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LOWER EXTREMITY REVIEW

October 16 / volume 8 / number 10

Women's Work:

Overcoming gender barriers in lower extremity specialties

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CROSSOVER CONSEQUENCES OF UNILATERAL TREATMENTS

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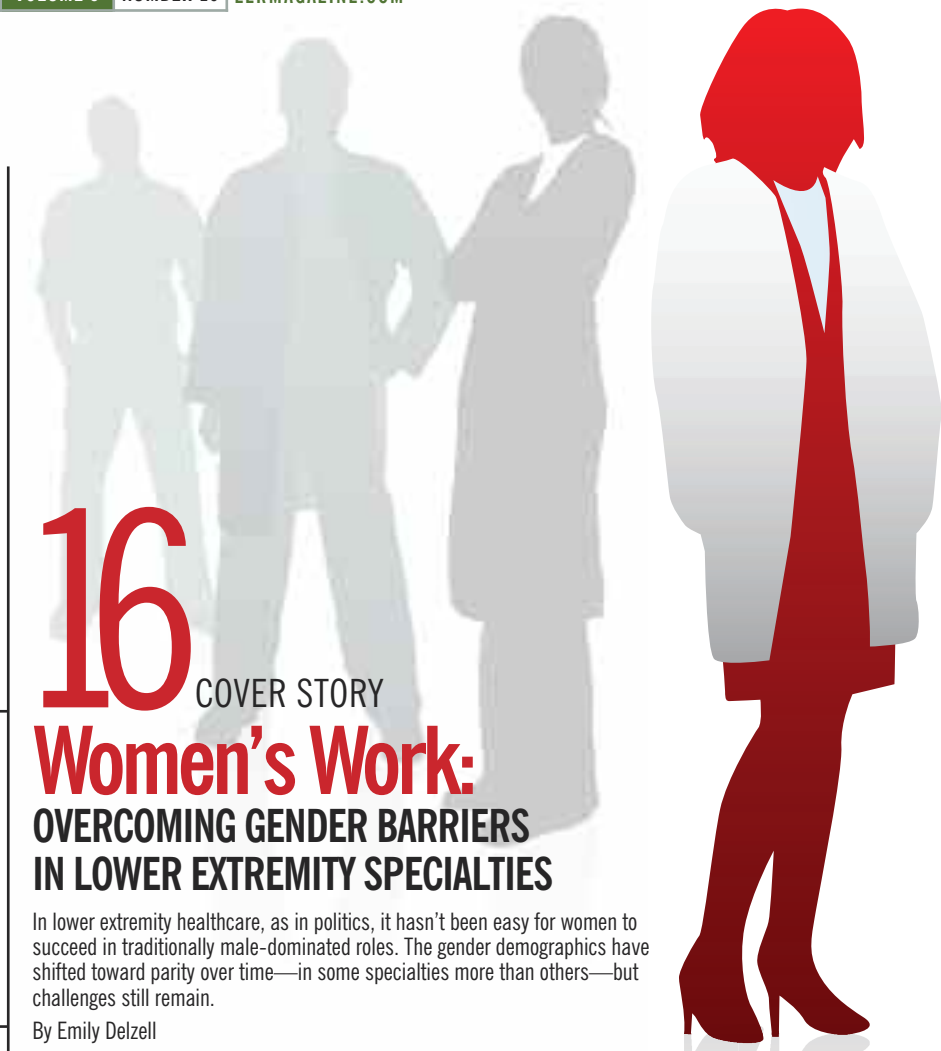

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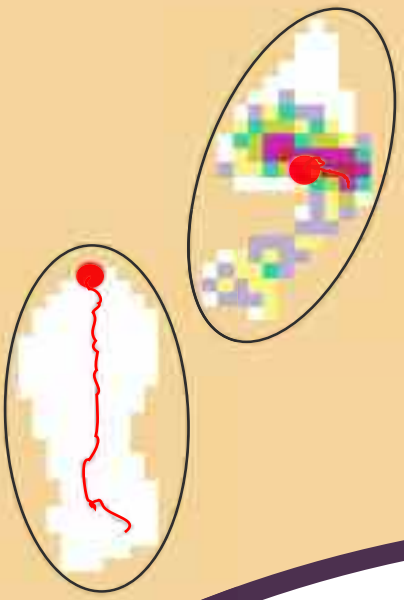

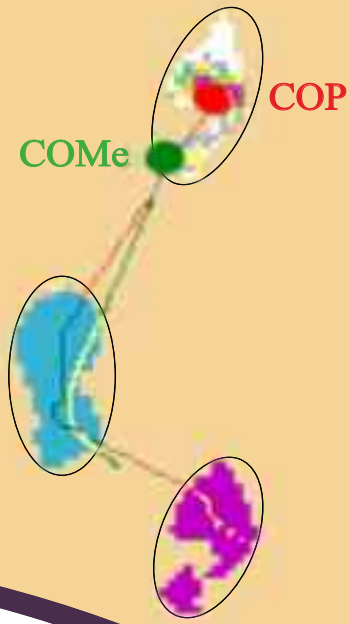

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Lower Extremity Review informs healthcare practitioners on current developments in the diagnosis, treatment, and prevention of lower extremity injuries. LER encourages a collaborative multidisciplinary clinical approach with an emphasis on functional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

Subscriptions may be obtained for $38 domestic. and $72 international by writing to: LER, PO Box 390418, Minneapolis, MN, 55439-0418. POSTMASTER: Please send address changes to LER, PO Box 390418, Minneapolis, MN, 55439-0418.

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out on a limb:
Weight loss vs wellness

Obese individuals often spend their entire lives telling themselves how much better their lives would be if only they were thin. But losing massive amounts of weight following bariatric surgery doesn't automatically make a person a better candidate for total knee arthroplasty (TKA)—any more than it automatically makes a person happy—if underlying issues have been ignored.

Lower extremity specialists are well aware that TKA is associated with significantly greater risks in obese patients than in their normal-weight counterparts (see "TKA in obese patients: Weighing the risks vs the benefits," February 2014, page 16). So it makes sense intuitively that, in patients who lose a significant percentage of their body mass following bariatric surgery, the risks associated with TKA would in turn be reduced.

But research suggests that's often not the case; TKA complication rates months after bariatric surgery can be as high as in obese patients who have not had a surgical weight loss procedure (see "Role of bariatric surgery in patients with knee OA," page 29). Experts say this may be because postbariatric patients too often don't receive follow-up care that will help them address their underlying comorbidities and nutritional issues. If postbariatric patients without knee OA aren't being encouraged to exercise, those with knee pain are probably receiving even less encouragement.

The concept of bariatric surgery as a cosmetic procedure rather than as just one component of a holistic treatment plan has become pervasive, as have its unfortunate consequences. Jen Larsen's 2013 memoir, *Stranger Here: How Weight-loss Surgery Transformed My Body and Messed with My Head,* is just one of a growing number of testimonials detailing the many ways an obese person can achieve thinness without necessarily achieving happiness—at least, not without working through any number of underlying behavioral health issues first.

Larsen lost 180 pounds after her weight-loss surgery, but continued to struggle with low self-esteem and dysfunctional relationships with food, alcohol, and other people. "I think it was comfortable and easy to let fat be my whole problem," she wrote. "And when I was left with no fat but plenty of problems…it's like I had cleaned out the flooded basement, which is great and all, but now I had to actually address the cause of the flooding, and it was harder than you think."

> Postbariatric weight loss won't make a patient with knee OA healthier or happier, if underlying issues have been ignored.

The weight loss that follows bariatric surgery won't cure a patient's knee OA, but it does often result in significantly decreased pain and improved gait mechanics. Those positive outcomes put the patient in a much better position to focus on exercise, which in turn can help address some of those underlying comorbidities that can complicate TKA. It's unfortunate that so many aren't aware of this opportunity.

It won't be easy, and some patients won't want to put in the necessary work. But postbariatric patients deserve to know that weight loss is just one leg of their journey to a happier, healthier life. And they also deserve access to the type of postbariatric lower extremity care that can help them complete that journey.

Jordana Bieze Foster, *Editor*

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Hip check

Proximal focus could help CAI rehab

By Katie Bell

Chronic ankle instability (CAI) is associated with centralized feed-forward neuromuscular alterations that affect the hip as well as the ankle, according to research from Boston University that may have implications for rehabilitation programs in that patient population.


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"Because we do see that those with CAI demonstrate changes in muscle activation and neuromuscular control throughout the lower extremity, including at the hip, clinicians should evaluate the hip musculature in patients with CAI to enhance rehabilitation protocols and ensure the entire lower extremity chain is involved in the rehabilitation process," said lead author Kathryn Webster, PhD, ATC, a clinical assistant professor in the physical therapy and athletic training department at Boston University.

The cross-sectional study included 16 physically active individuals with CAI (eight women), with an average age of around 20 years, and 16 control participants without CAI who were matched for age, height, body mass, and sex. Investigators measured electromyographic (EMG) activation of the tibialis anterior, peroneus longus, gluteus medius, and gluteus maximus muscles 200 ms before and after the participants landed from a lateral hop.

EMG was assessed before and after a fatigue protocol, which included cone drills (involving combinations of forward sprints, lateral

Continued on page 14

Biceps femoris activation decreases following foam rolling of quadriceps

Foam rolling of the quadriceps muscle is associated with decreased biceps femoris activation, an effect that may be related to pain perception, according to research from the Memorial University of Newfoundland in St. John's, Canada.

In 18 recreationally active individuals (eight women), the investigators used surface electromyography to assess vastus lateralis, vastus medialis, and biceps femoris activation during a single-leg landing from a hurdle jump under four foam-rolling conditions: application to the hamstrings only, the quadriceps only, both, and neither.

Biceps femoris activation was significantly lower for the conditions in which foam rolling was applied to the quadriceps. However, the reverse was not true: Foam rolling of the hamstrings had no significant effect on activation of either of the quadriceps muscles.

The authors hypothesized that the perceived pain associated with quadriceps foam rolling, which was significantly greater than that associated with hamstrings foam rolling, may trigger the alteration in antagonist muscle function.

The findings were published in September by the *Journal of Strength & Conditioning Research*.

– Jordana Bieze Foster

Source:

Cavanaugh MT, Aboodarda SJ, Hodgson D, Behm DG. Foam rolling of quadriceps decreases biceps femoris activation. J Strength Cond Res 2016 Sep 6. [Epub ahead of print]

Externally focused instruction boosts jump height regardless of visual input

Externally focused instruction results in greater jump height than internal focus or no instruction, regardless of whether the jumper's eyes are open or closed, according to research from the Czech Republic.

Investigators from Palacky University Olomouc assessed maximum jump height in 24 young adults under two vision conditions (full vision and no vision) and three instructional focus conditions (external focus, internal focus, and no focus). Externally focused instruction involved telling participants to concentrate on the ceiling and try to touch it. Internally focused instruction involved telling participants to focus on their fingers and try to bring them up as high as possible.

Regardless of visual condition, the external-focus condition was associated with a significantly higher mean jump height than the other two instructional focus conditions. Overall, full vision was also associated with a significantly higher mean jump height than no vision. However, there was no statistical interaction between vision and external focus, suggesting the two variables affect jump height independently.

The findings were published in September by the *Research Quarterly for Exercise and Sport*.

– Jordana Bieze Foster

Source:

Abdollahipour R, Psotta R, Land WM. The influence of attentional focus instructions and vision on jump height performance. Res Q Exerc Sport 2016 Sep 16. [Epub ahead of print]

Continued from page 13

shuffles, pivoting, and backward running), repeated two-footed lateral hops, and a drill that involved stepping up and hopping down from boxes of different heights.

Just before landing a lateral hop, activation values in the peroneus longus and gluteus maximus muscles were higher in participants with CAI than in the control group. Between-group differences were also evident for prelanding activation in the same muscles following the fatigue protocol.

The tibialis anterior was the only muscle for which post-fatigue activation was significantly higher than prefatigue activation; this was true across both groups, for both the prelanding and postlanding measurements.

The findings were published by the *Journal of Athletic Training* in September.

The increased muscle activation prior to landing in participants with CAI supports the concept of a centralized feed-forward neural adaptation—involving both proximal and distal muscles—to a compromised ability to protect the ankle, the authors suggested in the paper.

"Because the effects of CAI are seen throughout activities of daily living, rehabilitation involving restoration of proper neuromuscular control is important to attempt to prevent subsequent injury," Webster said.

Individuals with CAI also demonstrated greater proximal muscle activation than controls in a study published in the April issue of *Knee Surgery, Sports Traumatology, Arthroscopy*. In that study, CAI was associated with increased surface EMG activation of the gluteus medius muscle during the late stance and early swing phases of walking.

"If someone has decreased hip strength following an ankle injury, a clinician should consider implementing hip exercises to target that specific deficit," said first author Rachel Koldenhoven, MEd, ATC, a doctoral student in the Department of Kinesiology and Sports Medicine at the University of Virginia in Charlottesville.

The fatigue protocol used in the Boston University study may not have been sufficient to produce fatigue effects in the proximal muscles, which are larger than the distal muscles and may take longer to fatigue, Webster said. But the fact that the between-group differences for gluteus maximus activation were maintained after fatigue suggests it may be important for rehab programs to address both proximal and distal muscle function during a fatigued state.

"Neuromuscular control is negatively impacted with fatigue, and because this control is so closely tied to ankle instability, it seems reasonable to include stability exercises in rehab close to the end of a session, when a patient may be more fatigued," Webster said.

Sources:

Webster KA, Tome J, Pietrosimone BG, Gribble PA. Muscle activation during landing before and after fatigue in individuals with or without chronic ankle instability. J Athl Train 2016 Sep 14. [Epub ahead of print]

Koldenhoven RM, Feger MA, Fraser JJ, et al. Surface electromyography and plantar pressure during walking in young adults with chronic ankle instability. Knee Surg Sports Traumatol Arthrosc 2016;24(4):1060-1070.

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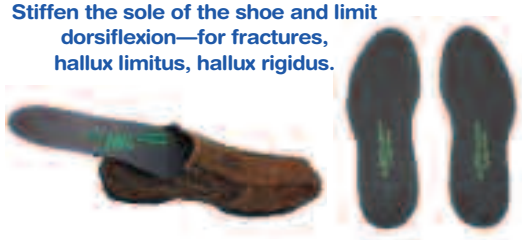

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Women's Work:

Overcoming gender barriers in lower extremity specialties

In lower extremity healthcare, as in politics, it hasn't been easy for women to succeed in traditionally male-dominated roles. The gender demographics have shifted toward parity over time—in some specialties more than others—but challenges still remain.

By Emily Delzell

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ONE NEED LOOK NO FURTHER than the current presidential election to know that, even though it's 2016, being a woman in a traditionally male field still makes a difference. Yet, if the majority of current polls prove right on November 8, Hillary Clinton will shatter one of the last glass ceilings for women in the US, becoming this country's first female chief executive.

In some lower extremity specialties those barriers began falling long ago, and the faces of leaders in O&P, podiatry, biomechanics, athletic training, and even orthopedic surgery (notorious, at least in the past, for its "jock and fraternity" culture[1-3]) are increasingly female. Some are even at or approaching parity, especially among students. But women are still in the minority in many of these fields.

According to the American Orthotic & Prosthetic Association (AOPA), in 2014 20% of practitioners who had registered with the American Board for Certification in Orthotics, Prosthetics and Pedorthics (ABC) were women, a 748% increase since 1994; ABC also estimates women and men now enter O&P in about a 1:1 ratio.[4] Among professional members of the American Society for Biomechanics (ASB) who report their gender, 31% are women, as are 42% of student members (2016 data).[5]

American Podiatric Medical Association (APMA) data show that, in 2015, the profession was almost exactly 75% men and 25% women. The APMA has been tracking gender in the profession only since 2012, when it reported 22.79% of podiatrists were women.[6] The American Association of Colleges of Podiatric Medicine has been following the gender balance among podiatry students for decades, however. In 2015, 39% of its student members were women, up from 23% in 1985.[6]

"I recall in the not so distant past looking around a conference room and picking out just a handful of women in row upon row of attending podiatrists, but now this is less visible with many, many young women filling up those seats," said Georgeanne Botek, DPM, podiatry section head at the Cleveland Clinic in Ohio. "The dynamic for me as a female has been a positive one—most of the time."

Fewer than 14% of orthopedic surgery residents in 2010 were women, the smallest percentage for any medical specialty except cardiothoracic surgery[1] and, in a 2015 American Academy of Orthopaedic Surgeons (AAOS) census, just 5% of respondents were women.[7]

Women make up more than 50% of the National Athletic Trainers' Association (NATA) membership (and 60% of its student membership) but hold 32.4% of collegiate head athletic trainer positions and only 19.5% of Division I head athletic trainer positions, according to a 2014 survey.[8]

Botek and the other six women interviewed for this article, who are leading their lower extremity fields in clinical, research, and professional roles, agreed paths to education, advancement, and leadership are more open and welcoming to women than ever.

There are still challenges. Solid gender-specific data in these fields are hard to come by, but many of these women think equal pay for equal work isn't a given, that reasonable parental leave, for most, is rarer, and that work-life balance in a demanding career is always going to be challenging.

Their perspectives span the last 50-plus years, a period that saw the rise of what historians sometimes call "second-wave feminism," a postsuffrage movement aimed at dismantling the societally entrenched idea that women's biology made them fundamentally unsuited—emotionally and physically—for "male" professions, as well as the fight for equal pay and against workplace discrimination.[9]

Among the movement's accomplishments was the successful enactment in 1972 of Title IX, legislation prohibiting sex discrimination in education programs, including athletics, that receive federal funds. Schools were given six years to implement the law in full.

It ultimately brought millions of girls into athletics. Before Title IX

Continued from page 17

Donna Robertson, MS, ATC, LAT, CPed, (clockwise from left) with her plaque in 2000 as the first woman inducted into the Alabama Athletic Trainer's Association Hall of Hame; at the 2004 Athens Olympics with track and field silver medalist Coby Miller; and at Foot Solutions in The Villages, FL, with pro golfers Nancy Lopez and Helen Alfredsson.

only 3.7% of high school girls played a sport, versus 50% of boys.[10] Today about 40% of high school girls take part in athletic programs,[9] and many who become lower extremity professionals come to their fields by that route.[4]

Old school

Athletic training and pedorthic pioneer Donna Robertson, MS, ATC, LAT, CPed, began her career in athletics before Title IX. It was sports, along with an athletic injury, that led her directly into her future professions. Her junior college record as a volleyball player earned her a scholarship in 1972 to the University of Northern Alabama (UNA) in Florence, the first year the university offered women sports scholarships.

A fall from a horse in the spring of her second year in junior college kept Robertson from using the award.

"I dislocated and had multiple fractures to my ankle, which ended my volleyball career," she said. "The volleyball team had managers to carry water and towels and do first aid, and the coach asked if I'd consider that. I told her no, I was so disappointed in not being able to play. But after I thought about it for about a week, I decided I wanted to be involved. And I wanted to find a way to help my own ankle."

Robertson learned to treat her injury and many others from a male athletic trainer at UNA; since women weren't allowed in the training room, she'd knock on the door and wait for him to come out and answer questions. She gained knowledge and experience, focusing on foot and ankle injuries.

In her senior year, members of the 1968 Olympic women's volleyball team and coaches Mary Jo Peppler and Marilynn McReavy Nolan were in the audience when Robertson delivered a presentation on injury prevention for female athletes. They invited her to work with players at the Olympic training facility in Pasadena, TX. She then earned another scholarship, this time for a graduate assistantship at Murray State University in Kentucky with athletic trainer Tom "Doc" Simmons, ATC, who was starting the first coed athletic training room in the southeast.

In 1975, legendary football coach Paul "Bear" Bryant personally hired Robertson as the first women's athletic trainer at University of Alabama (UA) in Tuscaloosa. Her $650 budget was a fraction of the men's and her training room tiny—a converted storage area carpeted with old turf from UA's Bryant Denny Stadium.

"Coach promised me that if I would contend with that storage area and take care of women's athletics, at that time two-hundred-plus athletes, I'd get a new training room within the year," Robertson said. "And, of course, every day as a female athletic trainer you had to prove yourself because that was a man's world."

She eventually got her new space, and in 1977 she became the first female certified athletic trainer in the Southeastern Conference. In 1978, she earned a master's degree in health, physical education, and recreation from UA. In 1987 she became a certified pedorthist, fitting athletic teams around the US. Along the way she opened University Orthopedic Clinic (the first sports medicine clinic in Alabama) and an athletic shoe store called The Total Approach, both in Tuscaloosa, and a clinical practice at the Pedorthic Care Center in Birmingham.

"As women in these roles we have to continually prove ourselves, and I feel education is our key," she said. "Having my master's degree and athletic training experience gave me more respect

Continued on page 20

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Continued from page 18

Mary Lloyd Ireland, MD, at the 1992 Olympics (top) and in 2007 (left) and 2014 (right).

within the male community. Getting my athletic training certification carried me further, and starting the sports medicine clinic opened up a whole new level."

Among patients, acceptance was easier.

"I saw each patient as a gift to extend my knowledge and professional career, and I feel like what boosted my career was the people I treated and their successful outcomes, which they told others about," she said.

Like Robertson, Mary Lloyd Ireland, MD, associate professor of orthopedic surgery at the University of Kentucky in Lexington, was an elite pre-Title IX athlete, swimming competitively through medical school at University of Tennessee Center for Hip Sciences (UTCHS) in Memphis and trying out for the Olympics in 1972 and 1976.

She also had early athletic injuries to her shoulder and back. Her orthopedist didn't encourage her to think about his field as a profession, but she already had the "competitive bug" and wanted a career in medicine.

"My adviser at UTCHS discouraged me from going into orthopedics. There was a sex bias then that women shouldn't go into orthopedics," said Ireland, who graduated from medical school in 1978. "So I started off doing pediatrics, and after a couple days I said, there's no way I can do this. I'd thought I wanted to do orthopedics, but by then I knew I'd be miserable if I didn't. I followed my passion."

She did her residency at the University of California, Irvine, where she was the only woman among 16 orthopedic surgery trainees.

"Having been an athlete, I knew I had to compete and be a team player," Ireland said. "In any specialty, women have to do a better job and stand out a bit more, because you will stand out positively. If you don't do a good job, then they'll sure remember that too."

With patients, Ireland saw her status as a woman as far less important.

"I had the confidence to know I could take care of patients, and I listened to them. What athletes really care about is that you know what you're doing," said Ireland, who was the team physician for the University of Kentucky's football and other athletic programs for 12 years starting in the mid-1980s, one of her many roles as a lead physician for college and Olympic athletes.

One of her early mentors was the late Jacqueline Perry, MD, a pioneer in gait and biomechanics, who is perhaps best known for her work with postpolio syndrome patients. Ireland worked with Perry while a resident at Rancho Los Amigos Medical Center in California.

In terms of equal pay and benefits, Ireland, who spent 22 years in private practice before joining the University of Kentucky faculty eight years ago, said it wasn't much of an issue for her when she was one of three orthopedists in her own practice.

"Since I joined the university, I feel my voice may not be heard as well," she said. "That was one of the reasons I went into private practice, because I could control my money, put it into research or however I wanted to direct it. It's been good to be with a university at the end of my career, and I enjoy teaching, but you still have some questions about how much of a difference you can make within the university structure being female."

Inroads

Orthopedic surgeon Jo A. Hannafin, MD, PhD, and biomechanist Irene Davis, PhD, PT, FACSM, FAPTA, FASB, went through their education and training a little later than Robertson and Ireland.

That small gap in years (Hannafin earned her MD and a PhD in physiology and biophysics in 1985, and Davis got her master's and PhD in biomechanics in 1984 and 1990, respectively) meant at least a few more female peers and perhaps faster acceptance (or at least less surprise) from male peers and faculty.

Hannafin, for example, was encouraged by a male surgeon to go into orthopedics, and in a way that made her change her mind about the specialty, which she'd already ruled out during a rotation in medical school at the Albert Einstein College of Medicine in the Bronx, NY.

"My stereotype was of a big ex-jock doing a lot physical stuff, with not a lot of devotion to the details of patient care, and that stereotype was wrong, but that's what I thought then," said Hannafin, a professor of orthopaedic surgery at Weill Cornell Medical College and attending surgeon and senior scientist at the Hospital for Special Surgery (HSS), both in New York, NY.

Then came the need for a one-month elective that would give Hannafin—another elite athlete—the flexibility to leave work for five days to race at the trials for the women's rowing world championships.

Continued on page 22

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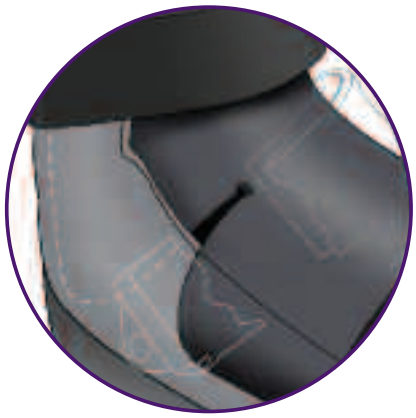

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Continued from page 20

Irene Davis, PhD, PT, FACSM, FAPTA, FASB, above and in the gait lab.

"Martin Levy [an orthopedic surgeon at Albert Einstein, where he now directs its orthopedic surgery residency program] said we could work it out, and he was amazing—he taught me how to suture and how to assist in the operating room," Hannafin said. "He just poured his energy into me, and at the end of the month said something very telling that I'll never forget: 'You could be good at this.' After watching him in his practice I thought, he has so much fun doing what he does. He's taking care of athletes all day, and he's solving their problems."

Hannafin made it onto the world championship team and, while at training camp, made what she calls "a visceral decision based on this one-month interaction with this remarkable guy" to apply for orthopedics instead of pediatrics.

Davis, in some ways, got into biomechanics because of a then-insurmountable no-women policy in another male-dominated field.

"I wanted to be an FBI agent. I love using information and seeing what I can sort out; research is kind of like that, so it still satisfies that part of me," said Davis, professor of physical medicine and rehabilitation at Harvard Medical School and director of the Spaulding National Running Center in Boston.

She was 15 years old then, and wrote to the FBI to ask about opportunities. She still has the letter she received, signed by J. Edgar Hoover, saying the FBI didn't allow female agents.

Davissaid she found biomechanics much more open to women.

"I went to my first biomechanics meeting in 1987

Jo A. Hannafin, MD, PhD, at the 2016 Rio Games with rowing silver medalist and future orthopedic surgeon Gevvie Stone, MD.

and there were only a handful of women, but other than that I honestly never thought about it. I feel like this profession has always been very welcoming to women," she said.

Leadership, role models, and gender bias

During her training and early career, Davis was able to follow the example of a few pioneering women in biomechanics, including Doris Miller, PhD, who in 1999 became the first woman to serve as ASB president. While working on her PhD at Pennsylvania State University in State College, Davis, who in 2008 was the ASB's fourth woman president, formed strong, lasting bonds with the two other women in the program.

O&P and athletic training also saw women taking the lead role in major professional organizations by the turn of the 21st century.

The AAOP had its first female president in 1999 (Stephanie D. Langdon-Bash, CPO, FAAOP) and the NATA (Julie Max, MEd, ATC) did so in 2000. It wasn't until 2009 that a woman became president of the American College of Foot & Ankle Surgeons (Mary Crawford, DPM), while the American Podiatric Medical Association (APMA) marked the milestone in 2010 (Kathleen M. Stone, DPM). Jo Hannafin in 2013 was the first woman president of the American Orthopaedic Society for Sports Medicine (AOSSM). The AAOS has yet to have a woman president.

Michelle Hall, MS, CPO, FAAOP(D), prosthetics residency director at Gillette Lifetime Specialty Healthcare in St. Paul, MN, said the career of Langdon-Bash, currently a practitioner for Hanger Clinic in Phoenix, AZ, and the West Coast lead for its residency programs, inspired women in her generation. Hall's first AOPA meeting, in 2003, was "very male-dominated," she said.

Michelle Hall, MS, CPO, FAAOP(D).

"It felt like a boys' club initially," said Hall, who was the AAOP's third female president in 2013. "Granted, I was new to the profession and didn't know many people. Thankfully I had a good mentor [Donald Shurr, CPO, PT] who started introducing me. I use the same approach with my protégés."

Hall did say she encountered not-so subtle gender bias when interviewing for residencies.

"I will never forget one interviewer's question; she asked, 'This is a male-dominated profession; do you think you'll be able to handle that?' I said, 'Well, I came from engineering.' Enough said! I hadn't really felt [gender] would be an issue. I was surprised, and I think in retrospect, a bit disappointed that sort of question was being asked."

Georgeanne Botek experienced something similar when applying for postgraduate training in the 1990s.

"There were programs that had reputations for taking only men," she said. "I remember interviewing for a particular residency and feeling I didn't get the time of day, as my interviewers were watching and discussing football as my interview was going on. Now those same

Continued on page 24

Continued from page 23

Georgeanne Botek, DPM.

residencies previously known to take only men are accepting female residents."

Today, Botek sees gender as much less of an issue.

"I'm happy that now, as a staff attending and holding a leadership role in my institution, I can help facilitate and impact the profession of younger women in podiatry," she said. "At times, it can be difficult jumping into a conversation when surrounded by men, but feeling comfortable in one's skin and having more life experiences enables me to do so."

Hall said her experience is consistent with research suggesting that women generally benefit more than men from mentors, female or male.[11,12] She recalls having had "fantastic" male mentors for her clinical and national leadership roles.

"I'm very thankful to those individuals," she said. "It hasn't really been until the last few years that I've had an informal female mentor [Alicia J. Davis, MPA, CPO, FAAOP]. She's a longtime residency director, and it's been really helpful to ask her questions and rely on her expertise."

Women's professional groups within lower extremity specialties match mentors with mentees, provide a structure for women to discuss female-centric issues, and promote professional development and leadership. These include the Ruth Jackson Orthopaedic Society (rjos.org), The Perry Initiative (perryinitiative.org), the American Association of Women Podiatrists (americanwomenpodiatrists.com), the Women in Orthotics and Prosthetics Committee (oandp.org/wop), and many others.

Female role models don't just benefit women at the start of their professions. Rosemary Ragle, MS, ATC, recently left the University of Connecticut in Storrs after 16 years as head athletic trainer for women's basketball, a span that saw the Huskies win nine Division I national championships. She's now a clinical instructor at HSS and head athletic trainer for the New York Liberty of the Women's National Basketball Association.

A major part of her decision to join HSS was the inspiring array of women she'd be working with, including Jo Hannafin.

"I was so impressed with the women of HSS, from the physical therapists to the athletic trainers to the orthopedic surgeons to the chief medical officer," Ragle said. "College athletics still tends to be very male-dominated, and I was intrigued by and wanted to be part of what I saw as a female-dominated group. My hope is to learn from these impressive women and become a better, stronger female in my field."

Balance

When asked if athletic training in general is male-dominated, Ragle initially demurred, saying that, even as an undergraduate at Troy State University in Alabama in the 1990s, there were more women in her program than men.

"But you know, when I think about it, I'm the last female in my graduating class still in the profession, and I'm also unmarried and have no children—think there's a connection?" she said. "I think a lot of women are drawn to the field because they love athletics and, unfortunately or fortunately, I didn't have that barrier where you had to make a decision."

Irene Davis, who feels that, in biomechanics, her gender hasn't mattered much, said one way women who are considering the field differ from men is in their concern with work-life balance.

"The questions of males and females are very similar; basically, how do I advance my career, but what females come to me differently about is to ask, 'How do you balance it all?'" said Davis.

Hannafin's group at HSS, which includes four female orthopedic surgeons who live very different lives, gives younger women who are interested in the profession a chance to see examples of women striking a good balance in diverse ways.

Taking time off for childbirth, child care, and other family responsibilities is one reason Michelle Hall thinks there are still too few female O&P practitioners who are business owners and managers.

"I think a lot of people were choosing family and were less able to take on leadership roles. In the same respect, many didn't have those extra hours to do the volunteering [that comes with achieving those roles], often done at home after work is done," said Hall, who considered orthopedic surgery but ultimately decided on O&P, in part because of the better life-work balance she thought it offered.

With more and more women entering and rising in the profession, however, said Hall, "the pendulum is starting to swing toward employers allowing the flexibility to have that family and career balance."

Mentoring should remain a high priority, she said.

"Even as the gender gap closes, there's still a strong need for mentoring within our profession," Hall said. "Mentors, regardless of gender, can really encourage us to push the envelope of what we can do and how we can participate within our profession." ler

References are available at lermagazine.com.

Rosemary Ragle, MS, ATC, in the UConn training room and at one of the Huskies' regular-season games.

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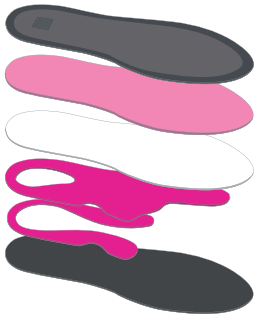

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Management of athletes with excessive pronation

By Frank Layman, PT, DPT, EdD, MT;
and April Wilson, PTA, BS, CI, CKTP, IASTM

Pronation is a triplanar movement and is the combination of rearfoot eversion, midfoot abduction, and talocrural dorsiflexion.[1] Pronation in normal gait allows flexible, adaptive changes to varying types of terrain; it dissipates ground reaction forces; and encourages lower extremity internal rotation.

Foot pronation—often observed as inward tilting of the ankles and flattening of the arches—is a normal part of walking and running. But when it's excessive (movement of the foot to the point that the medial longitudinal arch [MLA] flattens fully or close to it), it can lead to foot, ankle, or even knee pain.[2] This can have a profound impact on athletes and their performance in the short term, and in the long term these biomechanical influences could exacerbate or contribute to other dysfunctions.

Most of the literature on excessive pronation has focused on runners;[3-5] however, in our clinical experience, it can be associated with an increased incidence of injuries in other athletes—including basketball, tennis, and volleyball players—not always with respect to the direct mechanism of injury, but in association with the training these athletes do to be ready to play.

In athletes, excessive foot pronation has been shown to be associated with the incidence of:

- Metatarsal stress fracture[3,6]
- Plantar fasciitis[4]
- Achilles tendinopathy;[4,7]
- Patellar tendinopathy[8]
- Medial tibial stress syndrome (MTSS)[5]
- Patellofemoral pain[5]

In our clinical experience, excessive pronation in athletes can also be associated with pelvic misalignments, functional scoliosis, and excessive lumbar lordosis.

In 2013, Menz et al reported that pronated foot function may contribute to low back symptoms in older women,[9] and suggested that interventions to modify foot function, such as orthoses, may therefore have a role in prevention and treatment of low back pain. Athletes suffering from low back pain who have had local treatment to no avail could potentially benefit from these types of interventions.

We aren't suggesting a direct link between pronation and any of the dysfunctions mentioned above, but noting there is a relationship that needs to be acknowledged and addressed, if necessary, as part of clinical management. Other contributing factors—including body mass index, level of experience in a specific sport, training methods, history of injury, strength, endurance, stiffness, and neuromotor deficits—also have to be evaluated, considered, and addressed as warranted.[10]

Examination

Excessive pronation is a common lower extremity postural distortion pattern that can lead to other movement dysfunction patterns throughout the kinetic chain and ultimately contribute to injury. When conducting an examination to identify excessive pronation, a comprehensive analysis of the weightbearing structures—from the foot to the midspine—and their biomechanical linkage is important. Sometimes, the problem can be traced to a link in the superior aspect of the chain, and at other times it is located inferiorly. This discussion will focus on what should be included in a foot examination.

Static and dynamic assessments of the foot and ankle complex can help to identify lower extremity dysfunction patterns associated with excessive pronation. Once these have been identified, following a systematic corrective exercise strategy can help to improve functionality and movement quality, leading to decreased risk of injury.[11]

Components of the examination can include these static tests:

- Navicular drop test[12]
- Measurement of the rearfoot-to-leg angle[13]
- Measurement of the medial longitudinal arch angle[13]
- Jack's test[14]
- Too many toes sign[15]
- Foot posture index[16]

In addition to static tests, we advocate a dynamic examination. Pronation is a necessary and protective mechanism during walking and running as it allows attenuation of impact forces.[17-19] In the clinic it helps to assess pronation during gait before taking corrective action.

When we assess gait in the clinic we don't use an external instrument to measure pronation. Instead, we record video of the patient walking barefoot, and then review the video at a slower speed using a movement analysis app. Posteriorly, we look at the angle created when a line bisecting the lower leg and a line bisecting the heel come together at the ankle. A similar assessment can be done from an anterior view, looking at the angle created by a line bisecting the lower leg and another line from the ankle to the second metatarsal joint.

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In a patient with a normal gait, these angles will vary by a few degrees through the course of the gait cycle, in particular at foot flat and just before toe-off. When the range of pronation slightly exceeds this expected range, we might employ interventions including biofeedback and verbal cueing. In patients with pronation that is more excessive but still relatively minor, we would recommend the same treatments plus therapeutic exercise, manual physical therapy, and corrective footwear. In patients with moderately excessive pronation that does not respond to the previously mentioned methods, we advocate adding foot orthoses.


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Treatment strategies

We cannot underestimate the impact pronation has on lower extremity pain and the restrictions that can follow. Foot pain, planus foot posture, and pronated foot function are associated with self-reported difficulty undertaking common weightbearing tasks.[1] Interventions to reduce foot pain and improve foot posture and function may therefore have a role in improving mobility in athletes.

Excessive pronation can be a compensation for a lack of ankle dorsiflexion. Unlocking the midtarsal joint, to allow for dorsiflexion and abduction movements at the midtarsal joint's oblique axis, can result in excessive pronation that can stress the plantar fascia.[20]

The use of foot orthoses, footwear, and other strategic clinical interventions can help mitigate the adverse effects of excessive pronation in athletes. Addressing lower extremity alignment to positively influence biomechanical changes is part of the intervention strategy we employ successfully in the clinic, which we also have recommended to other clinicians. Stretching can also be part of an effective treatment approach. It has been theorized that inflexibility of the gastrocsoleus complex can contribute to excessive pronation, as well as overcompensation of the plantar fascia at the first metatarsophalangeal joint.[7]

Orthotic intervention

Both the American Physical Therapy Association and the American College of Foot and Ankle Surgeons recommend multimodal interventions in patients with plantar fasciitis that include the use of custom or prefabricated foot orthoses.[21,22] Findings that runners with plantar fasciitis have lower arches than their pain-free counterparts suggest that addressing pronation may be one component of foot orthosis effectiveness in this population.[23]

Research suggests foot orthoses can help reduce symptoms in runners with Achilles tendinopathy.[24-26] The mechanism for these positive effects is likely multifactorial, but may involve reducing rearfoot eversion and vertically aligning the calcaneus.[27]

In a systematic literature review, Gross et al concluded that runners and other patients with patellofemoral pain (PFP) may benefit from foot orthoses as an adjunct to other interventions, if they also have excessive foot pronation, which may be accompanied by excessive lower-extremity internal rotation during weightbearing and a greater-than-normal Q angle (the angle formed by the thigh and shin).[28] The authors suggested the mechanism for this positive effect might involve reducing internal rotation, reducing Q angle, reducing laterally-directed soft tissue forces, or reducing patellofemoral contact pressures.

A more recent study by Barton et al found limited ankle dorsiflexion and wearing unsupportive footwear—both potentially related to excessive pronation—were among the factors that were clinically predictive of foot orthosis efficacy in patients with PFP.[29] Lower levels of pain and immediate reduction of pain with orthosis use were also clinically predictive variables.

Custom foot orthoses have been associated with reduced rates of MTSS in a military population, which has some similarities to athletes.[30] Although that study did not control for foot posture, a systematic review and meta-analysis found strong evidence that excessive pronation was associated with an increased risk of MTSS.[5]

Farahpour et al found higher ground reaction forces during gait in people with pronation and low back pain than in those with low back pain alone.[31] This finding suggests that in athletes with low back pain as well as pronation, orthotic intervention may need to provide shock absorption to reduce ground reaction forces, along with addressing any excessive pronation.

Clinical insights

Addressing excessive pronation in athletes as part of a comprehensive global approach to management of pain, the facilitation of mobility and fluid movement, and performance is strongly advocated and supported by research. Clinicians are advised to be familiar with relevant tests to detect excessive pronation and treatments to comprehensively address it while focusing on stretching, shoe design, and orthotic devices.

Keep in mind that the potential dysfunctions associated with excessive pronation are not limited to the foot and ankle. So the next time you are setting up a plan of care for an athlete with a knee or calf complaint, don't just examine the local issues. Remember to look down.

Frank Layman, PT, DPT, EdD, MTC, is an administrator and clinician at Randolph Specialty Group in Asheboro, NC, an adjunct faculty member of the Department of Physical Therapy at High Point University in North Carolina, and a vice president of business development for Tapout Fitness in Raleigh, NC. April Wilson, PTA, BS, CI, CKTP, IASTM, is a physical therapy assistant at Randolph Specialty Group and the owner of Footwise, a company that offers individualized foot fittings for athletes, also in Asheboro, NC.

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Role of bariatric surgery in patients with knee OA

Weight loss following bariatric surgery can have biomechanical and symptomatic benefits for obese patients with knee osteoarthritis (OA). But it's less certain whether that weight loss can also reduce the risk of obesity-related complications following total knee arthroplasty.

By Shalmali Pal

During a radio interview, the producer of an online biopic series on Pablo Escobar noted that actor Wagner Moura gained 40 pounds to better embody the Colombian drug lord. While the weight gain may not have put the normally slender, 5'11" Moura, on the obesity spectrum, he did have to maintain his new girth for two years of filming, which had biomechanical consequences.[1,2]

"[Moura as Escobar] had such a great gait that he found," explained *Narcos* series producer Eric Newman in an NPR interview.[3] "This walk that was almost like a waddle, and when he put the weight on, it made it even better." Moura eventually lost the weight, crediting a vegan diet, and has described his time as a heavier person as "horrible."[2]

On a small and temporary scale, Moura experienced some of the biomechanical effects associated with obesity (usually defined as a body mass index [BMI] of 30 kg/m^2 or higher), which include elevated loads on the knees. Obese patients are 2.63 times more likely to develop knee osteoarthritis (OA) than their normal-weight counterparts, according to a 2010 meta-analysis.[4]

Many patients with obesity turn to invasive surgery to help them shed that potentially life-threatening weight. In 2015, an estimated 196,000 bariatric surgeries were performed in the US—17,000 cases more than just two years earlier, according to the American Society for Metabolic and Bariatric Surgery. More than half of the 2015 cases (nearly 54%) involved a gastric sleeve, and about 24% involved a Roux-en-Y gastric bypass.[5]

Bariatric surgery can certainly help with weight loss, but does that weight loss render any positive changes in the knee mechanics and knee OA symptoms? And does bariatric surgery improve total knee arthroplasty (TKA) outcomes in obese patients with end-stage knee OA?

The answer to the first question is a fairly straightforward "yes."

"There's about a one-to-four relationship—for every one pound you gain, you put about four pounds of stress on the knee. Now the reverse is that, for every pound you take off, you lose four pounds

Postbariatric care too often falls short in emphasizing the importance of exercise, not only to boost and maintain weight loss but to potentially improve knee health.

Continued from page 29

of stress on the knee,"[6] explained Stephen P. Messier, PhD, director of the J. B. Snow Biomechanics Laboratory and of the Wake Forest University Runners' Clinic at Wake Forest University in Winston-Salem, NC, who has coauthored numerous studies on the effects of weight loss interventions (diet and exercise) on knee OA symptoms.

The anticipated decrease in stress on the knee—and the decrease in knee pain that typically results—is a great motivator for weight loss, Messier said.

"I wish my [financial] investments had that kind of return," he joked.

Determining if that weight loss will also pay off in regard to TKA, however, is not as simple. Research has shown that obese patients who undergo TKA can have higher complication rates compared with normal-weight patients for several reasons, including technical challenges during the procedure, comorbidities (such as type 2 diabetes or vascular disease), or even changes in activity levels (see "TKA in obese patients: Weighing the risks vs the benefits," February 2014, page 16). But studies of the timing of TKA relative to bariatric surgery have had mixed results, underscoring the complexity of the factors involved.

Loading and beyond

The hazards of excess weight seem to take place on two levels. First, there's the mechanical component.

"Knee OA is a disease of the whole joint, so the bone, the cartilage, the musculature, the range of motion, and the neuro-inputs to the muscle," explained Daniel Kenta White, PT, ScD, assistant professor in the Department of Physical Therapy at the University of Delaware in Newark, and a spokesperson for the American Physical Therapy Association. "Excessive weight can certainly contribute to those disease features."

There's also an inflammatory component, noted Michael H. Parks, MD, a physician at the Hospital for Special Surgery in New York, NY, and a spokesperson for the American Academy of Orthopaedic Surgeons.

"Just as heart disease and obesity are linked by inflammation of the vessels...there's an inflammation that leads to degradation of the cartilage and OA," he said.

While obese patients are at a much higher risk for developing knee OA,[7,8] not all of them do, Parks cautioned. For some, carrying the extra weight may impact the knee cartilage, but it isn't necessarily detrimental to the point of disease development.

"If that were the case, then everyone who is obese would have OA, but we know that's not true," he said. "So there is something else going on there that leads to the development of knee OA."

Paul DeVita, PhD, a professor in the Department of Kinesiology at East Carolina University in Greenville, NC, concurred.

"No one really understands what causes OA. For a while, biomechanics experts were blaming mechanical load, but now they are backing off a bit on that, and saying the inflammation part is pretty important," DeVita said. "There's an idea that if people are obese, they can condition their cartilage to withstand the weight because not every obese person gets OA."

A 2013 review article[9] concluded that "the precise metabolic pathways through which obesity contributes to joint structural damage are currently not known, although thought to involve aberrant adipokine expression with direct and downstream effects leading to the destruction and remodeling of joint tissue."

Sometimes the problem isn't so much the extra load on the knee because of the weight itself, but how load is being exerted, and how other knee components respond.

"OA is not just a wear-and-tear disease," Messier said. "It's more complicated than that, in the sense that the cartilage is not made to handle that excessive load. So that load is handled by the underlying subchondral bone, which has a lot of space and is a nice shock absorber."

But when the load becomes excessive on the subchondral bone, and that bone grows thicker to carry that weight, it loses its shock-absorbing ability, he noted, which can lead to OA symptoms, such as pain, stiffness, swelling, loss of range of motion, and difficulty walking.[10]

Weight loss and knee mechanics

Patients with OA are most likely looking for a few things when they contemplate TKA: to alleviate the symptoms of OA, improve range of motion and activity level, and boost quality of life (QOL). Both weight loss intervention and TKA have been shown to help patients achieve those goals.

Messier and colleagues (including DeVita) have conducted several trials that have shown success with the diet-and-exercise route. In the Intensive Diet and Exercise for Arthritis (IDEA),[11] they tested the hypothesis that intensive weight loss (with or without exercise) would reduce inflammation and joint loads sufficiently to alter disease progression in overweight and obese (BMI, 27-40.5 kg/m^2) older adults (55 years and older) with pain and radiographic knee OA.

Almost 90% of the 450 participants completed the 18-month intervention, and the mean weight loss was 10.6 kg for the diet-

Continued on page 34

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Continued from page 30


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plus-exercise group, 8.9 kg for the diet-only group, and 1.8 kg for the exercise-only group.

After 18 months, peak knee compressive forces were significantly lower than baseline in all groups, and were significantly lower in diet-only participants than exercise-only participants. Also, the diet-plus-exercise group had less pain, better function, and better QOL scores than the two single-modality groups.

Messier pointed out that, in effect, the diet-plus-exercise regimen decreased the load on the knees, but also strengthened the muscles around the knee. He also noted that in the exercise-only group, loads on the knees went up for the first six of 18 months, partly because participants developed a faster walking speed after weight loss and decreases in peak knee compressive forces.

"They were not accustomed to their new walking speed," he explained. "So the stress went up initially, but then came back down from months six to eighteen. My feeling is that they were adapting to that new walking speed, so everything got stronger—their muscles got stronger so they started walking better. The exercise offered better [walking] mechanics."

In a 2016 study, DeVita and colleagues determined the effects of weight loss on knee muscle and joint loads during walking in class III obese adults (BMI, 40-59 kg/m^2).[12] They enrolled patients who had undergone gastric bypass and used motion capture, force platform measures, and biomechanical modeling to study the impact of that weight loss while patients walked at a controlled velocity and at self-selected velocities. DeVita told *LER* none of the partici-

pants in the study had an official knee OA diagnosis, but "that doesn't mean they didn't have knee OA."

They reported that weight loss equal to 34% of initial body weight led to a reduction in maximum knee compressive force by 824 N at the controlled velocity, representing a 2:1 reduction in knee force relative to weight loss.

But the unconstrained walking condition, which was more indicative of walking behavior than the standard velocity condition, led to a reduction in compressive knee force of just 392 N, resulting in an approximately 1:1 ratio of reduction in knee force relative to weight loss.

This may reflect gait changes associated with patients' initial weight loss, including increases in stride length and knee flexion, which would increase load on the knee, DeVita said.

Similar gait changes, along with functional improvement, have also been reported following bariatric surgery.[13-17] Although researchers have yet to specifically analyze knee loading in bariatric patients, they have observed decreases in knee adduction and flexion moments, which are associated with knee OA symptoms and progression.[15,16]

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Continued on page 36

Continued from page 35

Time for TKA?

Given the risks associated with TKA in obese patients, it makes sense intuitively that the weight loss associated with bariatric surgery could help reduce those risks. Some studies have supported this hypothesis,[18-20] but others have not.[21-23]

In a 2012 study Jasvinder Singh, MD, MPH, a professor of medicine at the University of Alabama at Birmingham, and colleagues compared outcomes—including total operative time, duration of hospital stay, 90-day complication rate, and transfusion rates—of 125 patients with knee OA who underwent bariatric surgery either before or after TKA.[24]

They found the total operative time differed significantly between patients who had undergone TKA before bariatric surgery (183 minutes), within two years of bariatric surgery (191 minutes), or more than two years after bariatric surgery (144 minutes). The incidence of 90-day complications also differed among the three groups (21%, 4%, and 16%, respectively) but those differences were not statistically significant, and in all three groups the complication rate was significantly higher than the overall institutional complication rate.

"Patients who undergo bariatric surgery and TKA experience increased rates of perioperative complications regardless of the temporal relationship between bariatric surgery and TKA," the authors concluded.

A holistic approach

Parks agreed that there may not be such a thing as an "ideal" time for bariatric surgery patients to undergo TKA. He said that before discussing TKA with a postbariatric patient, he considers their overall health.

"Even if after bariatric surgery, they are still significantly overweight, I want to see that they are managing their weight," Parks noted. "I tell my patients, 'You need to show me that you are working on your weight. You don't have to come in looking like a runway model for me to consider performing TKA.' But they do have to show me that they are in charge of their weight and their health."

After bariatric surgery, there is an adjustment in the baseline nutritional status,[25] he noted, which can also be an issue. Despite high calorie consumption, obese patients are often deficient in important nutrients, such as antioxidants and fat-soluble vitamins. Bariatric surgery can result in additional nutritional deficiencies, or worsen pre-existing ones. Patients are often put on supplements to address these deficiencies.

"The body needs nutrients to heal," Parks said. "You don't want a patient who is nutritionally depleted to undergo [TKA] because that's going to compromise their recovery."

He added that he also needs to see that if comorbidites such as diabetes or heart disease are present, those are being medically managed.

Finally, he explained, the way a patient experiences OA can be another marker for whether TKA is appropriate.

"You have to look at OA as a waxing and waning disease—there are days [patients with knee OA] feel good and days they feel bad," Parks said. "It's the patients who don't have the waning aspect anymore that I will consider for TKA, because it's just painful all the time. With the TKA, we aim to ameliorate those symptoms and give them more good days."

Messier pointed out that results from the IDEA trial provided "convincing evidence that a 10% weight loss, combined with moderate exercise, results in a 50% reduction in pain in older adults with chronic knee OA," in turn improving function and QOL.[11] Since patients who undergo bariatric surgery are likely to lose more than

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10% of their body weight, it's possible that weight loss could improve their knee OA symptoms enough to delay TKA. But Messier agreed with Parks that a healthful lifestyle must be adopted and maintained.

Messier said he considers TKA a "last resort," for improving knee health in obese patients, but he acknowledged that when a person is in "excruciating pain and...can't move, TKA can be effective."

Given his group's findings about gait adaptation after weight loss, DeVita suggested that performing TKA soon after bariatric surgery may not be the best route.

"I will hypothesize that it may be better to wait some period of time for these individuals to develop and adapt to their new locomotion biomechanics," he said. "For example, in our [2016] study, we measured patients at six months and twelve months, but it's not entirely clear how quickly these adaptations occur. My guess is that postbariatric patients need time to settle into their new health status [before considering TKA]."

Long-term goals

The experts interviewed for this article expressed concern that postbariatric care often falls short in emphasizing the importance of exercise—not only to boost and maintain weight loss, but to potentially improve the health of the knees.

This could help explain the findings of a 2016 study of veterans who underwent bariatric surgery, in which patients with OA experienced less weight loss than veterans who did not have OA, as long as five years after the bariatric procedure.[26]

White expressed concern that bariatric surgery patients may be considered automatic candidates for TKA to manage their knee OA, without their having first made attempts to manage their weight with diet, and seeing if that leads to improvements in their knee OA symptoms. After bariatric surgery, the majority of patients with knee OA aren't given a prescription for exercise, let alone physical therapy or other nonsurgical modalities, he said.

"After bariatric surgery, the focus is so much on diet, it's like exercise is just an afterthought," White said. "The problem with that is that clinicians are missing a 'teachable moment' with this patient to get them on a trajectory of long-term health. If you focus solely on diet, that isn't going to lead to stronger muscles. I think there is a real need to address this gap in exercise prescription, and I think physical therapists can play a major role in calling attention to that in these patients."

Ensuring that exercise is part of bariatric patients' overall care continuum is key, he said.

"I like to keep it simple," he said. "I think the more complex an exercise regimen gets, the less likely people are to follow through long term. So encourage bariatric surgery patients with knee OA to get themselves a [step monitor] and try to reach six thousand steps a day."

But White acknowledged that nonsurgical methods of symptom management may not work in all patients, including those who have experienced weight loss after a bariatric procedure.

"From a PT perspective," he said, "if somebody is losing the ability to do the things they enjoy and becoming inactive, it's probably time to start considering TKA." ler

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

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Crossover consequences of unilateral treatments

The mechanisms underlying the so-called crossover effect—when a unilateral intervention results in bilateral changes—are still unclear, but clinical applications related to lower extremity strengthening, fatigue, and stretching are already being explored by rehabilitation specialists.

By Cary Groner

When *LER* reported last year on the effects of foam rolling, we noted that even if only one leg was rolled, the other experienced a similar decrease in soreness.[1] That a unilateral intervention should have bilateral effects hinted at a neural component to the procedure's efficacy that wasn't yet fully understood.

This phenomenon—often called the crossover effect—was first described in the literature more than a hundred years ago and has intrigued researchers and clinicians ever since. The exploration and development of practical applications has begun only relatively recently, but a growing body of research into the neurological basis of crossover effects is shedding light on aspects that include muscle strengthening, fatigue, and stretching. And, though researchers are still elucidating the underlying mechanisms, clinical applications are already being suggested, particularly in situations requiring rehabilitation for unilateral conditions such as a broken leg or poststroke hemiplegia.

The need for effective interventions in such cases is clear, as even relatively brief periods of immobilization can have devastating consequences for the lower extremities. For example, one study reported that immobilization of the leg resulted in a 47% decrease in quadriceps maximum voluntary contraction (MVC) after just three weeks.[2]

Strength

Yale University researchers first reported in 1894 that unilateral strength training of a single limb increased strength in the untrained contralateral limb.[3] Now, 122 years later, experts agree that neural adaptations are at the core of the phenomenon, and that cortical, spinal, and peripheral mechanisms are all likely involved.[4] Researchers have found crossover effects associated with training protocols that include isometric, dynamic, electrically stimulated, and even imagined muscle contractions,[4] and eccentric contractions reportedly produce triple the contralateral strength gains than do concentric or isometric ones.[5]

> Experts agree that neural adaptations are at the core of the crossover phenomenon, and it's likely that cortical, spinal, and peripheral mechanisms are all involved.

Continued from page 39

Although strength transfer appears more predictable with some approaches than others, the degree of strength gained in the untrained limb is usually proportional to that gained in the trained limb. Training variations such as speed, intensity, and contraction type contribute to the wide range of strength transfer reported,[4] though a 2006 meta-analysis found that the average reported strength gain in the untrained limb was 7.6%, a number that, according to some experts, reflects roughly a third of the gains in the trained limb.[6]

Crossover effects likely arise out of the neuromuscular system's propensity for symmetry. Human motor systems operate within a range of normal lateralization of function, and mechanical or neurological injuries disturb this homeostasis.[7] The goal of therapeutic interventions, then, is to take advantage of this natural tendency to restore symmetry to the greatest degree possible. In mechanical injuries, actual symmetry is a reasonable goal; in the case of a stroke, however, this may simply mean restoring whatever function the patient can achieve in the affected limb.[7]

"The interconnectivity of the body is phenomenal," said David Behm, PhD, a university research professor in the School of Human Kinetics and Recreation at the Memorial University of Newfoundland (MUN) in St. John's, Canada. "Whether you're looking at muscle fatigue, resistance training, pain, or stretching, they're all interconnected, and what we do on one side of the body influences the rest of it. This can be beneficial, in terms of trying to open up and excite new pathways on both sides of the body; it can also be troublesome in that it can inhibit pathways on both sides."

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Researchers at Deakin University in Melbourne, Australia—including Ashlee Hendy, PhD, a lecturer in motor learning in the School of Exercise and Nutrition Sciences—are among the leaders in studying crossover effects, particularly regarding strength training. In a 2012 review article, for example, Hendy and her colleagues analyzed the state of knowledge about the phenomenon and reported that muscular mechanisms likely don't play a major role, given that research to date hasn't identified significant peripheral muscle adaptations in the untrained limb.[4] At the neurological level, moreover, spinal mechanisms may be less important than cortical ones, though the relative degree of involvement appears partly dependent on whether upper or lower extremities are evaluated.

At the cortical level, Hendy reported, complex interhemispheric connections and ipsilateral corticospinal fibers from the primary motor cortex provide pathways for stimulation of the inactive opposite muscle during unilateral contraction. This corticospinal activity, referred to as "motor irradiation," seems to contribute to strength transfer following unilateral training.

The Deakin team employs a couple of particularly helpful technologies, Hendy told *LER*.

"We apply anodal transcranial direct current stimulation [a-tDCS] to the brain during training to try to enhance the magnitude of crosstransfer by making the neurons in the untrained area of the brain more excitable," she said. "We also utilize transcranial magnetic stimulation [TMS] to measure physiologically whether the a-tDCS has had an effect."

In one study, researchers used TMS to demonstrate that corticospinal mechanisms underpinned the maintenance of strength and muscle thickness in an immobilized limb after unilateral training of the free limb.[8] In another, participants undertook leg-press strength training for eight weeks; the trained leg showed a strength increase of 29% while the untrained one increased 20.4%.[9]

The lead author of the second paper, Chris Latella, a doctoral candidate at Deakin, said the team trained the dominant leg because they'd begun to notice that strength transfer seemed to work better from dominant to nondominant limbs, though this hasn't yet been verified or fully explained. In addition to the strength gains, the team reported a decrease in corticospinal inhibition in both legs (by 17.3 ms for the trained leg and 20.8 ms for the untrained leg).

"I've seen two related nervous-system effects with this kind of training—both increased excitability and decreased inhibition," Latella said. The former is the readiness of the neuronal pathway to send excitatory stimulation to the muscle, causing a contraction; the latter is the degree of the pause between such signals, which reduces the overall neural drive to the muscle.

Continued on page 42

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Continued from page 40


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Deakin researchers have also noticed that increasing the demands of a training regimen seems to increase the crossover effect.[10]

"We believe that higher-load and more cognitively demanding strength training, such as using a metronome to control movement, facilitates the magnitude of transfer," Hendy said. "It's more demanding on the nervous system, both in motor output to control the movement and with afferent feedback, particularly when your muscles are lengthening. So we're trying to make the movement as skillful as possible. It's all about learning the activation, learning to relax your antagonists, and applying force using motor unit recruitment in the optimal manner."

The researchers continue to refine their knowledge of what works and what doesn't. For example, in a 2015 paper, Hendy reported that crossover strength gains in the untrained limb were more likely to be maintained at 48 hours when strength training was combined with a-tDCS, versus strength training with sham a-tDCS—a finding with implications for improving rehab outcomes after unilateral injury.[11] An interesting aspect of the study was that the authors used a-tDCS to stimulate the side of the brain associated with the untrained limb.

"To get a crossover effect, you want to maximize activity in that hemisphere," Hendy explained.

She acknowledged that much of the Deakin research has been conducted in the upper limbs, and that extrapolating their conclusions to the lower extremities should be done with caution. Even so, she thinks the potential for crossover effects in the legs might be even greater than in the arms.

"There may be more skill-based learning effects because we

have the ability to apply complex, multijoint movements in the legs," she said. "I also think those effects might be facilitated more at the spinal level. In any case, I see no harm in utilizing these types of training to try to maintain neural connections when someone is partially immobilized. I can't think of any potential detrimental effects other than exacerbating the bilateral difference."

Studies in the lower extremities bolster Hendy's position. For example, in 2009, Norwegian researchers concluded that enhanced neural drive to the contralateral agonist muscles contributed to cross-education of soleus strength over a four-week training regimen.[12]

In 2015, Italian investigators reported in *Gait & Posture* that crossover effects occurred in ankle dorsiflexors, both for peak torque and muscle work, and in fact the untrained leg gained more than the trained leg, a counterintuitive finding yet to be explained.[13] (A similar paper by the same group, also published last year, found the gains were similar in both trained and untrained legs.[14]) Finally, echoing one of Hendy's conclusions, researchers at the University of Central Florida in Orlando reported this year that four weeks of unilateral strength training resulted in increases in strength and size of the trained muscles, but crossover of only leg-press strength—not muscle size, activation, or hormonal response—to those on the untrained side.[15]

Fatigue

The flip side of strengthening muscles is fatiguing them, and David Behm of MUN, as well as other researchers, have investigated crossover fatigue effects extensively. According to Behm, such effects are typically easier to measure in the lower body than in the upper body.

Continued on page 44

Continued from page 43

"We have reflexes that allow us to walk automatically, without thinking about it," he said. "There are more interconnections in the lower body, which facilitates the crossover effect."

The research about crossover fatigue has been equivocal, however; some studies support the idea and some don't.[16] One of Behm's coauthors, Jalal Aboodarda, PhD, a MUN colleague who will begin postdoc work in kinesiology at the University of Calgary in Canada this fall, told *LER* that several investigations currently under peer review have shown no such effect.

"I believe the acute deterioration of muscle performance, which has been observed in only fifty percent of studies, does not necessarily mean that unilateral fatiguing exercise provides longitudinal inhibitory neurophysiological effects," Aboodarda said.


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In a 2014 study coauthored by Behm and Aboodarda,[16] a unilateral fatigue protocol of knee extension exercises showed moderate effects on the contralateral limb (23.7% to 34.6% decreases in MVC in the first 100 ms); by contrast, a 2015 paper by Behm and other colleagues reported no significant changes in force production in the nonfatigued limb.[17] For that matter, Aboodarda, Behm, and colleagues published a paper the same year showing that upper-body fatigue, achieved through elbow-flexion exercises, affected electromyographic responses in the knee extensors. However, this did not decrease their strength, supporting the idea of a centrally mediated fatigue mechanism, the overall effects of which remain unclear.[18]

Other investigators have reported, for example, that a unilateral fatigue protocol induces crossover fatigue during single-leg landings;[19] that fatigue-induced anticipatory postural adjustments occur in both fatigued and nonfatigued muscles;[20] that two bouts of fatiguing exercise rather than one were needed to produce a crossover effect;[21] and that crossover fatigue affected postural control after both stimulated and voluntary contractions.[22]

What to make of it all?

"The neurons that control whether your muscles are going to activate or not are interconnected with a lot of synapses," Behm said. "Some are excitatory, but some are inhibitory, so that if you're getting really tired the system will help prevent you from having a catastrophic event. Bilateral effects make sense because the body would want to slow you down on both sides. This may have to do with the brain; if it's been pushing your left leg for the last three minutes and then you try to push the right leg, the brain's ability to concentrate may have been diminished, and if you have less ability to concentrate you're more likely to have crossover fatigue."

In terms of practical applications, Behm said that athletes may want to allow time between training different parts of the body.

"If I'm doing an upper-body training program, then going for a run, the run is probably going to be affected by the upper-body workout," he said. "Nonlocal effects are more apparent with prolonged, high-intensity contractions, so if you want to minimize those effects, you shouldn't push yourself to total fatigue and failure."

Israel Halperin, MSc, a colleague of Behm and Aboodarda's at MUN and coauthor of several of their papers, is now completing his PhD as a scholar at Edith Cowan University in Canberra, Australia, in conjunction with the Australian Institute of Sports. In a recent literature review, he concluded fatigue crossover effects are more prevalent in the lower limb muscles studied (mainly quadriceps) than in the upper (mainly elbow flexors)—76% of outcome measures versus 32%, respectively—and appear dependent on the muscle group studied.[23] Moreover, nonlocal fatigue effects appear to be associated with four different but connected pathways: neurological, biochemical, biomechanical, and psychological.

In a 2014 paper, Halperin and his MUN colleagues reported nonlocal fatigue effects in the knee extensors regardless of whether the opposite knee or the elbow flexors were exercised, but also found the elbows weren't similarly affected by first working the knee.[24] Perhaps inevitably, other papers by the team have shown elbow flexors are affected by knee extensor fatigue,[25,26] but Halperin stands by his conclusion that the greater effects remain in the legs. In any case, he echoed Behm's perspective about practical applications of the research.

"Given that the legs are most susceptible to nonlocal muscle fatigue, that should affect exercise programs," Halperin said. "Lower body exercise should come before upper body exercise to minimize the fatigue-related crossover effects."

Neurological implications

Researchers and clinicians are investigating the potential utility of crossover effects in patients with neurological deficits, as well.

In a 2016 proof-of-concept study in multiple sclerosis (MS) patients, for example, Italian researchers reported crossover strengthening effects in the ankle dorsiflexors.[27] Increasing attention is being paid to the potential for treating the weakness associated with post-stroke hemiparesis, as well.

"Once you've had a stroke, the system tries to find alternative pathways to allow you to function," said David Behm. "So if you can

Continued on page 46

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Continued from page 44

work and coordinate the good side, it should help get the other side to improve those pathways."

Research is beginning to support this view. For example, in a 2013 paper from the University of Victoria in Canada, investigators reported unilateral high-intensity resistance training of the dorsiflexors on the less-affected side led to significant gains in muscle activation contralaterally. This included four patients who were unable to generate any dorsiflexion before the intervention and could do so afterward, demonstrating residual neuroplasticity years post-stroke.[28] In a related paper,[7] coauthor E. Paul Zehr, PhD, professor and director of the Rehabilitation Neuroscience Laboratory at the University of Victoria, wrote that "musculoskeletal and neurologic rehabilitation can move beyond the concept of deficit compensation and toward attempting to tap into the intrinsic biology of the nervous system to facilitate motor relearning and functional activation."

"Of course, the best way to train something is directly," Zehr told *LER*. "But we've had people in our studies who couldn't produce measurable force in the [paretic] limb at the beginning. Then, after five weeks of contralateral training, they can activate that limb and start to train it. To see someone move their ankle even a little when they couldn't do it before is amazing, and the participants themselves get very excited. But I don't think of this approach as existing on its own; it's got to be part of a bigger picture of therapeutic and rehabilitative intervention."

From here

As researchers and clinicians refine their understanding of the neurological underpinnings of crossover effects, a variety of patients stand to gain. Those needing rehabilitation after injuries or stroke, or those with other conditions such as MS, may find new, more efficient pathways to strength and independence. After all, as a clinician once told a friend of mine: "The whole body's connected: Take a look!" ler

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

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Insole research explores postural control effects

A growing body of evidence suggests that foot orthoses may be a helpful addition to other therapies for improving balance and potentially reducing the risk of falls. The findings have been mixed, however, and clinical enthusiasm for this type of insole intervention also varies.

By Hank Black

As the earliest humans began to stand, they also began to fall, having trouble staying upright in stance. Balance and postural control, they learned, required myriad body systems to work together in parallel. Thousands of years later, modern humans are learning that foot orthoses may help facilitate that complex process.

Humans—those who are active and young, sedentary and aged, or those who have diabetic neuropathy[1], multiple sclerosis,[2] Parkinson disease,[3,4] or another pathology—are still losing their balance and falling in great numbers. Particularly among the elderly, fall prevention has become a global concern. Worldwide, falls are the second leading cause of accidental or unintentional injury deaths, and 37.3 million falls that require medical attention occur annually.[5]

Maintenance of balance and the control of body sway is largely dependent on ankle joint proprioception—the complex interplay of coordinated visual, vestibular, and somatosensory information, together with signals to the central nervous system from ankle ligaments and surrounding muscles, to communicate a sense of the body's position in space.[6-9] Proprioception, in other words, involves all sensory mechanisms used by the body for ankle joint stability.[10]

When that joint's stability is diminished—due to an ankle sprain, disease, or the progressive laxity of ligaments and other tissues from aging—healthcare professionals enter the picture with a variety of treatments ranging from ankle taping to ankle surgery.

Evidence is now accumulating that foot orthoses may be a helpful addition to other therapies for improving balance. Some studies have failed to confirm this, and among practitioners, the degree of enthusiasm for it varies.

Custom devices

Multiple clinical trials have found custom foot insoles beneficial for postural control.[11-14] Some investigators have found unmolded prefabricated foot insoles can improve postural stability,[15,16] but others found no benefit from wearing noncustom orthoses for this purpose.[17]

Growing awareness of plantar mechanoreceptors and their processing centers has prompted an upsurge in research related to balance-facilitating foot orthoses.

Continued from page 49

"Custom foot orthoses can give increased balance and proprioception, and it's not wrong to use them as a starting point for balance," according to Matthew D. Sorensen, DPM, FACFAS, a foot and ankle surgeon who practices at Weil Foot and Ankle Institute in Chicago. "They won't cure everything, but it can be helpful in an instability situation. For severe balance issues, I think it's an underpowered modality."

Sorensen considers prefabricated insoles hit-or-miss in treating ankle instability.

"Most off-the-shelf insoles are accommodative devices without a lot of internal structure," he said. "They're quite flexible and don't really control the mechanics of the foot. They're fine for cushioning, but don't hold a candle to the true, functional, custom-made device."

Robert A. Weil, DPM, in private practice in Aurora, IL, is quick to prescribe foot orthoses to enhance stability and balance.

"For youngsters, superstar athletes, and your grandma, proper foot and ankle alignment and support is always helpful for balance, and custom orthotics can provide an advantage," he said.

Weil sees top athletes in many sports.

"You can't show me a sport that requires the ultimate in precision and balance more than figure skating," Weil said. "I've been prescribing custom orthotics for decades in skating, including for 2010 Olympic gold medalist Evan Lysacek, who was 10 when we first put them in his skates. And the improvement in everything, including balance and stability, is quite remarkable."


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The same improvement is often seen in seniors, he said, when fall prevention is being stressed.

Orthoses are not prescribed only to support the foot, Weil noted.

"Many foot types like high arches don't need support. Orthotics help position the foot joints properly so supination for push-off is timed with optimum stability," he said. "Often, repetitive ankle instability is directly associated with pushing off on a hyperpronated foot."

Patrick A. DeHeer, DPM, of Hoosier Foot and Ankle Podiatry in Indianapolis, IN, prescribes custom foot orthoses for improving balance among his patients with ankle instability and other pathologies.

"They can be beneficial if they have a biomechanical association, such as rearfoot varus," DeHeer said. "The key is understanding the underlying biomechanical etiology."

Thomas W. Kaminski, PhD, ATC, professor of kinesiology and applied physiology and director of athletic training at the University of Delaware in Newark, recommends custom orthoses for improving balance, particularly in individuals with chronic ankle instability.

"Custom orthoses are key," Kaminski said. "They get the foot back to its more anatomically correct position; that may be of particular benefit to those whose ankles tend to sprain."

Like DeHeer, Kaminiski noted custom foot orthoses designed to reposition the rearfoot can be particularly useful for improving balance.

"Excessive rearfoot supination at heel strike may be leading to episodes of ankle instability, because as the patient lands they're already in a position of vulnerability with the ankle wanting to turn inward or give way," he said.

Prefab potential

Certified athletic trainer Chris J. Hamlyn, MS, LAT, ATC, however, uses off-the-shelf foot insoles in his practice at Anderson University in Anderson, IN, where he is director of athletic training education in the Department of Kinesiology.

Hamlyn was the lead author of a 2010 study[15] that found prefabricated orthoses were associated with improved postural stability in individuals with functional ankle instability. He said some prefabricated insoles have the presumed advantage of cupping the heel better or providing increased arch contact (vs no insole), "similar to what a custom orthotic would have to provide more proprioceptive feedback, allowing that individual to be more aware of the position of their foot and ankle."

Hamlyn said the use of foot orthoses for better balance has not yet become part of the normal clinical practice or the standard of care for ankle instability.

"The relatively small amount of research in this field, while growing, has yet to provoke widespread adoption," he said. "The price of a custom orthotic is prohibitive for most individuals or athletic training programs."

For the study, Hamlyn and colleagues recruited 40 individuals with unilateral functional ankle instability, as confirmed by the Cumberland Ankle Instability Test. Postural stability was determined using a force plate to measure center of pressure. In the first of three sessions, participants were asked to shift from double-leg stance to single-leg stance and maintain balance with eyes closed for 20 seconds while wearing their own athletic shoes.

In session two, the 20 participants in the experimental group were tested with prefabricated insoles in both shoes. The insoles were full-length semirigid orthotic devices with a urethane base and an ethylene vinyl acetate top cover, designed to support the medial longitudinal arch and stabilize the rearfoot. The participants were instructed to wear the inserts daily for two weeks, then returned for the same test in session three. (A control group of 20 participants repeated the testing protocol from the first session for all three visits.)

In the experimental group, postural stability was significantly better in sessions two and three than in session one. There were no differences across sessions for the control group.

Continued on page 52

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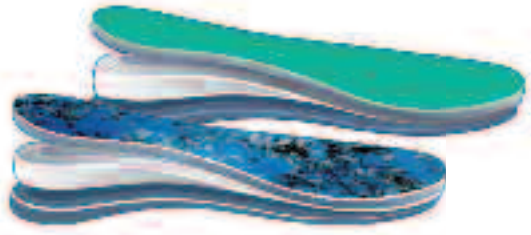

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- Faux leather top cover
- Cobra shell
- M-Sole or suede bottom cover

MatPLUS™
www.matplusinc.com

Continued from page 50

Investigating instability

Among the general population, ankle sprain is the lower limb injury that most often results in an emergency department visit.[18] The National Electronic Injury Surveillance System reports an estimated incidence of 2.06 ankle sprains per 1000 people a year. Ankle joint sprain is the most common sports injury, accounting for 15% of athletic injuries,[19,20] and can lead to chronic ankle instability (CAI).[21,22]

"CAI has an impact on activities of daily life, lowering overall quality of life. They may never again run or move confidently because of this," said Kaminski, lead author of the National Athletic Trainers' Association position statement on Conservative Management and Prevention of Ankle Sprains in Athletes[23]—which does not include a role for foot orthoses.

The instability likely will not go away, Sorensen agreed.

"The joint becomes mechanically unstable, usually with the lateral ligament actually stretching out or being partially torn or ruptured," he said. "And it generally does not completely recover. Whenever you stretch a ligament badly, there's always a little plastic deformation, and the ligament attenuates and becomes a little longer. It's difficult for the ligament to reestablish its normal physiologic tension. That occurs even if the ankle joint is immediately immobilized."

While the number of clinical studies of orthoses and balance for ankle instability have increased in recent years, Kaminski said, more research is needed.

"This is not yet a mainstream intervention," he said.

The somatosensory system is under increasing investigation as researchers try to suss out how each component works and integrates with other components. Multiple types of mechanoreceptors are found on the plantar surface, for example, which receive sensory information such as touch, temperature, and pain.[24] Signals they send to the central nervous system result in the activation of muscles to control posture, though the role of each individual sensory system in balance regulation is unclear.[3,25,26]

Research suggests neurophysiological factors can affect the biomechanical alignment of the lower limb.[27,28] Orthoses placed under the midfoot and forefoot may enhance afferent feedback from cutaneous receptors and reduce eversion due to contraction of inverting muscles.[29]

In part, it's the existence of these plantar mechanoreceptors and their processing centers that has prompted an upsurge in balance-facilitating foot orthoses in recent years. One research group found a custom insole with a compliant raised ridge located around the posterior perimeter of the rearfoot significantly increased postural stability for older adults who had mild age-related loss of foot sensation and for people with Parkinson disease.[30-32]

Texture and vibration

Others have explored the effects on balance and postural stability of textured insoles and even noise-enhanced orthoses. Mechanoreceptors are seen to respond to mechanical stimuli, including recesses and stretching of the skin to provide information on the spacing, roughness, and direction of the texture pattern.[33]

In several clinical trials, textured insoles have produced such improvements. McKeon and colleagues assessed the effects of textured shoe insoles that provided no mechanical support on postural control. Twenty healthy physically active participants with self-reported CAI

each balanced in shod single-limb stance with eyes open and eyes closed while wearing textured insoles, sham insoles, or no insole. They found the textured insoles were associated with significant reductions in time-to-boundary measures for the mediolateral (ML) direction.[34]

In a study of 25 patients with relapsing-remitting multiple sclerosis, Kalron et al found textured insoles altered static postural control parameters such as center of pressure when participants were examined with eyes closed, but not with eyes open.[35] The textured insoles did not have significant effects on the spatiotemporal parameters of gait.

In a 2015 systematic review, a Brazilian group affirmed the support in the literature for positive effects on postural control associated with textured insoles.[33] Four clinical studies reported these insoles helped activate the tibialis anterior muscle and reduce postural oscillations, especially in the ML direction.[3,29,36,37] The insoles studied differed with regard to materials, thickness, and Shore value—one featured pyramid peaks or a convex circular pattern, another had rigid discs and spikes.

This review also considered three studies of balance-enhancing effects of insoles that vibrate due to piezoelectric elements in the insole.[38-40] Based on the phenomenon of stochastic resonance, the vibration provides a mechanical noise that allows auditory feedback, with a resultant improvement in postural stability. The three studies detected improvements in balance and oscillation velocity in the anteroposterior direction associated with stochastic resonance insoles.[38-40] Priplata et al found vibrating insoles provided a significant reduction in sway parameters in patients with diabetic neuropathy, stroke patients, and healthy older adults.[40]

A more recent study of postural responses to this vibrotactile noise found the vibration stimulus modulates the impact of other environmental sensory demands, such as visual field rotations and mental calculations. Improvement of postural stabilization was seen when multiple sensory demands were present, though with less effect than without the other sensory input.[41]

Not all studies of textured insoles have produced positive results for balance and postural sway. A review published this year by an Iranian team concluded vibratory or magnetic insoles were associated with an increase in balance control, but textured insoles were not.[42]

Muscle activation onset

Faster neuromuscular responses to a potential ankle inversion may prevent a fall. Dingenen et al found[43] that shoes and foot orthoses produce significant neuromuscular effects in participants with CAI who previously used foot orthoses.

Using a single force plate and surface electromyography of nine lower extremity muscles, the group measured changes when transitioning from double-leg to single-leg stance with eyes open and closed. Participants were tested barefoot and with shoes only, shoes with standard foot orthoses, and shoes with custom foot orthoses.

Compared with wearing shoes plus standard foot orthoses, wearing shoes with custom foot orthoses was associated with quicker muscle activation onset times at the ankle for the peroneal longus and tibialis anterior muscles and at the knee for the vastus medialis oblique and vastus lateralis muscles.

However, the neuromuscular effects of foot orthoses appeared to vary between individuals, which is a consistent theme in the foot orthoses literature.[44]

Continued on page 54

Continued from page 53

"Future research should try to further identify the underlying mechanisms for these in order to finally better define the group of individuals who may benefit most from this intervention," said Bart Dingenen, PhD, PT, a physical therapist and postdoctoral researcher on the Faculty of Kinesiology and Rehabilitation Sciences at the University of Leuven in Belgium.

"We had only one measurement at one specific point in time and participants were already adapted to their foot orthoses. Other researchers may be interested in how these neuromuscular adaptations may develop over time," Dingenen said. "The potential interaction of this intervention with others, such as exercise therapy, remains unknown."

Multimodal training

Weil incorporates orthoses along with training for balance, proprioception, and strengthening exercises for the foot, ankle, and lower extremities using rubber bands and surgical tubing.

"Creating imbalance on wobble boards, mini trampolines, or Bosu ball demands all the body's stabilizer muscle groups to work to strengthen all areas that balance and stabilize the joints, and, importantly, strengthening of the body core," he said. "That's why you should include both custom orthotics and instability training when you're looking for optimum balance and stability."

DeHeer is among those who lean heavily on a physical examination and a detailed history that includes determining under what circumstances balance become problematic. He sends patients to a physical therapist for evaluation and to introduce fall-prevention strategies. His team looks at an individual's need for muscle strengthening and stretching, as well as biomechanics, gait, and foot structure.

"But it all comes back to the underlying reason for the problem, possibly including vision and inner ear, and we treat accordingly," he said.

Sorensen does not make use of formal balance questionnaires.

"It's not for me," he said. "I conduct a fairly straightforward evaluation. A lot has to do with what the patient tells me in their history—when do they not trust their steps, when must they go slowly and hold on to something as they go. If someone is walking down the street and turns an ankle, that's clearly instability. If they have trouble going down the stairs while holding on, that's a whole different thing that may require a more comprehensive evaluation for additional pathologies before settling on a specific therapy or orthotics."

The manual examination of the foot and ankle is important to gauge overall strength and pain, Kaminski said. He and most practitioners interviewed for this article said they assess balance by looking at the patient's single-leg stance over 20 seconds with and without eyes open.

"We look at range of motion, flexibility, and other tangible measures. But equally important is his or her answer to questions designed to determine when the ankle gives way," Kaminski said. "What's the situation when that happens—is it stable when walking but unstable when jogging? Is going up and down stairs a problem? That helps us focus on how to design our interventions."

Hank Black is a freelance writer in Birmingham, AL.

References are available at lermagazine.com.

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DonJoy POD Ankle Brace

The Protection On Demand (POD) Ankle Brace helps to provide protection from ankle injury for all athletes, from youth to elite levels. The adjustable POD brace is designed to offer freedom of movement and stability without breaking down, protecting the ankle while allowing athletes to maintain or improve their footwork and speed. The POD brace is designed to engage specifically when needed to proactively resist inversion ankle sprains and other common ankle injuries. The lightweight POD brace features a soft EVA (ethylene vinyl acetate) lining, a low profile cuff, and an adjustable underfoot closure.

DonJoy Performance,
a division of DJO Global
844/331-7767
donjoyperformance.com

Lunatec materials from nora

nora Systems now offers two new materials designed to absorb shearing forces associated with walking. Lunatec motion, an EVA (ethylene vinyl acetate) material, is available on its own or as part of a composite sheet called Lunatec combi motion. With a hardness of about 10 Shore A, Lunatec motion is designed to provide an extremely soft bedding for people with foot pain. It is available in 2-mm, 4-mm, 6-mm, or 8-mm thicknesses. The vulcanized composite Lunatec combi motion features 6 mm of Lunatec motion plus a 10-mm stabilizing layer of Lunasoft SL in light blue, which has a hardness of 40 Shore A.

nora Systems
770/687-2552
nora-shoe.com

Orthozone Thermal Slippers

Orthozone introduces Thermoskin Circulation Thermal Slippers. These thermal slippers feature three therapeutic layers to help increase circulation and decrease foot pain. The outer layer provides light compression and a comfortable fit for those who suffer from arthritis, diabetes, Raynaud syndrome, and cold or sensitive feet. The middle layer traps warmth to raise the temperature of cold feet and increase blood flow. And a Trioxon inner lining wicks away moisture and facilitates air flow to prevent overheating. These indoor slippers have a rubberized antislip sole and pull loops for easy on and off.

Orthozone
844/656-5500
orthozone.com

Z-Coil Footwear

Z-Coil Footwear Company offers footwear that is engineered to relieve foot pain. Like shock-absorbers for the body, the Z-Coil's patented conical-coil steel heels are designed to absorb up to 50% of the heel-strike impact associated with walking or running, while delivering a 40% to 50% energy return. The coil-suspension system works in conjunction with a built-in orthosis that cradles and supports the foot, distributing pressure more evenly to help reduce the risk of heel spurs and plantar fasciitis and reduce any associated pain. Thick cushioning under the forefoot and a rocker sole also help to reduce pain.

Z-Coil Footwear
800/268-6239
zcoil.com

roducts

4Jointz Pain Relief Cream

Now entering the US market is 4Jointz, a natural over-the-counter pain relief cream developed in Australia. 4Jointz is formulated for those suffering from osteoarthritis (OA), sports injuries, and everyday wear and tear. 4Jointz combines natural allantoin, present in a standardized comfrey extract, with tannic acid and eucalyptus oil in a fast-acting, easy-to-use herbal formula. A 2012 randomized controlled trial of patients with knee OA demonstrated that, as an adjunct to existing medications, 4Jointz reduced pain and improved function at 12 weeks more effectively than a placebo cream.

4Jointz
844/4JOINTZ (844/456-4689)
4jointz.com

Haruka Dynamic Walking Shoes

Waldlaufer introduces the Darryl lace-up oxford and Harlo slip-on shoes for women, both built on the company's new Haruka Dynamic construction. This lighter weight line, part of the Dynamic Walking Collection, is designed for patients suffering from plantar fasciitis, heel spurs, hallux limitus, or metatarsal pain. The mild rocker sole supports the arch while gently propelling the foot through the gait cycle, helping to reduce load on the heels, soles, toes, and joints while maintaining stability during gait. Haruka footwear is made in a European H width, which is equivalent to a US women's C width.

Waldlaufer
866/537-8363
waldlaufer.com

Guna Pain Relief Products

Guna, an Italian company, has released two new products for temporary pain relief. Guna-Flam is an anti-inflammatory, low-dose homeopathic medicine intended for minor aches and pains due to acute and chronic inflammation, trauma, or acute fever. Ingredients include aconitum napellus for pain relief, belladonna for fever, and pyrogenium for anti-inflammatory relief. As the name suggests, Guna-Arthro is formulated to treat inflammation in individuals suffering from arthritis and other musculoskeletal conditions. Both formulas are available in 1-oz bottles; oral dosing involves a few drops added to water.

Guna s.p.a.
484/223-3500
shop.gunainc.com

Cypress Adaptive Vista Ankle

Cypress Adaptive has launched the Vista Ankle, a universal, single-axis prosthetic ankle designed for mechanical elevated vacuum suspension. The achievable level of vacuum is determined by the compression of the plantar flexion bumper that occurs during gait; the unit comes with four different plantar flexion bumpers, each of which can be fine-tuned. The barb is located inside the proximal tube clamp so that the hose can be hidden in the pylon, eliminating system failure caused by an unprotected hose-barb connection. The Vista Ankle is compatible for use with any low profile K2-K3 prosthetic foot.

Cypress Adaptive
888/715-8003
cypressadaptive.com

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

ler new products

ProLine Orthotic Cutting Strip

Cascade Orthopedic Supply offers the new ProLine Orthotic Cutting Strip, an affordable, reusable tool for various orthotic fabrication applications. The ProLine Orthotic Cutting Strip is durable, flexible, and latex-free. Sold singly, this yellow cutting strip is available in 20" and 40" lengths. It can be used in these set lengths, or it can be cut in cases in which customization is warranted for a particular patient's unique needs. Cascade Orthopedic Supply, a comprehensive distributor of prosthetic and orthotics supplies, serves O&P facilities from advanced distribution centers in California, Texas, Illinois, and Pennsylvania.

Cascade Orthopedic Supply
800/888-0865
cascade-usa.com

Apex Sydney Women's Shoe

The Sydney is the newest addition to the Petals Collection of footwear from Apex, for women who enjoy style but need superior foot support and footwear adjustability. The soft, light Sydney is a casual boat-style shoe, crafted from supple leathers, that is suitable for all seasons. Like all shoes in the Petals Collection, the Sydney features soft, breathable mesh linings and a slip-resistant rubber outsole for improved traction and stability. It also features 5/16" removable depth in two layers to accommodate orthotic devices. Available in sizes 5-11, 12, and 13, and in two colors, bone (A2300) or camel (A2200).

Apex
800/252-2739
apexfoot.com

Pro-Tec Pain Relief

Pro-Tec Athletics offers a new topical product for pain relief. Pro-Tec's Pain Relief, available in spray or roll-on formulas, is all natural. Both versions are designed to provide fast-acting, deep-penetrating relief of pain associated with muscle tightness and strains, joint pain, tendinitis, arthritis, and sprained ligaments. The analgesic contains the active ingredient menthol, combined with a high concentration of natural ingredients including arnica, boswellia, nitric oxide, hyaluronic acid, methyl sulfonylmethane, eucalyptus, and yucca root. The spray formula comes in a 4-oz bottle; the roll-on version is 3 oz.

Pro-Tec Athletics
425/497-0887
pro-tecathletics.com

Coral Cal Mag Supplement

Coral Cal Mag, a calcium and magnesium supplement boosted with more than 70 other essential trace minerals, is designed to promote strong, healthy bones along with a well-functioning nervous system and a healthy heart. The supplement provides calcium and magnesium in a 2:1 ratio. The easy-to-digest-and-absorb formula features calcium safely harvested from above-sea, EcoSafe coral, which naturally includes 72 additional minerals; vitamin D3 has also been added to aid in calcium absorption. Coral Cal Mag, which is free of soy, dairy, gluten, and wheat, is available in a 180-count (60 servings) container.

Coral
800/882-9577
coralcalcium.com

market mechanics

By Emily Delzell

Össur acquires Medi Prosthetics, awards second #MyWinningMoment prize

Reykjavik, Iceland-based Össur announced that, effective September 1, it has acquired Medi Prosthetics, a global provider of mechanical lower limb prosthetic components located in Bayreuth, Germany, with total sales in 2015 of $17 million. Össur expects full integration of the business by 2017.

In October, Foothill Ranch, CA-based Össur USA named 10-year-old Diego Mercado the second #MyWinningMoment winner. Mercado won the online video- or photo-submission contest celebrating amputee mobility and an all-expense-paid trip to Össur's Running & Mobility Clinic, presented by the Challenged Athletes Foundation, and the 2016 Aspen Medical San Diego Triathlon Challengein La Jolla, CA.

In his winning video, Mercado, who was born with a congenital condition that resulted in the loss of his left leg and most of the fingers on his left hand, is shown working out with Marine Sergeant Jose Luis Sanchez, flipping a tractor tire that's taller than he is and outweighs him by several hundred pounds. ler

SmartCEO recognizes BOC head Zacharias

SmartCEO in September named Owings Mills, MD-based Board of Certification/Accreditation (BOC) President and CEO Claudia Zacharias, MBA, CAE, a 2016 Circle of Excellence Award finalist.

The Circle of Excellence program recognizes the area's most-accomplished business leaders for their industry impact and market leadership. This honor puts Zacharias in the running for her second award of 2016; in August, *The Baltimore Daily Record* named her one of Maryland's 2016 Most Admired CEOs.

In the seven years Zacharias has been with BOC, revenue has increased nearly 50%, due in part to the addition of two new credentialing programs, the Certified Durable Medical Equipment Specialist (CDME) and Pharmacy Accreditation. Zacharias's innovative launch of an inside sales program, unconventional in the nonprofit sector, combined with a focus on technology and partnership-building, also contributed to BOC's fiscal results.

Additionally, under her leadership, BOC is the only one of eight approved accrediting organizations to achieve net growth in the number of facilities accredited in recent years. Finally, Zacharias spearheaded a revamped customer service experience that in a four-year period garnered BOC five prestigious Stevie Awards for customer service and innovation.

The 2016 Circle of Excellence Awards finalists will be honored November 15 at the B&O Railroad Museum in Baltimore. Zacharias and other finalists will be profiled in the November/ December issue of *Baltimore SmartCEO* magazine. ler

medi USA invests in Topical Gear wearables

Whitsett, NC-based medi USA announced in September that the compression therapy, orthopedics, spinal bracing, prosthetics, and foot care business has made a strategic investment in a sports medicine company, Topical Gear, headquartered in Lakeway, TX.

A team of orthopedic sports medicine clinicians formed Topical Gear in 2010 and created performance wearables with T:25 Technology, which activates neuromuscular communication and targeted compression to train muscles, increase proprioception, and enhance performance to decrease the incidence of injury. ler

AAOS announces CEO retirement, guidance for infection control and fragility fractures

The American Academy of Orthopaedic Surgeons (AAOS) in October announced that its CEO, Karen Hackett, will retire in April 2017.

During her 14-year tenure as CEO, Hackett has overseen a staff of 250 employees, an annual budget of $60 million, and the opening of AAOS's orthopedic headquarters in Rosemont, IL. Prior to joining AAOS, she served as the COO and executive vice president of the American College of Healthcare Executives.

She's received various awards for her AAOS work, including in 2009 the Association Forum of Chicagoland's Samuel B. Shapiro Award, which recognizes CEOs for accomplishments in association management, and in 2011 induction into the Orlando-based University of Central Florida College of Business Hall of Fame.

AAOS in September approved appropriate use criteria (AUC) specifying when to consider antibiotic administration prior to various dental procedures to prevent infection of orthopedic replacement joints or implants.

The AUC, available through the AAOS OrthoGuidelines website (orthoguidelines.org) and app, includes questions for clinicians to gauge risk related to the type of dental procedure, given the patient's implant status and overall health. There are 64 scenarios, each with an antibiotic appropriateness rating from 1 to 9, determined by a 14-member voting panel of orthopedic surgeons, dentists, oral surgeons, and epidemiologists. Specific antibiotics and dosage are provided for scenarios when antibiotic treatment is recommended.

Also in September, the AAOS published a revised position statement on orthopedic care of patients with fragility fractures, created in conjunction with the American Orthopaedic Association (AOA), the Orthopaedic Trauma Association (OTA), and the International Geriatric Fracture Society (IGFS).

Physicians should proactively screen, monitor, and, if necessary, assist in getting treatment for elderly and other at-risk patients for osteoporosis following an initial bone fracture to prevent subsequent fractures, according to the revised position statement.

Read the full statement at aaos.org. ler

Pedorthist Alpert joins Foot Solutions

Atlanta-based Foot Solutions in September announced that Teresa Alpert, CO, CPed, has joined its Aurora, CO, location as director of education for pedorthics. In this role, Alpert works directly with healthcare professionals and their staffs. Before moving to Colorado she was in private practice in Baltimore, where she also owned a pharmacy.

Alpert completed her initial orthotics and prosthetics studies at Northwestern University in Chicago and is a past chair of the Board for Certification/Accreditation International. She has worked in patient care and in educational programming and is a past member of the Board of Directors of the Board for Certification in Pedorthics, which merged with the American Board for Certification in Orthotics and Prosthetics (ABC), and a speaker and educator in programs sponsored by the Pedorthic Footcare Association.

She previously served as education chair for the National Shoe Retailers Association. Email her at teresa@footsolutions.com or call 720/328-8785. ler

Continued on page 62

market mechanics

Continued from page 61

Ipsen reports extended Dysport-for-CP data

The principal investigator (PI) for a randomized controlled trial of Basking Ridge, NJ-based Ipsen Biopharmaceutical's Dysport on September 22 reported extension study data on the botulinum toxin type A (ABO) for pediatric patients with cerebral palsy (CP) at the American Academy of Cerebral Palsy and Developmental Medicine annual meeting in Hollywood, FL.

Study PI Mauricio Delgado, MD, director of the Texas Scottish Rite Hospital for Children in Dallas, shared results the open-label extension study (up to four additional injections) following the phase 3 trial of Dysport in 235 pediatric patients aged 2 to 17 years with dynamic equinus due to CP.

Researchers measured mean change in Modified Ashworth scale (MAS) and mean Physician's Global Assessment (PGA) response to treatment. Both parameters improved significantly at four and 12 weeks; 207 patients opted to enter the extension study and received at least one ABO injection.

Most (99.6%) patients had injections to the gastrocsoleus complex, 17% to 24% of patients had hamstrings injections, and 11% to 12% patients had injections into other lower limb muscles.

Mean change in MAS scores from baseline to week 4 were: -1 (n = 170), -1.1 (n = 122) and -1 (n = 66) in cycles one, two, and three, respectively. Mean week four PGA scores were 1.5 (n = 195), 1.5 (n = 159), and 1.4 (n = 78), respectively. Patients who received ABO vs placebo also significantly improved muscle tone in the knee flexors (mean change in MAS scores ranged from -.2 to -.8 across cycles). ler

AAOP reports rising numbers for O&P jobs

Data from the Washington, DC-based American Academy of Orthotists and Prosthetists (AAOP) in September indicate a number of health trends are continuing to increase demand for O&P practitioners and that robust employment opportunities continue in this sector, despite an overall stagnant 4.9% unemployment rate reported by the US Bureau of Labor Statistics.

Health trends contributing to this demand include increased rates of diabetes, heart disease, and obesity, as well as a growing aging population that has a high demand for O&P services. AAOP also found 24% of O&P practitioners are aged 55 years and older and will likely retire in the next decade, fueling a need for more students to enter O&P programs.

Average compensation within the O&P profession ranges from $39,500 to $75,300 annually, according to the AAOP data. ler

Data support Smith & Nephew system

London, UK-based Smith & Nephew's single-use negative pressure wound therapy system can significantly improve outcome predictions and reduce complications after orthopedic surgery using Pico, according to randomized control trial data presented in September at the European Bone and Joint Infection conference in Oxford.

The 12-month trial compared the use of Pico with standard dressings on closed surgical incisions in 220 patients undergoing primary hip or knee replacement.

Patients receiving Pico had a significant four-fold reduction in extreme wound exudate, a 6% reduction in superficial surgical site infections, and fewer dressing changes and extended hospital stays (1-10 days for the Pico group vs 2-61 days for controls). ler

Muller is CSU Dominguez Hills O&P chair

Gary Sayed, PhD, dean of the College of Health, Human Services, and Nursing at California State University, Dominguez Hills (CSUDH) in October named Mark Muller, CPO, FAAOP, MS, the new chair of the university's Department of Orthotics and Prosthetics.

Muller joined CSUDH in 2006 and developed new gait and biomechanics curricula and upgraded all the department's course objectives. Prior to becoming a member of the CSUDH faculty, Muller was in private practice in San Diego, served as education manager for Össur Americas, and taught at Northwestern P&O Center. Muller is a past president of the American Academy of Orthotists and Prosthetists.

He replaces Scott Hornbeak, CPO, MBA, FAAOP, director of the program since 1994 and instrumental in its success. Hornbeak will remain as a senior faculty member.

CSUDH's three-year O&P plan is to implement an assistant-level curriculum and a post-professional master's program, increase evidence-based practice and clinical research, utilize additive manufacturing, and experiment with new interface designs. ler

Curbell backs OPAF First Swim and Dance

Orchard Park, NY-based Curbell Plastics reported in September that it helped sponsor the Orthotics and Prosthetics Activities Foundation's (OPAF) First Swim and First Dance events held in Dallas.

Curbell, which supplies plastic sheet, rod, tube, film, adhesives, sealants, and prototyping materials, made a financial contribution to support the events after being approached by students in the Orthotics and Prosthetics Program at the University of Texas Southwestern Medical School in Dallas, who were organizing the adaptive sports clinics in partnership with OPAF.

Both events took place September 17 at the Bachman Therapeutic Recreation Center. ler

Oxford University Press to publish *PTJ*

The Alexandria, VA-based American Physical Therapy Association's (APTA) scientific journal, *Physical Therapy (PTJ)* is moving to "the next level" with its partnership with Oxford University Press (OUP), according to *PTJ's* Editor-in-Chief, Alan Jette, PT, PhD, who published an editorial in the October issue describing the partnership.

According to Jette, OUP will publish *PTJ* through a platform that will offer "state-of-the-art dissemination and display of scholarly work," and will increase the journal's exposure through other channels, including promotion in the OUPblog. The *PTJ* editorial board and staff will maintain full control over the content of the journal, which will shift to an online-only format in the next few years.

PTJ's is also giving authors open-access options, which allow sharing of articles for non-commercial purposes, as well as unrestricted open access that allows authors and others to reproduce and share the article in any way, including for commercial purposes.

According to Jette, these new capabilities will make *PTJ* an attractive venue for authors working with high-profile funding sources such as the Wellcome Trust and the Bill and Melinda Gates Foundation, which often require publication in journals that offer open-access options. ler

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