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While the patient is always the practitioner's first priority, establishing a convivial relationship with a child's parents can mean the difference between victory and failure when it comes to diagnosing, treating, and rehabilitating lower extremity problems in pediatric patients.

By Shalmali Pal

15 Toe walking researchers revisit idiopathic label

Two recent literature reviews underscore the lack of high-level evidence to support the various treatments available for idiopathic toe walking. But new research is starting to fill that void, and is also engendering new theories about factors that may contribute to the condition.

By Larry Hand

From the editor: Parents are people too



With so much of healthcare now automated, and so many demands on each practitioner's time, it's dangerously easy to lose sight of patients as individuals. Yet often it's the personal details that can make the difference between a successful outcome and a less successful one.

Knowing a little girl's preference for twirly skirts, a practitioner can screen for brace components that might be prone to snags. Knowing a little boy's favorite

cartoon character can make possible the creative customization of orthotic devices he is more likely to wear.

For clinicians who treat pediatric patients, it's also dangerously easy to stop thinking of patients' parents as individuals. When your focus is on the child—as it should be—it's understandable to think of his or her parents primarily as a means to an end, specifically a positive clinical outcome. And certainly there are effective strategies for managing parent behaviors in ways that will benefit the child in question (see "Parents: How to make them your clinical allies," page 9).

But here's another suggestion. Just as parents would prefer their children not view them as glorified cooks, cleaners, or cash machines, I suspect many parents also would prefer that their children's practitioners see them as more than a means to an end. Try taking just a few moments out of each visit to talk to the parents about an aspect of their lives that isn't clinical. It might make them a lot more collaborative.

Just as treating patients as people can motivate them to help themselves, treating parents as individuals with unique challenges can motivate them to help you help their children.

Jordana Bieze Foster, *Editor*

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Rates of chronic ankle instability in children are surprisingly high

Experts push for better sprain rehab

By P.K. Daniel

Primary ankle sprains often occur before adulthood, and a recent literature review from Australia suggests that some pediatric populations exhibit a high rate of ankle injury recurrence and chronic ankle instability (CAI). This finding, which echoes what has long been observed in adults, has raised concerns that ankle sprains in children are not being managed properly.

A systematic review of chronic ankle instability in children by University of Sydney researchers found that as many as 71% of children with a history of ankle sprain had perceived instability and as many as 47% had mechanical instability.

"We still don't know exactly what percentage of children will go on to develop CAI, as no prospective study has been done. However, it is an outcome that is under-recognized," said study coauthor Claire Hiller, PhD, a postdoctoral fellow in the university's Arthritis and Musculoskeletal Research Group.

More than half (53.5%) of all ankle sprains occur in individuals aged between 10 and 24 years, according to a 2010 study. That study also found that teenagers and young adults have the highest rates of ankle sprain, with a peak incidence of 7.2 per 1000 person-years for those aged 15 to 19 years.

"As currently the only known predictor of a sprain is a previous sprain, having an ankle sprain early in life gives you a much greater opportunity to have another one and develop long-term problems," Hiller said.

And yet, adults have been the focus of chronic ankle instability research.

The Australian review, which was published in March by the *Journal of Foot and Ankle Research*, analyzed nine studies on CAI focused on children and included ages up to 18 years. Many of the studies looked at specific youth populations, ie, dancers, soccer players, and those who had experienced "severe ankle trauma." The review found that the prevalence of CAI was equal to or higher than that of

adult populations. However, the overall shortage of studies on CAI in children led the review article authors to determine that more research was required.

Prevalence of perceived instability ranged from 31% in children with severe ankle injuries to 71% of children who were dancers. Nearly half (47%) of the dancers had mechanical instability.

"If our younger populations are exhibiting such high rates of ankle injury recurrence, it raises concerns that ankle sprains in this age group are not being managed properly," said Phillip Gribble, PhD, ATC, associate professor in the Division of Athletic Training at the University of Kentucky in Lexington. "This is likely [be-

Part of the problem is that clinicians treating children may not be aware that chronic ankle instability is a potential issue.

cause of a lack of recognition for the need for proper immediate care and evaluation, as well as a lack of thorough rehabilitation before returning back to activity."

Tricia Turner, PhD, ATC, an associate professor in the Department of Kinesiology at the University of North Carolina at Charlotte, said part of the problem is that children are being seen by practitioners who may not be aware that chronic ankle instability is a potential issue in children.

"Ankle sprains in children need to be treated and taken more seriously," Turner said.

Balance training exercises, taping, and prophylactic bracing can minimize the risk of future instability, but access to healthcare professionals who can effectively implement these practices is limited in the adolescent population.

"And typically nonexistent for the pre-




pubescent populations participating in sports," Gribble said. "The treatment decision then rests with the parents. They are likely not to seek formal management and rehabilitation for their child's ankle sprain, leaving the injured ankle at a higher level of susceptibility for reinjury."

Fereshteh Pourkazemi, PhD, a physiotherapy lecturer in the School of Science and Health at the University of Western Sydney and coauthor of the Australian review article, said less developed patterns of motor and postural control, combined with higher levels of activity, may increase the risk of ankle sprains and development of chronic ankle instability in children.

"We should really be cautious, go slow, and be very, very conservative with the treatment," said Thomas W. Kaminski, PhD, ATC, director of athletic training education and professor in the Department of Kinesiology and Applied Physiology at the University of Delaware in Newark.

Patrick McKeon, PhD, ATC, an ankle researcher with Ithaca College's School of Health Sciences and Human Performance in Ithaca, NY, echoed that approach, also indicating that the return-to-play timeline probably needs to be longer for children than adults.

"Joint deficit influences coordination, and their coordination is in the development stage, as opposed to the refinement stage," McKeon said. "We need to allow them more time to heal." 

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Gait compensations vary in kids with limb length discrepancies

Location of shortening is key factor

By Larry Hand

Contrary to popular perceptions, children with limb length discrepancy (LLD) may each use multiple compensatory strategies when they are walking, depending on where their discrepancy is, and those gait patterns may present a dilemma for practitioners.

In a recent study published in the *Journal of Pediatric Orthopedics*, Michael Aiona, MD, chief of staff at the Shriners Hospital for Children in Portland, OR, and colleagues found that children can compensate for LLD with multiple gait patterns, depending on which aspect of the limb is shortened.

The researchers used a motion capture system to analyze 45 children (24 girls) with an average age of 12.8 years and an LLD of more than 2 cm and 20 typically developing controls as they walked at a self-selected speed along a two-meter walkway.

Of the 45 children with LLD, 18 used multiple strategies to compensate for the shortening.

These included:

- Pelvic obliquity with the short side lower;
- Knee flexion in the longer leg during stance;
- Ankle plantar flexion in the shorter leg through the gait cycle; and
- Vaulting.

"We looked at a bunch of different kids with a bunch of different causes for differences," Aiona told *LER*. "Basically, in some areas they were putting a bit more pressure on certain joints and doing more work in certain areas. They also took different strategies."

Of the 45 children, four had a diagnosis of Legg-Calve-Perthes, nine had a diagnosis of developmental hip dysplasia, six had growth plate damage due to infection or trauma, five had shortening of the femur, seven had shortening of the tibia, five had syndromes creating limb shortening, and nine had other diagnoses.

Children with a length discrepancy in the femur used compensations at the ankle, which led to more work at the ankle joint on the short limb compared with those in the control group.

Children with tibia shortening demonstrated pelvic obliquity (when the pelvis is

lower on the short side throughout the gait cycle), and a few also compensated with knee flexion, which led to more work at the hip on the short limb compared with normal parameters. These findings suggest that underlying factors related to tibial shortening, whether specific to muscles or joints, limit the ankle's ability to perform increased work, the authors wrote.

Because many clinicians believe that children with LLD who are otherwise healthy develop compensatory strategies specifically to maintain a level pelvis during gait, Aiona and colleagues were surprised to find that 24 children in their study had persistent pelvic obliquity.

"A lot of the kids actually walked with their pelvis uneven, which is a little bit sur-

Children with shortening of the femur used compensations at the ankle, and those with tibial shortening used compensations at the hip.

prising to us," Aiona said. "There's some concern whether that has any effects on long-term hip joint development. You could argue that, if hip joint development is affected, then you need to more aggressively manage kids earlier on to get things a bit more equal."

A lift or surgery may be in order, he said, depending in part on the extent of the discrepancy.

"You could use a lift to equalize, but it's hard for the kid to play, and you can't modify every shoe," Aiona said. "It's the practicality and the cosmetic things that are involved in it that make it tricky."

Options for intervention also may be less clear in children who use multiple compensation strategies, which also appears to be associated with the magnitude of the discrepancy. The Shriners study found that all children with shortening of more than 7 cm used multiple compensation strategies. By



comparison, only three of 11 children with discrepancies between 4 cm and 7 cm used multiple gait strategies.

"For me, the take-home message is, when the discrepancy becomes greater, that's when you have to worry more about different ways of how they walk to compensate," Aiona said.

Mark Geil, PhD, director of the Center for Pediatric Locomotion Sciences at Georgia State University in Atlanta, said the study definitely adds to the evidence base.

"I've often taught in my classes that it's very difficult to predict which strategy an individual will employ given a leg length discrepancy, and in my own lab I've found that, when introduced with an acute, artificial leg length discrepancy [eg, shortening a prosthetic pylon], some subjects will immediately adopt multiple strategies before paring down to one over just a few dozen steps," Geil told *LER*.

The Shriners findings may provide a new perspective on those observations, Geil said.

"I honestly had not thought of the possibility this paper raises, that LLD etiology might predict gait strategy," Geil said. "But it makes sense." [\(ler\)](#)

Larry Hand is a writer in Massachusetts.

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Below-knee amputation level has subtle functional effects

Syme, transtibial gaits are similar

By Hank Black

The relative functional benefits of transtibial and Syme amputations in adults have been discussed in the medical literature, but few studies have addressed similar issues in pediatric patients. A sizeable recent study found statistically significant kinematic and kinetic differences between the two amputation levels in children and adolescents, but the subtle nature of those differences suggests that decisions about amputation level should be decided on an individual basis.

"We found only subtle differences in gait data between Syme and transtibial-level patients, mostly due to underlying etiology, but in an earlier study we found that this does not result in increased oxygen consumption and heart rate," said Donald Cummings, CP, a study coauthor and director of the Orthotics and Prosthetics Department at Texas Scottish Rite Hospital for Children in Dallas.

The study, which was published in the October issue of *The Journal of Bone and Joint Surgery*, used 3D gait analysis to assess 64 children and adolescents, aged 4.7 to 19.2 years, who had undergone unilateral below-knee amputations, with 41 patients in the Syme cohort (which also included three Boyd amputations). Patients wore their current prostheses and walked at a self-selected speed.

A total of 12 types of prosthetic feet were involved, with each categorized as permitting a high, medium, or low activity level as defined by Medicare for prosthesis prescription. Six patients wore high-performance dynamic response feet, and five of those were transtibial amputees; 59% of the study population wore medium-performance feet, and 31% wore low-performance feet. The PODCI (pediatric outcomes data collection instrument) was completed by the accompanying parents.

Total ankle excursion and peak power of the prosthetic ankle were significantly greater in the transtibial patients than the Syme patients. Patients in the Syme group walked with more external hip rotation during stance phase than those in the transtib-

ial group, and also had greater peak coronal-plane hip abductor power. However, the authors noted that the kinematic differences between groups, despite being statistically significant, were small enough that they were unlikely to be clinically relevant. Rather than amputation level, they hypothesized, the kinematic differences at the hip probably were related to the fact that more than half the Syme patients had fibular hemimelia, which is associated with femoral external rotation, and the differences at the ankle probably resulted from the foot types used. PODCI measures did not differ significantly between groups.

Prosthetic ankle range of motion was significantly greater in the patients with high-performance, dynamic response feet than in those with medium- and low-perfor-

The kinematic differences between groups, despite being statistically significant, were unlikely to be clinically relevant.


mance feet. Lower-tech feet were actually associated with greater happiness or satisfaction scores than more advanced feet, possibly because the low-tech versions were more likely to be worn by younger children.

"A major challenge facing the clinical team and the parents is coming up with criteria about when we should be fitting higher-end feet, which require more space between the ground and the distal tibia," Cummings said. "Parents want their kids to develop as normally as possible in their peer group, not necessarily expecting the child to become a top athlete, but at least to be on par with peers in active play and sports. With T-ball, soccer, and other active sports and play that involve running, the controversy starts within a year or two of the first fitting, if not at the start."



Photo courtesy of Fillauer.

Of course, the space available between the end of the residual limb and the floor, patient size, and available pediatric components often determine prosthesis prescription. Growth modulation or revision surgery can provide patients with a shorter limb and greater choices, but surgical shortening of the residual limb, which allows more choices of high-tech components, remains controversial, Cummings said. A Syme amputation, in addition to having structural advantages in growing children, also offers the potential ability to walk at least very short distances without a prosthesis, which 18 of the study's Syme patients said they could do.

In a commentary accompanying the online version of the article, orthopedic surgeon Michael Aiona, MD, chief of staff at Shriners Hospital for Children in Portland, OR, suggested the Dallas group's findings could be used to outline a management program for the child with a limb deficiency. Specifically, he wrote, the data support the current gold standard of an amputation that maximizes limb length; they also suggest that low-cost SACH (solid ankle cushion heel) feet can be worn by young children without compromising their gait, function, or satisfaction, and that more expensive, high-performance feet can wait until a child has reached adolescence. 

Hank Black is a medical writer in Birmingham, AL.

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Parents: How to make them your clinical allies

While the patient is always the practitioner's first priority, establishing a convivial relationship with a child's parents can mean the difference between victory and failure when it comes to diagnosing, treating, and rehabilitating lower extremity problems in pediatric patients.

By Shalmali Pal

These days, there are as many labels for parenting styles as there are names for mother and father: There's kangaroo mom versus stroller mom; strict tiger parents versus permissive parents; helicopter (aka anxious) dad versus secure dad.

But when a child has special needs that include lower extremity impairments, parenting reaches another level, as mom, dad, and the rest of the family adopt and adapt to a unique way of life. In turn, the lower extremity professionals who work with these pediatric patients, and their parents, have to be comfortable with many different labels: healthcare practitioner, counselor, cheerleader, teacher, and diplomat, to name a few.

While the patient is always the first priority, establishing a convivial relationship with the parents (or even one parent) can make the difference between victory and failure when it comes to diagnosing, treating, and rehabilitating lower extremity problems.

"The success of the patient really is tied to the interaction with the parents," said Tyler Sexton, MD, a pediatrician who works with kids with disabilities including cerebral palsy (CP). "Sometimes, parents are the only advocates for these children. As practitioners, sometimes we only see these kids in fifteen- to thirty-minute segments, so we really have to rely on the parents to find out how things are going with the child, what the potential problems are. In that sense, we are treating the whole family."

And, as in any family, it's best if everyone gets along. Sexton and other experts shared their advice for creating successful working relationships with parents and what to do when those relationships prove challenging.

First impressions

The introductory meeting between the practitioner, the patient, and the parents is crucial, practitioners agree, as it will lay the foundation for future interaction.

Chad Brown, a BOC (Board of Certification/Accreditation) pedorthist at Metro Orthotics in St. Louis, MO, likes to jump in with both feet.

An enthusiastic-but-pushy parent can be easier to manage than a resistant one, simply because the former has an interest in seeing the child improve.



Photo courtesy of SureStep.

"It's very important to me to learn as much as possible about the family and the environment that the patient is living in, so I ask a fair amount of questions," he said. "What kinds of activities does the patient participate in? What kind of progress would [the parents] like to see? What have they tried in the past [with regard to the lower extremity problems] and what hasn't worked out? The more information I have about the entire situation puts me in a better position to meet, or hopefully exceed, their expectations."

The first meeting is also a time for Brown to get a sense of the family dynamics: Does one parent tend to dominate the conversation? Does one seem more protective of the child? Is the child able to communicate on his or her own at any level?

Sexton takes a slightly different approach during that first meeting: He does a quick intake of the child based on pediatric behavioral classifications: The easy-going child, the slow-to-warm child, and the difficult child. From there, he begins to paint a picture of the parents.

"The easy child will adapt pretty easily. The child is willing to try anything, whether it's a new type of therapy or a new device, and the parents have that same attitude," explained Sexton, who is president and chief executive officer of Caribbean Hyperbaric Medicine in Zephyrhills, FL.

"A slow-to-warm child will take a bit longer to get started. There will be some wariness at first for the child and the parents, but they will eventually warm up, and work with you," he continued. "Now the difficult child, no matter what you do, it's hard to get them motivated, it's hard to show them rewards. Those parents are going to

have a different mindset; they may need additional encouragement along with the child. But they may also have a system of tips and tricks to get the child to comply, so you'll want to learn those as soon as possible."

Lisa Swenson, PT, C/NDT, opts for an unhurried approach. She is a senior instructor at the ENRICH/JFK Partners program for developmental disabilities at the University of Colorado School of Medicine in Denver, and is the primary physical therapist at The Rise School of Denver, an inclusive preschool for children with and without special needs.

"You can't really obtain all this information at once," she said. "We work to develop a relationship with the family."

Swenson consults with families in their homes as part of the ENRICH/JFK Partners program and also at the school.

At the home, Swenson does an environmental intake: Are there siblings or extended family present? What kind of support system do the parents have? How busy is their typical day?

"I can get a real sense of what home life is like," she explained. "I have a questionnaire that I use to find out more about the daily routine. I might ask questions like 'How is it getting your child into the car seat? How is it helping her get dressed?' I'm trying to find out what's working well at home in terms of the daily routine."

At the school, the child undergoes an intake evaluation by the occupational or speech therapist. The child's teacher, along with Swenson and the other therapists, then develop a unified plan for working with the child, whether it's on behavioral issues or mobility problems.

While parent-teacher conferences are held semiregularly, Swenson's interaction with parents often happens more casually, such as an introduction in the hallway or at a school event, she said.

Whatever approach is taken, a key point to remember during this inquiry phase is that "whether the patient has a more serious condition related to Down syndrome or CP, or a more common ailment like Sever's disease or heel pain, the dominant category that parents fall into is that they want the best outcome possible for their child," Brown said.

Motivation, communication, compliance

Having open lines of communication with parents is vital, whether that's because they are the child's main spokesperson or because they are paying the bills. But establishing those lines will require a practitioner to get a handle on the parents' motivation, as that can play a large part in the treatment decision-making and compliance.

There are two extremes when it comes to parents: There are the highly motivated ones who are determined to see their children succeed as soon as possible. They can sometimes be aggressive communicators, with unrealistic expectations and demands for nearly immediate results with a treatment course.

At the other end are the permissive, less-driven parents who won't follow through with any home-based PT exercises, or don't want to struggle with getting the child to wear a device daily. These parents can sometimes be defensive about their lack of motivation, although they may not necessarily be any more realistic about treatment progress than their aggressive counterparts.

The majority of parents fall in the middle of the spectrum, so



Photo courtesy of Cascade Dafo.

developing tools to deal with parents at either extreme will give practitioners an edge.

The experts agreed that sometimes an enthusiastic-to-the-point-of-pushy parent can be easier to manage than a resistant one, simply because the former has a vested interest in seeing the child improve.

Continued on page 12

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"With a motivated parent who has very high expectations, I break those expectations down into smaller, more attainable goals," Sexton explained. "That's the key: Coming up with a realistic treatment plan and then getting everyone to focus on implementing that plan, step by step."

For example, therapy for a child with autism spectrum disorder (ASD) and severe hypotonia may never put that child in a position

to join other children on the playground. Sexton will set more realistic goals, such as helping the child gain confidence so he has fewer outbursts or improving her strength so she can help dress herself.

"My motto is: under-promise and over-deliver," Sexton said. "Set those small, realistic goals that you know the child can achieve. And, when the aggressive parent sees the child succeeding, it'll make them happy, and they'll see the benefit of moving forward with treatment in a planned, methodical way."

Ryan Hines, CO, from Park Nicollet Health Partners in St. Louis Park, MN, manages expectations by making sure that parents understand the logic behind a treatment course.

"Let's say you fit a pair of ankle foot orthoses (AFOs) for toe walking," he said. "The more motivated parents might want to come back in six months to see if there's been any improvement, but that may be too soon to see changes, depending on the age of the child. Then you'll have parents who don't want to have to come back for another year, and that may be too long. So we make it a point to discuss the logical progression of when and why the child needs to be seen again, because kids will outgrow a device."

Brown said he likes to give parents two different options, cov-

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ering the pros and cons of both, make his recommendation, and then let the parents decide because that gives them a sense of ownership in the treatment process.

For example, for a child with heel pain, “one course of action would be trying an over-the-counter, mass-produced insole. I’d explain that the price point is lower on that, and it’s something we can try for a couple of weeks without a huge financial commitment,” Brown said. “If that doesn’t work out, then we move on to the option of fabricating a device, and again, go through the same decision-making process, with the parents having the final say. Making them partially responsible for the outcomes can help with compliance.”

Sometimes noncompliant parents are really just frustrated parents, Swenson pointed out. If getting a child into her AFOs every morning to get to school on time is an ordeal, the parent may be more likely to give up on the devices.

“We’ll say to the parent ‘There’s no point in all of you struggling in the morning under pressure. Bring the AFOs with you when you drop the child at school, and we’ll work on it there,’” she said. “We’ll make donning and doffing the AFOs part of the daily routine at school, so then the family can start implementing that routine at home. It becomes very matter of fact. It also takes away that sense that the parent is forcing the child to do something.”

Hines emphasized that showing parents the logical progression of treatment can act as an incentive toward compliance. For instance, when treating hypotonia, he’ll tell parents that they may be looking at two sets of supramalleolar orthoses (SMOs) before the child stops growing, based on a child’s age at the time of the initial prescription and his or her projected growth rate.

“We’ll let them know that we’ll examine the feet and legs at every visit and that, if we see progressive improvement with the SMOs, there’s the possibility that a new device will be necessary—maybe a set of UCBL [University of California Biomechanics Laboratory] foot orthoses—which are less expensive and less of a process to put on,” he explained.

It takes a village

The concept of a healthcare team has gained popularity in modern medicine, and it’s especially important when consulting with pediatric patients and their families.

For Swenson, the team approach is already built in at her school, but even during home visits, she emphasizes that she, the family, and other healthcare providers need to work as one unit.

“My job is to be the specialist who gives my knowledge to the family. I want to use my experience to help parents make decisions.... You’ve got to have them see that they are part of the team, and the team includes any other therapists they see, physicians they consult with, and the orthotists that I may refer them to. I make it a point to keep open lines of communications with everyone.”

So when a father stops Swenson in the hallway and asks her to check if his child is outgrowing an AFO, Swenson can relay that information to the orthotist.

Sexton also tells parents that, “It’s not just about coming to see me. You must see the PT, you must see the speech therapist, you must maintain visits with the orthotist or prosthetist if that’s appropriate. There’s no quick fix. We are all creating a huge road map that everyone needs to contribute to.”


To that end, parents should be encouraged to speak up about

any concerns they have, especially if those concerns have to do with a device that the child is using. Hines reassures cost-conscious parents that, “we don’t charge for adjustment. We bill for the delivery of the device, and that includes the follow-up. So no news to us means the device is working out fine. Parents should always feel free to let us know that there may be a problem.”

Hines also pointed out that an interpreter is part of the healthcare team for non-English speaking parents (although the child may be quite comfortable in the language).

“The language barrier is an issue that we deal with a lot. You still have to communicate and answer all the questions, but it’s more challenging because the process is much slower,” he said.

Ultimately, practitioners need to keep in mind two major points when navigating the patient-parent-provider pathway, Sexton stated.

“First, all parents want the best quality of life for their child; that’s universal,” he said. “Second, with a special needs child, when parents get involved, the child is going to do better. This is a long-term commitment, and I think it’s important to everyone, including us as healthcare providers, to make that commitment.” 

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

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Toe walking researchers revisit idiopathic label

Two recent literature reviews underscore the lack of high-level evidence to support the various treatments available for idiopathic toe walking. But new research is starting to fill that void, and is also engendering new theories about factors that may contribute to the condition.

By Larry Hand

Hard evidence continues to elude researchers investigating the origins of and treatments for idiopathic toe walking (ITW) in children, but more are now focusing on identifying factors that may contribute to the condition—which many believe may not be idiopathic at all.

Looking into what children with ITW feel when they walk, for example, may point to an underlying cause. And studies that can compare children with ITW and children whose toe walking is diagnosis-specific may identify some commonalities.

At the American Orthotic & Prosthetic Association National Assembly in September, Mark Geil, PhD, director of the Center for Pediatric Locomotion Sciences at Georgia State University (GSU) in Atlanta, presented results of a trial he conducted involving 15 children with ITW and 15 typically developing children.

The children, who had a mean age of 6.7 years, a mean height of 1.2 meters, and a mean body mass index of 27.8 kg/m², walked barefoot at a self-selected speed on three different surfaces: a rounded gravel surface, a standard pile carpet, and the smooth gait lab floor. Geil and GSU colleague Daniel Fanchiang, PhD, had the children walk 10 times on each surface and measured heel heights relative to each child. A heel marker height above baseline before 32% of the gait cycle may indicate early heel rise or toe contact.¹

The ITW children walked with significantly lower heel height (indicating less toe walking) when walking on the gravel surface than on other surfaces. The analysis also showed identical gait patterns for the ITW and typically developing children when walking on the gravel surface, probably because the gravel provided more sensory input and stability, which may be a clue that could help identify a cause of ITW, according to Geil.

“The result we found wasn’t expected because the experiment we were doing was not designed to test the effectiveness of a terrain like that in this population,” he told *LER*. “But it was one of those happy, unexpected outcomes. What we really need to do is to design a study that, from the beginning, is focused on investigating the potential for walking barefoot on different terrains and effectiveness in controlling toe walking.”

A recent study found that children with ITW walked with lower heel height on a gravel surface than on other surfaces, suggesting sensory input plays a role.

In the gait lab at Georgia State University, reflective markers are attached to anatomical landmarks on the foot and ankle to monitor ankle angle at initial contact and the presence of early heel rise. (Photo by Steve Thackston, courtesy of Georgia State University.)



He and his team are also considering expanding their study population base to include children with autism spectrum disorder who toe walk.

"Kids with autism have been excluded from our studies so far because we've been looking for individuals with no known diagnosis, something truly idiopathic. We recognize the sensory component there [in the autism population], too, and since we have what we think is an effective intervention, we could see how it works in that population, as well," Geil said.

Vibration and vibration perception

Geil is seeking funding to expand his research into the sensory pathways involved in toe walking, with or without an underlying diagnosis.

"One of the focal areas we were really excited about is the potential for whole-body vibration as a different intervention that would address that sensory link to the need for toe walking in these kids," he said.

But, in an article epublished in September by the *Journal of Child Neurology*,¹ Geil and colleagues described unexpected results when they tested vibration as a therapy in children with ITW. They were seeking to expand on work done by Cylie M. Williams, PhD, and colleagues in Australia,² who found that children who present with toe walking are more sensitive to vibrations than their typically developing peers.

"Children may be changing gait pattern to adjust to sensations they perceive during walking," Geil said. "Our thought was, if we could flood that sensory pathway in these kids with standing for a minute on a whole-body vibration machine, it might affect their need to toe walk."

In the study, 15 children with ITW and 15 typically developing children walked barefoot at self-selected speeds over a four-meter walkway before and after standing on a whole-body vibration machine for 60 seconds at 30 Hz, the minimum vibration frequency of the machine.

"We worked in a lot of protection for the kids in our protocol and the kids had plenty of opportunities to stop, but most of them actually really enjoyed standing on the machine barefoot," Geil told *LER*.

The researchers analyzed velocity, cadence, step length, and step width, as well as the timing of heel rise, which previous research has shown to be an indicator of potential gait abnormalities.³

They found no significant differences between the two groups in gait patterns, and both groups experienced similar significant

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changes in vibration perception after the vibration intervention.

"The outcomes weren't what we had hoped, so we're looking to do a new round of a study like that," Geil said. "The machine that we used was very limited. It was all we could afford. If we can figure out a proper dose, which involves both time on the machine and the frequency and amplitude at which the machine vibrates, then it's three variables to sort out. It still has potential. It just needs a lot of tweaking at this point."

Geil's results appear to contrast with what Williams, now adjunct research fellow in the Department of Physiotherapy at Monash University in Victoria, Australia, and colleagues found.² The Australians identified for the first time that otherwise healthy children with ITW exhibited motor and sensory deficits in a series of tests when compared with children who do not toe walk.

"There is a great deal of research being undertaken to better understand the challenges of sensory processing," Williams told *LER*. "I think what has emerged from my body of research was that clinicians need to think more about the reason that the child may be toe walking, as current treatments have been showing limited success in long-term gait change. To better tailor treatment, sensory processing abilities should also be considered as part of the holistic approach to treating the child."

Evidence for treatment

There is still much to be learned about ITW, Williams said.

"Given the family history, there may be a potential genetic link," she said. "There may also be the possibility that ITW, in fact, may be a very mild form of cerebral palsy that is variable in presentation, or it may be associated with [having a] very high-functioning autistic

spectrum disorder that is not able to be picked up on any current assessment. We also do not know the long-term impact of toe walking. While there are many family members who toe walk or toe walked as children who have an ITW gait, we do not know what is happening with their gait now."

Williams and her colleagues assessed current treatments for ITW in a review published in the May/June 2014 issue of the *Journal of the American Podiatric Medical Association (JAPMA)*.⁴ They gauged 21 published studies against levels of evidence. Briefly, they found some support in the literature for surgical interventions, serial casting, and botulinum toxin type A (BTX).

In the first of two case studies included along with the literature review in the *JAPMA* article, researchers placed a small arch filler in the footwear of a 7-year-old boy to increase the sensation of full foot contact. They reported a "notable" decrease in toe walking at three and six months when the child wore the footwear, with similar toe walking levels in and out of footwear. At 36 months of follow-up, the researchers reported minimal toe walking in or out of the footwear. They hypothesized that the improvement was related to an increase in plantar contact area created by the arch fillers.

In the second case study, a 7-year-old girl underwent weight-bearing serial casting and developed an allergy to the casting materials. She then received night splints and underwent an exercise regimen of heel raises on a small board. She did heel-only walking exercises with the foot dorsiflexed, which resulted in minimal improvement. Researchers injected BTX into the medial and lateral heads of the gastrocnemius muscle and casted her for seven days using a different material.

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Then, researchers fitted a full-length carbon-fiber custom orthotic device with rearfoot control and instructed her to wear it as much as possible. Three years after she initially presented, she was not toe walking and she was wearing normal athletic shoes. Later, however, they observed that, though overall toe walking had been reduced, residual equinus persisted.

"There is still much to be understood about idiopathic toe walking and its relationship to sensory processing difficulties," Williams said. "I believe this condition [ITW] is complex and the group of children presenting with this gait type is not homogenous. This makes it extremely difficult to tailor treatment and to understand the origin of the gait. There is currently no literature supporting or disproving that all children with ITW have sensory processing difficulties, only enough evidence to prompt clinicians that sensory processing abilities should be considered if providing treatment."

Better with BTX?

Although BTX use in the child's case described above was associated with an apparent benefit, the effectiveness of BTX in other studies has been mixed.

Pärr Engström, MD, and colleagues at the Karolinska Institute in Stockholm, Sweden, found in a randomized trial⁵ published in 2013 that adding BTX injections prior to cast treatment for ITW is not associated with better outcomes than cast-only treatment. In a trial published in 2010,⁶ the same group found that a single BTX injection in combination with an exercise program may improve walking pattern in children with ITW, but only occasionally led to cessation of toe walking.

Their later study included children evaluated at their clinic for ITW between 2005 and 2010. They randomized 26 children to receive casting only for four weeks and 21 children to receive casting plus BTX (four injections in each calf, 12 units/kg body weight) one to two weeks prior to casting for four weeks. The researchers conducted gait analysis before treatment and at three and 12 months after cast removal, as the children walked barefoot at self-selected speeds. Parents' perceptions were part of the study's primary endpoints, Engström said.

"When you examine a ITW child in your clinic and ask them to show how they walk, they never walk as they normally do, as the child is aware his or her walk is being examined," he said. "Normally our walking pattern is handled on spinal level and we 'do not use our brain' to walk. But when you concentrate or think about your walk, then the brain overrules your normal walking pattern."

The researchers found no difference between the groups for any gait parameter. Parents rating their children's performances during barefoot walking before and after treatment also found no difference between groups. However, both groups showed "a marked improvement in all of these parameters after their respective treatments, at both three and twelve months."

"Our study did not show any additional benefit with BTX compared to only casts," Engström told *LER*. "If BTX is to be used, someone needs to show in a prospective randomized study that BTX has any role in the treatment of ITW. Will repeated injections of BTX have a better effect? We have no knowledge about that at present and, therefore, we believe BTX should not be used in the treatment of ITW."

Both Engström studies were cited in a September 2014 systematic review of ITW literature published in the *Journal of Reha-*

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bilitive Medicine.⁷ In that review, Annette A.A. van Kuijk, MD, and colleagues at the Rehabilitation Centre Tolbrug in the Netherlands concluded that the sustainability of beneficial effects after physical therapy or casting appears to be short, although preliminary evidence exists for beneficial effects of serial casting and surgery on passive ankle dorsiflexion. Sustainable effects lasting more than a year occur only after surgery, they wrote.

Limitations of the literature

Much of the research into ITW treatments or causes is lacking basic information, however, according to Louis J. DeCaro, DPM, a pediatric specialist in Massachusetts and president of the American College of Foot and Ankle Pediatrics, who treats at least five toe walking patients a week.

"I don't really believe that there is a good standard of measuring dorsiflexion accurately in subtalar neutral, so I think some of the results are skewed," he said. "I think a lot of the literature is flawed because the most critical part in what I believe in treating toe walking is being able to assess what is causing it. I don't really believe there really is idiopathic toe walking. There's a reason for it all, including things such as vision, autism spectrum, or undiagnosed equinus."

Orthotic management of ITW has not been studied very well, DeCaro said. In the *JAPMA* review, only three of the papers analyzed discussed orthotic management, and the highest level of evidence was a case series.⁸

"You have many people making many different kinds of orthotics, but I see in practice as well as in research articles that there's a big deficit in the type of orthotic that a child gets. It's not controlling enough. If you don't control whatever position you cast or 'Botox' in, you're going to get failing results," he said. "We need studies that have consistency in measuring dorsiflexion, consistency in casting techniques, consistency in orthotic treatments following any sort of successful therapy. As well, there's no talk of referring to optometrists anywhere. It's a huge factor in all of this. I've seen kids get glasses and immediately they walk on their heels."


And when vision isn't an issue?

"Regardless of if I cast, do surgery, or use Botox, I make sure I put a kid in a proper orthotic, no matter what age, to inevitably control the toe walking," DeCaro said.

But research momentum may be building in a positive way.

"Longitudinal studies are very difficult to conduct due to both time and funding, especially when it is a rather benign condition," Williams of Australia told *LER*. "I am really glad, though, that through the research we have done, there have been a number of research groups being established all over the world looking to better understand why some kids walk on their toes."

Past research has focused on treating the symptoms of ITW because the cause has been considered unknown, Georgia State's Geil added.

"That's part of the reason why we've shifted our focus to investigations that might be able to get at the cause," he said. "Then I think we can do some real good." 

Larry Hand is a writer in Massachusetts.



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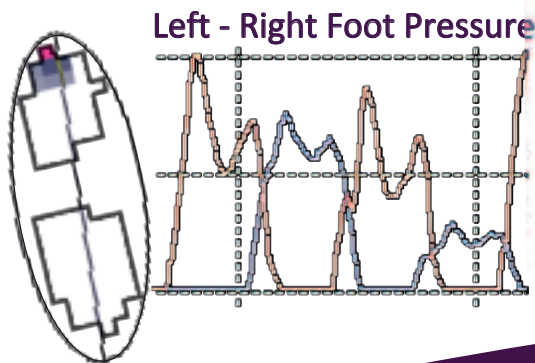
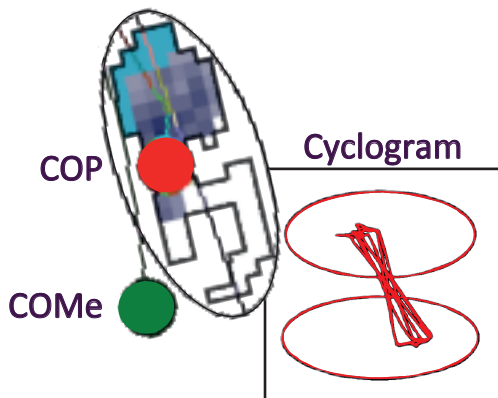
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