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LOWER EXTREMITY REVIEW
June 23 / volume 15 / number 6

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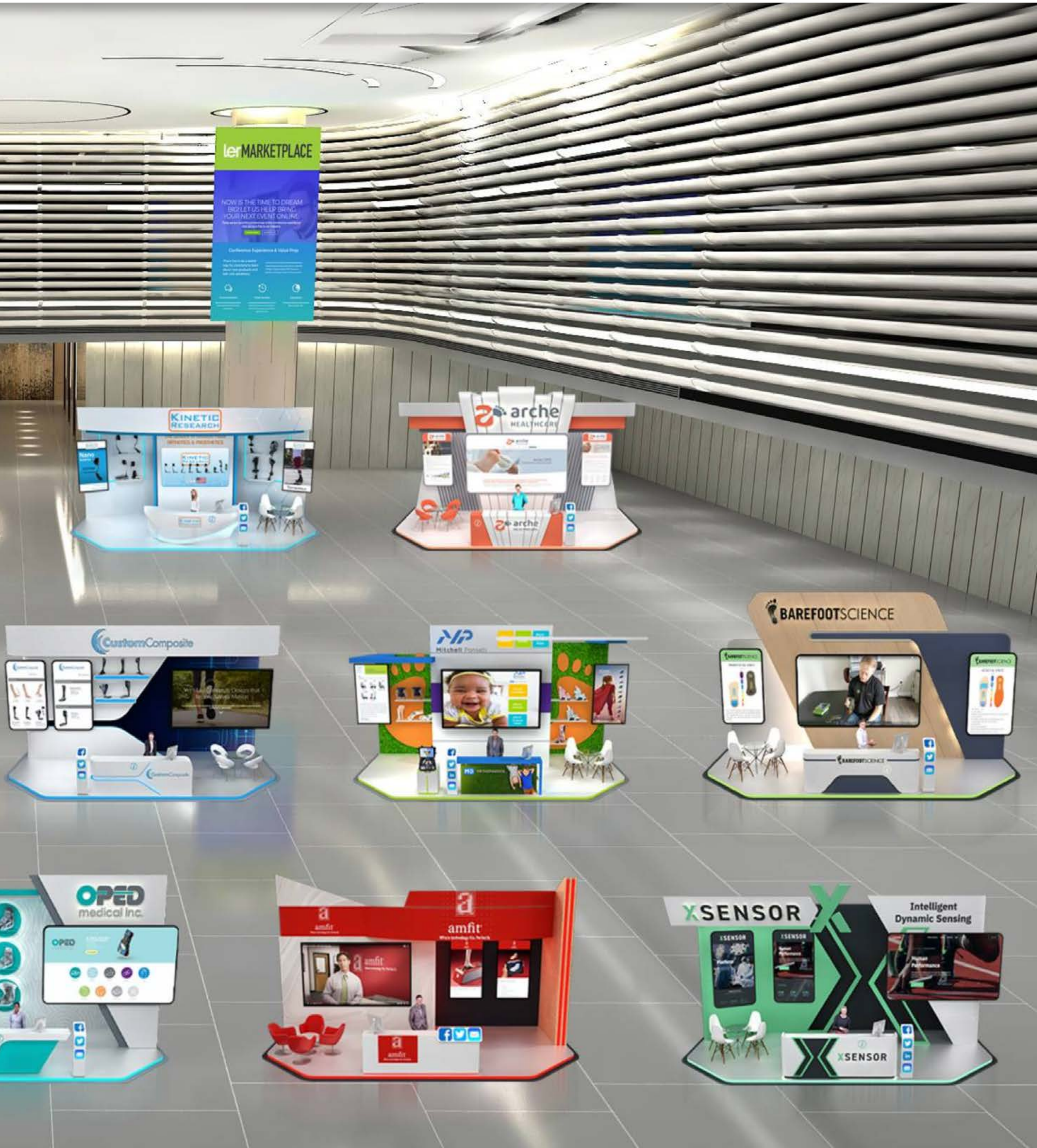


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LOWER EXTREMITY REVIEW

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Lower Extremity Review

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

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Lower Extremity Review Mission

Showcasing evidence and expertise across multiple medical disciplines to build, preserve, and restore function of the lower extremity from pediatrics to geriatrics.

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- Movement is essential
- Injury prevention is possible
- Diabetic foot ulcers can be prevented
- Collaborative care leads to better outcomes

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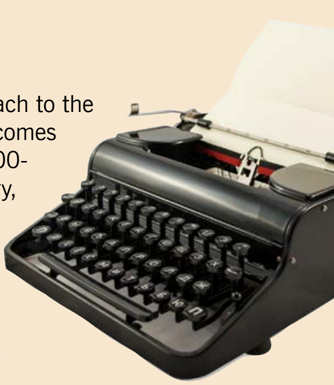

LER encourages a collaborative multidisciplinary clinical approach to the care of the lower extremity with an emphasis on functional outcomes using evidence-based medicine. We welcome manuscripts (1000-2000 words) that cross the clinical spectrum, including podiatry, orthopedics and sports medicine, physical medicine and rehabilitation, biomechanics, obesity, wound management, physical and occupational therapy, athletic training, orthotics and prosthetics, and pedorthics.

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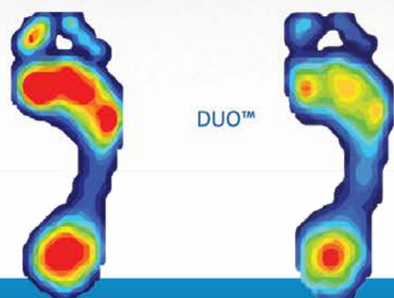

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Editorial **Observations**

I Asked Dr. Google…
How Much Water Should You Drink?

By Janice T. Radak, Editor

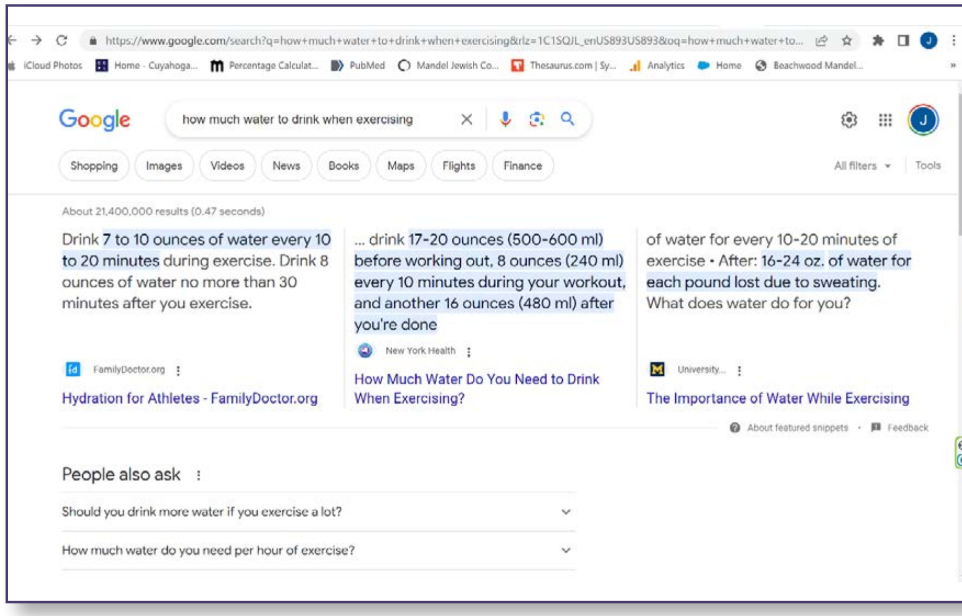
With summer upon us, I thought it a good time to see just how much water I should be drinking or encouraging my friends and readers to drink. So I asked Dr. Google. Yes, yes, I know what you're thinking. But this was an exercise in perhaps the original form of data verification—get 1 answer and see if it can be replicated by a reputable source. So I asked, "how much water to drink when exercising?"

I got 21,400,000 results in less than half a second.

FamilyDoctor.org said "drink 7 to 10 ounces of water every 10 to 20 minutes during exercise. Drink 8 ounces of water no more than 30 minutes after you exercise." So let's assume I exercise for 30 minutes. That means I drink 8 ounces every 10 minutes (24 ounces) and then another 8 ounces within 30 minutes. Total = 32 ounces. There's no mention of weight or age or health condition. But note, I didn't go into the page itself—just took Google's word for it, like the typical Google user.

New York Health said, "drink 17–20 ounces (500–600 ml) before working out, 8 ounces (240 ml) every 10 minutes during your workout, and another 16 ounces (480 ml) after you're done." Using the same 30-minute workout, here I drink 17–20 ounces BEFORE I even start, then I drink 24 (3 x 8) ounces during the workout, and another 16 after. Total = 60 ounces. Again, no mention of weight/age/health status. And again, just took Google's word for it.

The listing from the University of Michigan was not enough to provide a quick answer, so I had to click through. This took me to a PDF file from *M healthy* titled, "The Importance of Water While Exercising," dated 2011. The file offers the symptoms of dehydration for patients and its complications (very briefly)



and then provides this response to the query: How much water should I drink?

> Remember it is important to drink water before, during, and after exercise. Exact amounts of water needed will vary from individual to individual (gender, exercise environment, type of exercise, and intensity of exercise are all factors).
>
> - **Before:** 17–20 oz. of water at least 2 hours prior to exercise
> - **During:** 7–10 oz. of water for every 10–20 minutes of exercise
> - **After:** 16–24 oz. of water for each pound lost due to sweating

Hmmm, to calculate how much to drink with this, I have to weigh myself BEFORE and AFTER my exercise workout….so let's say, my workout wasn't very vigorous and I didn't really sweat, so I didn't lose a pound or 4. The New York Health guidance is very similar, just lacks the weight-loss stipulation for post-workout water needs. Total = 60+ ounces.

When I clicked on Google's infamous "People also ask '*How much water do you need per hour of exercise?*'" Truesport.org took me to a page titled, "How Much Water Do Youth Athletes Need?" Searching on the site I learn that Truesport is the United States Anti-Doping Agency's (USADA) youth sport outreach program.

This page is dated April 2017 and identifies proper hydration as "one of the most important steps a youth athlete can take toward achieving peak performance in their sport." And it mentions that there's "conflicting advice on how much water youth athletes should drink and when." I want to tell them, it's not just youth athletes who face such conflicting advice.

The good news is, Truesport goes on to explain the 4 ways fluids get lost—exercise intensity, sweating, temperature, altitude—and that some ways may not affect your particular performance (eg, I'm not at a high altitude).

And then it answers our key question with

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this straightforward advice:

A good rule of thumb for athletes is to divide their body weight in half and drink at least an ounce per pound of body weight throughout a typical day (e.g., someone weighing 160 pounds should drink 80 ounces of water a day). This amount should then be adjusted for the day's activity level and outside temperature.

On high-activity days, the timing of hydration becomes an extra–important factor. As general rules of thumb, the following guidelines can be helpful:

- **Before Exercise:** Drink 16 ounces of water 2 hours before physical activity begins, and another 8–16 ounces right before exercising.
- **During Exercise:** Every 15–20 minutes, drink at least 4–6 ounces of fluid during vigorous exercise. For less vigorous exercise, decrease the amount slightly.
- **After Exercise:** Drink 16–24 ounces of water for every pound lost during physical activity. Consuming rehydrating beverages (like fruit smoothies) and eating watery foods (such as fruits and vegetables) along with salty ones can help replace lost fluids and electrolytes.

A simpler way for most athletes (or anyone) [emphasis added] to drink enough water is to remember the Rule of 8: 8 times throughout the day, drink a big glass of water (8 total).

OK, so in this last scenario, I should aim for 8 big glasses of water 8 times a day. Let's assume an 8-ounce glass 8 times a day. Total = 64 ounces. But it seems clear that if I did consider myself an athlete, I'd need a whole lot more.

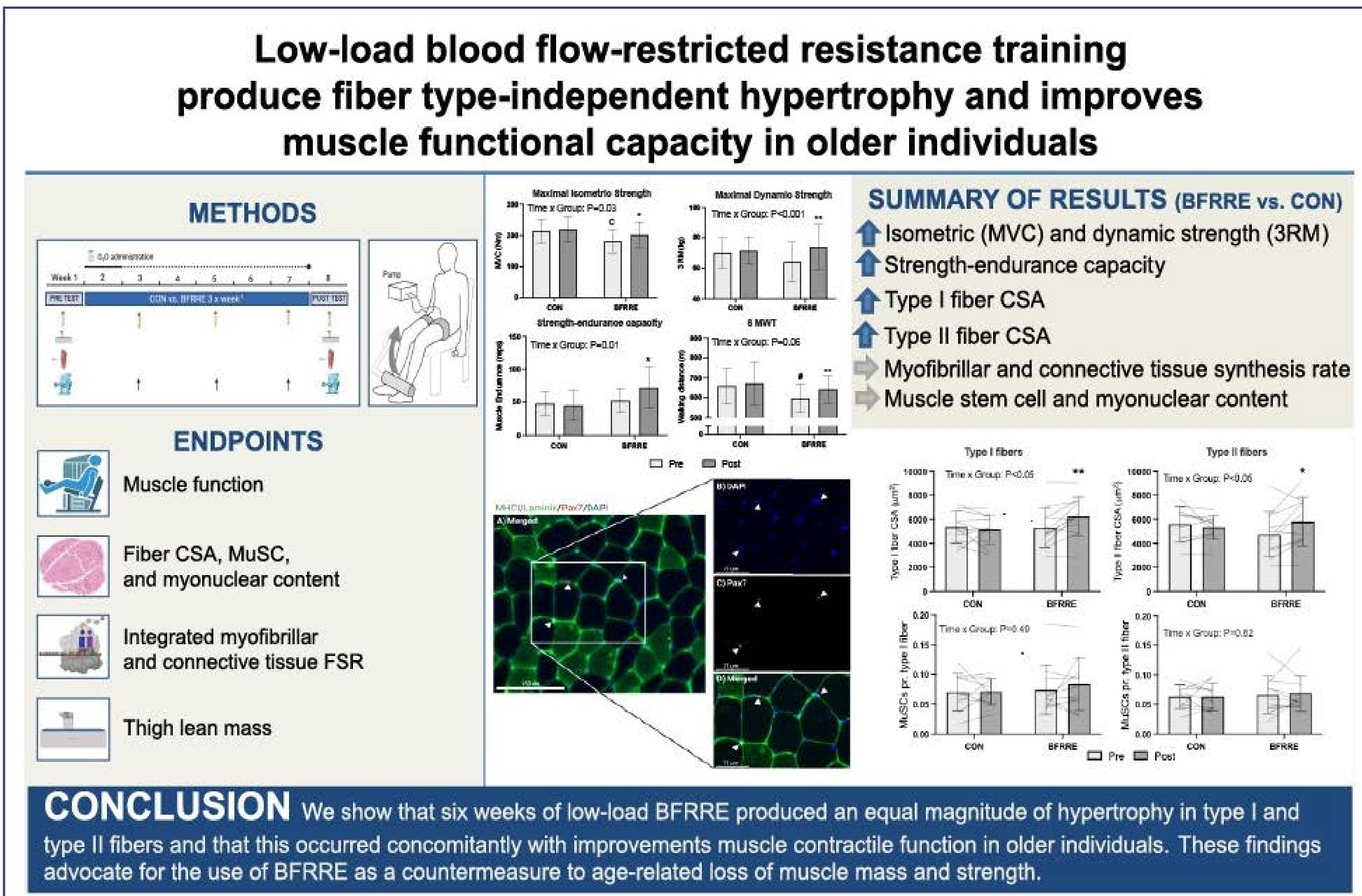
So what to do? USADA's advice seems most straight forward and more importantly, easiest to follow, so, like the average internet user, I'll take that advice! Stay Hydrated! ler

Janice T. Radak is Editor of Lower Extremity Review and her chosen form of exercise is water jogging.

BFRRE IMPROVES MUSCLE FUNCTIONAL CAPACITY IN OLDER ADULTS

Low-load blood flow-restricted resistance exercise (BFRRE) constitutes an effective means to produce skeletal muscle hypertrophy in as little as 6 weeks. Its applicability to counteract the age-related skeletal muscle decay at a cellular level, however, is not clear. Danish researchers investigated the effect of BFRRE on muscle fiber morphology, integrated muscle protein synthesis, muscle stem cells (MuSCs), myonuclear content, and muscle functional capacity in healthy older individuals. Twenty-three participants with a mean age of 66 yr (56–75 yr) were randomized to 6 wks of supervised BFRRE (3 sessions per week) or non-exercise control (CON). Biopsies were collected from the vastus lateralis before and after the intervention. Immunofluorescent microscopy was utilized to assess muscle fiber type-specific cross-sectional area (CSA) as well as MuSC and myonuclear content. Deuterium oxide was orally administered throughout the intervention period, enabling assessment of integrated myofibrillar and connective tissue protein fractional synthesis rate (FSR). BFRRE produced uniform ~20% increases in the fiber CSA of both type I and type II fibers ($P < 0.05$). This occurred concomitantly with improvements in both maximal muscle strength and strength-endurance capacity but in the absence of increased MuSC content and myonuclear addition. The observed muscle fiber hypertrophy was not mirrored by increases in either myofibrillar or connective tissue FSR. In conclusion, BFRRE proved effective in stimulating skeletal muscle growth and increased muscle function in older individuals, which advocates for the use of BFRRE as a countermeasure of age-related deterioration of skeletal muscle mass and function. ler

Source: *Wang J, Mogensen A-M G, Thybo F, et al. Low-load blood flow-restricted resistance exercise produces fiber type-independent hypertrophy and improves muscle functional capacity in older individuals. J Appl Physiol. 2023;134(4):1047-1062. doi: 10.1152/japplphysiol.00789.2022.*



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MUSCLE SYNERGIES IN CHRONIC ANKLE INSTABILITY


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Lateral ankle sprains are among the most common musculoskeletal injuries. Indeed, nearly 70% of these patients will go on to develop chronic ankle instability (CAI) with lingering mechanical and functional deficits.

Although neuromuscular deficits in people with CAI have been identified, previous researchers have mostly investigated the activation of multiple muscles in isolation. Investigating muscle synergies in people with CAI would provide information about the coordination and control of neuromuscular activation strategies and could supply important information for understanding and rehabilitating neuromuscular deficits in this population.

An international team of researchers sought to assess and compare muscle synergies using nonnegative matrix factorization in people with CAI and healthy control individuals as they performed different landing-cutting tasks. They used a cross-sectional study design set in a laboratory.

Patients/participants: A total of 11 people with CAI (5 men, 6 women; age = 22 ± 3 years, height = 1.68 ± 0.11 m, mass = 69.0 ± 19.1 kg) and 11 people without CAI serving as a healthy control group (5 men, 6 women; age = 23 ± 4 years, height = 1.74 ± 0.11 m, mass = 66.8 ± 15.5 kg) participated.

Main outcome measure(s): Muscle synergies were extracted from electromyography of the lateral gastrocnemius, medial gastrocnemius, fibularis longus, soleus, and tibialis anterior (TA) muscles during anticipated and unanticipated landing-cutting tasks. The number of synergies, activation coefficients, and muscle-specific weighting coefficients were compared between groups and across tasks.

Results: The number of muscle synergies was the same for each group and task. The CAI group exhibited greater TA weighting coefficients in synergy 1 than the control group (P = .02). In addition, both groups demonstrated greater fibularis longus (P = .03) weighting coefficients in synergy 2 during the unanticipated landing-cutting task than the anticipated landing-cutting task.

Conclusions: These results suggest that, although both groups used neuromuscular control strategies of similar complexity or dimensionality to perform the landing-cutting tasks, the CAI group displayed different muscle-specific weightings characterized by greater emphasis on TA function in synergy 1, which may reflect an effort to increase joint stability to compensate for ankle instability.

Source: *Kim H, Palmieri-Smith R, Kipp K. Muscle synergies in people with chronic ankle instability during anticipated and unanticipated landing-cutting tasks. J Athl Train. 2023;58(2):143–152. https://doi.org/10.4085/1062-6050-74-21*

TO DECREASE PAIN, INCREASE PHYSICAL ACTIVITY


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A randomized controlled trial from Japan examined whether compared with a program without increased physical activity, an intervention program with increased physical activity could prevent the development of musculoskeletal pain in community-dwelling older adults.

Seventy-nine community-dwelling older adults without musculoskeletal pain were randomized into 2 groups: an intervention group (n = 40) that engaged in increased physical activity and an exercise class and a control group (n = 39) that participated only in the exercise class.

The exercise class consisted of weekly 60-min sessions over 24 weeks. The program to increase physical activity required the participants to record their daily step counts using pedometers. The primary outcome was the development of musculoskeletal pain, and secondary outcomes were physical function, psychological status, cognitive function, and physical activity levels.

The researchers reported that 24 weeks after the intervention, the intervention group had a significantly lower prevalence of musculoskeletal pain (12.8%) than the control group (32.4%; $P = .040$). A time-by-group

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interaction emerged for cognitive function (P = .01) and physical activity levels (P < .001), both of which favored the intervention group. The intervention group also showed greater improvement in psychological status 24 weeks after the intervention than the control group (P = .018).

Writing in their conclusion, the researchers noted that the intervention program with increased physical activity prevented the development of musculoskeletal pain and improved cognitive function, physical activity levels, and psychological status more effectively than the program without increased physical activity. They theorized that their intervention program may be an effective pain prevention approach for older adults.

Source: *Hirase T, Inokuchi S, Koshikawa S, Shimada H, Okita M. Preventive effect of an intervention program with increased physical activity on the development of musculoskeletal pain in community-dwelling older adults: a randomized controlled trial. Pain Med. 2023;24(5):507-514. doi: 10.1093/pm/pnac164.*

BONE STRESS INJURIES AT THE ANKLE AND FOOT

Writing in Seminars in Musculoskeletal Radiology, 2 European experts review typical anamnestic/clinical findings, epidemiology and risk factors, imaging characteristics, and findings at typical locations of bone stress injuries in the foot and ankle that may help guide treatment strategy and patient recovery. Bone stress injuries (BSIs) are a frequent finding in athletes, particularly of the foot and ankle. A BSI is caused by recurring microtrauma to the cortical or trabecular bone exceeding the repair capacity of normal bone. The most frequent fractures at the ankle are low risk, characterized by a low risk for nonunion. These include the posteromedial tibia, the calcaneus, and the metatarsal diaphysis. High-risk stress fractures have a higher risk for nonunion and need more aggressive treatment. Examples are the medial malleolus, navicular bone, and the base of the second and fifth metatarsal bone. They note that imaging features depend on the primary involvement of cortical versus trabecular bone and that conventional radiographs may remain normal up to 2 to 3 weeks. For cortical bone, early signs of BSIs are a periosteal reaction or the "gray cortex sign," followed by cortical thickening and fracture line depiction. In trabecular bone, a sclerotic dense line may be seen. In their opinion, magnetic resonance imaging enables early detection of BSIs and can differentiate between a stress reaction and a fracture.

Source: *Jungmann PM, Schaeffeler C. Bone stress injuries at the ankle and foot. Semin Musculoskelet Radiol. 2023;27(3):283-292. doi: 10.1055/s-0043-1766098.*

POOLED ANALYSIS: 75 MINS/WK OF MODERATE PHYSICAL ACTIVITY PREVENTS 1/10 DEATHS

One in 10 early deaths could have been prevented if everyone had met just half the recommended weekly target of 150 minutes of moderate intensity physical activity, according to the largest pooled data analysis of its kind.

The analysis, published in the *British Journal of Sports Medicine*, shows that just 75 minutes a week substantially reduces the risks of early death, cardiovascular disease, and certain cancers, including those of the head and neck and myeloid leukemia.

Higher levels of physical activity are associated with lower risks of death from all causes. But differing methods used in previous pooled data analyses on which these associations are based, make it difficult to pinpoint reduced risks for specific outcomes. And workplace physical activity, which is hard to measure, has often been included in these analyses, explain the researchers.

To overcome these issues, the researchers deployed a new framework that enabled them to compare studies measuring and reporting physical activity in many different ways; to exclude resting energy expenditure; and for the first time, to explore the dose-response links between leisure time physical activity and specific types of cancer.

They included studies of at least 10,000 adults that looked at physical activity and deaths from all causes, cardiovascular disease, and cancer; new cases of cardiovascular disease, coronary heart disease, stroke, and heart failure; all new cancers and 14 specific cancers.

They pooled the results of 196 studies of more than 30 million people, most of whom reported leisure time physical activity below 17.5 metabolic equivalent of task (MET) hours/week—equivalent to 300 minutes of moderate intensity physical activity.

In general, higher levels of weekly physical activity were associated with a lower risk of all outcomes.

Differences in risk were greater between 0 and 8.75 weekly MET hours—equivalent to the recommended 150 minutes/week of moderate physical activity—with smaller marginal differences in risk above this level up to 17.5 MET hours/week.

Associations were stronger for deaths from all causes and from cardiovascular disease than those from cancer. Compared with inactive adults, those clocking up 8.75 MET hours/week had 31% and 29% lower risks

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of death from all causes and from cardiovascular disease, respectively; the difference in the risk of death from any cancer was 15%.

At 8.75 MET hours/week, the risk of cardiovascular disease was 27% lower. But the associations were weaker for different types of heart disease. The association was weaker for any diagnosis of cancer (12% lower risk), but stronger for head and neck cancers, myeloid leukaemia, myeloma, and stomach (35% to 22% lower).

To contextualise the results, the researchers estimated the proportion of preventable deaths and disease outcomes at different levels of leisure time physical activity.

They calculated that if all insufficiently active people had managed 8.75 MET hours/week, almost 16% of all recorded premature deaths would have been prevented. And notably, 10% of all deaths would have been prevented if everyone clocked up half this weekly target—in other words, just 75 minutes of moderate intensity physical activity.

Source: *Garcia L, Pearce M, Abbas A, et al. Non-occupational physical activity and risk of cardiovascular disease, cancer and mortality outcomes: a dose-response meta-analysis of large prospective studies. Br J Sports Med. 2023:bjsports-2022-105669. doi: 10.1136/bjsports-2022-105669.*

MEASURING SARCOPENIA

Sarcopenia is associated with adverse outcomes in elderly persons, including functional disability, falls, and even death. Therefore, older adults should be routinely screened for sarcopenia. Due to the unsatisfactory sensitivity of the SARC-F questionnaire, 4 modified versions have been elaborated: SARC-CalF (calf measurement), SARC-F+EBM (BMI), SARC-F+AC (arm circumference), and SARC-CalF+AC (calf measurement + arm circumference). Polish researchers from the Department of Palliative Medicine at Poznan University of Medical Sciences conducted a study to compare the diagnostic performance of the 4 modifications of SARC-F.

They performed sensitivity/specificity analyses and compared the overall diagnostic accuracy of the 5 questionnaires in 260 community-dwelling volunteers aged ≥ 60 yrs from Poland. The study used 3 reference standards: the European Working Group on Sarcopenia in Older People (EWGSOP1), EWGSOP2, and modified EWGSOP2 criteria.

The results found that the prevalence of sarcopenia based on these criteria was 20.8%, 11.2%, and 17.3%, respectively. Concerning the 3 reference standards, the sensitivity of SARC-F, SARC-CalF, SARC-F+EBM, SARC-F+AC, and SARC-CalF+AC ranged from 31.5–44.8%, 57.4–65.5%, 48.1–62.1%, 71.4–79.2%, and 71.4–79.2%, respectively. The specificity ranged from 86.6–87.4%, 86.1–90.3%, 82.3–84.0%, 69.4–78.2%, and 72.1–79.7%, respectively. The Area-under-the-curves of SARC-F, SARC-CalF, SARC-F+EBM, SARC-F+AC, and SARC-CalF+AC ranged from 0.643–0.700, 0.757–0.792, 0.740–0.775, 0.767–0.812, and 0.771–0.852, respectively.

In their conclusion, the team wrote that the SARC-F questionnaire had low diagnostic accuracy, which limits its usefulness as a sarcopenia screening tool. Incorporating 2 simple anthropometric measurements, ie, arm and calf circumference, they wrote, notably improves the diagnostic performance of SARC-F. Based on these results, they concluded that SARC-CalF+AC seems to be the best screening tool for sarcopenia screening in community-dwelling older adults.

Source: *Krzymińska-Siemaszko R, Deskur-Śmielecka E, Kaluźniak-Szymanowska A, Murawiak M, Wieczorowska-Tobis K. Comparison of Diagnostic Value of the SARC-F and Its Four Modified Versions in Polish Community-Dwelling Older Adults. Clin Interv Aging. 2022;18:783-797. doi: 10.2147/CIA.S408616.*

NEW GUIDELINE FOR TIMING OF ELECTIVE TJA

The American College of Rheumatology (ACR) and the American Association of Hip and Knee Surgeons (AAHKS) released a summary of the new guideline for hip and knee replacement timing titled "The Optimal Timing of Elective Hip or Knee Arthroplasty for Patients with Symptomatic Moderate to Severe Osteoarthritis or Osteonecrosis Who Have Failed Nonoperative Therapy." While previous joint guidelines from the 2 groups focused on the timing of medication use around surgery, this guideline focuses on the timing of hip and knee arthroplasty, and when additional nonoperative treatment or delays for medical optimization are appropriate for patients with advanced osteoarthritis and osteonecrosis who have failed nonoperative therapy.

This guideline follows the ACR guideline development process, which includes the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) methodology, and adheres to the Appraisal of Guidelines for REsearch & Evaluation (AGREE) criteria. A panel of rheumatologists, orthopaedic surgeons, and patients performed a systematic literature review for clinically relevant population, intervention, comparator, and outcomes (PICO) questions, and reached consensus on the following recommendations, taking into consideration available evidence, clinical

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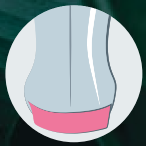

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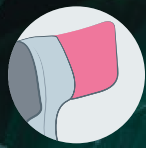

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experience and expertise, and patient values and preferences.

All of the recommendations (see Table) are conditional as the panel graded the available evidence as low or very low quality, primarily due to indirectness. While none are "strong" recommendations, there was high consensus for all of the identified recommendations.

Key among the take-home messages was that the decision of when to proceed with TJA should be made through a shared decision-making process between the physician and patient during which the unique risks and benefits for the individual patient are considered (guiding principle).

Source: *ACR/AAHKS. Total Joint Arthroplasty Guideline Summ ry 2023. Available at https://rheumatology.org/indications-for-total-hip-and-knee-arthroplasty-guideline. Accessed May 31, 2023.*

FaceBook post of the month!

Summary: Clinical Practice Guideline for the Optimal Timing of Elective Total Hip or Knee Arthroplasty for Patients with Symptomatic Moderate to Severe Osteoarthritis or Osteonecrosis Who Have Failed Nonoperative Therapy

Recommendation for patients with radiographically moderate to severe OA or ON of the hip or knee using standard radiographic grading such as Kellgren-Lawrence or Tonnis, and moderate to severe pain or loss of function who have been indicated for elective TJA through a shared decision-making process with their physician and have completed one or more trials of appropriate nonoperative therapy	Certainty of Evidence
In our defined population, we **conditionally** recommend proceeding to TJA without delay over delaying arthroplasty three months.	Very low
In our defined population, we **conditionally** recommend proceeding to TJA without delay over delaying arthroplasty for a trial of physical therapy.	Low
In our defined population, we **conditionally** recommend proceeding to TJA without delay over delaying surgical treatment for a trial of nonsteroidal anti-inflammatory drugs (NSAIDs).	Very low
In our defined population, we **conditionally** recommend proceeding to TJA without delay over delaying surgical treatment for a trial of braces and/or ambulatory aids.	Very low
In our defined population, we **conditionally** recommend proceeding to TJA without delay over delaying surgical treatment for a trial of intra-articular glucocorticoid injections.	Very low
In our defined population, we **conditionally** recommend proceeding to TJA without delay over delaying surgical treatment for a trial of viscosupplementation injections.	Very low
In our defined population with body mass index (BMI) > 50, we **conditionally** recommend proceeding to surgery without delay to achieve weight reduction to BMI < 50.	Very low
In our defined population with body mass index (BMI) 40 - 49, we **conditionally** recommend proceeding to surgery without delay to achieve weight reduction to BMI < 40.	Very low
In our defined population with body mass index (BMI) 35 - 39, we **conditionally** recommend proceeding to surgery without delay to achieve weight reduction to BMI < 35.	Very low
In our defined population with poorly controlled diabetes mellitus, we **conditionally** recommend delaying TJA to improve glycemic control.	Very low
In our defined population with nicotine dependence, we **conditionally** recommend delaying arthroplasty for nicotine use reduction/cessation.	Low
In our defined population with bone loss with deformity or severe ligamentous instability, we **conditionally** recommend proceeding to TJA without delay over delaying arthroplasty for optimization of non-life-threatening conditions.	There were no studies that either directly or indirectly answered our PICO question.
In our defined population with a neuropathic joint, we **conditionally** recommend proceeding to TJA without delay over delaying for optimization of non-life-threatening conditions.	There were no studies that either directly or indirectly answered our PICO question.

This summary was approved by the ACR Board of Directors on February 22. 2023, and the AAHKS Board of Directors on March 8, 2023. These recommendations are included in a full manuscript, which will be submitted for publication in Arthritis & Rheumatology, Arthritis Care and Research, and the Journal of Arthroplasty.

*All recommendations are conditional, largely due to the quality of the evidence.

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Hoverboard-Related Lower Extremity Injuries Treated at United States Emergency departments

By Mathias B. Forrester, BS

Background: First available in the United States (US) in 2015, hoverboards have become popular, with millions purchased. There is risk of injury when operating hoverboards. This study characterized hoverboard-related lower extremity injuries treated at United States (US) emergency departments (EDs).

Methods: An analysis was performed of hoverboard-related lower extremity injuries using data from the National Electronic Injury Surveillance System of the US Consumer Product Safety Commission during 2000-2022.

Results: There were an estimated 26,622 hoverboard-related lower extremity injuries treated at US hospital EDs during the time period. The most common circumstances leading to lower extremity injury were 73.3% fell off the hoverboard, 6.8% collision while on the hoverboard, and 5.7% run over by the hoverboard. The patient age distribution was 5.9% 0-5 years, 50.5% 6-12 years, 15.8% 13-19 years, and 27.8% 20 years and older. The most common types of injuries were fracture (28.0%), strain or sprain (26.9%), and contusion or abrasion (21.5%). The affected body part was 27.2% ankle, 27.2% foot, 16.4% toe, 16.2% knee, 11.6% lower leg (not including knee or ankle), and 1.4% upper leg. The patient was treated or examined at the ED and then released in 95.3% of the estimated injuries.

Conclusions: Hoverboard-related lower extremity injuries occur under a variety of circumstances, the most common being falling off the hoverboard, collision while on the hoverboard, and run over by the hoverboard. Most patients were children. The most common type of injury was fracture, followed by strain or sprain and contusion or abrasion. The majority of patients were treated or examined in the ED and released.

A hoverboard is a battery-powered, hands-free, self-balancing vehicle consisting of two wheels connected by a long board.[1,2] To operate a hoverboard, a person stands on the long board and shifts their weight to activate gyroscopic pads that cause the vehicle to move without pedaling. Hoverboards first became available in the United States (US) in 2015;[1,2] since then, they have become popular in the US, with millions purchased.[3]

A person operates a hoverboard by balancing without using their hands, and the vehicle can turn at speeds of 15 mph or more. For these and other reasons, injuries may occur when using hoverboards.[1,3-8] Studies have found fractures to be the most common type of hoverboard-related injury and the upper extremity to be the body part most often involved in hoverboard-related injuries.[1,4,5,7,8] Although the majority of injuries result from a fall, a portion may be due to other circumstances.[7,8] Furthermore, fires or explosions related to hoverboard batteries have been reported.[9,10]

While most hoverboard-related injuries involve the upper extremity, a portion involve the lower extremity.[4,5] The objective of this study was to characterize hoverboard-related lower extremity injuries treated at US hospital emergency departments (EDs).

Methods

This study used data from the National Electronic Injury Surveillance System (NEISS) website (https://www.cpsc.gov/cgibin/NEISSQuery/home.aspx). The NEISS is operated by the US Consumer Product Safety Commission (CPSC) and collects data on consumer product-related injuries from the EDs of a stratified random sample of 100 hospitals from the more than 5,000 hospitals in the US. The random sample is stratified by hospital size, geographic location, and hospital type (general and pediatric hospitals). Professional NEISS coders view the medical charts at participating hospitals and, for patients with injuries that meet NEISS inclusion criteria, collect and code information such as treatment date; patient age, sex, and race; injury diagnosis and body part injured; discharge disposition; consumer product(s) involved in the injury; location where the incident occurred; and a brief narrative describing the incident.[11,12] Data are publicly available and de-identified; therefore, the study is exempt from institutional review board approval. The NEISS database has been used previously

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Table 1. Year and patient demographics of hoverboard-related injuries treated in United States emergency departments, National Electronic Injury Surveillance System, 2015-2022

Variable	Lower extremity (LE) injuries		All injuries		LE/total injuries
	Estimate	%	Estimate	%	%
Year					
2015	533	2.0	2,341	1.4	22.8
2016	5,013	18.8	22,602	13.9	22.2
2017	3,786	14.2	22,728	14.0	16.7
2018	4,655	17.5	26,177	16.1	17.8
2019	3,092	11.6	21,927	13.5	14.1
2020	3,907	14.7	26,700	16.4	14.6
2021	3,292	12.4	23,605	14.5	13.9
2022	2,344	8.8	16,630	10.2	14.1
Patient age (years)					
0-5	1,575	5.9	11,529	7.1	13.7
6-12	13,447	50.5	87,521	53.8	15.4
13-19	4,206	15.8	20,294	12.5	20.7
20-29	2,686	10.1	12,174	7.5	22.1
30-39	2,308	8.7	13,152	8.1	17.6
40+	2,400	9.0	18,041	11.1	13.3
Patient sex*					
Female	15,285	57.4	89,431	55.0	17.1
Male	11,337	42.6	73,272	45.0	15.5
Total	**26,622**		**162,711**		**16.4**

*Patient sex was not reported in all cases.

Estimate = Weighted estimate (sum of the Weight numeric field in the National Electronic Injury Surveillance System database). The numbers in the Weight field are not whole numbers but include decimals. As a result of rounding to whole numbers when performing analyses, the sum of the estimates for a given variable might not equal the total. The Consumer Product Safety Commission considers an estimate unstable and potentially unreliable when the number of records used is <20 or the estimate is <1,200.

to examine hoverboard-related injuries;[3,5,6,13,14] however, none of these studies had focused on lower extremity injuries.

Cases were hoverboard-related lower extremity injuries reported to the NEISS database during 2015-2022; 2015 was chosen as the start of the study because that was the year hoverboards first because available in the US. The publicly available NEISS database contains three numeric fields for coding the product involved in the injury (Product_1, Product_2, Product_3). However, there is no product code specific to hoverboards. The NEISS database contains a text field (field name Narrative) that provides a brief summary of the circumstances of the injury. The NEISS database was searched for all records that included the letter groups "hover," "hoover," "hovr," or "hoovr" in the Narrative field. The Narrative fields of the resulting records were individually examined, and any records that appeared to involve a hoverboard-related injury were included in the study. That the injury involved a lower extremity was based on the Body_Part numeric field (a field that documents the injured body part) containing codes for a lower extremity (upper leg, knee, lower leg, ankle, foot, toe). The NEISS database contains another numeric field for documenting whether a second body part was injured (Body_Part_2); however, this field was only added in 2018,[12] although this field does not appear to have been used until 2019. For consistency over the entire study period, only the Body_Part field was examined. (Thirty-four cases had a lower extremity coded in the Body_Part_2 field but not in the Body_Part field during 2019-2022.)

The variables examined were treatment year and month (grouped into three-month periods), patient age and sex, location where the incident occurred, circumstance of the injury, type of injury (diagnosis), affected body part, and disposition. The NEISS database does not have a field for circumstance of the injury. The circumstance of the injury was identified by review of the Narrative field and was assigned to one of the following groups: fell off hoverboard, collision while on hoverboard, ran over by hoverboard, body part caught in hoverboard, tripped over hoverboard, hit hoverboard, hit by person on hoverboard, hit by hoverboard, while carrying hoverboard, hoverboard caused fire, other, and unknown.

Analyses were performed using Microsoft 365 Access and Excel (Microsoft Corporation,

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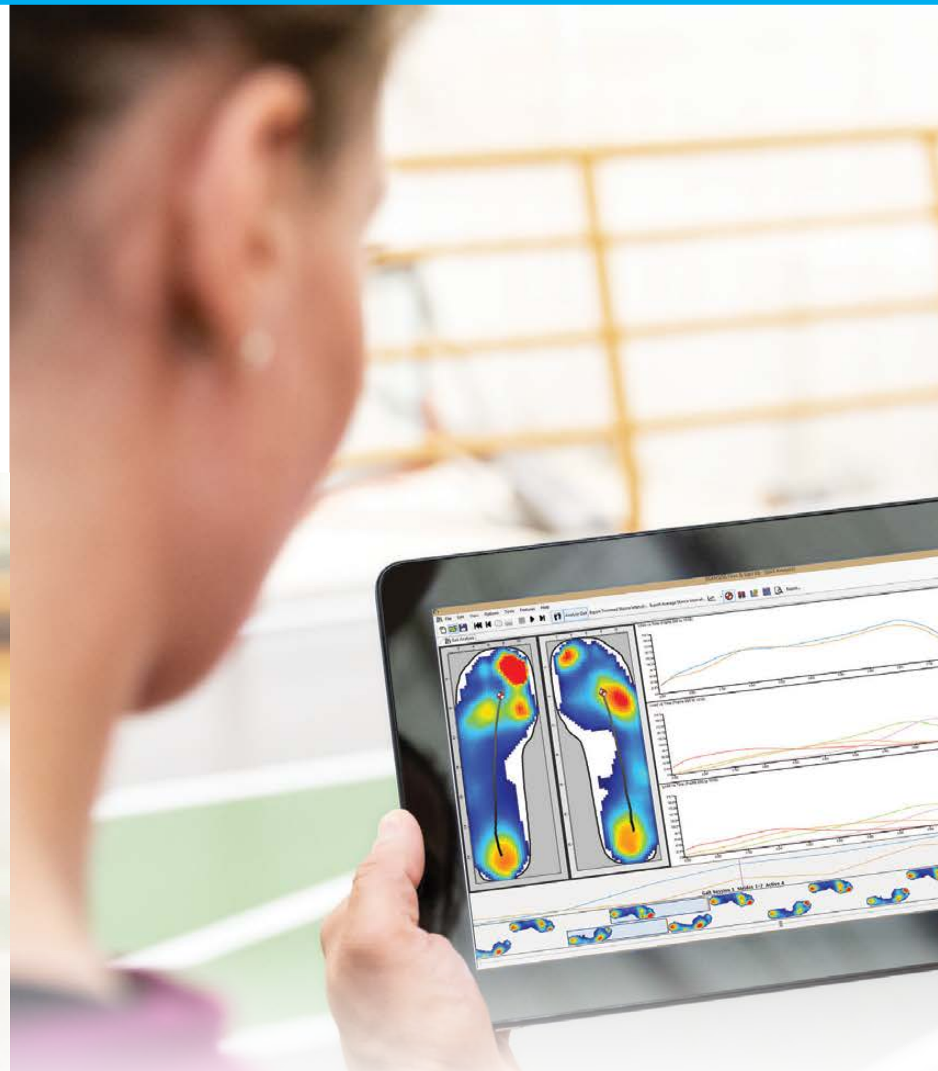

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Table 2. Location and circumstances of hoverboard-related injuries treated in United States emergency departments, National Electronic Injury Surveillance System, 2015-2022

Variable	Lower extremity (LE) injuries		All injuries		LE/total injuries
	Estimate	%	Estimate	%	%
Location of incident					
Home	9,731	36.6	61,253	37.6	15.9
Street or highway	1,589	6.0	10,160	6.2	15.6
Other public property	987	3.7	6,668	4.1	14.8
Place of recreation or sports	456	1.7	4,704	2.9	9.7
School	0	0.0	197	0.1	0.0
Not recorded	13,860	52.1	79,730	49.0	17.4
Circumstances of injury					
Fell off hoverboard	19,514	73.3	146,327	89.9	13.3
Collision while on hoverboard	1,797	6.8	4,051	2.5	44.4
Ran over by hoverboard	1,505	5.7	2,673	1.6	56.3
Body part caught in hoverboard	117	0.4	1,993	1.2	5.9
Tripped over hoverboard	437	1.6	1,680	1.0	26.0
Hit hoverboard	358	1.3	540	0.3	66.2
Hit by person on hoverboard	407	1.5	439	0.3	92.7
Hit by hoverboard	359	1.3	427	0.3	84.0
While carrying hoverboard	0	0.0	162	0.1	0.0
Hoverboard caused fire	0	0.0	148	0.1	0.0
Other	609	2.3	1,421	0.9	42.8
Unknown	1,520	5.7	2,850	1.8	53.3
Total	**26,622**		**162,711**		**16.4**

Please see footnote in Table 1.

Redmond, Washington, US). For the selected variables, the distribution of the national injury estimates was determined for both total hoverboard-related injuries affecting any body part and the subset of hoverboard-related lower extremity injuries. Comparisons were made between the two groups for the studied variables by calculating the percent of total injuries that were lower extremity injuries. National injury estimates were calculated by summing the values in the Weight numeric field in the publicly available NEISS database. The CPSC considers an estimate unstable and potentially unreliable when the estimate is <1,200.[11]

Results

An estimated 26,622 hoverboard-related lower extremity injuries were treated at US hospital EDs during 2015-2022, representing 16.4% of the 162,711 total estimated hoverboard-related injuries. The estimated number of lower extremity injuries by body part was 7,233 (27.2%) ankle, 7,232 (27.2%) foot, 4,373 (16.4%) toe, 4,321 (16.2%) knee, 3,100 (11.6%) lower leg (not including knee or ankle), and 363 (1.4%) upper leg.

The first hoverboard-related lower extremity injury was treated in October 2015. Table 1 shows the estimated annual number of injuries. The estimated number of lower extremity injuries was greatest in 2016 then decreased over the rest of the study period. In contrast, the estimated number of total injuries increased to a peak in 2020 before declining over the next two years. The percent of total estimated injuries consisting of lower extremity injuries declined from 22.8% in 2015 to 14.1% in 2019 and ranged between 13.9% and 14.6% during 2020-2022.

Excluding 2015, during which hoverboard-related injuries were only treated during the last 3 months, there were an estimated 26,089 hoverboard-related lower extremity injuries during 2016-2022. The distribution of estimated hoverboard-related lower extremity injuries by season for this 7-year period was 8,572 (32.9%) in December-February, 6,903 (26.5%) in March-May, 5,680 (21.8%) in June-August, and 4,934 (18.9%) in September-November. The months with the greatest estimated number of lower extremity injuries were December (estimate = 3,535, 13.6%) and January (estimate = 3,170, 12.2%).

Table 1 presents the distribution of hoverboard-related injuries by patient demographics. Approximately half of the patients with lower extremity injuries were age 6-12 years; 72.2% of the patients were age 0-19 years and 27.8% were age 20 years and older. A higher proportion of patients were female.

Table 2 shows the distribution of hover-

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Table 3. Diagnosis and disposition of hoverboard-related injuries treated in United States emergency departments, National Electronic Injury Surveillance System, 2015-2022

Variable	Lower extremity (LE) injuries		All injuries		LE/total injuries
	Estimate	%	Estimate	%	%
Most common diagnosis*					
Fracture	7,453	28.0	64,661	39.7	11.5
Contusion or abrasion	5,729	21.5	28,216	17.3	20.3
Strain or sprain	7,154	26.9	19,575	12.0	36.5
Internal organ injury	0	0.0	13,578	8.3	0.0
Laceration	1,748	6.6	10,862	6.7	16.1
Concussion	0	0.0	5,896	3.6	0.0
Disposition					
Treated or examined and released	25,361	95.3	153,350	94.2	16.5
Treated and admitted for	1,505	5.7	2,673	1.6	56.3
hospitalization	849	3.2	5,007	3.1	17.0
Treated and transferred to another	437	1.6	1,680	1.0	26.0
hospital	128	0.5	2,071	1.3	6.2
Held for observation	91	0.3	545	0.3	16.7
Left without being seen/Left	359	1.3	427	0.3	84.0
against medical advice	193	0.7	1,737	1.1	11.1
Total	**26,622**		**162,711**		**16.4**

*Diagnosis includes only diagnosis listed in the first of two diagnosis fields in the National Electronic Injury Surveillance System database. The second diagnosis field was only used for records during 2019-2022. Please see footnote in Table 1.

board-related injuries by location and circumstances of the incident. Of those estimated lower extremity injuries with a recorded location, the majority occurred at home with the next most common locations being street or highway followed by other public property. Most estimated lower extremity injuries occurred when the patient fell off the hoverboard; the next most common circumstances were collision while on the hoverboard and ran over by the hoverboard. The proportion of total estimated injuries consisting of lower extremity injuries varied by the circumstance of the injury. For example, the lower extremity rates for collision while on the hoverboard (44.4%) and ran over by the hoverboard (56.3%) were 3.3 and 4.2 times that for fell off the hoverboard (13.3%), respectively.

Table 3 provides the distribution of hoverboard-related injuries by type of injury and patient disposition. The most common diagnoses for lower extremity injuries were fracture, strain or sprain, and contusion or abrasion. Estimated lower extremity injuries comprised a higher proportion of total estimated injuries for strains and sprains (36.5%) and contusions or abrasions (20.3%) than for fractures (11.5%). The majority of patients were treated or examined at the ED and released.

Discussion

This study described the pattern of hoverboard-related lower extremity injuries treated at US hospital EDs and compared these to total hoverboard-related injuries. This information is important because knowledge of the pattern of hoverboard-related injuries allows healthcare providers to allocate resources to help manage these injuries. In addition, injury prevention programs can design the information they provide to target particular populations.

This study found that the proportion of total injuries represented by lower extremities varied with the injury circumstances. Of the three most commonly reported circumstances, lower extremities represented only 13.3% of injuries resulting from falling off the hoverboard but 44.4% of the injuries resulting from a collision while on the hoverboard and 56.3% of the injuries resulting from being run over by the hoverboard. And lower extremity injuries accounted for more than 13.3% of the total injuries for six of the nine remaining circumstances. These differences in rates likely reflect differences in the specific mechanics of the circumstances with some of the circumstances more likely to result in lower extremity injuries than others.

While the estimated annual number of total hoverboard-related injuries increased from 2015 to 2020 and then declined, the estimated annual number of lower extremity injuries was greatest in 2016 and decreased through the rest of the time period. Consequently, the proportion of estimated total injuries represented by lower extremity injuries declined through 2019 and then remained relatively constant through 2022. One possible explanation for this pattern is the introduction of the second data field for documenting injured body parts in 2019. It could be that, from 2019 onward, a portion of lower extremity injuries were documented in the second data field instead of the first. However, there

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were only 34 cases reported during 2019-2022 where a lower extremity was documented in the second data field and not in the first. Thus, this is not likely to significantly account for the decline in the proportion of total injuries represented by lower extremities.

A more likely explanation would be temporal changes in the circumstances resulting in hoverboard-related injuries. If the pattern of circumstances resulting in injuries changed over time, then the relative contribution of lower extremities to total injuries might likewise change. The proportion of estimated total injuries resulting from collision or being run over was 5.3% during 2015-2018 but 3.2% during 2019-2022.

Estimated lower extremity injuries were seasonal, with 25.7% reported in December and January. Other studies of hoverboard-related injuries have reported a similar pattern, attributing the surge in injuries during December and January to hoverboards being received as Christmas gifts.[3,13]

Over half of the estimated lower extremity injuries involved patients age 6-12 years and 72.2% age 0-19 years. Previous studies likewise observed that most patients were children.[1,5,13,14] Children may be more likely to use hoverboards or more likely to experience injuries resulting in treatment at hospital EDs.

Fractures, strains or sprains, and contusions or abrasions accounted for 76.4% of the estimated lower extremity injuries. In most cases, these types of injuries might not be expected to require hospital admission or transfer to another hospital. This study found that 95.3% of the patients were treated or examined in the ED and released.

Various recommendations have been offered to prevent hoverboard-related injuries.[1,4] Appropriate protective gear such as wrist guards should be used when operating a hoverboard. Children should use hoverboards under adult supervision. Use of hoverboards in confined spaces should be avoided. Considering that a high proportion of injuries occur around Christmas, educational materials and warnings should be disseminated around that time.

This study has various limitations. Hoverboard-related injuries were identified by searching for letter combinations in the Narrative text field. If these letter combinations were not used for hoverboard-related injuries, then these cases would not have been included in the analysis. This study only included patients who were treated at hospital EDs and not patients who were treated at other locations. Inclusion of this latter group of patients would provide a more complete understanding of hoverboard-related lower extremity injuries.

In conclusion, hoverboard-related lower extremity injuries occur under a variety of circumstances, the most common being falling off the hoverboard, collision while on the hoverboard, and run over by the hoverboard. The specific circumstances differed in the risk of causing lower extremity injury compared to injury of any body part. The majority of patients were children. The most common type of injury was fracture, followed by strain or sprain and contusion or abrasion. The majority of patients were treated or examined in the ED and released.

Mathias B. Forrester, BS, is an independent researcher in Austin, Texas.

Now retired, he previously performed public health research for various university and government programs for 38 years.

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If You Want to Ride a Hoverboard, Train For It!

By Robert Weil, DPM


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Hoverboard continues to be an increasingly popular ride option for all ages. But these rechargeable self-balancing scooters with electric motors and batteries require serious attention to safety.

Designed for personal transportation, today's hoverboards can reach speeds of 10 mph, with the average clocking in at 7 mph. Most are designed to be ridden on a flat, dry surface that is smooth – off-road terrains, uneven pavement, and rain should be avoided with these models. Then there are the all-terrain hoverboards, which have sturdier tires, and are touted as off-road balancing boards. These can face mud, rain, grass, hills, and even rocks, according to many of their manufacturers. Before you go anywhere, be sure to check the warranty.

Hoverboards do come in different sizes that carry different weight limits — but check the product you are purchasing because they vary widely. A quick scan of available models found these ranges:

- 10-inch hoverboards can carry 95 - 330 pounds;
- 8-inch boards, 75 - 265 pounds;
- 6.5-inch boards, 60 - 220 pounds;
- 4.5-inch boards, 33 - 120 pounds.

Riding a hoverboard can be a fun experience but it also requires physical coordination and balance. They are similar to, although not as common as, skateboards and rollerblades, and require similar amounts of training to ride safely and with ease. Considering the types of potential injuries noted in the article on pages 23-30, they are definitely not without risk.

Here are some tips and recommendations for hoverboard riding.

1. Start slowly: To avoid accidents or falls, it is important to start riding at a slow speed until you are comfortable with the hoverboard and how you need to work your body while on it. Be sure to start on a flat surface.

2. Wear protective gear: Make sure to wear proper safety gear like helmets and elbow, knee, and wrist guards. For younger children, mouth guards may even be in order.

3. Wear good supportive sports shoes – no flip flops or high heels!

4. Keep your body relaxed and avoid making sudden movements – this will help you maintain balance and reduce the risk of falling.

5. Pay attention to your posture: Keep your back straight and feet shoulder width apart. This helps maintain balance and provides better control of the hoverboard.

6. Avoid speed bumps or rocky surfaces: Hoverboards don't have suspension systems.

7. Practice in an open & flat area until you are comfortable with it. Avoid narrow spaces, crowds and traffic.

It is also smart to help train and condition your body for safe hoverboard riding! Strengthening feet, ankles, and legs makes good sense.

Also balance, postural and core strengthening can be very helpful – note some of the exercises we've included on page 35.

It is also important to remember that hoverboards are not suitable for children under the age of 12, though some manufacturers make shortened hoverboards they claim are safe for 5- to 8-year-olds (these have a shorter wheelbase, smaller wheels, and do not go above 5 mph). And always follow the manufacture's guidelines for use and safety precautions.

Here's to fun & safe Hoverboard rides!

Robert A. Weil is a sports podiatrist in private practice in Aurora, Illinois. He hosts The Sports Doctor, a live weekly radio show on bbsradio.com. His book, #HeySportsParents, written with Sharkie Zartman, is available on Amazon.com and ranks among the seller's top 100 books in both Children & Youth Sports (#59) and Children's Sports Coaching (#62). Dr. Weil was inducted into the prestigious National Fitness Hall of Fame in April 2019.

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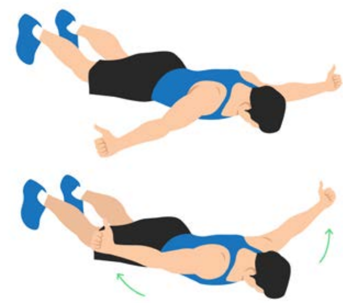
1. Tree yoga pose.

2. Core control rear lunge exercise.

3. Floor T raise exercise.



4. Bodyweight squats.

5. Work out on a bosu.

6. Groiners exercise.

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Requirements, Needs, Wishes of AFOs for Children with CP

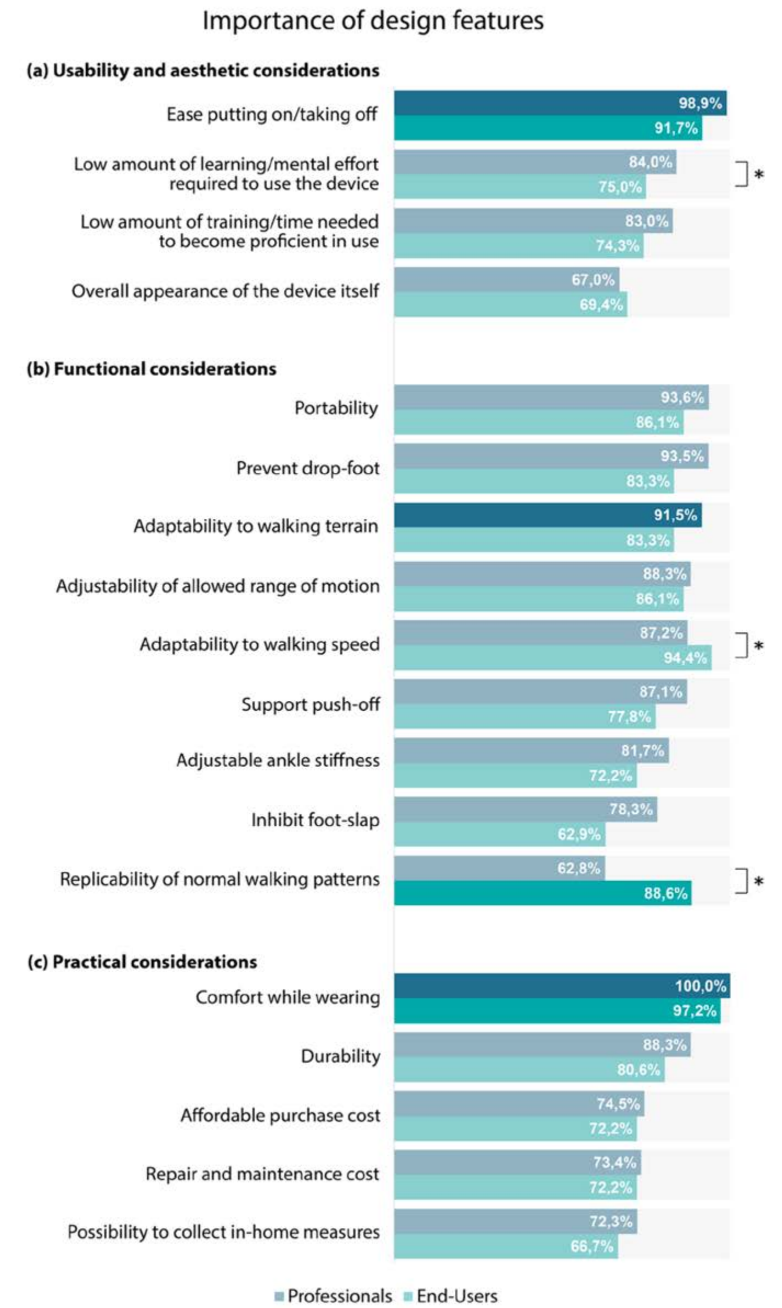
By Cristina Bayón, Marleen van Hoorn, Antonio Barrientos, Eduardo Rocon, Joyce P. Trost, and Edwin H. F. van Asseldonk

Ankle-foot orthoses are extensively used as a primary management method to assist ambulation of children with cerebral palsy (CP). However, certain barriers hinder their prescription as well as their use as a mobility device in all kinds of daily-life activities.

Improving the walking ability of patients with CP is a primary goal to allow for a more active and independent lifestyle. Due to the role of the ankle joint in gait and the greater muscle dysfunction of distal lower-extremity muscles in CP, ankle-foot orthoses (AFOs) are the foremost used type of assistive devices. Technological advances over the last decades have resulted in the development of AFO designs for CP, which are typically prescribed depending on the pathological gait pattern and the functional capacities (level of the Gross Motor Function Classification System, GMFCS) of the child. However, certain barriers hinder their prescription as well as their use as a mobility device in daily-life activities. This exploratory research attempts to further understand the existing limitations of current AFOs to promote a better personalization of new design solutions.

Methods

Stakeholders' (healthcare professionals in CP and end-users with CP) perspectives on AFO technology were collected by 2 online surveys. Respondents evaluated the limitations of current assistive solutions and assessment methods, provided their expectations for a new AFO design, and analyzed the importance of different design features and metrics to enrich the gait performance of these patients in daily life.



Percentage of respondents who ranked the design features as 4–important or 5–very important. Significant differences between GP and GU reported by the Mann–Whitney U tests are marked with (*). The darker bars represent those features that were selected as the top priority by the respondents within each category **(a–c)**

This article has been excerpted from "Perspectives on Ankle-Foot Technology for Improving Gait Performance of Children with Cerebral Palsy in Daily-Life: Requirements, Needs and Wishes," J NeuroEngineering Rehabil 20, 44 (2023). https://doi.org/10.1186/s12984-023-01162-3. Editing has occurred, including the renumbering or removal of tables, and references have been removed for brevity.

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Results

The survey respondents comprised 94 professionals who specialize in CP (GP) and 36 end-users with CP (GU). The most highly rated design features by both stakeholder groups were comfort and ease of donning and doffing the AFO. In general, professionals preferred new features to enrich the independence of the patient by improving gait at functional levels. End-users also considered their social acceptance and participation. (See Table 1.) Healthcare professionals reported a lack of confidence concerning decision making about AFO prescription. To some degree, this may be due to the reported inconsistent understanding of the type of assistance required for each pathological gait. Thus, they indicated that more information about patients' day-to-day walking performance would be beneficial to assess patients' capabilities.

Healthcare professionals reported a lack of confidence concerning decision making about AFO prescription.

Discussion

The most valuable feature identified by both groups was the "comfort while wearing" the AFO, ie, avoiding skin pressure, friction, or abrasions. The second most valuable design feature highlighted by both groups was the "ease of putting on and taking off" the device. Stakeholders also proposed a change to have a more breathable and softer AFO material and a better fit to the child's foot. The rated importance for these cost features did not override the comfort and usability of the device.

Regarding "replicability of normal walking patterns," 62.8% of GP vs 88.6% of GU considered this feature to be "important" or "very important." While professionals preferred to provide the child with higher autonomy by making the AFO "adaptable to different walking terrains," end-users preferred having a "more normal walking pattern."

Concerning the classification that professionals made of the type of AFO with respect to the level of the GMFCS: (1) patients classified as GMFCS I normally have the ability to walk, so minimal additional assistance of any type is needed; (2) patients classified within levels GMFCS IV and V can barely walk, so they do not benefit that much from AFOs; and (3) patients classified within GMFCS I+ to III can benefit the most from the extra support provided by dynamic AFOs. In these cases, the prevention of drop foot is more important for less severely affected gait patterns (GMFCS I+ and II), while push-off support becomes more important as gait patterns get more severely affected (GMFCS II+ and III).

This convoluted connection between the level of the GMFCS, the patient's pathological gait and the type of assistance needed makes it hard to prescribe the most suitable AFO for a specific patient.

Implications for future devices

Existing traditional (passive) solutions present an inherent function as mobility devices; however, from the survey responses, the AFOs are not adaptable to a specific patient's needs, nor do they enhance their existing capabilities. Although there have been promising advances, especially with adjustable dynamic AFOs, they still lack the necessary evidence to demonstrate the adaptability to different scenarios and the achievement of lasting improvements and long-term effects in general gait quality.

For new AFO designs, the benefits of robotic technology (eg, tailoring the assistance provided) should be considered. Users' expectations to adopt a new solution are positive. However, the survey respondents indicated it is key to address the current problems of powered devices, including comfort, weight, bulkiness, safety, operability, and user-friendliness. To satisfy the requirements of both healthcare professionals and end-users, there should be a trade-off between the improvement of functional levels, the provision of higher autonomy, and the social acceptance while using the device.

> Incorporating sensors in new AFO designs might provide metrics to better assess a user's gait in daily life

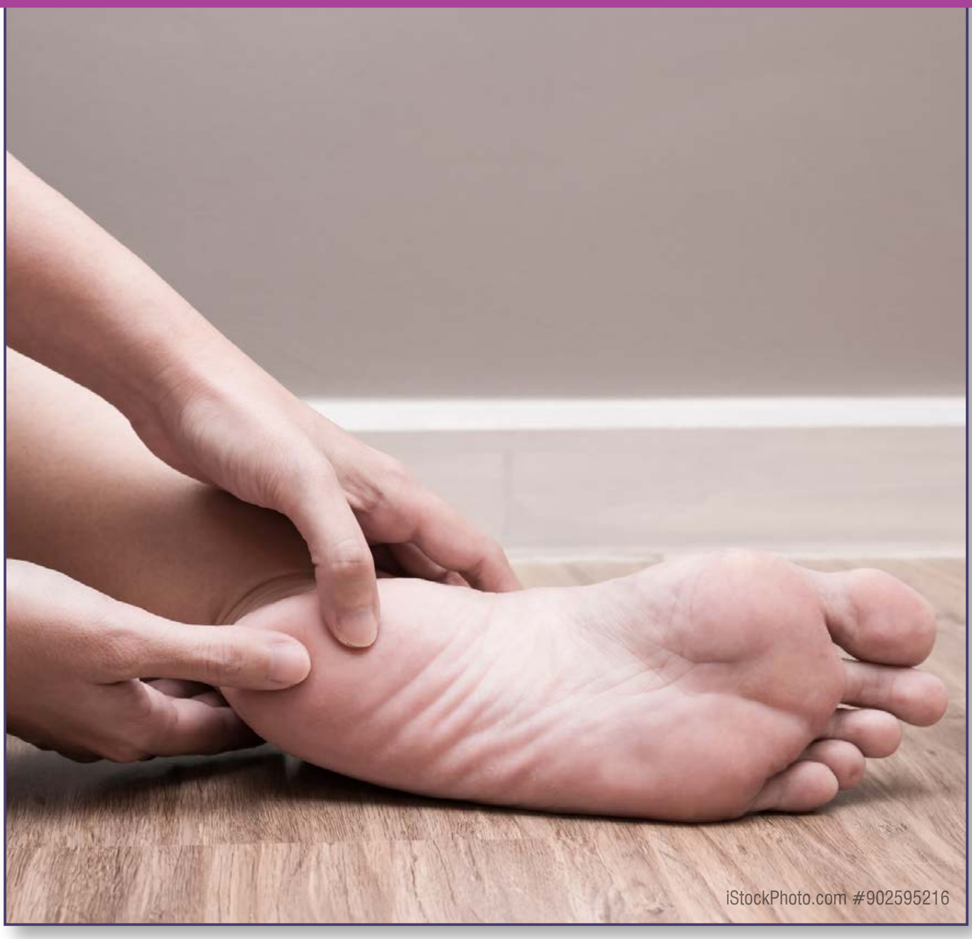
Finally, the incorporation of sensors within the design of new AFOs might be an option to provide metrics and assess the user's gait in daily life to inform clinical decision making.

Conclusion

This exploratory study provides insights into the weighted desires of children with CP, their families, and professionals in the field toward the use and design of AFOs. The stakeholders' needs and criteria reported here may serve as insights for the design of future assistive devices and for the follow-up monitoring of these patients. ler

The Struggle to Stay Physically Active with Persistent Plantar Fasciopathy

By Marianne Mørk, Helene Lundgaard Soberg, Aasne Fenne Hoksrud, Marte Heide, and Karen Synne Groven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Plantar fasciopathy pain forces individuals to make adjustments in physical activity leading to reduced quality of life.

Plantar fasciopathy (PF) is the most common cause of heel pain, and is associated with decreased physical activity level and quality of life. There has been limited research on the experiences of patients with PF. With an emphasis on including psychosocial aspects along with the biomedical approach in treating patients with PF, the present study seeks to bridge a gap in the literature and contribute with in-depth insight into the bodily experiences of individuals with PF. This was done by addressing the following question: "What are the experiences, thoughts, and concerns of patients with persistent plantar fasciopathy, and how do they cope with everyday life?"

Methods

The study cohort comprised 15 participants with longstanding PF (11 females, 4 four males; age 31–65). In order to capture a range of characteristics, the study authors used a purposeful selection method based on gender, age, body mass index (BMI), work status, duration of symptoms, and pain intensity (numeric rating scale (NRS) ranging from 5–10) (See Table 1). Face-to-face, semi-structured interviews were audio recorded, transcribed verbatim, and analyzed using Braun and Clark's reflexive thematic analysis. An inductive approach led by a phenomenological theoretical framework was used.

Results

Three core themes and 9 sub-themes were identified. The first theme was 'Struggling to stay active' with sub-themes 'Struggling with pain and how to adjust it,' 'Finding alternative activities,' and 'Longing for the experience of walking.' The second main theme was 'Emotional challenges' with the sub-themes 'Feelings of frustration and self-blame' and 'Worries of weight gain and related consequences.' The third main theme was 'Relations to others' with the sub-themes 'Participation in family and social life,' 'Visible in new ways,' 'Striving to avoid sick leave,' and 'Bothering others.'

Discussion

The study authors aimed to explore the experiences of individuals with longstanding PF. To address their research question, they discussed their findings with reference to the body from a phenomenological theoretical perspective, supplemented with previous research.

A major finding in the study was that participants regarded pain during and after walking as the most problematic aspect of living with PF. They experienced fear of pain and uncertainty as they struggled to find a balance

This article has been excerpted from "The Struggle to Stay Physically Active—A Qualitative Study Exploring Experiences of Individuals with Persistent Plantar Fasciopathy," J Foot Ankle Res 16, 20 (2023). https://doi.org/10.1186/s13047-023-00620-4. Editing has occurred, including the renumbering or removal of tables, and references have been removed for brevity.

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Table1. Participant characteristics with fictitious names

Names	Age	Work status	Physical activity level	BMI	Duration symptoms	NRS
Anne	57	100% work	walking/ biking ≥ 4 h/w	27.4	12–24 months	6
Beate	33	unemployed	walking/ biking ≥ 4 h/w	26.8	> 24 months	5
Kristin	48	100% work	walking/ biking ≥ 4 h/w	30.7	6–12- months	7
Elisabeth	46	100% work	recreational sport ≥ 4 h/w	24.3	3–6 months	5
Fredrik	51	100% work	walking/ biking ≥ 4 h/w	31.9	3–6 months	7
Hanna	54	70% sick leave	walking/ biking ≥ 4 h/w	27.5	3–6 months	5
Julia	65	50% disabled	walking/ biking ≥ 4 h/w	26.2	6–12 months	10
Kine	43	50% sick leave	walking/ biking ≥ 4 h/w	25.2	12–24 months	9
Mary	47	100% disabled	walking/ biking ≥ 4 h/w	33,4	12–24 months	10
Naomi	41	100% work	walking/ biking ≥ 4 h/w	27	3–6 months	9
Oda	31	100% work	walking/ biking ≥ 4 h/w	27.4	> 24 months	7
Pernille	38	20% sick leave	walking/ biking ≥ 4 h/w	33.5	12–24 months	7
Robert	54	100% work	exercise/competition	27	6–12 months	8
Thomas	58	100% work	walking/ biking ≥ 4 h/w	26.8	3–6 months	7
Victor	49	100% work	walking/ biking ≥ 4 h/w	33.1	12–24 months	8

between challenging their pain and trying not to aggravate it, and expressed how their foot pain became the focus of their attention. They could not take their body for granted anymore, and experienced their body as an obstacle in everyday life. These doubts led them to continuously monitor their pain and dominated their decisions regarding avoiding painful physical activities, limiting their freedom to move.

This study highlights the participants' challenges with having to adjust their physical activity. While some expressed negative emotions associated with becoming significantly less active, others elaborated on the importance of finding alternatives to weight bearing activities when coping with PF. Participants felt that swimming, biking, rowing, and strengthening exercises were all feasible activities that contributed to positive experiences.

Participants in this study emphasized the importance of walking prior to being diagnosed with PF. Many participants experienced better mood, more energy, and the feeling of happiness when walking. Prevented from walking as they had before, participants described a longing for the experiences of eu-appearance when walking, a bodily awareness in which mind and body work harmoniously together.

Participants in this study described how their heel pain led to a limping gait, the need for crutches, or being unable to maintain the same pace as others, which made them feel embarrassed and uncomfortable. The body became thematized as a problem disrupting communication with others.

The participants in this study experienced their heel pain at present as severe and overriding, giving rise to feelings of powerlessness regarding how to influence or speed up the healing process. These results show that the participants experienced frustration and psychological distress due to their present pain and being unable to stay as physically active as they used to, as well as sadness for what they missed out on, but at the same time, many had hope for the future, albeit with some uncertainty.

According to the study findings, participants experienced that heel pain limited their participation in social activities. Being unable to join friends and family in physical activities like they used to triggered feelings of loneliness and distanced them from those closest to them. They experienced guilt for not being able to contribute to family life as they had before and increasing the burden on others.

According to the study findings, concerns regarding being overweight, in the sense that their BMI was classified as overweight or obese (BMI range from 24–33), predominated. Participants commonly feared developing lifestyle diseases and also mental illnesses like depression due to weight gain. Those who had previously emphasized intensive physical activity as a means of preventing overweight, anxiety, or depression, worried about their future in terms of how stress and fear would develop. Participants in this study often felt overwhelmed, passive, and out of control when handling their pain, but at other times, some felt in control when finding alternative ways to stay active and avoid weight gain.

The study participants described the value of working on a daily basis and interacting socially with colleagues, both of which helped them to focus on something other than pain. They worried about how they would cope on sick leave, and feared experiencing isolation, depression, and an increased focus on their pain. Some of the participants struggled for a long time at work, trying to ignore their foot pain. When the pain began affecting their sleep, it became impossible to perform their duties at work and they had to go on sick leave. Being on sick leave seemed to entail less heel pain for those with standing or walking jobs; however, participants found it hard to come to terms with both in regard to their own self-respect as well as the fear of losing the respect of others.

Along with the desire to remain in work, participants explained how avoiding involving family, friends, colleagues, and employers was

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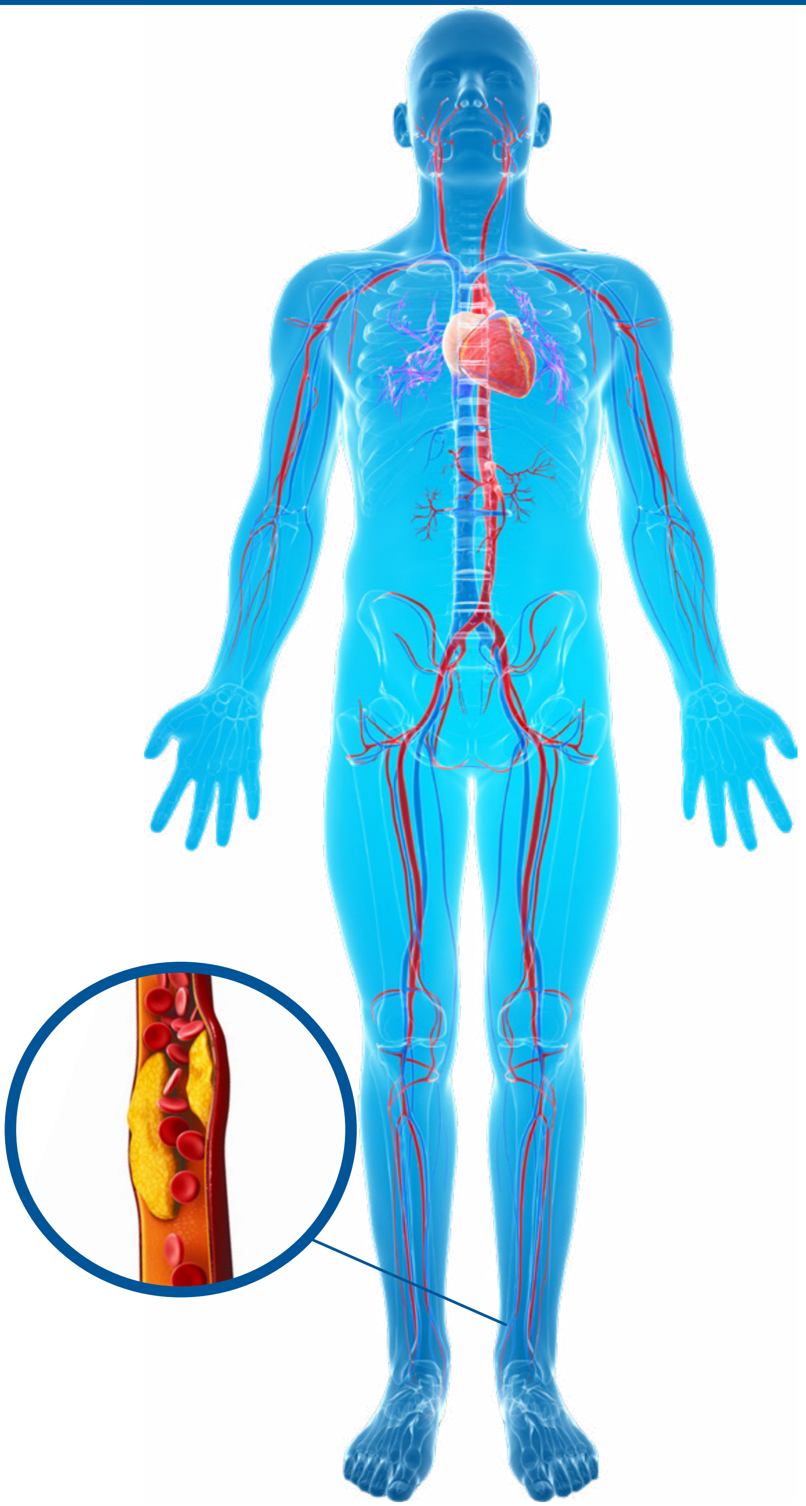

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Continued from page 42

the best way to handle the pain. They did not wish to be seen as whiners, and many were uncomfortable asking others for help.

Some of the participants in this study experienced fear of being disbelieved by others, in particular by their colleagues and employers. Not being met with empathy made the participants hesitant to involve others in handling their pain. By not involving others, they avoided focusing on their painful heel, and the fear of being objectified or not being met with empathy. On the other hand, by not reaching out for support, they missed out on empathy, compassion, and support from others.

Although the majority of the participants in this study managed to stay in work and believed it helped them to cope, they might also experience increased pain and higher level of psychosocial distress, which could influence their recovery from heel pain.

> According to the study findings, participants experienced that heel pain limited their participation in social activities.

Conclusions

The study results demonstrate how heel pain permeated the participants' lives in a complex and intertwined way. The suffering from persistent PF does not seem to be limited to the foot alone. Participants in this study explained how they struggled on an individual level, but also how their pain affected their relationship with others and their surroundings. Aggravated pain while walking and the efforts to stay physically active predominated the participants' lives. Furthermore, feelings of frustration, hopelessness, self-blame, diminished social interaction with others, and worries of weight gain and its related consequences became daily experiences for participants with persistent PF. They emphasized the importance of finding alternative ways to stay active and avoiding sick leave.

The clinical implications of these findings point to supplementing a bio-psycho-social perspective with a bodily phenomenological approach acknowledging the lived experiences of pain in order to provide holistic and individually tailored care for individuals with persistent PF. Clinicians should help individuals with PF to find ways to stay in work and remain physically activity, either with load management regarding weight-bearing activities or by finding alternative activities. Furthermore, these results suggest that it is important to show empathy and interest regarding the patients' concerns about living with longstanding heel pain. Caregivers should seek to understand each unique subjective experience of people living with PF in order to help individuals trapped with stubborn heel pain.


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Determining Test Battery to Evaluate Patients with CAI

By Sofia Ryman Augustsson and Erik Sjöstedt

Chronic ankle instability—a recurring "giving way" of the lateral (outer) side of the ankle causing instability—results from repeated ankle sprains. These authors aimed to find a test battery that could be used easily and could discern true injury in this special population.

In sports, the ankle has been shown to be one of the most common injured body sites after the knee. Lateral ankle sprain is one of the most common traumatic musculoskeletal injuries and up to 40% develop CAI after this injury. Typically, severe sprains are followed by additional sprains and a feeling of instability, which can then affect range of motion (ROM), muscle strength, and functional performance. ROM is often reduced, perhaps mainly in the acute phase, but it can also be a long-term problem. Both initial and a long-termed reduced muscle strength have been noted, and balance and postural control may be impaired as a result of ankle sprains. Overall, this often affects gait, running, and the ability to land when jumping, and if not managed appropriately, a cascade of negative alterations to both the joint structure and a person's movement patterns continue to stress the injured ligaments.

Common tests to identify possible impaired functions are balance test, strength test, and various forms of jump test. However, studies investigating ankle condition in subjects with CAI using an on-the-field test battery are scarce. Understanding which tests that are most challenging for these subjects has the potential to set realistic goals in rehabilitation and return-to-sports criteria. Thus, the primary aim of this study was to investigate CAI subjects regarding strength, balance, and functional performance with an easily used test battery that required minimal equipment. A second aim was to evaluate which of these tests has the highest ability to discriminate impaired function between the injured and non-injured ankle in CAI subjects.

Methods

This study was conducted with a cross-sectional design. Twenty CAI subjects, engaged in sports, and 15 healthy subjects serving as a control group, were tested for assessment of strength, balance, and functional performance. A test battery was developed accordingly: isometric strength in inversion and eversion, the single leg stance test (SLS), single leg hop for distance (SLHD), and side hop test. The limb symmetry index was calculated to determine whether a side-to-side lower limb difference could be classified as normal or abnormal. The sensitivity of the test battery was also calculated.

Inclusion criteria for the study were men and women with recurrent unilateral ankle problems due to previous sprains, aged 15–40 years, sought treatment on at least 1 occasion for ankle injury and have had a minimum of 3 recurrent sprains in the past year.

Results

Of the 20 CAI subjects, 10 had right ankle and 10 had left ankle instability. The test battery total score was significantly better for the non-injured compared to the injured ankle ($P < 0.01$). The subjects were 20% (18 N) weaker on the injured side compared with the non-injured side in eversion ($P < 0.01$) and 16% (14 N) weaker in inversion ($P < 0.01$). For the SLS test, the mean score of the injured side was 8 points (67%) higher (more foot lifts) compared to the non-in-

This article has been excerpted from "A Test Battery for Evaluation of Muscle Strength, Balance and Functional Performance in Subjects with Chronic Ankle Instability: A Cross-Sectional Study," BMC Sports Science, Medicine and Rehabilitation. 2023;15(1):55. (2023). Doi: 10.1186/s13102-023-00669-5. Editing has occurred, including the renumbering or removal of tables, and references have been removed for brevity.

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jured side ($P < 0.01$). The mean distance of the SLHD was 10cm (9%) shorter for the injured side compare to the non-injured side ($P = 0.03$). The mean number of side hop was 11 repetitions (29%) fewer for the injured side compare to the non-injured side ($P < 0.01$). (See Table 1.)

Differences were found between men and women, in favor for the male subjects, in the strength tests and the SLHD ($P \geq 0.04$). Men also performed better at the side hop test on the non-injured side ($P < 0.0$) but not on the injured side ($P = 0.22$). No differences were found between men and women in the SLS test for either side ($P \geq 0.26$). Differences were found between injured and healthy subject in SLS ($P = 0.01$), SLHD ($P < 0.01$), and the side hop test ($P < 0.01$) whereas no differences were found for the strength tests ($P \geq 0.25$). (See Table 2)

Table 1. Test results for balance, strength and functional performance for injured and non-injured ankle in CAI subjects. Data are presented with mean (± standard deviation) (N = 20).

	Injured side	Non-injured side
	Mean (SD)	Mean (SD)
Eversion strength (N)	73 (±20)	91 (±30) *
Inversion strength (N)	72 (±33)	86 (±32) *
SLS	20 (±12)	12 (±8) *
SLHD (cm)	96 (±30)	106 (±22) *
Side hop (repetitions)	27 (±12)	38 (±12) *

SLS=Single leg stance

SLHD=Single leg hop for distance

*=significant difference between injured and non-injured side.

Discussion

The main observation in this study was that impairments in strength, balance, and functional performance seem to be quite common in CAI subjects. The total score for the test battery was significantly better for the non-injured compared to the injured ankle ($P = 0.01$). The sensitivity was high for the SLS (100) and the side hop test (85), and thus provides a high ability to discriminate impaired performance between injured and non-injured ankle in CAI subjects. When the 5 tests were combined to produce 1 test battery, a sensitivity of 100% was found.

The CAI subjects in the present study had reduced strength with a 20% difference in eversion and 16% in inversion between injured and non-injured ankle, but strength values did not differ compared to healthy subjects. One plausible explanation for the non-existent difference between CAI and healthy subjects might be the difference in disparity between men and women in the 2 groups. In the group of CAI subjects, 11 (55%) were women whereas there were only 5 women (33%) in the group of healthy subjects. The male subjects were found to be stronger in the strength tests, and these dissimilarities most likely exist in healthy subjects as well.

The sensitivity of the eversion strength test was 65%, with 13 CAI subjects classified as abnormal, whereas the sensitivity of the inversion strength test was 60%. The reduced strength in inversion noted in this study is in accordance with the outcome from an earlier study. Thus, reduced strength seems to be present in CAI subjects, suggesting that continued strength training after rehabilitation is probably important to reduce the risk of re-injury. In addition, the result from this study suggests that isometric testing can detect strength deficits in CAI subjects and should be recommended for clinical use.

In this study, CAI subjects performed significantly worse at the balance test on the injured side. The differences of 67% in the SLS and the test sensitivity of 100% noted in this study between the injured and non-injured ankle suggests that evaluation of balance is of utter importance in this group of subjects and that rehabilitation should aim to improve balance ability.

Impairments in functional performance were also noted for the CAI subjects in the present study. There was a 29% difference, with 11 repetitions fewer in the side hop test on the injured side. Seventeen of the 20 CAI subjects were classified as abnormal giving the test a sensitivity of 85%. The mean distance of the SLHD was 10cm (9%) shorter for the injured side compared to the non-injured side ($P = 0.050$). However, the sensitivity of the SLHD in this study was only 45% and only 9 of the 20 CAI subjects were classified as abnormal. Thus, the deficits in SLHD performance could be considered as minor compared to the side hop performance and strength impairments. This study confirms that a SLHD does not appear to be as challenging as other functional tests such as the side hop test.

Not surprisingly, there was a relatively strong correlation between the 2 strength tests (r_s=0.73) and a moderate correlation between the 2 hop tests (SLHD and side hop) (r_s=0.49). Moderate correlations were also noted between the strength tests and the side hop test (eversion, r_s=0.59, $R^2 = 0.35$ and inversion r_s=0.56, $R^2 = 0.31$) and the SLHD (eversion, r_s=0.51, $R^2 = 0.26$, inversion, r_s=0.45, $R^2 = 0.20$) suggesting that maximum muscle strength has an impact on functional performance in this group of subjects.

Correlations could not be found between the balance test and any of the other parameters in this study ($P \geq 0.48$). However, the absence of a correlation between ankle strength and balance has previous been demonstrated in healthy individuals. Assessment of muscle strength was carried out isometrically, which may not provide necessary information regarding the nature of a balance test. One previous study revealed that strength training increased strength in subjects with functional ankle instability but did not

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improve proprioception. Thus, other factors than muscle strength may be of more importance for balance performance in CAI subjects. However, this does not explain the absence of correlations between the balance test and the tests of functional performance.

Conclusion

Deficits in muscle strength, balance, and functional performance appear to be present in CAI subjects with the largest impairments in balance, side hop performance, and eversion strength, which stresses the need for better return-to-sport criteria for this group of subjects. The findings also indicate that the SLHD test does not seem to be sufficiently challenging when it comes to evaluating functional performance in CAI subjects, whereas the more challenging method of the side hop test used in this study could be recommended. The SLS, inversion and eversion strength tests, and the side hop test had high ability to discriminate performance between the injured and the non-injured ankle in CAI subjects.

Table 2. Test results for balance, strength and functional performance in CAI subjects presented by sex. Data are presented with mean (± standard deviation) (N = 20).

	Men	Women	Men	Women
	Injured side	Injured side	Non-injured side	Non-injured side
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Eversion strength (N)	84 (±20)	64 (±20) *	110 (±26)	75 (±23) *
Inversion strength (N)	93 (±34)	55 (±18) *	108 (±32)	68 (±32) *
SLS	24 (±18)	18 (±7)	11 (±4)	14 (±10)
SLHD (cm)	112 (±32)	84 (±24) *	116 (±27)	97 (±13) *
Side hop (repetitions)	31 (±15)	24 (±7)	46 (±11)	32 (±8) *

SLS = Single leg stance

SLHD = Single leg hop for distance

*= significant difference between men and women.

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Getting the Most Out of Gait Evaluations

By Richard Blake, DPM, MS

This chapter concerns the study of gait from an office setting, the understanding of what is considered normal, and the symptoms related to gait variations.

In my training, gait evaluation was a crucial part in assessing how the [orthotic device] worked in controlling excessive motion, correcting for a short leg, improving someone's posture, but also in spotting all sorts of problems. These gait problems could be very obvious, like limping from pain, or more subtle, like a twist in the foot at propulsion from abnormal pronation (abductory twist).

I have had my share of patients over the years who stated my findings on gait evaluation led to the proper diagnosis of a neurological disease, or an arthritic hip, and many other problems, and then the proper treatment. Even though a thorough understanding of structural deviations is vital to our training as taught with Root Biomechanics, gait evaluation really became my key to unraveling why someone hurts and sometimes where they hurt. In gait evaluation, you should look for signs of excessive pronation or supination or both (called medial-lateral instability), signs of short leg syndrome, signs of poor shock absorption, signs of limping and tight muscles, signs of weak muscles or instabilities, and signs of obvious structural problems, like bow legs, knock knees, tibial varum, genu valgum, high arches, etc. You never waste anyone's time doing gait evaluations, and no other profession seems to be doing it.

I have also had a patient tell me after 4 years of unsuccessful treatments elsewhere, that my gait evaluation was the only thing that unlocked the answer to their particular problem. I believe in gait evaluation and try to make sense of my biomechanical measurements and what I see in gait. If one third of patients with pes cavus pronate, one third stay near neutral, and the last one third supinate, I want to know why. The general rule is that all patients with pes cavus supinate. If you only take static measurements, and forget gait evaluation, you may miss the entire reason for the patient's problem.

So, where do we begin? When you watch someone walk, even from a podiatrist's standpoint, you want to start at the top. You need the patient in shorts, with their shirt tucked in, not looking down at their feet, and walking at a normal pace. I love to place a dot on the center of the knee cap and bisect both heels for easier observation. Hopefully, you can find a well lit hallway (all of these are ideals and most podiatrists will have to settle for less). You want them to walk 5 to 10 times up and down the longest hallway you can access so that they can get into a normal stride.

Typically, if they have orthotic devices, I watch them walk with shoes and their orthotic devices first, then shoes tied up tightly without their orthotic devices. I want to see the difference in gait with and without their present orthotic devices. Then I will watch them walk barefoot to check any differences from shoe walking. Some people are more stable with shoes than barefoot, and some the opposite. Sometimes the most stable environment is barefoot, with shoes second, and shoes with orthotic devices third (which should be the opposite of what you would have expected). You have to look and make observations. You are a scientist making observations.

You have to not use general rules, but

Continued on page 55


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Continued from page 53

here is where you begin to individualize for the patient in front of you. Gait evaluation can help slow the pace of your practice and allow great observations to help your patients. Some orthotic devices take a slight adjustment to make them more stable, and some need to be completely redone as an example. Some patients only need to learn power lacing, also called runner's knot or stability lacing, to achieve more stability. Sometimes patients just come in with very poor shoes, and the proper evaluation of the function of orthotic devices will not occur until they purchase a better shoe.

I also like to have patients bring in 2-4 pairs of shoes at times, especially some with a lot of wear, so I can see how they break down their shoes. It can take several visits to get a good gait analysis done. They may not have appropriate shoes, like runners rushing from work and not having their actual running shoes. They may be in enough pain that gait evaluation has to be postponed. I also do not like to look at their orthotic devices (especially if I did not make them originally and recently) until I watch them walk or run with them. The best-looking inserts can function terribly, and the worst looking orthoses can function the best. If I make any adjustment for comfort, fit, or stability of an orthotic device, I want to watch the patient walk and/or run to decide if I achieved that goal. Always lean toward making someone more stable with inserts, unless there is nerve pain (from arch pressure) that you have to compromise by lowering the arch.

> You never waste anyone's time doing gait evaluations, and no other profession seems to be doing it.

Biomechanics Question #80: What factors are not part of typical gait evaluation?

1. Comparison of orthotic devices to no orthotic devices
2. Looking at what environment the patient is the most stable
3. Starting at the feet for clues of stability
4. One walk down a long hallway should be enough
5. Never watch a patient barefoot, since they are never barefoot in real life for more than a few seconds.

Richard Blake, DPM, MS, is adjunct faculty at the California School of Podiatric Medicine. He has practiced podiatry at the Sports and Orthopedic Institute of St. Francis Memorial Hospital in San Francisco, CA. His book, Practical Biomechanics for the Podiatrist, Book 1, is available from Amazon.com and Barnesandnoble.com, as well as from the publisher at bookbaby.com.

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INSOLES FOR REMOTE PATIENT MONITORING

The INVIZA® Sole 1.0 is a self-charging, medical-grade wearable device that is designed as a thin insole that can be worn within most kinds of shoes. The insoles' sensors can accurately measure the patient's heart rate, body temperature, percent of blood oxygen saturation, and other critical parameters in real time and uninterrupted by running out of battery power. They can also provide data on daily physical activity, including accurate step count and type (eg, sitting, walking, running, and more). This data is then sent to the Health Insurance Portability and Accountability Act (HIPAA)–compliant INVIZA Cloud and INVIZA Portal 1.0 cloud dashboard for monitoring by licensed medical professionals, and to the INVIZA Care 1.0, a complementary smartphone app that allows users to view their biometrics in real time and graphically. Using advanced energy-harvesting technology, the insoles scavenge mechanical energy from steps, allowing them to recharge during use.

INVIZIA Health

invizahealth.com

WEARABLE SENSOR MONITORS MUSCLE ATROPHY

Researchers at The Ohio State University (Ohio State) have fabricated the first wearable sensor designed to detect and monitor muscle atrophy.

Allyanna Rice, a graduate fellow in electrical and computer engineering and Asimina Kiourti, PhD, a professor in electrical and computer engineering, designed the device to work by employing 2 coils, 1 that transmits and 1 that receives, as well as a conductor made out of "e-threads" that run along the fabric in a distinct zig-zag pattern. The final product uses a stretchy material and resembles a blood pressure cuff.

Their findings showed that they were able to demonstrate the sensor could measure small-scale volume changes in overall limb size, and monitor muscle loss of up to 51%.

The zig-zag stitching amplifies the sleeve's elasticity. Photo courtesy of Getty Images.

"Ideally, our proposed sensor could be used by healthcare providers to more personally implement treatment plans for patients and to create less of a burden on the patient themselves," said Rice. "Our sensor is something that an astronaut on a long mission or a patient at home could use to keep track of their health without the help of a medical professional."

Though the wearable is still years away from implementation, the next major leap would most likely be to connect the device to a mobile app that could be used to record and deliver health information directly to health care providers. Rice is also looking forward to combining the sensor with other kinds of devices for detecting and monitoring health issues, such as a tool for detecting bone loss. This work was supported by the National Aeronautics and Space Administration.

SMART SOCKS PREVENT FALLS, IMPROVE MOBILITY

The "Patient is Up" (PUP®) smart sock incorporates tiny proprietary conductive threads that are sewn into the sock fabric. The sock is designed for acute care hospitals, as well as facilities for rehabilitation, long-term care, and physical therapy. When a patient fitted with the socks stands up or attempts to walk unassisted, the system issues an immediate alarm to the nearest nurses and the nursing station via an intelligent notification system—allowing the nurse to respond quickly to prevent patient falls. This enables the simultaneous monitoring of all patient rooms, eliminating the need to hold or predesignate fall-risk rooms. Additionally, PUP technology can be used as a progressive mobility improvement program by delivering valuable patient gait and distribution data. Graphs, pressure percentages, and tables enable the rapid identification of asymmetries, abnormalities, or treatment effectiveness.

Palarum

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KNEE WEARABLE FOR WIRELESS SENSING OF JOINT MOTION

Singapore University of Technology and Design (SUTD) researchers have developed a fully knitted, circuit-embedded knee wearable for wireless sensing of joint motion in real time. Compared to other knitted electronics, this model has fewer externally integrated components and a more sensitive sensor. The innovation is a collaboration between Associate Professor Low Hong Yee, PhD, and her colleagues from SUTD, along with Tan Ngiap Chuan, MBBS, MMed (Family Med), FCFP(S), MCI (NUS), FAMS, of SingHealth Polyclinics.

Their key considerations when designing the wearable were sensor data accuracy and reliability and for the sensor to rely on as few external components as possible. The result was a highly stretchable, fully functional sensing circuit made from a single fabric. Because the knee joint is important for lower limb mobility, the wearable was designed for the knee.

Image courtesy of SUTD.

To develop this single-fabric circuit, the team mechanically coupled an electrically conductive yarn with a dielectric yarn of high elasticity in various stitch patterns. Dimensions were customized according to the subject's leg. The functional components—sensors, interconnects, and resistors—formed a stretchable circuit on the fully knitted wearable that allowed real-time data to be obtained.

The team assessed the wearable through extension-flexion, walking, jogging, and staircase activities. Subjects wore the knee wearable together with reflective markers that were detected by a motion capture system, which allowed the comparison between sensor data and actual joint movement. The sensor response time was less than 90 milliseconds for a step input. Additionally, the smallest change in joint angle that the sensors could detect was 0.12 degrees. The sensor data showed strong correlation with joint movement data acquired from the motion capture system, demonstrating reliability of the sensor data.

DIGITAL LIGAMENT TENSIONER

Smith+Nephew has introduced its new CORI™ Digital Tensioner—a purpose-built device that lets surgeons measure the ligament tension in a knee prior to cutting bone. By enabling a surgeon to quantify joint laxity in the native knee and achieve an optimal ligament tensioning force, the CORI Digital Tensioner helps to reduce variability when balancing the knee in surgery. This helps make surgical planning more objective versus other commercially available alternatives. The device produces a surgeon-defined, quantifiable force to distract the knee joint, apply consistent tension to the ligaments, and provide objective gap data for procedure planning and execution. A small clinical case series showed the CORI Digital Tensioner reduced variability of tensioning by 64% when compared to a manual technique.

Smith+Nephew
smith-nephew.com

ANKLE EXOSUIT MAY PROVIDE MORE INDEPENDENCE FOR POST-STROKE WEARERS

A new portable, flexible, and user-friendly ankle exosuit has been designed for autonomous usage and has the capacity to assist stroke survivors in enhancing their walking capabilities beyond laboratory settings and in their everyday routines. The ankle exosuit has been shown to aid stroke survivors in improving their walking propulsion, increasing overall confidence while ambulating, and enhancing their ability to navigate within their residences, workplaces, and neighborhoods. The research was spearheaded by Conor Walsh, PhD, and his team at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS).

The exosuit incorporates an actuator to assist in plantarflexion, propelling the foot and body away from the ground. A passive actuator, which behaves similarly to a spring, assists in dorsiflexion, keeping the wearer's toes elevated during swing phase of the foot, thereby preventing them from catching their toes on the ground. A mobile application facilitates seamless interaction between the wearer and the exosuit while also enabling remote communication with the research team. The mobile app empowers wearers to independently activate the device and inform the exosuit when they are ready to begin walking.

Strategically positioned sensors on the foot, shank, and pelvis capture relevant data that is then processed using a machine-learning algorithm, offering insights into the wearer's ability to generate appropriate ankle mechanics and walk efficiently. Image courtesy of Biodesign Lab / Harvard SEAS.

Furthermore, the team integrated sensors into the exosuit to enable remote monitoring of the wearer's progress throughout their rehabilitation journey. By collecting data while individuals walk with the exosuit, the team can track and analyze improvements in their gait over time. This information can contribute to a more comprehensive understanding of the wearer's progress and facilitate a tailored and effective rehabilitation program.

TECH-AUGMENTED FOOTWEAR SERVICE

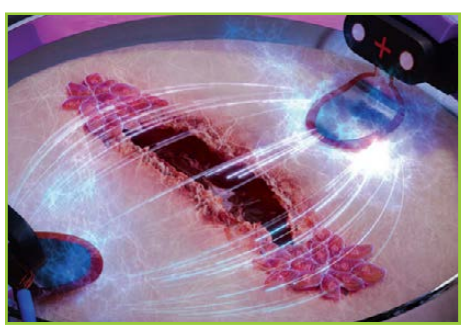
Footwear brand Baliston® has launched BALISTON BY STARCK, its debut collection of tech-augmented, 100% recyclable, extremely comfortable footwear created in collaboration with world-renowned creator Philippe Starck. The shoes are designed with an embedded proprietary sensor module that measures biomechanical data on the quality of the wearer's posture and gait (symmetry, pronation, supination, propulsion, heel impact force) and on the intensity of the physical activity (speed, number of steps). In the Baliston Connect™ app, this information is transformed into a suite of personalized analysis and recommendations, helping the wearer understand their body, how it moves, and the implications. The company also uses this advanced gait-analysis technology to provide a fitted insole designed to support how the wearer walks, enabling them to experience ultimate personalized support. The shoes are available on a subscription basis, and this inaugural collection will be limited to 5,000 members.

Baliston
720/994-3701
baliston.com

ELECTRICITY SHOWN TO HEAL WOUNDS 3X AS FAST

Using electric stimulation, researchers in a project at Chalmers University of Technology, Sweden, and the University of Freiburg, Germany, have developed a method that speeds up the healing process, making wounds heal 3 times faster. The work has implications for elderly people and those with diabetes.

The researchers worked from an old hypothesis that electric stimulation of damaged skin can be used to heal wounds. The idea is that skin cells are electrotactic, which means that they directionally 'migrate' in electric fields. This means that if an electric field is placed in a petri dish with skin cells, the cells stop moving randomly and start moving in the same direction. The researchers investigated how this principle can be used to electrically guide the cells to make wounds heal faster. Using a tiny engineered chip, the researchers were able to compare wound healing in artificial skin, stimulating 1 wound with electricity and letting 1 heal without electricity. The differences were striking, "which clearly led to it healing 3 times as fast as the wound that healed without electric stimulation," said Maria Asplund, PhD, associate professor of bioelectronics at Chalmers and head of this research project.



New research shows that wounds on cultured skin cells heal 3 times faster when stimulated with electric current. Image courtesy of Science Brush | Hassan A. Tahini.

The researchers also focused on wound healing in connection with diabetes. "We saw that when we mimic diabetes in the cells, the wounds on the chip heal very slowly. However, with electric stimulation we can increase the speed of healing so that the diabetes-affected cells almost correspond to healthy skin cells," said Asplund.

LOWER LIMB COMPRESSION SLEEVES

CEP Compression has announced its new line of orthopedic products including the Knee Sleeve, Ankle Sleeve, Achilles Sleeve, and Plantar Sleeve. These new products will benefit joints, muscles, and tendons with added support and security. They are available in LIGHT, MID, and MAX support levels, with different compression strengths. CEP ortho products encourage healing by promoting circulation and increasing blood flow while reducing swelling and discomfort. The MAX Support products provide the level of support and stability needed for recovery from serious injuries and offer relief from severe, acute pain. The MID Support products support weakened joints from past/moderate injuries and relieve moderate pain and inflammation. The LIGHT Support products are a perfect option for all-day wear and apply enough pressure to reduce inflammation without any bulk or restriction of movement.

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KT Tape PRO Oxygen™ is said to be the first kinesiology tape to feature CELLIANT® Infrared Technology from Hologenix. KT Tape PRO Oxygen is designed to increase cellular oxygenation and promote muscle support during physical activity. The CELLIANT fine mineral powder is a natural blend of infra-red-generating bioceramic minerals. Printed on the tape's surface, it converts body heat into full-spectrum infrared energy. This delivers improved cellular oxygenation where tape is applied, bringing more oxygen to the cells and increasing local circulation. Thus, KT Tape PRO Oxygen premium kinesiology tape is super-charged to support muscles and joints through physical activity. The tape's elasticity allows for a full range of motion and helps to lift the skin for a temporary increase in local blood flow. PRO Oxygen incorporates high-strength water-resistant adhesive and ultra-breathable PRO synthetic fibers making it durable.

KT Tape
kttape.com

WEARABLE ULTRASOUND PATCH PROVIDES DEEP TISSUE MONITORING

A team of engineers at the University of California San Diego has developed a stretchable ultrasonic array capable of serial, non-invasive, 3D imaging of tissues as deep as 4 centimeters below the surface of human skin, at a spatial resolution of 0.5 millimeters. This new method provides a non-invasive, longer-term alternative to current methods, with improved penetration depth. The device consists of a 16-by-16 array. Each element is composed of a 1-3 composite element and a backing layer made from a silver-epoxy composite designed to absorb excessive vibration, broadening the bandwidth and improving axial resolution.

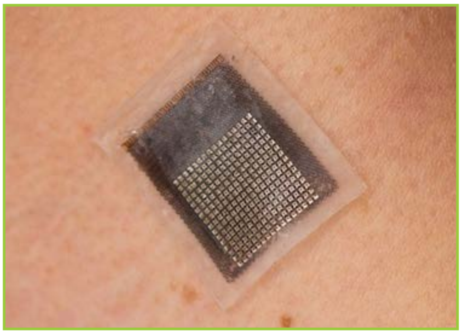

Image courtesy of Jacobs School of Engineering, University of California San Diego.

Wearable ultrasound patches accomplish the detection function of traditional ultrasound and also break through the limitations of traditional ultrasound technology, such as 1-time testing, testing only within hospitals, and the need for staff operation. "This allows patients to continuously monitor their health status anytime, anywhere," said Sheng Xu, a professor of nanoengineering at UC San Diego Jacobs School of Engineering, from whose lab the researched emerged.

The monitoring system has several key applications:

- Monitoring muscles, tendons, and ligaments can help diagnose and treat sports injuries.
- In medical research, serial data on pathological tissues can provide crucial information on the progression of diseases such as cancer, which normally causes cells to stiffen.
- Current treatments for liver and cardiovascular illnesses, along with some chemotherapy agents, may affect tissue stiffness. Continuous elastography could help assess the efficacy and delivery of these medications. This might aid in creating novel treatments.

MODULAR PROSTHETIC SOCKET

Ottobock's innovative Varos modular socket structure is easier and faster fitting than with standard sockets. The socket can be custom made to the patient model or direct with patient with easy length adjustment by modifying socket shell and side rails. It is fabricated with thermoformable material for patient-specific customizations. Benefits for the O&P practitioner include: time savings as fewer patient fittings are needed to achieve a good fitting result; less effort for socket fit adaptations; and easy alignment optimization (spherical adapter included allowing for a hip flexion compensation up to 15 degrees). Benefits for the user include: adjustability of the socket for limb volume variations and different activities with the Boa Fit System, high wearing comfort, secure hold in the socket (magnetic distal liner connection, good static friction properties of the specific Varos liner), light weight construction, and easy donning and doffing.

Ottobock
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Source: Spiering BA, Clark BC, Schoenfeld BJ, Foulis SA, Pasiakos SM. Maximizing strength: the stimuli and mediators of strength gains and their application to training and rehabilitation. J Strength Cond Res. 2023;37(4):919–929.



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