Lower Extremity Review

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November 2015

Barefoot running: Debate moves to developing feet

Biomechanical care for juvenile idiopathic arthritis

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- International O&P outreach work
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From the editor:
Adding experts to care team

True multidisciplinary care can yield great benefits for patients, but despite all the emphasis that makes the statement almost a cliché, it's not always what patients receive. I first realized this when I was interviewing the heads of various departments and divisions of a large academic medical center, where for many years I was an editor publishing on the faculty's clinical work and research.

At some point most said something like, "We want to emphasize that we provide specialized, multidisciplinary care."

I'd give a little mental editor sigh—because this applies to almost everyone in a major tertiary care center—and ask for specifics. Then I'd hear about the cardiac nurses, exercise physiologists, dietitians, diabetes educators, pharmacists, and psychologists involved in cardiac rehabilitation or the team of medical oncologists, radiation oncologists, surgical oncologists, radiologists, oncological nurses, social workers, and others providing care and support to patients in the cancer center.

I'm also reminded about the advantages—and the challenges—of a collaborative approach by articles in this issue of *LER: Pediatrics*.

In "Biomechanical care for juvenile idiopathic arthritis" (page 15), for example, experts interviewed by writer Shalmali Pal discuss a number of ways in which podiatrists, physical therapists, and other lower extremity practitioners can reduce pain and improve mobility and function for children with this most common form of childhood arthritis. The experts also note these specialists aren't typically on treating physicians' radar.

This theme is echoed by orthopedic surgeon Amy Yin, MD, in "Biomechanical stress, overuse raise young dancers' injury risk" (page 6), a research news article reporting on her epidemiological study of pediatric dance injuries. She says, too often, these dancers don't seek care from physicians with training in dance or sports medicine and rely on dance teachers or general physicians who may not be aware of the potential for the injury—and continued practice—to cause long-term problems.

To bridge the gap, experts suggest lower extremity practitioners with interests in these areas reach out to treating clinicians and explain what they have to offer. Patients, they say, will benefit. That may be a cliché—but I couldn't agree more.

Emily Delzell, *Senior Editor*

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O&P teams treat limb loss, deformity in developing world

Donating parts, funds aids efforts

By Brigid Galloway

Each year, Dino Scanio, CO, LO, and his five-member team of pediatric O&P specialists arrive in Guatemala City to perform a challenging task. In just four days in their most recent clinic in August, for example, they fit nearly 50 young patients with custom devices and trained local practitioners on fabrication and maintenance techniques.

Scanio and his wife, Lisa, established the Tampa-based Florida O&P Outreach Team (FOOT) Foundation in 2011. They are part of an effort among practitioners to find creative ways to sustain the O&P needs of the world's resource-poor nations. In Guatemala the gross national income per capita is $3410. There, advanced medical care—let alone prostheses—is not widely available.

As the clinic heads into its ninth year, Scanio looks forward to seeing familiar faces during the group's May 2016 trip. Among those will be five-year-old Christian (pictured) and his mother, who will travel five hours by foot and bus from their rural home. Three years ago, Christian, who was born without legs, walked for the first time after being fitted with his first artificial limbs at the FOOT Foundation clinic.

"The first day we put legs on him, we were all crying," said Scanio. "We weren't sure how he would respond, but now we're watching him grow up. He's done exceptionally well."

Children like Christian can outgrow an artificial limb every eight to 10 months, so the demand for quality O&P devices is ongoing. It's made more difficult by challenges in attaining appropriate components. "Materials we commonly use in the US, such as gel liners, cannot be sustained in Latin American countries where temperatures are hot and the gel breaks down quickly," Scanio said. "In many parts of the world, if a component breaks, it can't be replaced. So it's very important that we use readily available materials that are indigenous to the area and can withstand the terrain and living conditions."

The FOOT Foundation relies on financial contributions to underwrite its philanthropic work, but it also solicits a different type of donation: used parts. US regulations prohibit the use of recycled O&P components, but this form of recycling is acceptable in Guatemala. "Parents happily bring their [outgrown] child's braces in the hope that they can be used by other, less fortunate children," said Scanio, who is a pediatric orthotist at Shriner's Hospital for Children in Tampa.

He's selective. He only uses what is "repeatable and repairable," and, while in Guatemala, he trains local practitioners to maintain the prostheses with available materials. Pediatric pylons, knees, and feet are the most in-demand components. Because the FOOT foundation custom builds orthoses onsite, the group doesn't accept fabricated limbs. (Some organizations, such as Physicians for Peace, do.)

> Recycling O&P parts in resource-poor nations isn't new, but some distributors are unethical, selling parts for premium prices.

Recycling O&P parts in resource-poor countries is not new, but some distributors may be less than ethical, Scanio said. Demand for materials often inspires opportunists to sell donated parts on the black market at premium prices, and Scanio cautioned against donating prostheses to anyone who cannot demonstrate membership with a bona fide humanitarian organization.

He advises that donations of parts and funds be given only to organizations like FOOT, which has been awarded the Code of Conduct for Humanitarian Organizations Seal by the International Society for Prosthetics and Orthotics (ISPO). This code requires that humanitarian organizations support sustainable healthcare through the use of local materials, manufacturers, maintenance, and support, and take care not to defray the income of local businesses or practitioners.

Christian and FOOT Foundation team member Bryan Sinnott, CPO, LPO. (Photo courtesy of the FOOT Foundation.)

Seattle, WA-based Mobility Outreach International (MOI) works with children and adults with limb loss or deformity and is another of the 13 organizations to which ISPO has given its seal.

"I admire volunteer efforts of practitioners who take initiative and give freely of their time, expertise, and resources to help impoverished communities," said Raymond Pye, director of MOI Emerging Programs. "But, invariably, donors don't last forever, so our goal is to develop self-sufficiency."

Pye manages MOI teams in Sierra Leone and Haiti, and is developing new efforts in the world's poorest communities. The teams seek out local technicians, compatible materials, and manufacturers that can fabricate prostheses from local materials. For example, MOI often uses a simple but durable monolimb design for below knee prostheses.

Scanio and Pye agreed that meeting O&P needs in these economically disadvantaged communities is a challenge, but said organizations such as the FOOT Foundation and MOI are finding solutions.

For more information about the FOOT Foundation or to make a donation, go to footfoundation.org. To donate to MOI, go to mobilityoi.org. To review the compete list of organizations with the ISPO seal, go to drfop.org/humanitarian.

Brigid Galloway is a freelance writer in Birmingham, AL.

Biomechanical stress, overuse raise young dancers' injury risk

Prevention requires team approach

By Hank Black

The inclusion of physicians, including specialists in pediatric orthopedic surgery and sports or dance medicine, in a team with teachers, physical therapists, parents, and others could help identify and prevent injuries in growing young dancers, according to authors of an epidemiological study of pediatric dance injuries published August 28 in *Physical Medicine & Rehabilitation*.

Lead study author Amy X. Yin, MD, noted empirical data on specific pediatric dance injuries are lacking, possibly because many young dancers don't seek early medical advice and rely more on advice from dance teachers and physical therapists. While nearly all professional dancers seek medical attention for injuries, up to 30% of young dancers do not, said Yin, who completed the study while she was a fellow physician of sports medicine at Stanford University in California.

She and her colleagues analyzed dance injuries from a sample of children and adolescents aged 5 to 17 years seen over 10 years by sports and dance medicine physicians at a tertiary pediatric medical center. They looked at 181 dancers (171 girls, aged 14.8 ± 2 years) with 216 classifiable injuries to determine injury diagnoses, body location, type, and treatment.

Most injuries were to the lower limbs. The knee, ankle, and foot and toes were the most common injury sites on the body, and the most common diagnoses were related to overuse: tendinitis/tendinopathy, patellofemoral pain syndrome (PFPS), apophysitis, ankle impingement syndrome, and hip labral tear.

Joints sustained 42% (n = 90) of all injuries, 31% (n = 67) affected soft tissue, and 20% were skeletal (n = 43). Physeal injuries accounted for 7% (n = 16).

PFPS was the most frequent joint injury. Yin et al noted that not only is the knee the most commonly injured joint in young athletes, but that adolescent girls—and therefore most dancers—incur anterior knee pain more often than boys.

The most common skeletal injuries seen were pars stress reaction/spondylolysis, other stress reactions/stress fractures, and nonstress fractures; physeal injuries included apophysitis and two cases of Salter-Harris (epiphyseal plate) fracture. Most soft tissue injuries were tendinitis/tendinopathy, sprain, and strain.

"Skeletally immature young dancers are vulnerable to injuries such as apophysitis and Salter-Harris fractures," Yin said. "A lot of injuries happen in this age group because of a pattern of overuse associated with poor dance technique."

An example is iliac crest apophysitis: "The turned-out position required for dancing promotes tight external hip rotators and abductors," she said. "When this is combined with repetitive hip flexion, particularly in a still-growing dancer, injury becomes more likely."

Yin noted there are few studies on dance-related physeal injuries, and she and her coauthors called for more emphasis on the needs of skeletally immature dancers because of the potential for physeal injuries to cause significant long-term disability and deformity.

> "A lot of injuries happen in this age group because of overuse associated with poor dance technique."
>
> —Amy X. Yin, MD

"A physician with an interest in dance can help teachers and their staff become aware of biomechanical issues that can lead to injury," she said "The multidisciplinary team approach that should be the focus of dance injury prevention may also include physical therapists, exercise scientists, dance instructors, and informed parents."

Yin, who is now an orthopedic and sports medicine surgeon at Spherical Medicine in Oakland, CA, noted risk reduction interventions might include an individualized conditioning program based on injury history and functional movement screening, as well as tailored programs in resistance training to correct biomechanical imbalances that can result from intense training during the growing period. She also suggested tapering dance intensity before performances to help prevent injuries from overtraining.


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Reed Estes, MD, assistant professor in the Department of Orthopedic Surgery at the University of Alabama at Birmingham (UAB), said, "The study is well done, and I agree the majority of the injuries are related to overuse and are therefore preventable." Estes is chief of UAB Sports Medicine and director of its Dance Medicine Clinic. His training included work with the Boston Ballet and other dancers and athletes.

Estes pointed out that the tertiary nature of the sports medicine clinic involved in the study might have skewed results, as many patients would have sought treatment elsewhere for minor injuries or already attempted conservative management. "Also, the frequency of surgeries performed [29.8% of the sample underwent surgery] may be slightly higher because conservative management had already been attempted," he said.

"Many dancers don't feel comfortable with a healthcare provider who doesn't understand the extreme demands they are under," he said. "It's crucial that practitioners for this age group have experience and knowledge in dance medicine. The prevalence of young dancer injuries shows the need for knowledgeable practitioners, as well as education about how to prevent and identify injuries." (ler)

Hank Black is a medical writer based in Birmingham, AL.

Source:
Yin AX, Sugimoto D, Martin DJ, Stracciolini A. Pediatric dance injuries: a cross-sectional epidemiological study. PMR 2015 Aug 28. [Epub ahead of print]

Foot disability in Down syndrome linked to hallux valgus, narrow shoes

Regular foot checks may curb problems

By Erin Boutwell

A recent study published in the *Journal of Foot and Ankle Research* found that hallux valgus and too-narrow footwear contribute to foot-specific disability in children with Down syndrome. Interestingly, the study found foot posture wasn't associated with foot-specific disability in the same children.

The investigators, from La Trobe University in Australia, were particularly interested in determining the influence of footwear and foot structure on patient function and well-being.

"We have to always remember that quality of life extends beyond the absence of pathology; it extends to enabling participation," said Nikolaos Nikolopoulos, BPod (Hons), MBusSys, LLM, a lecturer at the university and coauthor of the February 2015 study.

Prior to the La Trobe study, the precise foot posture and footwear factors associated with foot-specific disability—and consequently, lack of participation—had not been determined. The La Trobe researchers performed a cross-sectional study of 50 children with Down syndrome (aged 5-18 years) to address this question. They measured foot posture, presence of forefoot deformities, and footwear fit (length and width) and determined the children's foot-specific disability using the Oxford Ankle Foot Questionnaire for Children (OxAFQ-C). More than one third (38%) of participants wore foot orthoses.

The study authors found that 76% of the children presented with flat feet (mean footprint-based arch index, .29), while 10% had hallux valgus.

Lower extremity experts not affiliated with the study noted the potential clinical relevance of the findings.

"Walking on a flat foot, or an overly pronated foot, is a little bit like driving your car with the front end out of alignment. You can still get from point A to point B, but you're going to have some abnormal wear on your tires," said Kathy Martin, PT, DHS, a professor and assistant program director of the Doctor of Physical Therapy Program at the University of Indianapolis.

Curt Bertram, CPO, FAAOP, national orthotic specialist for Hanger Clinic who works at Children's Hospital of Wisconsin in Milwaukee, used a similar metaphor to describe the importance of properly fitted footwear.

"I often relate shoes to tires on a car. You can have a new car with bad tires, and it will not drive well," Bertram said.

Ten percent of children in the study wore shoes that were too short for their feet, though shoe length was not correlated with changes in foot-specific disability. The children's shoes were 9 mm longer than their feet, on average, with a range from 14.3 mm shorter to 23.3 mm longer.

More than 58% of the children were wearing shoes that were too narrow for their foot (mean average, 4.5 mm too narrow; range, 26.5 mm too narrow-13.6 mm too wide). One possible conclusion is that children with Down syndrome may need wider shoes, but may not be communicating this information to their parents.

> Other factors in children with Down syndrome that may contribute to foot-specific disability include hypotonia and ligamentous laxity.

"Children with Down syndrome may not have both the cognitive and the language skills to appropriately convey to their parents that they don't like their shoes or that they're uncomfortable," Martin said.

Hallux valgus and narrow shoes were significantly associated with foot-related disability, but only accounted for 10% to 14% of the variance in OxAFQ-C scores. Also, somewhat surprising to the researchers, was that foot posture was not associated with foot-related disability.

The authors noted that limitations of the parent-completed OxAFQ-C for providing a true representation of foot-related disability may have influenced the findings. But the assessment does have its benefits, Nikolopoulos said.

"You've got to choose a questionnaire which is pointed, a questionnaire which is relevant, and a questionnaire that is 'easy' to complete," he said.

Photo courtesy of Surestep.

Martin and Bertram pointed out other factors that may contribute to foot-specific disability, including hypotonia and ligamentous laxity.

"The ligaments of children with Down syndrome are lax; the ability of the musculature to stabilize the joint is also impaired. So it's the entire kinetic chain that's affected," Martin said.

Additionally, the prevalence of ill-fitting footwear in these children may indicate a need to check for foot issues on a regular basis.

"There has to be an increased vigilance in terms of checking the feet for anything ranging from lesions, corns, and calluses, to orthopedic foot changes such as hallux valgus and joint positional changes, to infections," Nikolopolous said.

But vigilance alone may not be enough to prevent orthopedic deformity in adulthood, Bertram said.

"Properly fitting shoes are one tool that may be used to help mitigate the development of adulthood deformities but, as the severity of the deformities increases, prescription orthoses may be required in combination with the shoe," he said.

Erin Boutwell is a freelance writer based in Chapel Hill, NC.

Sources:

Lim PQ, Shields N, Nikolopoulous N, et al. The association of foot structure and footwear fit with disability in children and adolescents with Down syndrome. J Foot Ankle Res 2015;8(4):1-10.

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Barefoot running: Debate moves to developing feet

The most public battles about barefoot running and minimalist footwear have been fought over their use by adult athletes and the clinicians who treat them. There is, however, a separate discussion underway regarding barefoot and minimally shod running in children.

By Cary Groner

Much has been written about adults and barefoot running, including in *LER*,[1,2] but little research has focused on child and adolescent populations, so opinions are at least as plentiful as facts. Nevertheless, many of those opinions come from credible sources who take a commonsense approach based on clinical observation and experience. Moreover, in the past few years, researchers have finally begun to clarify the biomechanical effects of footwear and running in kids.

Kids' feet

When *LER* spoke to former Olympian Zola Budd Pieterse for an earlier article, she said one reason she could train and compete barefoot so easily was that she'd grown up that way in South Africa (see "The truth about barefoot running: It's complicated," page 20, November 2010).[2]

"For me, running barefoot was a lifestyle, not an option," she said. "All the kids in South Africa run barefoot, even today. It's just something natural."

According to Mark Cucuzzella, MD, a professor of family medicine at West Virginia University in Morgantown who blogs about the issue, the decision is crucial to children's development and future capabilities.

"The bones in kids' feet are malleable, so if shoes put tension on those bones that's not aligned with where they want to go, the bones will assume that direction," he said. "The question isn't how to transition kids to minimalist shoes; it's why should they ever be in footwear that bends the foot out of its normal position to begin with?"

What's considered normal for children should simply be the natural state of the foot, Cucuzzella said.

"I don't want to come across like some Paleo wacko; I don't think everyone should be eating raw steak and walking barefoot to school," he said. "But a shoe is a medical device for a foot. It affects

Research from Nike shows the dynamic arch continues to develop until children are about 7 years old, and that midfoot contact area during barefoot running also decreases over time.

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your bones, your gait; it's not like wearing a hat. So I think we should allow the foot to develop as naturally as possible for strength, mobility, proprioception, elasticity, response to the ground, coordination, control of the kinetic chain—all of those things."

Cucuzzella's theory comes into practice in his own house. His 10-year-old daughter refuses to wear any shoe that isn't flexible enough to fold up and put in her pocket, he said. The track team at his son's middle school now wears racing flats—not because anyone forces them to, but because they've tried various styles and decided they like them best.

One problem is that, as children enter adolescence, they become much more self-conscious about their appearance, and this can lead to suboptimal footwear choices, according to Cucuzzella.

"I just cringe when I see a teenager in middle school in high heels with pointy toes," he said. "I see those kids later, in high school, and they have severe hallux valgus—they can't rehab it with some stretching or taping, they've actually deformed their feet."

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The literature

Other clinicians have been making a similar case for years. In a 1991 paper in *Pediatrics*, for example, Seattle orthopedist Lynn Staheli, MD, surveyed anthropological literature and concluded that native people worldwide had far fewer foot problems if they lived their lives barefoot than if they wore shoes.[3] Staheli added that "stiff and compressive footwear may cause deformity, weakness, and loss of mobility," and that "shoe selection for children should be based on the barefoot model."

Roughly a decade later, William Rossi, DPM, wrote that nearly all juvenile footwear was bad for kids' feet.[4] He contended that any shoe that confined the feet or included any sort of heel rise should be eschewed. For example, the thick soles common in baby shoes "prevent 80 to 90 percent of the child's normal flex angle…thus denying the foot its normal step sequence."

In recent years researchers have begun to describe the effects of footwear on children's walking and running biomechanics in more detail.

For example, in 2008, German researchers reported that footwear limited midfoot motion during walking, and concluded that "slimmer and more flexible children's shoes do not change foot motion as much as conventional shoes."[5]

Then, in 2011, Australian researchers published a meta-analysis in the *Journal of Foot & Ankle Research* that examined 11 studies of more than 1200 children aged from 1.6 to 15 years.[6] They reported that, in kinematic running studies, shoes were associated with significant changes, including a smaller ankle plantar flexion angle at heel strike; smaller plantar foot angle at foot strike; lower angular velocity of the knee; and lower swing-back velocity of the tibia. Significant kinetic changes included less tibial acceleration and shock wave transmission.

The authors also reported that, while vertical ground reaction forces were not affected by footwear, there was a trend for shoes to be associated with a reduced loading rate. Children wearing shoes were more likely to heel strike (97%) than those who ran barefoot (62%).

In later papers, the Australian team reported that shoes did not significantly affect running agility, but that, during propulsion, shoes had a "splinting" effect on the feet.[7,8] That is, shoes reduced first metatarsophalangeal (MTP) joint motion during running from 31.5° to 12.6°, and midfoot sagittal plane motion from 27.4° to 9.6°. These limitations in midfoot motion may have lowered efficiency by reducing the windlass mechanism and the release of stored elastic energy, the researchers said. Although children partially compensated with increased ankle plantar flexion, this strategy may have increased the work of the triceps surae complex.

The lead author of the Australian papers was Caleb Wegener, PhD, who conducted the studies while completing his doctorate at the University of Sydney; he now does research and development for Sydney-based Mack Boots while retaining an honorary research associate position at the university.

"For most kids, walking and running barefoot means the arch rises over twenty degrees during the propulsive phase, but when they wear shoes, it only rises by about eight degrees, so it's quite a large reduction," he said. "When the arch rises, the foot shortens,

but most footwear doesn't shorten with it. And, when you put on a shoe and tighten it down, that has a binding effect; it pushes down on top of the foot as the foot is trying to rise. The effect on motion is a combination of these factors."

Our conversation was interrupted by a shriek; it was Wegener's young daughter trying to get at his laptop. She was, perhaps not surprisingly, running around the house barefoot. Wegener laughed and emphasized that, like Cucuzzella, that he's not an anti-shoe zealot.

"Shoes have beneficial effects; the attenuating effect on load is probably beneficial, you protect the feet from cold and from sharp objects, and kids walk faster in them," he said. "Those are good things, and we've been wearing shoes for thousands of years for those reasons. It's all about having the right functionality in the footwear so the foot can still function as designed."

Recent research from the Hospital for Special Surgery in New York City has produced compatible findings. In a 2013 study of early walkers published in the *Journal of the American Podiatric Medical Association*, for example, the authors reported that increased shoe flexibility promoted greater plantar loading, and that plantar pressures in the most flexible shoes were similar to barefoot levels. In conclusion, they speculated that this mechanical feedback might enhance proprioception.[9]


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Developing biomechanics

Irene Davis, PT, PhD, is well known for believing less is more in such matters. Davis, director of the Spaulding National Running Center in the Department of Physical Medicine and Rehabilitation at Harvard Medical School in Boston, told *LER: Pediatrics* that, in general, the less interference with normal motion, the lower the likelihood of injury.

"There was an Indian study[10] of kids from three different kinds of communities," she said. "Flatfoot was least prevalent in children from an area where they went barefoot. If you don't support the foot, the muscles get stronger; if you do, muscle demands decrease and the foot weakens. We need to be rethinking footwear in kids, because it changes the mechanics of the whole lower extremity."

In a 2011 paper in the *American Medical Athletic Association Journal*,[11] Davis wrote, "When children first learn to run, they naturally land on their forefoot with a

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relatively flat foot pattern. By the time they are four years old, and likely habitually shod, they have adopted a rearfoot strike pattern when they run."

Davis acknowledged that developmental biomechanics isn't her specialty, and said it would be interesting to know more about how young feet grow and change.

"I just think it's important to allow the foot to function the way it's supposed to throughout its development," she said.

Investigators at Nike in Beaverton, OR, have analyzed foot loading in developing children aged 3 to 11 years as they ran barefoot, though they drew no conclusions about footwear as a causative factor. In a paper presented at the 2009 meeting of the American Society of Biomechanics in State College, PA, Nike researcher Martine Mientjes, PhD, wrote that the dynamic arch continues to develop until children are aged about 7 years, and that midfoot contact area during running also decreases over time.[12] Moreover, increased loading as children age may affect midfoot contact area—increasing lateral contact—until they are aged at least 11 years. This may be due to increasing speed or muscle strength, coordination changes, or gender differences (boys had a broader midfoot than girls even allowing for weight differences).

In a second paper presented at the same conference, Mientjes reported that, at younger ages (3-5 years), about 80% of children landed on their heels when running barefoot; by the time they were aged 7 years, 93% were heel strikers, and, by 11 years, 100% were.[13] This upended the researchers' hypothesis that most younger children would land on their forefoot or midfoot when running barefoot.

Footwear and training

As with grown-ups, barefoot running isn't a panacea for children, experts say.

"There are always tradeoffs," said Peter Larson, PhD, a runner and blogger who performs gait analysis, offers footwear consulting, and coaches runners at Performance Health in Concord, NH. "When you reduce biomechanical work in one place, you increase it somewhere else. With barefoot running in adults, we've learned that taking off the shoes doesn't necessarily make injuries go away; it just moves the susceptibility to different parts of the body."

Although children are increasingly interested in distance running,[14] Larson said that not many participate in it where he lives, partly because of long, cold winters.

"It's mainly soccer—a lot of cutting and sprinting," he said. "So when the season starts, coaches try to ramp them up to competition level, and that exposes them to a lot of loading quickly. Whatever shoe they wear, if it's stressing them in a way they're not used to, that may be an issue that isn't faced by an adult who runs year-round."

Larson's own children—aged 11, 10, and 5 years—wear as little in the way of shoes as they can get away with.

"I wouldn't put them in a mini version of a traditional running shoe," Larson said. "I'm not opposed to cushioning, but I want them to be in something reasonably flexible that's not going to constrict their feet."

Seth Jenny, PhD, was so concerned about the lack of standards in children's distance running training protocols that he developed a number of recommendations to help keep kids both interested and uninjured.[14]

"Youth running programs have exploded in the US, but it's a little scary because we don't know what's safe," he said.

Jenny, formerly an exercise physiologist with the US Air Force and now an assistant professor in the Department of Physical Education, Sport, and Human Performance at Winthrop University in Rock Hill, SC, believes children have lower injury risks than adults in some ways, and higher risks in others.

"I think that, because they weigh less, there's less stress on the tissues," he said. "But risks for overuse and repetitive motion injuries may be similar. If they have poor running mechanics or inappropriate footwear, it can certainly cause problems requiring intervention."

As for shoes, Jenny isn't convinced that minimalist is the way to go. He saw lots of airmen get injured trying to transition to them too quickly, and he has his own kids wear typical running shoes. His says that his 3- and 5-year-olds are already running 400-m races and getting a kick out of it—in both senses of the word.

Down the road

As children's running biomechanics receive further study, presumably footwear recommendations will become clearer, as well. In the meantime, common sense suggests that what kids naturally gravitate to—bare feet when there's little risk of injury or frostbite—may be what's best for them. (ler)

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

References are available at lermagazine.com.

Recent study shows children prefer to wear DAFOs.

Research article *"Comparison of 2 Orthotic Approaches in Children With Cerebral Palsy"* published online in the APTA journal *Pediatric Physical Therapy, May 2015*

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Biomechanical care for juvenile idiopathic arthritis

Juvenile idiopathic arthritis (JIA) affects nearly a quarter of a million US kids younger than 16 years. The hallmarks of the autoimmune disorder include joint inflammation, stiffening, and damage, as well as changes in joint growth, all of which can prove painful.

By Shalmali Pal

JIA is the most common form of arthritis among US children. There are three general types of the disorder:[1] Oliogoarticular, in which just a few joints are affected, most notably in the knee or the ankle; polyarticular, in which five or more small joints are affected, most often in the feet and hands; and systemic, in which there is swelling, pain, and limited motion in at least one joint, along with other symptoms such as skin rash and inflammation of the internal organs.

Children with JIA often present with a long-term limp that can't be explained by other causes, such as an injury. They may also have a myriad of ankle and foot deformities (pes planovalgus, for example). If left untreated, these biomechanical limitations can cause long-term joint destruction and limit mobility and function.[2]

Children with JIA develop muscle spasm in an effort to limit their joint mobility, says Paul Scherer, DPM, founder and chief executive officer of ProLab Orthotics in Napa, CA. He noted, for example, that children with JIA commonly have fusion of the subtalar joints.[3] "There are three facets in the subtalar joints," he said. "If one of these facets does not form properly, it becomes arthritic. It then hurts for these kids to move the facets in the joint. Orthotic devices can help maintain stability of an arthritic joint in children [with JIA] so that the muscle spasm as a physiologic response is unnecessary."

JIA can result in a number of gait abnormalities.

In a 2010 study from Germany, adolescents with JIA (average age 13.2 years) underwent gait analysis, and investigators compared their results with healthy controls.[4] According to the authors, those with JIA showed reduced walking speed and step length, strongly anterior tilted pelvis, reduced maximum hip extension, reduced knee extension during single support phase, and reduced plantar flexion in push off.

Also, the foot's roll-off was decelerated, and there were lower peaks in ankle movement and power. "The gait of JIA patients can be explained as a crouch-like gait with hyperflexion in the hip and

Kids with JIA can have myriad ankle and foot deformities (eg, pes planovalgus). Left untreated, these biomechanical limitations can damage joints and limit mobility and function.

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Figure 1. An example of one adjusted orthosis from Coda's trial. Investigators used high-density EVA to create an antipronatory correction at the rearfoot and added a kinetic wedge at the first metatarsal head and shock absorption materials. (Photo courtesy of Andrea Coda, PhD.)

knee joints and less plantar flexion in the ankle," the authors wrote.[4]

Unfortunately, JIA management and treatment guidelines offer little help with regard to gait abnormalities and orthotic devices. The American College of Rheumatology's 2013 update to its treatment recommendations doesn't cover foot health and gait; neither do 2013 guidelines from the Children's Arthritis and Rheumatology Research Alliance.[5,6] Other organizations, such as Australia's National Health and Medical Research Council, discuss orthoses in their JIA management guidelines, but give podiatric interventions a "D" grade (indicating weak evidence for their use) and note clinicians should consider the use of foot orthoses on an individual basis.[7]

LER: Pediatrics checked in with experts on how to manage lower limb pathologies with orthotic devices, physical therapy, and exercise. They also discussed when lower extremity professionals should be called in to work with children with JIA.

Pain and devices

Orthoses can't address the characteristic joint inflammation of JIA, but they can help reduce pain and prevent ongoing damage to those compromised joints, said Mary Powell, RPT, of PT in Motion in San Diego, CA. Back in 2005, while Powell was at the Children's Hospital and Health Center in San Diego, she led one of the first trials that compared the clinical efficacy of custom foot orthoses, prefabricated devices, and supportive athletic shoes alone for reducing pain and improving function in 40 children with JIA.

Her group reported that, at three-month follow-up, those who received custom-made orthoses showed significantly greater improvements in foot pain, overall pain, speed of ambulation, limitations on activity, and level of disability compared with children in the other study arms.[8] An impetus for Powell to do the study was to find an alternative to the UCBL (University of California Biomechanics Laboratory) orthoses that patients with JIA were being prescribed at the time to manage lower extremity malfunction.

"I wanted to see if we could get the kids out of the UCBLs because they weren't wearing them—they were too rigid, too high, too stiff, and it was difficult to find shoes to accommodate them," she explained.

In a 2014 study, a group led by Andrea Coda, PhD, a lecturer at the University of Newcastle in Ourimbah, Australia, compared prefabricated fitted foot orthoses customized with "chair-side corrections" with the same orthoses without corrections in 60 children with JIA (study group: n = 31, mean age, 10.64 years; control group: n = 29, mean age, 11.17 years).[9]

The study group received foot orthoses adjusted for a better fit based on each patient's particular deformity, while the control group got the device as manufactured: a 1-mm leather board with a .75-mm black ethylene vinyl acetate (EVA) cover. All participants experienced a statistically significant reduction in pain measured with a visual analog scale from baseline to six months, with the adjusted orthoses group reporting greater improvement in both pain and in quality of life.[9]

Coda noted that the children completed 179 out of 180 assessments at various time points during the six-month study period, which speaks to the success of the corrected and uncorrected devices. "For a randomized, controlled trial, that kind of compliance is rare," Coda pointed out. "To me, this showed that the children welcomed the intervention…the fact that they were happy to come back, as were the parents to have the children assessed, at baseline, three months, and six months."

Coda and colleagues developed and implemented chair-side corrections (Figure 1) for the fitted orthoses in the study based on their clinical experience. The corrections, he said, are those "podiatrists are comfortable making in their daily practice." Adjustments were based on results from walkway-based gait analysis and in-shoe sensors that measured force data, plantar pressure, and temporal and spatial parameters.

These adjustments included, but weren't limited to: additions to varus rearfoot to prevent excessive pronation as well as the addition of antipronatory corrections at the rearfoot; heel raises to address anatomical leg length discrepancies; and metatarsal pads and cushioning top covers to deflect plantar pressure and provide shock absorption to reduce peak pressure and pressure time integral in areas of active arthritis.

Powell said she reserves rigid orthoses for patients with hypermobile feet who need maximum control and stability. Her preference is for a semiflexible material. "It has a shell that doesn't completely collapse, and more spring for shock absorption. Then I'll customize it with padding where it's needed—arch support, metatarsal pads, heel pads."

In terms of creating her custom devices, Powell said she uses a nonweightbearing cast that holds the patient in subtalar neutral. One of the main goals with the orthoses is to "achieve a more optimal alignment," she explained. Devices are then customized depending on the patient's needs, such as taking pressure off areas where there is joint inflammation.

"Then I will 'unweight' tender parts of the foot and distribute the weight across a bigger area of the foot," she said. "With that weight distribution comes less pain, less deformity, and fewer abnormal gait patterns. Also, when the weight is distributed and more shock is absorbed across the foot, patients ultimately can walk longer, faster, and participate more in life."

Powell cautioned that not every patient with JIA needs orthoses. "If they are not in a great deal of pain, and are reasonably mobile, then a supportive athletic shoe may be enough, or a shoe

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with an orthosis that offers padding or shock absorption. I don't want to give them more than they need," she said.

From a financial perspective, prescribing more than a child needs can be costly. Scherer noted that children outgrow custom-made orthoses fairly quickly. "A custom-made orthotic is really only custom for a year," he said. "The child's foot will get bigger, it'll get wider, it'll change shape." Prefabricated devices are a suitable alternative, but Scherer cautioned that practitioners need to consider the sizing.

"Select a prefab device with a very small gradient of change. One device may say it fits a toddler three to a toddler nine [shoe size], but that's a huge range," he said. "Would something that fits a toddler one to five be better? Usually, you can find prefab devices for children that are made with one-year size gradients."

Encouraging exercise

When it comes to physical activity, children with JIA are in a bit of a catch-22. There is mounting evidence that these children can improve their physical fitness and function, with no increase in disease activity, through physical activity. Pediatricians now recommend that, in general, children with JIA get the same amount of physical activity as healthy children—60 minutes of moderate to vigorous activity a day.[10] However, even if their disease activity is controlled with medications, these kids may still have pain and functional limitations, along with impairments in aerobic fitness and muscle strength, compared with typical children.[11]

Fortunately, the use of foot orthoses can improve ambulation and movement, potentially making it easier for children to be active. As part of their study, Coda's group looked at secondary outcomes of gait, both with and without orthoses. They reported significant improvements with fitted orthoses in gait time (seconds), gait velocity (cm/second), plantar surface contact area, and pain at the heel, midfoot, hallux, and fifth metatarsal head.[12]

"Logically, if a child is in less pain, they are more likely to be active," Coda said. "And, if they have a better quality of life, that's also going to encourage them to participate more, possibly in sports or other activities."

He added that compliance with JIA medications is sometimes less than ideal because of potential side effects (eg, nausea, vomiting, headache). However, when it comes to foot orthoses, "once the child has the shoe on with the orthotic, they generally forget about it and begin to move. So it's a cost-effective, fairly simple intervention that can make them more active," he said.

From a physical therapy perspective, Powell stressed the importance of determining how much pain the patient is experiencing and addressing that before trying to start an exercise or conditioning regimen. For alleviating joint pain, Powell relies on a variety of tools, including application of heat or cold, transcutaneous electrical nerve stimulation, (TENS), and ankle night splints to keep the foot in a neutral position.[13]

Once the pain has been addressed, patients can move on to activity-based physical therapy, including hydrotherapy or riding a stationary bike. But Powell would rather see kids get out of the clinic and join real-world activities.

She prefers noncontact activities, such as yoga, tai chi, or certain types of martial arts. She generally doesn't encourage impact sports—football, soccer, or basketball, for example—but doesn't rule them out. "I've got patients that I've seen through college, and they've played basketball happily and successfully," she said.

"You don't necessarily want to encourage them to do activities that will involve too much impact on their joints, but you also don't want to stop them from being kids and living their lives," she said. "So, if they aren't in pain and their inflammation is controlled with medication, can they jump on the trampoline at a birthday party? Sure. But I wouldn't tell the parents to go out and buy a trampoline for regular exercise."

Scherer concurred that patients with JIA and their caregivers should use discretion when deciding how much activity is appropriate, as excessive activity may increase the risk of muscle spasm.

Join the JIA team

"Current good clinic practice in JIA management supports early active intervention in an attempt to minimise long-term deformities," Coda's group wrote.[5,11]

How early is early enough? Coda noted that the patients in his 2014 study were aged between 5 and 18 years, and 5 years is the youngest age for orthotic intervention that he recommends because neither he nor others have tested foot orthoses in younger patients.

Scherer agreed that early intervention is key, but said it is going to require changing the mindset of referring physicians. Part of the problem may be that pediatricians and rheumatologists don't take complaints about foot pain as seriously as they should. Scherer cited a 2010 Canadian study that found a history of heel pain or enthesitis

was significantly associated with a longer time from symptom onset to the first visit to the rheumatology center, and with longer time from that first visit to a diagnosis of JIA, than for patients without heel pain or enthesitis.[14]

"If the [referring physicians] would understand the value of [devices], that would help with earlier intervention," he said. "By the time the child gets to the podiatrist, they've had the JIA for some time, they've been in pain for some time, and they may be suffering the effects of having limited mobility."

All three experts agreed that lower extremity practitioners need to be more active in treating these patients. Powell noted that, when she was at the children's hospital, she worked closely with a rheumatologist, Ilona Szer, MD, who insisted that physical therapy be part of the treatment protocol.

"I think it's very important to develop a relationship with the rheumatologists in your community," Powell advised. "Let them know that you have an interest in treating this patient population. I think sometimes the rheumatologists just don't know where to refer these patients."

Coda echoed this sentiment. "Podiatrists are not very present within the multidisciplinary pediatric rheumatology team, and that is something that I'd like to change," he said. "That was one of the reasons I wanted to do [the fitted orthosis] study—to show my colleagues that podiatric intervention in these patients can be justified and be very useful." ler

Shalmali Pal is a freelance writer in Tucson, AZ.

References are available at lermagazine.com.

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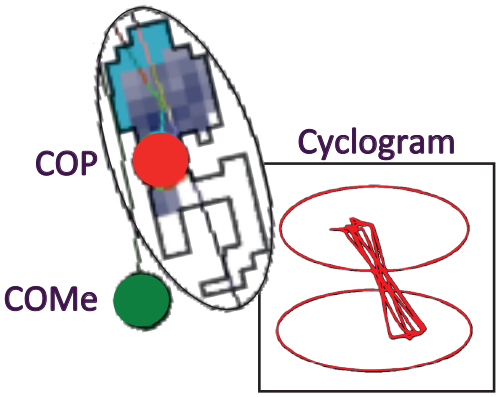

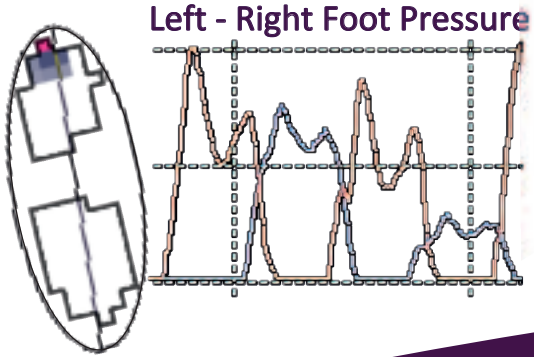

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