people have to wear MBTs a little at a time until they gain strength and stamina, so we recommend wearing them an hour a day for the first few days and to increase gradually until they feel strong enough to wear them for a full day," he said.

Researchers and clinicians also appear to share a common stance when it comes to determining optimal rocker-sole design.

"Individual tailoring of outsole geometry needs to be done with a specific biomechanical objective, such as reducing plantar pressure, altering joint moments, or changing muscle activation patterns," Preece said. "Essentially, this is a process of trial and error where the clinician will use a pressure measurement system to evaluate the effects. There is no definitive algorithm that allows us to predict the effect of changing geometries, but this is something we are working towards."

Davis, for one, incorporates personalization into his pedorthic practices.

"The way the foot functions depends on how the bones are shaped, which varies in everybody. So one-size-fits-all just doesn't work," he said. "What I aim for is finding that sweet spot for where the rocker helps with symptoms but the person still feels stable. There also has to be a flat spot [on the sole] so the person can stand still."

Rocking on

Even given the evidence in support of rockers for many applications,[1,3,7-17,19] additional high-quality research is still needed to more thoroughly evaluate their effects on gait, balance, pain, and function to optimize recommendations and reduce the risk of tradeoffs like falls and injury.[4,10,12,15,19]

"Although there have been several studies examining the biomechanical effects of rocker-sole footwear, very few clinical trials have actually been conducted," Menz said. "It would therefore be useful to quantify differences with various designs in more detail, so a biomechanical dose-response relationship can be determined, which could assist in appropriately targeting different models to individual patient needs. Until further clinical trials are performed, many of the proposed benefits of these shoes remain speculative."

In the meantime, pedorthists like Sobel will continue prescribing and customizing rocker soles for the multitude of patients with gait abnormalities who stand to benefit from them, based in part on his own experience.

"In my opinion, rocker soles are invaluable as far as gait restoration and a necessary tool," he said. "So it's an easy sell." ler

Greg Gargiulo is a freelance medical writer based in San Francisco.

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Chronic ankle instability and self-reported function

Using patient-reported outcome tools can give lower extremity clinicians insight into the disability experienced by patients with chronic ankle instability. A combination of instruments may be necessary, as different assessments may capture different aspects of the condition.

By Adam B. Rosen PhD, ATC; and Cathleen N. Brown PhD, ATC

Lateral ankle sprains are the most common athletic injury and account for more than 7% of all injuries reported in collegiate sports.[1] Repetitive sprain can lead to an increased risk of ankle joint osteoarthritis and to a debilitating condition known as chronic ankle instability (CAI).[2] CAI is characterized by episodes of "giving way," is associated with poorer quality of life than in those who have never sprained their ankle, and is difficult to manage for the sports medicine clinician.[3] There is no consensus on the exact causes of CAI, however, multiple factors are thought to contribute.[4,5] These factors include both mechanical and functional deficits, which decrease the capacity of the individual to control the ankle joint during dynamic movement.[4]

Recognition and classification of CAI is challenging for sports medicine clinicians, as no gold-standard clinical tests or imaging techniques exist to identify individuals with CAI.[6] However, patient-reported outcome tools (PROs) or self-report questionnaires, combined with patient history, are the benchmarks most often used to assess CAI.[6] For the sports medicine clinician, understanding the type of questionnaire being used and the aspects of dysfunction being assessed is paramount.

There are different types of PROs, ranging from generic health questionnaires such as the Short form-36 Health Survey to questionnaires that are specific to an anatomic region (eg, Knee Injury and Osteoarthritis Outcome Score [KOOS]), disease (eg, Cumberland Ankle Instability Tool [CAIT]), or dimension (eg, physical activity assessment).[7] These instruments will provide the clinician with objective information regarding the patient's current mobility, limitations, and health-related quality of life (HRQOL).[7] Scores may also be used for goal-setting during rehabilitation to monitor progress and functional improvements.

As many self-report questionnaires are readily available and geared toward clinician implementation, users should be aware of each tool's clinimetric properties and clinical utility, which may vary between tools. Moreover, several clinical factors have been identified

A small but growing number of studies suggest that certain patient-reported outcomes are associated with clinical factors related to chronic ankle instability.

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Table 1. Common self-report function instruments and their clinical utility

MEASURE	SCALING	VALIDITY/RELIABILITY	CLINICAL UTILITY	MDC OR MCID	OTHER
AII Ankle Instability Instrument (Docherty et al[10])	9 yes/no questions with 3 subtest multiple choice questions "Yes" to 5 or more yes/no questions indicates FAI	Test-retest reliability ICC = .70-.90 Cronbach α = .89 overall	Sn .73 Sp .85 (Simon et al[19]) LR+ = 4.90 LR- = .32 (tabled data)		IAC endorsed: "Yes" to at least 5 questions (Q1 plus 4 others) indicates CAI
AJFAT Ankle Joint Functional Assessment Tool (Rozzi et al[11])	12 questions 0-48 points Higher = greater function FAI score <22 (Wikstrom et al[13])		Sn .18 Sp .77 (Donahue et al[8]) LR+ = .78 LR- = 1.10 (tabled data)		Scores significantly improved in a single study's impaired and control groups following rehabilitation intervention
CAIT Cumberland Ankle Instability Tool (Hiller et al)[13]	9 questions, 0-30 pts Higher = greater function Rec: ≤27.5 cutoff Others: ≤25 (Wright et al[14])	Validity: strong to moderate Test-retest reliability: excellent ICC = .96 Cronbach α = .83	Sn .83 Sp .75 LR+ = 3.27 LR- = .23 Sn .56 Sp .86 (Simon et al)		IAC endorsed: cutoff score of ≤24
FAAM **FAAM-Sport** Foot and Ankle Ability Measure and Sport Subscale (Martin et al[15])	29 questions FAAM 0-84 pts FAAM-Sport 0-32 pts Scores converted to %; higher = greater function	Construct validity with SF-36 Physical Function ADL Subscale r = .84 Sport Subscale r = .78 ADL Subscale ICC = .89 Sport Subscale ICC = .87 Internal consistency Cronbach α: FAAM = .96-.98 FAAM-S = .96	Sn .59 Sp .78 (Simon et al[19]) LR+ = 2.7 LR- = .52 (tabled data)	FAAM: MDC = 7.76% (5.7 pts) MCID = 9.50% (8 pts) FAAM-Sport: MDC = 15.48% (12.3 pts) MCID = 28.10% (9 pts) (Houston et al[24])	Scores significantly improved in a single study's group expected change in ADL and Sport subscales following a 4-week intervention IAC endorsed: ADL <90% Sport <80%
FADI **FADI-S** Foot and Ankle Disability Index and Sport Subscale (Hale & Hertel[16])	34 questions FADI 0-104 pts FADI-S 0-32 pts Scores converted to % Higher = greater function	Reliability FADI ICC = .85-.98 FADI-S ICC = .67-.94		FADI: MDC = ± 4.48 pts FADI-S: MDC = ± 6.39 pts (Eechaute et al[17])	FADI and FADI-S scores significantly improved in 1 study after 6-week training intervention
FAOS Foot and Ankle Outcome Score (Roos et al[18])	42 questions 0-100 pts <75% in 3 or more categories indicates FAI	Construct validity with Karlsson score; Spearman correlation r = .58-.67 Internally consistent and reproducible Reliability ICC =.70-.92 Internal consistency Cronbach α = .88-.97	Sn = .56 Sp = .76 (Simon et al[19]) LR+ = 2.30 LR- = .58 (tabled data)		IAC endorsed: <75% in 3 or more categories
IdFAI Identification of Functional Ankle Instability (Simon et al[19])	10 questions 0-37 points ≥11 indicates FAI	Test-retest reliability ICC = .96 overall Internal consistency Cronbach α > .9 in all age groups (Gurav et al[20])	Using cutoff of 10: Sn = .83 Sp = .94 (Simon et al[19]) LR+ = 13.83 LR- = .17 (tabled data) Overall accuracy = 89.6%		IAC endorsed: score of ≥11

ICC = intraclass correlation coefficient; Sn = sensitivity; Sp = specificity; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; MDC = minimal detectable change; MCID = minimum clinically important difference; IAC = International Ankle Consortium.

as contributing to the disability perceived and the function reported by individuals with CAI.

Assessing self-reported function

A number of frequently used self-report questionnaires for ankle instability exist, each with differing clinical utility and varying levels of support.[7,8] This review focuses on region- and disease-specific tools for CAI or functional ankle instability. We selected these tools based on their common usage, endorsement by the International Ankle Consortium (IAC),[6] and the evidence to support their use. We have included both discriminative instruments that identify individuals with a specific pathology like CAI, and evaluative instruments that quantify an individual's perceived level of function.[7] We will not discuss dimension-specific or generic tools, though those have been discussed by Houston et al[7] and elsewhere.

The tools highlighted are summarized below, and key characteristics are reported in Table 1. The table includes basic information on scoring and interpretation, validity and reliability, and clinical utility where available.

Construct validity, or comparison to a gold standard, is reported, as are test-retest and/or internal consistency. Test-retest is commonly reported as an intraclass correlation coefficient (ICC), where greater than .8 is generally considered good to excellent reliability. Internal consistency between the questions is reported as Cronbach's alpha, where greater than .7 is generally acceptable. Not all measures of validity and reliability in the literature were reported in the table.

Clinical utility is reported from original studies, secondary analysis, or as calculated from tabled data. Sensitivity, the ability of the test to correctly identify patients with the disease, and specificity, the ability of the test to correctly identify patients without the disease, are reported.[9] Generally higher values are better (>.8), but not always, and values may be interpreted in relation to one another.[9]

Likelihood ratios provide information for the probability a person with a given test result does have the condition.[9] Positive likelihood ratio (LR+) values greater than 10 represent large and important shifts in probability and are meaningful, while values of 5-10 are moderate shifts in probability and are probably meaningful.[9] Values less than 5 are likely not clinically meaningful.[9] Negative likelihood ratio (LR-) values less than .1 represent large and important shifts in probability and are meaningful. Values of .1-.2 represent medium shifts in probability and are probably meaningful, while values greater than .3 are likely not clinically meaningful.[9]

Minimal detectable change (MDC) is the smallest change value needed to surpass measurement variability, while minimal clinically important difference (MCID) is the smallest change value patients report as beneficial.[7] Not all clinimetric values were available in the literature for all instruments reported in this review.

Assessment tools

The Ankle Instability Instrument (AII) was designed specifically to determine ankle instability. It captures the severity of the initial injury, history of ankle instability, and instability during activities of daily living (ADLs).[10] It has good test-retest reliability and is endorsed by the IAC,[6] but little evidence exists detailing its clinical utility. The sensitivity and specificity values are good, but likelihood ratios may not be meaningful.

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The Ankle Joint Functional Assessment Tool (AJFAT) compares limbs bilaterally, thus assuming unilateral instability in the patient.[11] There is limited evidence for clinical utility,[12] but it may be responsive to treatment/rehabilitation interventions.

The CAIT was developed to identify and quantify the degree of instability and assess each ankle independently.[13] It has good validity and reliability values. The IAC has recommended lowering the initial cut-point from 27.5[13] to 25[14] to 24.[6] The CAIT's sensitivity and specificity show good clinical utility, but the likelihood ratios are only moderate.

The Foot and Ankle Ability Measure (FAAM) and its Sport subscale (FAAM-S)[15] are refinements of the Foot and Ankle Disability Index (FADI) and its Sport subscale (FADI-S), which are described in the next paragraph.[16] The FAAM focuses on ADLs and sports, and has five fewer questions than the FADI and FADI-S. Points are scored numerically but converted to a percentage. It has good evidence for validity and reliability, but only moderate clinical utility. MDC and MCID values exist for both subscales. The IAC has endorsed it with cut-off scores,[6] and it is likely responsive to treatment/rehabilitation interventions.[8,15]

The FADI is the original version of the FAAM, including one sleep-related question and four pain-related questions that were dropped when creating the FAAM.[16] It has ADL and Sport subscales, and each limb is scored separately and converted to a percentage. It displays moderate to good reliability depending on the scale, MDC values are available,[17] and it may be responsive to treatment/rehabilitation interventions. Most researchers currently support use of the FAAM over the FADI.[6]

The Foot and Ankle Outcome Score (FAOS) is a longer questionnaire with five areas: pain, other symptoms, ADLs, sport/recreational function, and foot/ankle quality of life.[18] Scores are transformed to a percentage. It demonstrates good reliability and internal consistency and moderate clinical utility, and is endorsed by the IAC with cut-off values.[6,8]

The Identification of Functional Ankle Instability (IdFAI) was developed from the AII and CAIT.[19] It has good clinical utility,[20] but MDC and MCID values do not appear to be available.

With regard to region-specific HRQOL outcomes, a systematic review indicated consistent results across 27 studies for the FAAM, FADI, CAIT, and AJFAT.[7] Individuals with CAI consistently scored lower than uninjured controls and copers (individuals who had an ankle sprain but recovered).[7] Comparison of copers and controls is not as clear or consistent.

Clinical contributions

Although much knowledge has been derived from these questionnaires regarding CAI patients' quality of life, less is known about which clinical factors contribute to reports of decreased function.

Several studies have investigated clinical measures and their contributions to self-reported function as indicated by PROs, both individually and through multivariate analyses. These studies assess a range of factors and their relationships with various instrumented questionnaires.

For example, Hubbard and colleagues[21] evaluated the FADI

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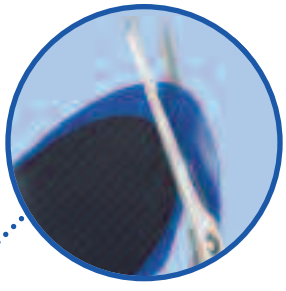

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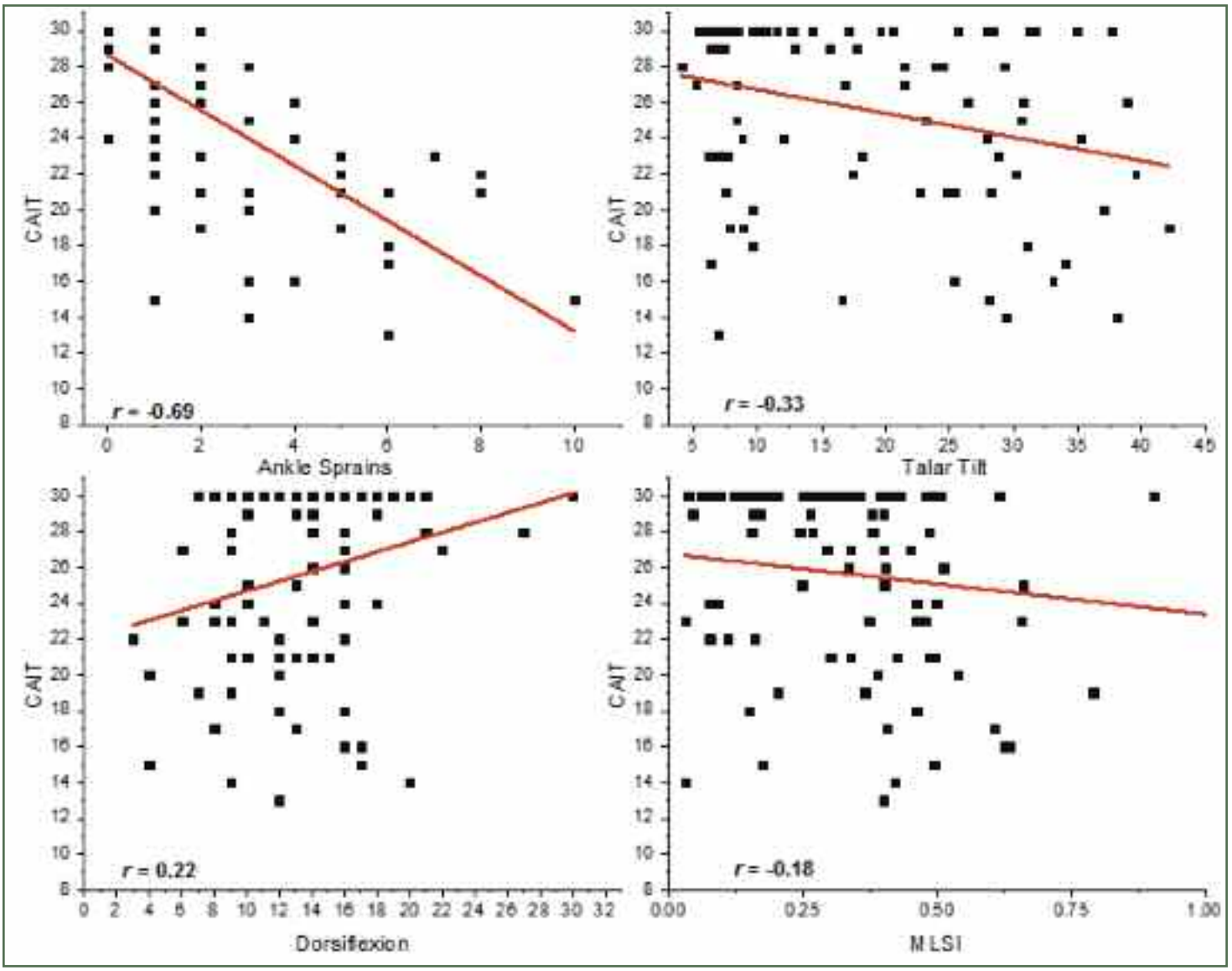

Figure 1. Scatter plots of individual factors that contribute to the Cumberland Ankle Instability Tool: ankle sprain history (top left); inversion laxity talar tilt (top right); dorsiflexion range of motion (bottom left); Medial Lateral Stability Index (bottom right).

and FADI-S in 30 individuals with CAI while also measuring a number of clinical measures including fibular position, an ankle arthrometer assessment of laxity, static and dynamic postural stability, isokinetic ankle and hip strength, and dynamic balance based on the Star Excursion Balance Test. The authors found that the FADI and its Sports subscale demonstrated moderate correlations with center of pressure measures during eyes-open and eyes-closed balance, indicating those with poorer function also had worse static balance. In a subsequent study by Hubbard,[22] mechanical laxity and the FADI and FADI-S were evaluated in 120 participants with unilateral CAI. Anterior laxity was strongly to moderately correlated (r = -.88) with the FADI and FADI-S (r = -.65), while inversion talar tilt was moderately correlated with the FADI (r = -.53) and FADI-S (r = -.45). These results suggest that increased laxity, especially anteriorly, may contribute to the perceived dysfunction reported by patients with CAI.

With regard to multivariate analysis, only two manuscripts have been published, one by our research team[23] on the CAIT, and another by Houston et al[24] that investigated several health-related quality of life measures.

Our study assessed 93 individuals with varying histories of ankle injury. Injury history, range of motion, dynamic postural stability, and laxity were taken for each of the participants. We found a history of lateral ankle sprain had the greatest influence on CAIT score, followed by laxity, dorsiflexion deficits, and medial-lateral dynamic postural stability, respectively (Figure 1). Combined, these variables accounted for 57% of the variability of the CAIT. This suggests those who report greater numbers of sprains report worse function, and that increased laxity, worse dynamic postural stability, and less dorsiflexion also contribute to perceived dysfunction, but to a lesser extent than injury history.

In the other study to include a multivariate assessment, Houston et al[24] evaluated isometric strength, static and dynamic balance, plantar cutaneous sensation, dorsiflexion range of motion, and laxity in 40 individuals with CAI. They examined these measures against

four different self-report questionnaires; the Short Form-12 (both mental and physical components), Disablement in the Physically Active Scale (DPA), Fear-Avoidance Beliefs Questionnaire (FABQ), and FAAM. Of the clinical measures assessed, static and dynamic postural control, dorsiflexion ROM, plantar cutaneous sensation, and laxity explained between 7% and 35% of the variability in PRO scores, depending on the questionnaire. More specifically, worse postural control, sensation, dorsiflexion, and laxity explained a significant portion of health-related quality of life in individuals with CAI.

Clinical implications

Using PROs can provide insight into the disability a patient with CAI experiences. For the sports medicine clinician, choosing an appropriate PRO or questionnaire to assess disability or for rehabilitation monitoring can be a daunting task, as many are available.

In this review, we have highlighted several useful tools with moderate to excellent clinical utility that are easy for clinicians working with CAI patients to administer and interpret, and may be responsive to change over the course of a rehabilitation program. The FAAM likely has the best clinimetric properties overall, but the CAIT, IdFAI, FAOS, and AII are all good alternatives. The IdFAI is a well-supported combination of two measures.[25] A combination of instruments may be necessary, as performance on one may be different than on another, and different assessments may capture different aspects of the condition.[7,8,17]

In addition to the utilization of PROs, understanding the factors that contribute to perceived dysfunction will allow sports medicine clinicians to more effectively treat patients with CAI. Reduced dorsiflexion ROM has been consistently related to dysfunction, indicating that improving ROM may have beneficial effects on self-reported function. Interventions such as joint mobilizations[26-28] and static stretching[29] have demonstrated robust improvements in dorsiflexion ROM.

Prior work also suggests preventive strategies that aim to reduce future sprains should be emphasized. Bracing and taping interventions may provide multiple benefits to those with CAI to assist in reducing the deleterious effects of mechanical laxity through altered arthrokinematics, as well as providing a secondary benefit of reducing the risk of future ankle sprain.[30] Given that both static and dynamic balance demonstrated small to moderate significant correlations with self-reported functional limitations, incorporating balance protocols into rehabilitation and preventive programs appears fundamental.[31]

The literature on patient-reported outcomes also underscores the concept that each individual with CAI may report a different combination of decreased functional ability and clinical measures. Because CAI is a multifactorial problem affecting a heterogeneous population, providing a comprehensive treatment plan may be necessary to improve individual patient outcomes.

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Foot posture, orthoses, and patellofemoral pain

Prescription of foot orthoses for runners with patellofemoral pain (PFP) is often based on the premise that individuals with excessive pronation are among those most likely to have a positive response. However, preliminary analyses indicate this may not be the case.

By Thomas Gus Almonroeder, DPT; and John Willson, PT, PhD

Running is a popular mode of physical activity for a variety of reasons (convenience, relatively low cost, etc). According to recent reports from Running USA, an organization that monitors running trends, there are typically more than 17 million participants in organized running events each year.[1] Unfortunately, running-related injuries are common, with the knee joint being most frequently affected.[2,3] Of these running-related knee injuries, patellofemoral pain (PFP) is most prevalent.[4]

Patellofemoral pain has traditionally been considered to be a self-limiting condition with relatively benign long-term consequences.[5] However, this premise appears to be misguided, as PFP can often persist if untreated[6] and may contribute to the development of patellofemoral joint osteoarthritis.[7] As a result, the development of effective prevention/treatment approaches is imperative. Unfortunately, traditional interventions (pain management modalities, foot orthoses, quadriceps strengthening, and general flexibility exercises) have been described as "unsatisfactory" by many patients with PFP.[8]

The pathogenesis of PFP is complex; however, it appears to be related to elevated patellofemoral joint stress.[9,10] Patellofemoral joint stress is dictated by the forces acting at the patellofemoral joint and the contact area between the patella and the trochlear groove of the femur. When patellofemoral forces are maintained, patellofemoral stress will increase with a decrease in contact area. In addition to factors local to the knee joint, a variety of proximal and distal factors also have the potential to alter patellofemoral joint contact area.[11] Not surprisingly, PFP prevention and treatment approaches often attempt to address these local, proximal, and distal factors either in isolation or in combination.

Pronation and PFP

Excessive foot pronation is a distal factor that has the potential to influence patellofemoral joint contact area. Foot pronation is a triplanar motion involving ankle dorsiflexion, calcaneal eversion, and forefoot abduction. Theoretical models have been used to explain

Although more research in this area is needed, the effects of foot orthoses on knee mechanics during running appear to be independent of foot posture or mobility.

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how excessive or prolonged pronation of the foot could influence the mechanics of the knee in a manner that would disrupt the normal function of the patellofemoral joint.[12,13] For instance, Tiberio et al in 1987 described a theoretical model in which excessive foot pronation results in a compensatory internal rotation of the leg and femur, which reduces patellofemoral contact area.[13] Excessive foot pronation may also reduce patellofemoral contact area secondary to increased knee abduction.[12]

The validity of these theoretical models is supported by reports that individuals with PFP commonly demonstrate a more pronated foot posture than individuals without PFP.[14,15] However, findings from prospective analyses have been relatively inconsistent, as both increased[16] and decreased foot pronation[17] have been reported to be risk factors for PFP, while two additional prospective studies found no association between foot mobility and PFP risk.[18,19] While our understanding of the precise role that foot pronation plays in the etiology of PFP is limited at this time, recent evidence[20] does indicate excessive pronation may be a contributing factor for a subgroup of individuals (see "Patellofemoral pain subgroups: A critical first step toward personalized clinical intervention," January 2017, page 18).

Foot orthoses and PFP

Due to the potential link between foot pronation and PFP, foot orthoses are often used in PFP management. The design of these orthoses varies considerably (eg, length, material, custom vs prefabricated), but they typically incorporate varying degrees of wedging along their medial border. It is believed that, by altering the alignment of the foot or changing the location of the center of pressure, an orthosis may influence knee mechanics during dynamic activities such as running, and that this has the potential to alleviate symptoms in individuals with PFP.[13]

There is evidence that foot orthoses may have clinical benefits in individuals with PFP, such as reduced pain and improved function.[21-23] In fact, the consensus statement published following the most recent International Patellofemoral Pain Research Retreat recommended the use of foot orthoses for short-term pain management.[24] However, the beneficial effects of foot orthoses appear to be relatively small and inconsistent among individuals, particularly in the long term.[21,25] As a result, there is a need to identify the subgroup of individuals with PFP who are likely to respond favorably to foot orthoses.

Two studies have attempted to develop clinical prediction rules for this purpose have identified clinical foot posture and mobility measurements as associated with a greater likelihood that an individual will experience reduced pain with the use of foot orthoses.[26,27] However, it is important to note that different clinical measurements were identified in these two studies and that neither rule has been cross-validated. Also, each of these studies utilized a single-arm design instead of developing these clinical prediction rules as part of a randomized controlled trial. As a result, it is impossible to determine if the factors identified are truly associated with foot orthoses' effectiveness or if the authors had instead identified factors associated with self-limiting PFP (ie, PFP that would have subsided without treatment). Regardless, more work in this area is justified.

Questioning the premise

Based on the theoretical rationale, foot orthoses are typically prescribed for individuals who demonstrate clinical evidence of "excessive" foot pronation.[28,29] This premise assumes the mechanical effects of the orthoses will be more pronounced in these individuals. However, two recent studies suggest this may not be the case.[30,31]

In the first, investigators classified 40 female runners aged between 18 and 35 years into three groups based on their calcaneal eversion angle during single-leg standing (inverted, neutral, or everted).[31] Calcaneal eversion represents the frontal plane component of foot pronation. Each participant performed running trials with and without full-length foot orthoses that included 6° of medial wedging. The mechanics of the knee (joint angles and moments) in the frontal and transverse planes were analyzed during the running trials. The authors of the study hypothesized that the effects of the foot orthoses would differ among the groups, with more

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prominent effects being demonstrated by the individuals in the 'everted' group. However, they found no group (inverted, neutral, everted) by condition (with orthoses, without orthoses) interaction, indicating the effects of the orthoses were not dependent on an individual's standing calcaneal eversion angle.

Similar results were reported in the second study, which analyzed the effects of foot orthoses with 5° of medial wedging on the frontal plane angle and moment time series in healthy male and female runners.[30] The authors reported the effects of the orthoses were not significantly related to an individual's navicular drop height. Navicular drop height is a commonly used clinical measure to assess foot mobility and pronation.

The results of these two studies indicate the effects of foot orthoses on knee mechanics during running may be independent of clinical foot posture or mobility. This is an important finding, as it challenges the underlying premise that foot orthoses should be prescribed to individuals with a more pronated foot.

However, it is important to note that clinical tests and measures involving static assessment of the foot, such as the standing calcaneal eversion angle and the navicular drop height, are limited in that they appear to be only weakly related to the behavior of the foot during dynamic activities, such as walking and running.[30,32,33] As a result, it is difficult to determine if the lack of a relationship between foot posture/mobility and the effect of foot orthoses on knee mechanics is the result of: 1) limitations associated with clinical measures of foot posture/mobility, or 2) a flawed assumption that foot orthoses will have greater mechanical effects in individuals with a more pronated foot. While future research efforts should be directed at developing reliable clinical measures that better reflect the dynamic behavior of the foot, further analysis of the theoretical basis upon which foot orthoses are often prescribed also appears warranted.

A step further

As clinical measures of foot posture/mobility may be poor surrogate measures of foot dynamics, Almonroeder, Benson, and O'Connor recently conducted a follow-up analysis[34] of their previous work that did not identify a relationship between the effects of foot orthoses and an individual's navicular drop height.[30] Like the analysis conducted by Boldt et al,[31] they categorized participants based on their peak calcaneal eversion. However, instead of a static measure of calcaneal eversion, they used a "dynamic foot motion" metric, which was the peak calcaneal eversion angle during running trials relative to the degree of calcaneal eversion during a relaxed standing position.

The study included 31 male and female recreational athletes aged between 18 and 45 years. Each participant performed running trials with and without medially wedged (5°) foot orthoses. The 10 participants with the greatest dynamic foot motion were identified (everted group), as well as the 10 participants with the least dynamic foot motion (inverted group). The everted group demonstrated approximately 8° more dynamic foot motion during the running trials than the inverted group. Interestingly, the effects of the orthoses on frontal and transverse plane knee mechanics did not differ among the groups. These results are consistent with the earlier findings that relied on a clinical measure of foot mobility, and further question the premise that foot orthoses will have more prominent mechanical effects in individuals with greater foot pronation.

Additional considerations

Despite this preliminary evidence, it is important to note that the results of previous analyses may be heavily influenced by the methods used to characterize foot posture or rearfoot dynamics. Although both the standing calcaneal eversion angle and the navicular drop height are commonly used, there is certainly a plethora of alternative clinical measures with which to classify individuals based on their foot posture or mobility.

There are also important factors to consider when characterizing individuals based on their rearfoot dynamics. The dynamic foot motion measure used by Almonroeder et al[34] reflected the motion of the calcaneus during running relative to its position during relaxed standing. It is possible that subtle methodological factors could have influenced participant assignment to the everted versus inverted groups. It is also possible that classifying participants based on dynamic foot behavior requires a more precise analysis than what is possible when the foot is modeled as a single rigid segment. Regardless, at this time it appears there is a further need to explore factors that will influence the mechanical effects of foot orthoses at the knee.

Despite the findings highlighted in this review, foot orthoses may still promote clinical benefits for individuals with a more pronated foot. In fact, a previous study indicates that individuals with greater calcaneal eversion during walking may be more likely to benefit from foot orthoses.[35] The authors of this study conducted a baseline 3D motion analysis of 25 individuals with PFP while they walked at a self-selected pace. Following the baseline testing session, participants were provided with prefabricated foot orthoses that included 4° of medial wedging. After 12 weeks of wearing the orthoses during their normal physical activities, participants were

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asked to rate their level of improvement. Seven of the participants reported that they were "markedly better." These individuals demonstrated significantly greater calcaneal eversion than the rest of the cohort during the baseline walking trials.

Although this finding indicates individuals with a more pronated foot may be more likely to benefit from foot orthoses, it is difficult to determine why this is the case in light of the available evidence. It is possible that the greater clinical benefits for individuals with a more pronated foot may be explained by nonmechanical factors (eg, altered lower extremity muscle activity).

There also is some evidence to support the premise that the positive clinical benefits associated with foot orthoses may not have a mechanical origin. For instance, a recent study randomly assigned a cohort of runners with PFP to either receive medially or laterally wedged orthoses.[36] Although medially wedged foot orthoses are typically used in the management of PFP, after six weeks both groups reported a significant reduction in their pain during running. Although the study did not involve any type of foot assessment (clinical or dynamic), the findings do highlight the fact that nonmechanical mechanisms deserve consideration when attempting to explain the underlying reasons why some individuals with PFP benefit from foot orthoses.

Conclusion

Prescription of foot orthoses for the management of PFP among runners is often based on the premise that their effect on knee mechanics will be greater in individuals with evidence of excessive pronation. However, preliminary analyses of running mechanics among participants classified according to clinical measures of foot posture or mobility indicate this may not be the case. Similar results were reported when individuals were classified based on their rearfoot dynamics during running. Although this is certainly an area that warrants additional analysis, current evidence suggests it may be necessary to reconsider the theoretical basis upon which foot orthoses are prescribed for individuals with PFP.

Thomas Gus Almonroeder, DPT, is a PhD candidate in the Kinesiology Program at the University of Wisconsin-Milwaukee. John Willson, PT, PhD, is an associate professor in the Department of Physical Therapy and director of the Human Movement Analysis Lab at East Carolina University in Greenville, NC.

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Putting prehab to the test highlights inconsistencies

The growing popularity of prehabilitation contrasts with mixed findings in the lower extremity literature: Specifically, the approach seems to be more effective in patients undergoing anterior cruciate ligament (ACL) reconstruction than those undergoing hip or knee replacement.

By Cary Groner

In recent years, lower extremity practitioners have been instrumental in developing "prehabilitation" regimens that aim to strengthen patients in advance of orthopedic surgeries, with the goal of making for a quicker and better recovery.

Papers describing outcomes have reported decidedly mixed results, however; in the lower extremity literature, specifically, prehab seems to be far more effective in patients undergoing anterior cruciate ligament (ACL) reconstruction than those undergoing hip or knee replacement. Increasingly, it appears that prehab's success—or lack thereof—depends on a number of variables that include the type of surgery performed and several aspects of the patient's profile.

Moreover, as the Center for Medicare & Medicaid Services (CMS) continues to phase in its Comprehensive Care for Joint Replacement (CJR) reimbursement model,[1] which includes financial penalties for exceeding a bundled payment, hospital administrators will be increasingly motivated to identify aspects of care that contribute to efficient recovery and to eliminate those that don't. Even before prehab is factored in, expenses associated with joint replacement procedures are high, according to CMS; Medicare patients received 400,000 hip or knee replacements in 2014, and per-procedure costs ranged from $16,500 to $33,000 across geographic areas.[2]

If clinicians want to promote prehab, then, they're going to have to justify it both therapeutically and in terms of cost efficiency.

It appears that prehab's success—or lack thereof—depends on a number of variables that include the type of surgery performed and several aspects of the patient's profile.

Prehab and joint replacements

As previously described in *LER*, clinicians in several therapeutic settings have tested prehab approaches for total knee replacements (TKAs) and total hip replacements (THAs).[3-5] The strengthening that usually accompanies a prehab regimen should theoretically offer benefits to these patients given that they almost always have painful osteoarthritis, which discourages exercise and leads to a concomitant loss of muscle tone. Nevertheless, the findings reported by

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these authors are typical of those found by others: the programs improve preoperative functional status, muscle strength, and related goals, but their effects rarely carry over postsurgically. These conclusions have been borne out in other papers by those same researchers, including a 2012 article in *Physical Medicine & Rehabilitation* reporting that, while a prehab intervention led to significant increases in quadriceps strength and walking speed before TKA, there were no benefits 12 weeks after the surgery.[6]

Jonathan Chang, MD, a clinical associate professor of orthopedics at the University of Southern California in Los Angeles, explained some of the challenges associated with prehab in such patients.

"For some of them, trying to do that kind of program is too painful," Chang said. "That's why you're planning the surgery, after all—things have deteriorated enough that it's the only hope. If you can get compliance with a prehab regimen you'll show improvement in strength, but does that translate into better postop success? It would make sense, but we're not really finding that. As a big advocate of exercise, it's hard for me to accept, but it has to be a consideration. It may be that the hit you get from the operation is sufficient that it knocks everybody back to baseline."

To be fair, some researchers have reported positive postoperative results from prehab, but they are not usually long-lasting. In one case, Thai investigators reported decreased pain, as well as improved quadriceps strength and quality of life (QOL), in the short term after TKA.[7] In another, researchers in Spain found that preoperative strengthening shortened postoperative length of stay and led to faster recovery.[8] And a 2014 study from Italy found that a prehab program led to better knee ROM just after surgery, though the advantage had vanished by six weeks out.[9]

These votes of confidence are far outweighed by the studies that have found little or no postoperative benefit from prehab for TKA and THA patients, however. For example, a 2004 Canadian study found prehab did not alter functional recovery or QOL after TKA.[10] A 2008 study in *Clinical Rehabilitation* reported that preoperative PT did not improve impairment or QOL after surgery in THA patients.[11] A 2014 paper found that eight weeks of prehab offered no additional benefits (over surgery alone) three months postoperatively.[12] A 2015 article from Switzerland, similarly, found no difference three months postoperatively between prehab and control patients.[13] A literature review of 13 studies that same year found no significant postsurgical benefits in function, QOL, or pain in THA patients, though it did note prehab may have reduced use of postoperative rehabilitation.[14] Finally, a 2016 article in *BMJ Open* reported that, whereas prehab may have slightly improved early postsurgical pain and function, the effects remained too small and short-term to be clinically important, and had no effect on key outcomes such as length of stay, QOL, and costs.[15]

Seeking better evidence

In one of the *LER* articles already mentioned, Claire Robbins, PT, DPT, coordinator of arthroplasty research at New England Baptist Hospital in Boston, described the comprehensive prehab model that had been instituted there for TKA and THA patients, including "evaluation, education, and therapeutic exercise designed to meet the functional, psychological, and social needs of patients undergoing joint replacement surgery."[4] She noted the program had helped modify patients' expectations of recovery and had decreased length of stay; moreover, in a separate article, she reported that in one patient subset—those who were obese—prehab exercises improved

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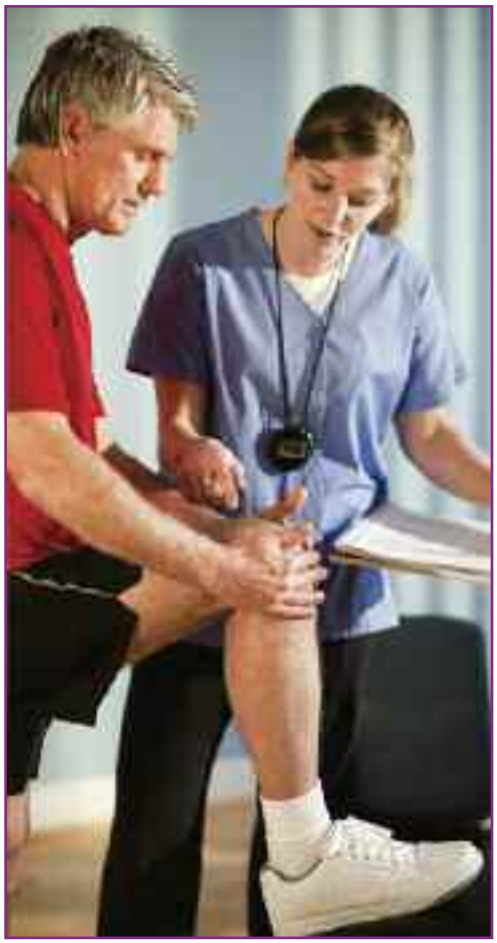
postop functional mobility and increased the rate of immediate home discharge (to 54%, vs 46% of those who didn't exercise preoperatively).[16]

When *LER* spoke to Robbins for this article, however, she acknowledged that in the general population, evidence for clinically significant advantages of prehab isn't yet available.

"I wish I could say we've documented positive clinical outcomes, but I don't think the physical therapy profession is totally on board yet in recording those and reporting them back to the surgeon," she said. "We have to start collecting that data—find out, for example, why some patients are more likely to come back within thirty days for manipulation of the knee. Then you know how to better gear your prehab and patient education."

Regarding the CMS reimbursement program, Robbins hopes it will spur improved prehab approaches and accountability.

"It's going to prompt facilities to look at their standards of care, how they are approaching this type of surgery, what can be done better," she said. "We need to establish a clinical pathway so that we get the best results. If prehab is part of that—if it looks like we have this group that did prehab and they didn't get readmitted within thirty days as often—then let's keep it. It's going to become hugely important going forward."



A different story with ACL repair

If it's challenging to make a case for the strength of prehab's positive effects in patients undergoing total joint replacements, the job becomes easier when it comes to those having ACL reconstruction. Studies dating back more than a decade have delineated the postoperative advantages of prehab in these patients.

For example, a 2003 Australian paper reported a significant correlation between quadriceps strength and functional stability both before and after ACL repair.[17] In 2013, Irish investigators reported that a six-week preoperative exercise program led to postoperative improvements in knee function, such as in the single-leg hop test.[18] Another paper that year, from the University of Delaware in Newark, found that preoperative quadriceps strength in patients given prehab predicted self-reported function six months after ACL reconstruction.[19] In 2015, Korean researchers reported that four weeks of prehab had positive effects three months postreconstruction, particularly in extensor strength deficits.[20] And a 2015 study in the *British Journal of Sports Medicine* found that Norwegian patients who received prehab had superior outcomes two years postoperatively versus those who had normal care—for example, 86% to 94% were within the normative range of the five Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales, versus 51% to 76% of those who did not receive prehab.[21]

Some of the benefits of prehab in ACL patients may have to do with the demographics of the population, according to Jonathan Chang.

"Most people—not all, but most—who have ACL reconstructions have them due to sports injuries," he said. "They're younger, they're used to working out, and there are fewer of the comorbidities and BMI [body mass index] issues that afflict older OA patients."

Claire Robbins agreed.

"The ACL is such a small structure, but it takes such great stress, that prehab conditioning is really important," she said. "The patients are in a protected period postop, their weightbearing and range of motion are limited, and after six weeks there's a huge decrease in strength and function. But, if those muscles are prepared preoperatively for that, if they're stronger and better able to handle that decline, I think it makes a difference."

Describing the advantages of prehab in these patients can become convoluted, given the complexities of the related physiology. For example, experts have long suspected that quadriceps activation failure—a neural inability to fully contract the muscle despite the absence of structural damage to it—contributes to the weakness that follows ACL reconstruction. However, until recently no one had studied the impact of preoperative activation on postoperative quadriceps function.

In 2016, however, researchers at the University of Michigan reported that preoperative activation was not associated with postoperative strength, in fact; rather, preop activation was related to postop activation, and preop strength to postop strength. The authors concluded therapeutic approaches should target both activation and strength for the most complete improvements after surgery.[22]

The paper's lead author, Lindsey Lepley, PhD, ATC, told *LER* that prehab in ACL patients is beneficial, in her experience.

"It improves postoperative functional performance in things like hop testing and agility measures that people use as return-to-sport criteria," said Lepley, now an assistant professor of kinesiology at the University of Connecticut in Storrs. "It also seems to be beneficial from a self-reported outcomes perspective. Another compelling argument for preoperative rehabilitation is that it's not that big of a time investment; emerging evidence[21] indicates that ten treatments over five weeks is beneficial."

Underlying neural factors

Lepley and her colleagues have focused particularly on the role of neural function in these patients and have done their best to tease out which aspects of prehab affect postsurgical outcomes.

"We're looking at some of the factors underlying poor quadriceps muscle strength after ACL reconstruction, and we're seeing that neural activity—someone's ability to fire their muscle on their own, to volitionally activate it—is also related to how well they can do that before surgery," she said. "Opening up the joint capsule to surgically repair the ACL is another neurological insult to the joint, compounding the neuromuscular deficits associated with the injury

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itself. That, in turn, could compromise the direct relationship between preoperative activation and postoperative strength."

Understanding this doesn't necessarily elucidate the underlying causes, Lepley acknowledged.

"Neural alterations at a variety of levels could be contributing to a depressed neural environment after ACL surgery," she said. "For example, someone could have altered information coming in from the joint, or descending cortical inhibition, or alterations at the interneuron level that could contribute to the inability to activate the muscle well. After ACL injury and reconstruction, all of these pathways could be involved."

Further complicating assessment, Lepley said, is that distinct pathways may be implicated before and after the reconstruction surgery.

"There could be different mediators affecting the patient's ability to volitionally fire their quadriceps preoperatively than postoperatively," she said.

As for how this relates to prehabilitation regimens, Lepley pointed out that good neurological activity contributes to strength, and to the patient's performance on agility tests.

"You may need to approach prehab the way you would postoperative care, acknowledging that there's a depressed neural environment," she said. "The clinician's goal should be to identify interventions that can promote someone's ability to fire their muscles on their own, because this underlying neurological factor is going to either help promote rehabilitation or delay it even more."

To that end, Lepley supports prehab neuromuscular training regimens that include perturbation, such as the one developed at the University of Delaware, which have been shown to improve gait symmetry prior to ACL reconstruction.[23]


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"You can achieve those perturbations through balance or rocker-board activities, and of course we want to reinstitute range of motion, minimize joint effusion, improve force production, and get good quadriceps strength overall," she said. "Ideally, we think patients should have ninety percent of their strength on their ACL-reconstructed limb, compared to the uninjured side, before they return to sport, and maybe those guidelines should be imposed before someone undergoes ACL surgery."[21]

Neuromuscular training

Investigators at the University of Delaware have investigated preoperative neuromuscular training in ACL patients, in fact, and found that it significantly improved outcomes two years after surgery.[24] The study compared 150 patients from the Delaware-Oslo Cohort (DOC) to 150 from the Multicenter Orthopaedic Outcomes Network (MOON) cohort, who did not have extended prehab. At two years, those who had participated in the Delaware regimen of progressive strengthening and neuromuscular training had significantly better scores on two knee outcome scales (IKDC and KOOS), and significantly more had returned to preinjury sports than in the MOON group (72% vs 63% respectively).

Lead author Mathew Failla, PT, PhD, now an assistant professor of physical therapy at the University of Vermont in Burlington, told *LER* that currently, the typical requirement for someone about to undergo an ACL reconstruction is that the knee be "quiet"—that is, that there be an absence of swelling, a return of visible quadriceps contraction, and full range of motion.

"We wanted to know whether that was good enough," Failla said. "So with the study we compared the two cohorts and saw that the one that underwent the additional preoperative rehab ended up having better postoperative outcomes at two years."

Although neuromuscular training targeted specifically for an ACL-deficient population was part of the study regimen for the Delaware cohort, he continued, the researchers don't yet know to what extent it contributed to the functional gains.

"We put them through ten sessions that included neuromuscular or perturbation training—a combination of high-level balance exercises and neuromuscular control exercises," he explained. "We still don't know if it was the neuromuscular training itself that led to those improved outcomes or the entire package. We've just begun to scratch the surface of prehab; we don't know what the ideal program is, and it's likely to be specific to certain populations or pathologies. As more prospective research is completed, we should be able to design targeted programs both pre- and postoperatively to maximize those outcomes."

Failla believes future therapeutic approaches will most likely balance the best of new and old.

"Historically, we've had a bias that what happens after surgery is most important," he said. "Now we're seeing that there is a potential to influence outcomes based on the status of the patient entering surgery. Even so, we don't want to get too fancy with treatments and technologies. Our evidence so far takes us back to the basics of a sound program that addresses strength, range of motion, and dynamic control of movement. It's a challenging program that's continually reassessed to make sure gains are being made. It's not sexy, but it's evidence-based, and so far it's withstood the test of time." ler

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

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The Functional Movement Screen (FMS) Test Kit is a quick and easy way for lower extremity clinicians to test and assess functional mobility, stability, and flexibility; a simple grading system can be used to quantify muscle weakness or imbalances. The kit is lightweight and portable, and comes with a travel bag for storage and transport. The kit also features a new Motor Control Screen Slide Box for more efficient testing of how individuals stabilize, balance, and control movement through single limb competency. This FMS Test Kit with the Motor Control Screen Box is only available from Perform Better.

Perform Better
800/556-7464
performbetter.com

Therapeutic Swede-O Socks

Swede-O Low Profile Performance Socks assist in preventing and treating plantar fasciitis, heel pain, heel spurs, and arch pain by focusing support and compression on specific areas of the foot and ankle. The Low Profile Performance Socks have targeted compression zones that provide firm support to help relieve tension and pain during the day when the patient needs it most. The medical-grade compression ranges from 16 mm Hg in the ball of the foot to 39 mm Hg at the Achilles. Silver microbial fibers in the toe and heel feature antibacterial and antiodor properties. The socks are available in five sizes (XS-XL).

Swede-O
800/525-9339
swedeo.com

Visit lermagazine.com/products for more products and to submit your new product listing.

ler new products

Quantum V Body Comp Analyzer

RJL Systems, a pioneer of Bioelectrical Impedance Analysis (BIA) technology, announces its latest body composition analyzer, the Quantum V Segmental BIA. Whereas previous generations focused solely on whole body composition assessment, the newest model is a Class II medical device that has been enhanced to provide accurate and fast segmental body composition assessments of lean soft tissue for 13 zones of the human body, including the lower extremities. For easy operation, the Quantum V's software automatically handles selecting eight leads, scanning multiple zones, and calibrating each zone.

RJL Systems
800/528-4513
rjlsystems.com

Contact Sport Arch Support

New from Birkenstock USA is the Birko Contact Sport, a full-length arch support for men and women that is anatomically shaped and cushioned to help reduce stress on the knees, hips, and spine. The new insole features a semirigid EVA (ethylene vinyl acetate) shell that is flexible and waterproof, with a latex/microfiber liner that aids in shock absorption and wicks away moisture. Most effective when worn with athletic shoes or work shoes, the Birko Contact Sport device is recommended for all arch types. The Birko Contact Sport is available in wide width only. The MSRP is $69.95 per pair.

Birkenstock USA
800/9497301
birkenstock.com

Ottobock Pheon and Prosedo

Ottobock announces the release of the Pheon and Prosedo mechanical prosthetic knees, designed to provide mobility and stability for less active transfemoral amputees. The Pheon polycentric knee joint helps restore the ability to stand and walk indoors and in limited community settings. It features an integrated optional lock that can be activated or deactivated by the clinician. The Prosedo monocentric locking knee joint features individually adjustable, hydraulically controlled support for sitting down, dampening knee flexion progressively to provide balance and reduce strain on the user's sound side.

Ottobock
800/328-4058
ottobockus.com

Premium Lace Up Ankle Brace

Dalco International offers its new Premium Lace Up Ankle Brace, designed to provide the benefits of a soft ankle support and a traditional stirrup. The brace is constructed of breathable mesh for comfort, performance, and durability. The figure-eight nylon straps provide inversion and eversion control, while external plastic stays surround the foot and bend with movement. The low-profile design helps the brace fit into most athletic or street shoes. The Premium Lace Up Ankle Brace is cut to fit either the left or right ankle and comes in a generic form (without branding or labels) that facilitates customization.

Dalco International
804/266-7702
dalcointernational.com

market mechanics

By Emily Delzell

SALSA study reports on Orpyx smart insoles

A study published in January found alerts given by Calgary, Canada-based Orpyx Medical Technologies' smart insoles at least once every two hours could help enhance patients' adherence to offloading cues.

In the study from the University of Arizona Southern Arizona Limb Salvage Alliance (SALSA) clinic led by David G. Armstrong, DPM, MD, PhD, 17 patients with diabetic peripheral neuropathy at a high risk of developing diabetic foot ulcers wore the SurroSense Rx pressure-sensitive inserts for three months. The inserts connect to a smartwatch that alerts wearers to dangerous levels of pressure, allowing patients to offload it.

When given alert-based feedback, patients spent 47% less time in high-risk pressure states.

Investigators defined a successful alert response as pressure offloading within 20 minutes. Patients whose response adherence increased over time got more alerts (.82 ± .31 alerts/hour) than patients whose adherence didn't improve (.36 ± .46 alerts/hour). By the study's final stages, participants who got at least one alert every two hours were more adherent with offloading than participants who received fewer alerts.

The *Journal of Diabetes Science and Technology* epublished the research on January 30. ler

FIMS makes *CSMR* its official journal

The Indianapolis, IN-based International Federation of Sports Medicine (FIMS) in February made *Current Sports Medicine Reports (CSMR)* the organization's official journal. It's now available to all FIMS members at acsm-csmr.org.

CSMR is published by the American College of Sports Medicine (ACSM) and helmed by editor-in-chief William O. Roberts, MD, MS. The journal divides sports medicine into 12 sections, each headed by a physician editor with extensive practical experience in that area. It is included in the Thomson Reuters database, and in the last two years has seen 50% growth in its impact factor, according to an ACSM release. ler

ACFAS conference draws record crowd

The Chicago-based American College of Foot and Ankle Surgeons (ACFAS) reported in March that its 75th anniversary annual Scientific Conference, held February 27-March 2 in Las Vegas, drew more than 1900 foot and ankle surgeons and featured a sold-out exhibit hall, making it the largest-ever conference for the organization.

The college's 76th annual Scientific Conference is scheduled for March 22-25, 2018, in Nashville. ler

AAOS appoints Arend chief executive

The Rosemont, IL-based American Academy of Orthopaedic Surgeons (AAOS) in February announced the appointment of Thomas E. Arend Jr, CAE, as CEO. Arend, whose appointment is effective April 1, will work directly with the AAOS board of directors and executive management team to oversee a staff of 250 and manage an annual budget of $60 million.

He will replace Karen L. Hackett, FACHE, CAE, who is retiring after 14 years.

Arend currently serves as executive VP, COO, and general counsel at the American College of Cardiology (ACC), based in Washington, DC. ler

APTA launches PT outcomes registry

The Alexandria, VA-based American Physical Therapy Association (APTA) launched the Physical Therapy Outcomes Registry at its Combined Sections Meeting in San Antonio, TX, held February 15-18.

The registry lets physical therapists make data-informed clinical decisions, track and benchmark outcomes against industry data, and demonstrate the value of physical therapist services to payers and fellow providers. It integrates with multiple third-party electronic health record (EHR) systems for secure data transfer.

The registry will align with current and future quality and compliance programs required by payers, such as the new Merit-based Incentive Payment System (MIPS). Users can access outcomes measures supported by the Centers for Medicare and Medicaid Services, as well as measures specific to particular EHRs.

Go to ptoutcomes.com to learn more. ler

White Sox name Verma head physician

The Chicago White Sox in February named Nikhil N. Verma, MD, head team physician for the Chicago White Sox.

Verma is a sports medicine physician with Midwest Orthopaedics at Rush and director of the Division of Sports Medicine for the Department of Orthopedic Surgery at Rush University Medical Center.

Verma takes over for Charles Bush-Joseph, MD, the Sox's head team physician since 2003, who is stepping down to assume the roles of incoming president of the American Orthopaedic Society for Sports Medicine (AOSSM) and board member of Rush Health. ler

Tru-Mold expands Thera-Medic shoe package

Buffalo, NY-based Tru-Mold in March announced it is extending its Thera-Medic package by applying special practitioner pricing to every shoe in its catalog, including a choice among 13 leather colors, common shoe enhancements such as padded tongues/collars and closure methods, and three pairs of 1/4" pink and 1/4" white Plastazote inserts.

Practitioners can also substitute the cost of one or both pairs of inserts to make other custom shoe modifications, such as rocker soles, heel raises, amputation fillers, Plastazote linings, or special soling.

Go to trumold.com for more information. ler

Steadman Clinic completes $68M expansion

The Vail, CO-based Steadman Clinic and Vail Valley Medical Center cut the ribbon on their expanded 26,056-square-foot facility, which includes the new Steadman Clinic and the Steadman Philippon Research Institute's surgical skills lab, robotics lab, regenerative medicine lab, biomotion lab, and administrative offices.

The enhanced facility is the result of a $68 million investment by Vail Valley Medical Center. ler

Pedors revamps site for mobile use

Hiram, GA-based Pedors Shoes in February announced its pedors247.com business-to-business ordering website is now fully mobile responsive.

Foot care professionals can now order products at any time using a smartphone, tablet, or laptop or desktop device. ler

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market mechanics

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BOC calls for Newberry award nominees

The Owings Mills, MD-based Board of Certification/Accreditation (BOC) in February established the Jim Newberry Award for Extraordinary Service, an honor named after longtime practitioner, BOC board member, and leader James Newberry Jr, BOCP, BOCO, BOCPD, who died last year.

Newberry began his O&P career while serving in the US Air Force, after which he joined Mahnke's Orthotics and Prosthetics in Oakland Park, FL, where he spent more than 40 years as owner, practitioner, and director of orthotics/prosthetics. His longtime passion was improving the lives of children, and his efforts included establishing four pediatric orthopedic clinics.

For 30 years Newberry served the BOC in numerous leadership roles, including board chair and interim executive director.

The award named for him will recognize outstanding individuals who perform extraordinary service to the BOC and its community of stakeholders.

BOC is accepting nominations for the award on an ongoing basis. Go to bocusa.org/newberryaward to learn more and submit an application. ler

Amputee makes horse-racing history

Below knee amputee Guy Disney on February 17 at Sandown Park in Esher, UK, became the first prosthesis-wearing jockey to win at a professional racecourse in Britain.

Disney, 34, who lost his lower leg to a rocket-propelled grenade in 2009 while serving in the British Army in Afghanistan, rode Rathlin Rose to a win in the Royal Artillery Gold Cup, a race restricted to riders who have represented the armed forces.

A few weeks later, on March 10, he rode Rathlin Rose to a second victory at Sandown, winning the Grand Military Gold Cup.

Disney, a captain in the Light Dragoons, was a winning point-to-point jockey before going to Afghanistan. After his injury, the British Horseracing Authority turned him down for an amateur license on the grounds of safety. With help from a physician involved in horse racing, and who'd done functional tests for getting pilots back into cockpits, Disney reapplied and was granted his license in 2012. ler

AOFAS, M2S launch foot/ankle database

The Rosemont, IL-based American Orthopaedic Foot & Ankle Society (AOFAS) and M2S, a hospital technology and services provider headquartered in West Lebanon, NH, in February launched the Orthopaedic Foot & Ankle Outcomes Research Network (OFAR), a patient-reported outcomes data collection system.

Using the M2S Pathways clinical data platform, OFAR will track clinical and patient-reported outcomes for most orthopedic foot and ankle conditions. Data collected through OFAR will allow providers to compare their performance with national benchmarks and provide insight into the effectiveness of orthopedic interventions. OFAR has established a research network and is collaborating with medical device companies and regulators to increase knowledge about existing and new devices and implants.

Patient data will be entered into the OFAR registry on a pilot basis beginning in mid-2017, with the network expected to expand to AOFAS members nationally by late 2017. ler

APMA honors Liswood for podiatric service

The American Podiatric Medical Association (APMA) honored Paul J. Liswood, DPM, with its 2016 APMA Meritorious Service Award in late January at the New York State Podiatric Medical Association (NYSPMA) Foundation for Podiatric Medicine's Podiatric Clinical Conference and Exhibition.

APMA gives the award in recognition of outstanding accomplishments on the local, state, or regional level in scientific, professional, or civic endeavors that have had a profound impact on podiatric medicine.

Liswood, who practices at Comprehensive Podiatry Services in Brooklyn and is NYSPMA's current vice president, was recognized for his role in advocating for the New York podiatric scope of practice and podiatry's critical role in preventive care. ler

Bioness gets FDA clearance for L300 Go

Valencia, CA-based Bioness reported in February that it has received US Food and Drug Administration (FDA) clearance for its functional electrical stimulation device system, which includes thigh and below-knee cuffs, an in-shoe gait sensor, and a wireless control unit.

The L300 Go provides 3D motion detection of gait events and muscle activation using data from a three-axis gyroscope and accelerometer. Applications include improving ankle dorsiflexion in adult and pediatric individuals with foot drop or assisting knee flexion or extension in adult individuals with stroke or spinal cord damage.

Patient movement is monitored in all three kinematic planes, and stimulation is deployed when needed during the gait cycle. An adaptive algorithm accommodates changes in gait dynamics, and a high-speed processor deploys stimulation within 10 ms of detecting a valid gait event. The L300 also offers multichannel stimulation that allows clinicians to precisely control the amount of dorsiflexion and inversion/eversion provided and independent adjustment of medial and lateral stimulation.

Bioness will begin commercial release of the L300 Go this spring; initially it will be available only to healthcare professionals, with home user availability targeted for late 2017. ler

AOPA adds OPAI,CMTA as congress partners

The Washington, DC-based American Orthotic & Prosthetic Association (AOPA), its international partner organizations, and the 2017 World Congress Planning Committee in February announced that two new partners—the Orthotics and Prosthetics Association of India (OPAI) and the Charcot-Marie-Tooth Association (CMTA)—will be participating in the 2017 AOPA World Congress, scheduled for September 6-9 in Las Vegas.

The CMTA supports development of new drugs to treat CMT to improve the quality of life for people with the condition, and, ultimately, to find a cure. OPAI is the leading national organization in India devoted to improving quality of life for persons with disabilities through innovative O&P services.

In partnership with the Center for O&P Learning & Evidence-Based Practice, AOPA has unveiled its 2017 Requests for Proposals (RFPs) inviting submissions for O&P research. AOPA will fund up to four pilot grants in 16 potential areas for up to $15,000 each.

View the full RFP and application at aopanet.org. ler

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