

Lower Extremity Review

# ler:PEDIATRICS

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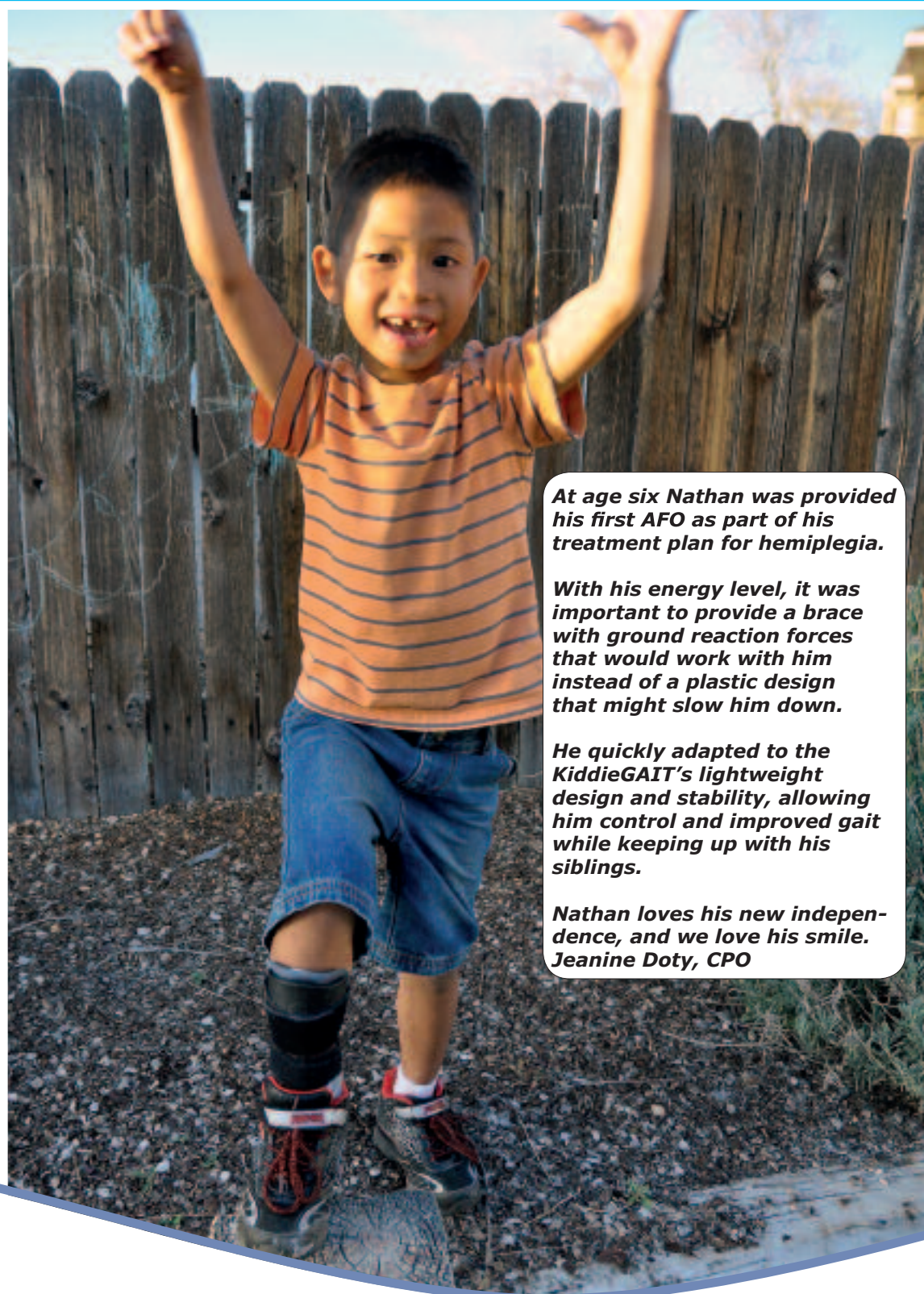
**When the shoe doesn't fit:  
Footwear in Down syndrome**

**Look out below: Injury  
risk on the trampoline**

## **PLUS:**

- Injuries in fast-pitch softball
- Obesity affects feet by age 2
- Tailor AFOs in CP for most gain

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### 15 Look out below: Injury risk on the trampoline

Trampoline use, both in backyards and in large recreational parks, is up. So are injuries incurred on the equipment, including fractures with potentially serious long-term sequelae. Some groups advise a ban on home use, but other experts disagree, citing the equipment's benefits for motor learning and active play.

By P.K. Daniel

## From the editor: The weight problem



Many, many stories in both *LER: Pediatrics* and its parent publication, *Lower Extremity Review*, highlight the biomechanical and physiological effects of over-weight and obesity.

It's cliché, but the problem is truly a vicious cycle. Physical inactivity, often a byproduct of an existing lower extremity condition, adds to the problem of excess weight, and excess weight promotes increasingly sedentary behavior. Patients gain more weight, lose mobility and function, and their risk for myriad comorbidities grows.

Research continues to show these effects can begin at very young ages.

A recent study on foot function in more than 7000 children found obesity starts increasing foot loading in children as young as 2 years (see "Excess weight affects foot loading, peak pressure even in young kids," page 6).

Previous research reported in *LER: Pediatrics* has also found evidence suggestive of conditions once considered purely adult diseases in kids who carry excess weight. Viennese researchers, for example, reported magnetic resonance imaging showed knee cartilage lesions in morbidly obese children as young as 9 years (see "Childhood obesity and OA: Can early care reduce risk?" August 2015, page 15).

Lower extremity practitioners are in a unique position to help these children and their parents by reducing pain and improving function and mobility. In-shoe orthoses, braces, physical therapy, conditioning programs, and other care all can help children lead more active lives.

Physical activity, however, can also lead to injury (see "Look out below: Injury risk on the trampoline," page 15). But, as sources for that article note, all activity that goes beyond sitting on the couch can potentially cause injury, and, sometimes, even exercise deemed "risky" may be preferable to the dangers of inactivity.

Here again, lower extremity practitioners can help by educating parents about injury prevention—and by talking early about the immediate and long-term effects of obesity on children's development and health.

Emily Delzell, *Senior Editor*

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# Lower body conditioning may cut upper body injury risk in softball

## Safety of underhand pitch is over-rated

By Hank Black

Better pre- and off-season lower-body conditioning may help prevent some serious overuse injuries to the upper extremities of young female fast-pitch softball players, according to the lead author of a recent prospective study of player-reported injuries.

"Because the lower body is the driving force of the windmill pitch, a good conditioning program for the gluteal musculature would be important in sequentially stabilizing the pelvis and trunk to provide support for the rest of the kinetic chain," said Matthew V. Smith, MD, lead author and assistant professor in the Department of Orthopedics at Washington University in St. Louis, MO.

The study included 98 select-level players: 48 pitchers and 50 position players aged 9 to 18 years. Investigators used a web-based survey to gather information on self-reported injuries during a single April to August season. They defined injury as pain that sidelined a player for the remainder of the current practice or game or from her usual participation the day after injury.

Forty-three of the players reported 49 injuries, with a cumulative incidence of injury of 40% (this includes 58 athletes who didn't respond to the survey); 70% of injuries were to the lower extremities.

The injuries that resulted in loss of significant playing time, however, were primarily to upper extremities and incurred by pitchers. Pitchers sustained 30 of the injuries; 18 of these were directly attributed to pitching.

"Positional players had the standard lower extremity sprains and contusions you'd expect to see in most sports and that kept them from participation for less than two weeks; these were, for the most part, unpreventable," said Smith. "In pitchers, however, severe shoulder injuries, as well as some stress fractures in the forearm, prevented participation for more than two weeks and appeared to result from overuse in an environment where they

pitch in two or three games a day in tournaments lasting up to four days."

The majority (78%) of pitching injuries happened in the first six weeks of the season, so an increased emphasis on off-season and preseason conditioning may be advisable, said Smith. He also noted the number and severity of pitching injuries counter the notion that fast-pitch softball's underhand windmill pitch is safe relative to baseball's overhand pitch. "Underhand pitching is not as safe as some think it is," he said.

In an ongoing follow-up study, the researchers are using motion-capture technology to gather data on pitchers' movements during simulated games, as well as collecting ground reaction force data.

**"As an athlete's arm and shoulder fatigue, their lower body mechanics change to try to maintain velocity."**

— Matthew V. Smith, MD

"We are evaluating what happens to lower extremity mechanics as pitchers tire. Our hypothesis is that, as throwing athletes fatigue in their arm and shoulder, their lower body mechanics will change in an attempt to maintain velocity. For example, trunk rotation or pelvic tilt may change to try to use more components of the kinetic chain to generate arm speed," Smith said.

"Many athletes of this age may get hitting or pitching instruction, but not a good conditioning program to get them ready for the intensity of their sport when the season starts. I think that's a really critical thing parents should push for: not so much performance training but performance conditioning," he said.


*Sports Health* published the study in its November-December 2015 issue.



"The paper is correct in citing studies that show softball pitching is no easier on the body than baseball pitching," said Gretchen D. Oliver, PhD, FACSM, ATC, director of the Sports Medicine and Movement Laboratory at Auburn University in Alabama. "Both baseball and softball pitchers will incur injury if their mechanics are flawed or inefficient."

Oliver, who is an associate professor in the School of Kinesiology, agreed that lower body mechanics of softball pitchers are important to prevent injury.

"Proper utilization of the kinetic chain allows for efficient kinetic energy transfer from the proximal segments to the distal segments. Dysfunction at a proximal segment may lead to altered energy transfer and dysfunction at more distal segments," she said. "We emphasize total body conditioning and focus a lot on postural control activities. The more body awareness a pitcher has, the better chance they have to develop consistency in their mechanics."

She noted, "The study did not examine preseason conditioning, so that could be a factor in the early season injuries, but there are many other factors that should be examined before we can determine the 'why.' We are now tracking pitch volume year-long, as well as examining performance measures." 

*Hank Black is a freelance writer in Birmingham, AL.*

Source:

Smith MV, Davis R, Brophy RH, et al. Prospective player reported injuries in female youth fast-pitch softball players. *Sports Health* 2015;7(6):497-503.

# Excess weight affects foot loading, peak pressure even in young kids

## Weight loss may improve function

By Katie Bell

Overweight and obese children present with higher overall foot loading and a disproportional impact on the midfoot and longitudinal arch, with those as young as 1 or 2 years of age affected, according to research from Germany that may have implications for abnormal foot loading prevention in children.

Lead author Steffen Müller, PhD, research associate at the University Outpatient Clinic, Sports Medicine & Sports Orthopaedics, at the University of Potsdam in Germany, remarked, "In our data we cannot really see a well-adapted gait strategy for these children [for foot loading] since no real compensation is visible. Therefore, it could be speculated that the obese children are not capable [of adapting] their gait sufficiently to extra weight, leading to higher and disproportional foot loading."

The study included 7575 children aged 1 to 12 years and examined foot-loading characteristics during gait. Of the participants, 6458 were categorized as normal weight, 746 as overweight, and 371 as obese, according to a German reference system based on age- and gender-specific body mass indices.

Plantar pressure measurements were taken during gait with a pressure measurement platform that was mounted on an instrumented walkway. The researchers calculated the contact area, arch index, peak pressure, and force time integral for the total foot, forefoot, midfoot, and hindfoot.

The data suggested a mean walking velocity of .95 m/s was evident in normal-weight, overweight, and obese children. However, obese and normal-weight children presented with the highest and lowest foot contact area, respectively, in all age groups. This was also the case for the arch index in children aged 5 to 12 years.

Müller suggested that prevention strategies, such as strengthening and sensorimotor exercises for the foot and lower extremity, should start at a young age.

"Additionally, we should try to enhance the compliance of these children to participate in an active life style and reduce weight," he added.

Meanwhile, overall foot loading and peak pressures increased consistently with age and were highest in the obese children and lowest in the normal-weight children. Increased foot loading for the total foot and forefoot was present from the age of 3 to 4 years, while excess foot loading at the rearfoot and midfoot was visible from age 5 to 6 years.

Müller said, "Since pros and cons for active versus passive treatments in the long run are well known, active interventions should be preferred in contrast to shoe and insole adaptations to address disproportional foot loading and/or foot stress/pain."

Weight-related differences in peak plantar pressure, while relatively small, were present at the mid- and forefoot by age 2 years.

The differences in peak pressure at the toes, rearfoot, and total foot were relatively small between normal-weight, overweight, and obese children, but were present at the forefoot and midfoot at age 2 years. *PLoS One* published the findings in February.

Commenting on the study data, Sharon Bout-Tabaku, MD, assistant professor of pediatrics at Nationwide Children's Hospital in Columbus, OH, said, "The implications are important because we can hypothesize that walking speed, lower extremity strength, and altered forces around the knee and hips will be affected."

She added that, "Early foot changes may affect the morphology of the bones and joints due to sustained low-level




systemic and local joint inflammation. Finally, we can guess that it may interfere with optimal physical function and can be associated with pain."

She also emphasized weight management. "Certainly maintaining a healthy weight or weight loss early is important because it can minimize alterations in morphology, forces, and gait across the entire lower extremity," she said. "Physical activity and normal childhood play is equally important to maintain bone development, strength and neuromuscular development."

She added that "in children who are symptomatic, orthotics, heel cups, and cushioning may provide some relief."

The study authors concluded the plantar pressure values assessed in this trial could serve as reference data to identify suspicious foot-loading patterns in children. Bout-Tabaku agreed, and noted, "This article provides nice reference data in a large sample and serves as a starting point for other studies: longitudinal studies; studies exploring associations with foot pressure and function, gross motor skills, and pain; and longitudinal studies looking at bone and joint development radiographically."

Bout-Tabaku added that "the take-home is that obesity is modifiable. Similarly, during childhood and adolescence, the musculoskeletal system is dynamic and very responsive to change, and can be positively modified with weight loss in childhood. The degree of positive changes in the musculoskeletal system is harder to attain with increasing age." 

Katie Bell is a freelance writer based in New York City.

#### Sources:

Müller S, Carlsohn A, Müller J, et al. Influence of obesity on foot loading characteristics in gait for children aged 1 to 12 years. *PLoS One* 2016;11(2):e0149924.

# Walking study in CP highlights need for tailored orthotic prescription

## Effects of AFOs on distance, speed vary

By Larry Hand

A recent study demonstrates the importance of personalizing prescriptions for ankle foot orthoses (AFOs) in children with cerebral palsy, rather than applying group data to individuals.

AFOs weren't consistently associated with the study's primary outcome, enhanced walking activity and intensity in a community-based setting compared with footwear alone. However, some individual children demonstrated significant improvements with AFOs.

"Orthotics are prescribed as individualized interventions," said Kristie F. Bjornson, PT, PhD, associate professor of pediatrics and developmental medicine at Seattle Children's Hospital in Washington. "While classical scientific inquiry uses group-based analysis, we know that, with children with cerebral palsy, none of them look exactly alike. We need to keep the individual level of analysis because that is what we do in clinical practice: prescribe on an individual level."

Bjornson and colleagues conducted a randomized crossover study involving 11 children with CP (mean age 4.3 years, range 3-6 years) who typically wore bilateral AFOs. They randomized the children to either AFOs plus footwear for two weeks or footwear only for two weeks. Then each group crossed over to the other condition for another two weeks.

At the group level the two conditions had similar results for average total strides per day (4660 strides, AFO-on; 4897 strides, AFO-off). Secondary outcomes, the percent of daytime hours walking, average number of strides faster than 30 strides/minute, and peak activity index, were similarly close.

Individually, however, the results varied, with no clear pattern for a child's age or AFO type.

- Two children (one aged 3.6 years with a solid AFO and a jump gait pattern, the other aged 4.3 years with a hinged AFO and a crouch gait pattern) took more steps per day with AFOs off than on. Another two children (one aged 3 years with a solid AFO and a true equinus gait pat-

tern, and the other aged 3.6 years with a solid AFO and jump gait) took more steps with the AFOs on.

- The two children whose steps per day improved with the AFOs on also spent more time walking with the AFOs on than off. Two more children (one aged 3.2 years with a solid AFO and a true equinus gait pattern, the other aged 5 years with a nonarticulated AFO and a true equinus gait pattern) demonstrated similar improvement. One of the children who improved in steps per day with the AFOs off (the older of the two) also spent more time walking with the AFOs off than on.

Individually, results of this real-world walking study varied, with no clear pattern for a child's age or AFO type.

- The same two children who improved in those two areas with AFOs on also had more strides per day at faster than 30 strides/minute and a higher peak activity index with AFOs on than off.

The pilot study results suggest most children weren't wearing orthoses or footwear that helped them improve their daily walking activity in amount or intensity, Bjornson and colleagues wrote. They pointed out that the two children whose shank-to-vertical angle was optimized were also those who demonstrated the greatest positive effects of AFOs and footwear on daily walking activity and intensity.

"When they walked, they walked at higher rates," Bjornson said. "Kids with CP walk slower and can't keep up with their peers. So, hopefully, interventions would help them walk more, and, when they do walk, walk faster. Hopefully they can keep up with their peers walking to the bus, or they can run to first base when they want to when they play baseball."




Photo courtesy of Cascade Data.

Elaine Owen, MSc, MCSP, a pediatric physical therapist at the Child Development Center in Bangor, North Wales, UK, told *LER: Pediatrics* the benefits for children with CP of walking outside with other children cover all areas of the International Classification of Functioning, Disability and Health, from body structure and functions to activities and participation.

"If they are walking with a good gait pattern they would be strengthening muscles, stretching muscles and joints, and [stimulating] motor learning, all things that will maintain or improve their physical condition," Owen said. "Potentially, then, they may start to use less energy when walking and need fewer interventions. It may mean they have less pain in the teen and adult years."

Bjornson is looking forward to more community-based research.

"Most orthotic research has been based on outcomes collected in a clinical or investigational gait lab. What a child does in front of somebody watching them is not necessarily what children do in their daily lives," she said. "To my knowledge, nobody has ever looked at gait lab data compared to walking activity data. It's a different kind of outcome." 

Larry Hand is a freelance writer in Massachusetts.

Source:

Bjornson K, Zhou C, Fatone S, et al. The effect of ankle-foot orthoses on community-based walking in cerebral palsy: a clinical pilot study. *Pediatr Phys Ther* 2016;28(2): 179-186.



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*Pediatric Physical Therapy*, May 2015



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## When the shoe doesn't fit: Footwear in Down syndrome

These children often have wider, more flexible, and more pronated feet than typically developing kids that don't fit well into conventionally sized and shaped footwear. Ill-fitting shoes are linked to foot-specific disability and many other issues. Here, clinicians share strategies for finding the right fit.

By Lori Roniger

So many things aren't designed for kids, who must make do in a world designed for relative giants. But most of them can enjoy getting a new pair of shoes in which they can walk, run and jump, and be raucous kids. However, finding footwear that fits well can be a challenge for the parents of children with Down syndrome.

In young children with Down syndrome, feet can be overlooked easily among the other challenges caregivers must handle, such as learning, cognitive, and dietary issues, and may not be a high priority, said Curt A. Bertram, CPO, FAAOP, national orthotics specialist and director of the National Residency Program at Hanger Clinic in Hartland, WI, who specializes in pediatrics.

The feet of children with Down syndrome often come with their own set of challenges. The dimensions of their typically wide feet tend not to conform to the conventional sizes in which most shoes are made. Their feet can be hypotonic, pronate significantly, and sometimes require ankle foot orthoses (AFOs) or other devices that can be difficult to fit in shoes. This makes it hard to find footwear in the proper sizes with appropriate support (see "Orthotic solutions for children with hypotonia," *LER: In Step with Pediatric Hypotonia*, 2013, page 12).

"You're trying to fit a foot into a last or a shoe that's made for a normal foot, and these feet are anything but normal," Bertram said. "I tend to see them come in with shoes that are not the most appropriate."

An article published in the *Journal of Foot and Ankle Research (JFAR)* last year that examined foot structure and footwear fit in 50 children and adolescents with Down syndrome found that ill-fitting footwear (often too narrow) was common and associated with foot-specific disability.<sup>1</sup>

Additionally, flat feet were present in 76% of the study's participants, hallux valgus in 10%, and lesser toe deformities in 12%. Hallux valgus was associated with foot-specific disability during school and play activities. The study also found foot structure and



Photo courtesy of Brian and Sarah Haigler, in memory of Maddy Haigler.

Findings from an Australian study suggest children with Down syndrome may not be communicating foot-related problems to their parents effectively.



Photo courtesy of Brian and Sarah Haigler, in memory of Maddy Haigler.

footwear fit were not significantly associated with parent-reported limitations regarding footwear choice, suggesting children may not be communicating foot-related problems to their parents effectively.

The study's authors concluded that footwear education and regular footwear assessments could be helpful for children and adolescents with Down syndrome.

"In the daily grind of the whole host of other concerns of individuals with Down syndrome, footwear can be placed literally and figuratively down on the bottom," said study author Nikolaos Nikolopoulos, BPod (Hons), MBusSys, LLM, a lecturer at La Trobe University in Melbourne, Australia, and a longtime clinical podiatrist.

In addition to ambulation and movement, footwear can also have implications for socialization and behavior, which can be important in children with Down syndrome, Nikolopoulos noted.

"Hopefully, we're presenting a good case for footwear," he said.

LER Pediatrics spoke with practitioners who work with this population about the challenges of finding footwear for

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children with Down syndrome that fits well and accommodates their unique needs.

Bertram recommended early intervention and assessment of the feet of children with Down syndrome. "Early" in this context means as soon as they start walking, which can occur later than in other kids, he said, and noted it's better to treat them early to minimize the risk of foot pain and other foot problems as children mature.

"I think the tragedy that we want to avoid is [caregivers] thinking that they'll outgrow it," he said. "They won't. They don't. Their condition is permanent."

## Not just wider

Why can't children with Down syndrome just wear wider shoes? Unfortunately, it's not so simple.

"The Down syndrome foot tends to be short and wide and very, very, hyper-flexible and pronated," said David Jenkins, DPM, FACFAS, FAAPSM, professor at the Arizona School of Podiatric Medicine in Glendale. "Most shoes are not made for the pronated foot."

Collapsed arches can make the feet of children with Down syndrome wider, and shoes wide enough to accommodate their flat feet may not fit properly in other areas.

A lot of parents get shoes that are too long, which can cause

difficulty when walking, said Faye McNerney, PT, DPT, C/NDT, who practices in Troy, OH. In the *JFAR* study, children's shoes were, on average, 9 mm longer than their feet (range, 14.3 mm shorter-23.3 mm longer).



Photo courtesy of Brian and Sarah Haigler, in memory of Maddy Haigler.

Orthoses, which require even more room in the shoes, can make footwear fitting more challenging. In the *JFAR* study, 38% of the children wore orthoses.

"A lot of children do have shoe-fitting issues, and we complicate this by giving them orthoses," Bertram said.

The feet of children with Down syndrome also tend to have a medial bulge with a forefoot that abducts, he said. "Instead of a C-shaped footprint, the pronated foot looks like the opposite of that," Bertram said.

## Mismatched lasts

Jenkins has conducted research on the foot-to-shoe mismatch in more than 4000 Special Olympics participants with Down syndrome and other disabilities (Special Olympics does not track its athletes' specific disabilities). Participants had a median age of 25.6 years, and some were as young as 5

years.<sup>2</sup> Foot screenings found a significant 41% mismatch of feet to shoes, and a 20% referral rate of athletes for professional follow-up. Mismatch was defined as shoes that were 1.5 sizes too big or too small for the foot; 28.6% of athletes wore shoes that were too



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large, while 12.8% wore shoes that were too short.

“Conventional shoes available to all of us are not made on a last that’s appropriate for the Down syndrome foot,” Jenkins said.

Jenkins has also found that shoes that don’t fit contribute to secondary problems in this population, such as blisters, bunions, and ingrown toenails, as well as pain, disability, and increased body mass index.

“A lot of things had to be related to the shoe mismatch,” he said.

To that end, he is serving as a consultant to a company that is developing shoes designed for the feet of children with Down syndrome about 8 years and older. The company, Foot Options, hopes to introduce the footwear line during the fourth quarter of this year.



Photo courtesy of Brian and Sarah Haigler, in memory of Maddy Haigler.

## Shoe specifics

When a child with Down syndrome comes in for an assessment, Bertram first makes sure she or he has a good pair of shoes that fit properly. Next, if needed, is adding arch support to the shoes. After that, if the patient needs more control, he considers a supramalleolar orthosis (SMO) or an AFO.

Practitioners and researchers who focus on the feet of children with Down syndrome note that finding appropriate footwear for those who require a lot of support is in some ways easier than for the children who don’t wear orthotic devices. Children who wear AFOs or SMOs don’t require as much support from a shoe, though finding footwear that accommodates a wide Down syndrome foot, as well as a brace, can be challenging.

An expensive shoe is not necessary, especially when kids are wearing an orthosis. “It’s basically a covering for the foot and orthosis,” McNerney said. A regular tennis shoe will do, and high-tops aren’t necessary.

“You still want a flexible forefoot, but you don’t need to have a particularly stable heel counter,” said Julia Looper, PT, PhD, associate professor of physical therapy at the University of Puget Sound in Tacoma, WA.

What is essential is for the footwear to fit over the device and stay put.

“Some parents buy cowboy boots,” McNerney said. “You don’t want that. You don’t want cute little church shoes.”

Even the thinnest braces can cause shoe-fitting problems and may require going up half a size, said Kathy Martin, PT, DHS, professor and assistant DPT program director at the Krannert School of Physical Therapy at the University of Indianapolis in

Indiana and a pediatric physical therapist who works with children with Down syndrome.

For children who don’t wear braces, Bertram said a three-quarter top or high-top will provide better foot control than a low-top shoe.

“With hypotonia, you tend to have feet that don’t function the way they should,” Bertram said.

He recommends a stiffer shoe with solid construction, as well as a good heel counter and a wide sole, such as a high-quality athletic-type shoe.

“If you don’t need an orthotic, a high-top shoe can give support to the heel and ankle bone so the foot can’t roll in as much,” Looper said.

Martin added that a shoe with a straight or slightly curved last is better for these children, as a more curved last can encourage pronation.

“They should be [wearing] a more supportive shoe because they don’t have intrinsic ligamentous support in the foot,” she said.

Bertram advises that children with Down syndrome who have mild pronation and require arch support wear shoes with lacing rather than Velcro closures. Laces provide more support and control, though Velcro is preferable if the child wants to take the shoes on and off themselves.

McNerney, who is a big proponent of SMOs in children with Down syndrome, recommends shoes with flexibility in the toe box and emphasizes the importance of the right width.

Not only do shoes with laces provide a snugger fit than Velcro, McNerney said, she recommends them because, when kids are little, they can’t take them off when parents double-knot them. She noted this could otherwise be a problem when shoes are paired with a brace that takes some work to put on and secure properly in



the shoe.

"I've heard this story a lot," she said, regarding kids removing their shoes and braces while sitting in the back of the car.

But how do parents find shoes that are wide enough but not too long?

"The best advice is to keep going to different shoe stores," McNerney said.

She said that some parents have gone to multiple shoe stores until they find the right shoes for their child with Down syndrome, and then they'll buy the shoe in the next bigger sizes so they have it when they need it. She recommends that parents gravitate toward cheaper discount shoe and general merchandise stores.

"They typically carry the wide shoes, the rejects," she said.

Looper suggested families learn which shoe brands work for their child's feet, while Bertram cautioned that cost is not necessarily indicative of quality or shoes that control pronation.

"I think the parents definitely need to have direction, otherwise they do really have a hard time," McNerney said about selecting shoes.

One trick Nikolopoulos recommended is tracing the foot on a piece of paper to provide a schematic of what is needed in the right shoe. Measuring both feet also can be helpful in this population, he said, particularly given that the children may be unlikely to report asymmetries in footwear fit that could become problematic.

## Thinking long term

Although there isn't yet any published research to prove it, some practitioners believe that not taking proper care of the feet of

children with Down syndrome could cause secondary problems when they're adults. Martin noted some adults with Down syndrome develop bunions—something seen in 10% of the children in the *JFAR* study—and overpronate.

Bertram said he sees blisters, calluses, and acquired deformities from shoe wear in teenagers and young adults who have Down syndrome. He said this can be due to wearing bad footwear that is too small or from uncontrolled deformities that were never managed. These anecdotal observations are consistent with studies indicating an association between hallux valgus and too-short shoes in typically developing children.

Bertram and Martin believe that individuals with Down syndrome are less likely to experience these secondary problems if, as children, they wear shoes that fit and provide support.

But, for now, children with Down syndrome still have imperfect options for finding well-fitting footwear that provides the support they need. And practitioners are doing their best to give their pediatric patients with Down syndrome and their caregivers sound advice about appropriate footwear.

Overall, though, practitioners like Martin concede they're not the ones dealing with the kids every day, and that parents are better equipped to know if Velcro should win out over laces or if it's reasonable to let their child wear cute sandals for a short amount of time.

"You pick your battles," Martin said. 

*Lori Roniger is a freelance writer based in San Francisco, CA.*

References are available at [lermagazine.com](http://lermagazine.com).



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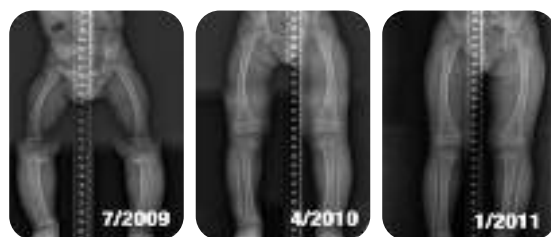
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## Look out below: Injury risk on the trampoline

Trampoline use, both in backyards and in large recreational parks, is up. So are injuries incurred on the equipment, including fractures with potentially serious long-term sequelae. Some groups advise a ban on home use, but other experts disagree, citing the equipment's benefits for motor learning and active play.

By P.K. Daniel

The late George Peter Nissen fashioned a canvas sheet to a rectangular steel frame in his parents' garage nearly a century ago to create the world's first bouncing apparatus, which he later called the trampoline. It's doubtful, however, that he had in mind toddlers jumping or multiple children bouncing simultaneously, scenarios that often result in lower extremity injury.

Despite repeated warnings from the American Academy of Pediatrics (AAP) about the dangers of the trampoline, its popularity hasn't waned. More than one million people suffered a trampoline injury resulting in an emergency department (ED) visit between 2002 and 2011, according to a national database study.<sup>1</sup>

"We see fractures from trampoline injuries almost every week in the summer months," said Aaron J. Provance, MD, medical director of the Pediatric Sports Medicine Program in the Department of Orthopedics at Children's Hospital Colorado in Aurora.

The national database study, conducted by researchers at Indiana University in Indianapolis, used the Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) to look at trampoline-related fracture patterns across a large population. The results, published in 2014 in the *Journal of Pediatric Orthopaedics*, noted that 29% of the trampoline injuries were fractures, and more than a third (35.7%) occurred in the lower extremity.<sup>1</sup>

Although 51.7% of those who suffered fractures were male, more female patients (54%) suffered lower extremity fractures. Nearly 93% of all fractures occurred in patients 16 years or younger (average age 9.5 years).<sup>1</sup>

There were nearly 105,000 ED visits in 2014 for trampoline injuries, according to Bob Segall, an investigative reporter at television station WTHR in Indianapolis, who in February reported on his analysis of NEISS data. In comparison, there were slightly more than 66,000 trampoline injuries requiring ED treatment in 1995.<sup>2</sup>

Tibia fractures often occur when a larger child is rebounding upward and a smaller child is landing simultaneously, causing significant compression force to the lower extremity.

At least one study attributes the rise in injuries to an increase in trampoline sales, and, subsequently, in participation.<sup>3</sup>

## Who's at risk?

The type of trampoline injury varies with age and size, but the youngest, smallest kids are at the greatest risk.

"Younger and smaller children are much more likely to sustain fractures of all types," said Michele LaBotz, MD, FAAP, a member of the national executive committee for the AAP's Council on Sports Medicine & Fitness, who practices at InterMed in South Portland, ME.

The AAP reported that smaller, typically younger children are 14 times more likely to incur injuries than larger children.<sup>4</sup>

Segal at WTHR also reported the majority (85%) of the 2014 ED visits for trampoline injuries recorded in the NEISS database involved children; those aged 2 to 5 years accounted for a quarter of the visits. And 42% of the injuries suffered by toddlers and preschoolers were bone fractures.

Although the AAP and the American Academy of Orthopaedic Surgeons maintain that the majority of trampoline injuries occur in home environments, the proliferation of trampoline parks is another source of injuries. There was a staggering 700% growth in trampoline parks between 2011 and 2014, according to the International Association of Trampoline Parks, which itself was established only in 2012. These parks cater to kids—even those who are very young.

Many parks lack oversight. Arizona and Michigan are the only states with specific laws related to trampoline safety, and there are zero federal regulations for trampoline parks.

"With the increased number of companies having indoor trampolines, the injury rates may be similar to home-based trampolines," said Provance. "Future research needs to be completed in this area." LaBotz also said that, due to a lack of data, it's unclear which setting—trampoline parks (with wall-to-wall and between-bed padding) or backyard home trampolines (some with safety nets)—results in more injuries.<sup>5</sup>

Anecdotally, however, LaBotz said sports medicine and ED doctors have noted marked increases in trampoline-specific injuries in geographic areas where trampoline parks have opened. "Visits to these trampoline parks often show an impressive list of rules and regulations upon entry, but enforcement of these policies (especially with regard to limiting numbers of jumpers on a mat) is highly variable," she said.

Despite repeated warnings by the AAP that children younger than 6 years are at an increased risk of fractures and dislocations and should not use trampolines, trampoline parks offer programs, with such names as Rockin' Tots and Toddler Time, specifically geared to this age group.

"[Toddlers'] lack of balance and muscle strength make them much more susceptible to more severe injury, especially in cases involving multiple simultaneous users," said LaBotz. "Forces associated with rebound on the soft trampoline mat are far greater than forces that are generated by a fall onto hard ground, especially for smaller children."

## The multiple-jumper problem

About 75% of injuries occur when multiple people use the trampoline at once, according to a Consumer Product Safety Review, which the AAP reported in its 2012 policy statement and reaffirmed in 2015.<sup>4</sup> When larger children are bouncing with smaller ones, they generate more recoil of the trampoline bed and more impact forces

# small feet



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than smaller users can generate independently.<sup>4</sup>

Larger people on the trampoline bed sometimes “rocket propel” smaller children, ie, get the kids much higher in the air than they could go on their own. When they fall onto the mat, they fall from a greater height than they otherwise would, while the trampoline bed recoils upward at the same time.

NEISS database study coauthor Randall T. Loder, MD, chair of Indiana University’s Department of Orthopaedic Surgery, told *LER: Pediatrics*: “[In] my anecdotal experience taking care of many of these children, there is often more than one person on the trampoline, and there is the double-hit phenomenon—the child hits the trampoline when the other child is landing, doubling the force.”

Provance noted that tibia fractures commonly occur when a larger child or adult is rebounding upward and a smaller child is landing simultaneously on the trampoline, causing a significant compression force to the lower extremity. If this compression force is large enough, the top of the tibia can incur a buckle or compression fracture.

## Injuries

Provance said most of the trampoline injuries he sees at the Sports Medicine Center at Children’s Hospital in Colorado are fractures of the upper and lower extremities. “The more serious injuries typically involve fractures at the top of the [tibial],” he said. “These fractures can have a risk of long-term complications. Even after these fractures have healed, there is a risk of further angulation of the leg months to years down the road.”<sup>6,7</sup>

LaBotz said one of the main risks with these injuries is a lack of recognition. Presentation depends on the site of the injury. For example, physicians don’t typically look for a buckle fracture, which is an incomplete fracture in which one side of the bone is compressed, causing the other side to bend, in the proximal tibia, she said.

“Some of these injuries are rarely seen outside of trampoline-associated trauma, and providers might not be aware of the usual patterns of presentation,” LaBotz added. “One of the most common of these missed injuries is the metaphyseal fracture seen in the proximal tibia of young children. This is commonly a ‘torus-type’ of injury, which sometimes seems to escape recognition even by experienced radiologists, although once it is appropriately treated it heals well.”

## Trampoline ankle

“Trampoline-related growth-plate fractures to the young ankle can be particularly severe and often require acute surgical intervention,” said LaBotz. “These injuries are at high risk for future growth arrest, which can be very problematic in the younger population.”

Paul Moroz, MD, a pediatric orthopedic and spine surgeon at Shriners Hospitals for Children in Honolulu, HI, agreed. He and colleagues addressed “trampoline ankle” in a study they conducted at the University of Ottawa in Canada and first published online in November 2015 in *The Journal of Pediatric Orthopaedics*.<sup>8</sup>

Moroz told *LER: Pediatrics* in its February issue that multiple jumpers are the primary cause of trampoline ankle (see “Multiple jumpers increase risk for trampoline ankle,” page 7). This injury involves the growth plates at the lowest part of the tibia and fibula, just above the ankle joint, making it unique to children.<sup>8</sup>

Just like the tibia fractures that Provance described as the result of compression forces, Moroz described how, when two individuals

*Continued on page 18*

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bounce out of sync, kinetic energy forces are generated that produce a high-impact effect. For youngsters this can cause serious distal as well as proximal growth-plate injuries that can result in long-term consequences, such as growth arrest.<sup>6,7</sup>

Because there is a broad spectrum of injuries associated with trampoline use, treatments range from simple bracing or splinting performed in emergency or outpatient settings to injuries that require hospitalization and potential surgical intervention.

## Improving safety

There doesn't seem to be a difference in the severity or prevalence of injury with the use of padding, netting, or other safety measures. The AAP has reported that the introduction of netting and other safety equipment in the late 1990s and early 2000s has not reduced injury rates.<sup>4</sup> Many injuries occur on the bed itself, where padding or netting can't mitigate injury risk. In addition, LaBotz said many suburban neighborhoods have trampolines with nets and padding that are inappropriately installed, in poor repair, or both.

Another problem, she said, with "safety nets" is the often false perception of protection they can produce. They may, for example, entice users to take additional risks on the apparatus; falsely assure parents and other adults that supervision is not needed; and can be additional sources of injury, particularly with children trying to climb netting or getting body parts caught in the net while jumping, all of which is why the AAP continues to advise against using backyard trampolines.

Not everybody is on the trampoline ban bandwagon, however. Norwegian researchers don't support the AAP's position. Instead, they advocate using the trampoline for lower extremity exercise to help children develop motor skills, strength, and balance.

In a 2006 issue of the *British Journal of Sports Medicine*, orthopedic surgeons from Trondheim, Norway, wrote: "Several reports on trampoline injuries recommend a ban on private, recreational trampoline use for children. We do not, for several reasons, support such a ban. Jumping on a trampoline gives children the ability to improve their motor control. It may also increase physical activity."<sup>9</sup>

Although the Norwegian researchers stressed the importance of being aware of trampoline-associated risks, they concluded the effects of inactivity outweigh the risks of trampoline use.

LaBotz agreed with the Norwegians. She said there is an intrinsic risk associated with any form of physical activity—everything from bicycling to football can be associated with higher rates of acute injury compared with sitting on the sofa.

"But, if sitting on the sofa is all someone does, it will certainly

contribute to one's early demise over the longer term," she said. "This risk-benefit balance will vary depending upon the nature of the activity itself, as well as of the population participating in it. Home trampolines are probably best compared to home swimming pools, in that they are very appealing and fun for many young kids, but, if not used appropriately and with adult supervision [supervision that is engaged and on site, not just peeking out the kitchen window], can be very hazardous. Our main concern at the AAP is not with trampolines per se, but with inappropriate use, and the current cultural perception and marketing of trampolines as toys."

Athletes, including gymnasts, divers, figure skaters, freestyle skiers, and the like, use the trampoline as an intrinsic part of learning certain skills. However, this training is done with trampolines that differ from those used by the public; it also includes dedicated and experienced spotting and oversight that make the risks associated with this activity much lower than with recreational home trampoline use.

There are steps, however, that the US Consumer Product Safety Commission recommends to reduce serious injuries.<sup>4</sup>

They include: limiting use to one person at a time; not attempting flips; keeping springs covered with padding; not placing trampolines near trees or other structures; not allowing children younger than 6 years on the trampoline; providing adult supervision at all times; placing an enclosure to prevent falls to the ground; and not placing a ladder near the trampoline.


"Trampolines were initially designed for training acrobats and military aviators, and can be a very helpful part of a structured and well-supervised athletic training program, but they are

not toys," said LaBotz.

Although not directly related to the lower extremity, LaBotz emphasized that .5% of trampoline injuries result in permanent neurologic sequelae, such as paralysis or paresis to the upper or lower extremities or both resulting from cervical spine injury.<sup>10</sup>

"While this one-in-two-hundred rate may seem low, given the severity of consequences and the overall numbers of trampoline-related injuries, it is important to keep in mind," she said. "The most common mechanism of cervical spine injury on the trampoline is due to failed attempts at aerial [front or back] somersaults or flips."

The Indiana University study numbers confirm the frequency of trampoline injuries presenting to EDs, but the problem is more widespread, and the actual figures are likely much higher, LaBotz noted.

"This likely reflects significant under-reporting, in that many of these injuries [particularly with the high cost associated with ED care] will present to their primary care provider or to urgent care/walk-in other outpatient facilities for evaluation and treatment," said LaBotz. "These injuries are not currently captured in NEISS or other large databases that are often used as information sources for these epidemiology studies." 

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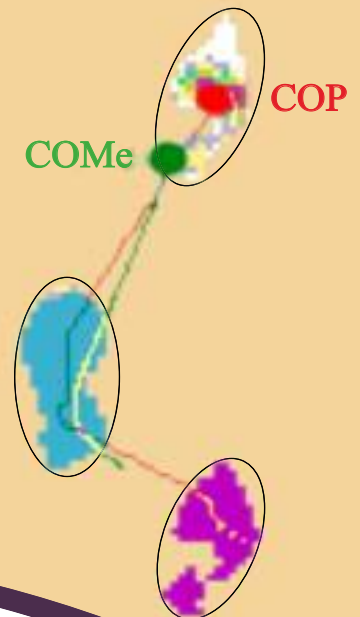
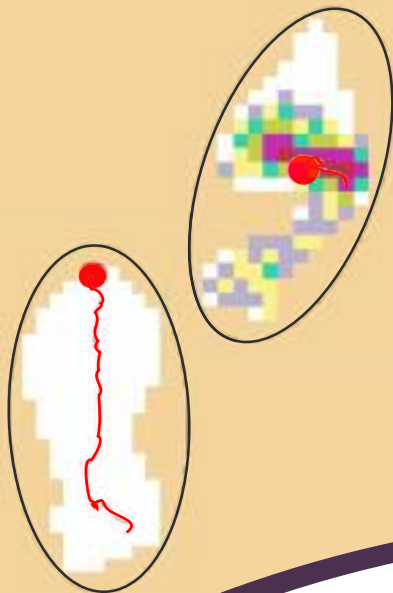
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