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LOWER EXTREMITY REVIEW

May 25 / volume 17 / number 5

Correcting Biomechanics to Run 1st Half Marathon at Age 60

17 LEREXPO CONVERSATIONS: NON-UNIONS OF THE HIND FOOT

20 CAGA DIRTY TRUTH #3: WHAT WE CAN'T SEE IS KEY

28 CIVILIAN LOWER EXTREMITY INJURIES RESULTING FROM FIRES

34 AI-FACILITATED BALANCE ABILITY CLASSIFICATION

44 PLYOMETRIC TRAINING & KNEE MECHANICS?

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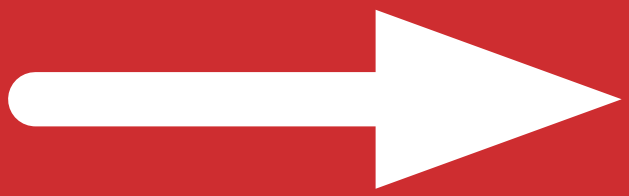

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VOLUME 17 NUMBER 5 LERMAGAZINE.COM

May 2025

contents

SHORTTAKES FROM THE LITERATURE

10
- Males/Females Experience Pain Through Different Mechanisms
- The Influence of Three-Dimensional Muscle Shape on Mechanical Output
- Study Shows Older Sprinters Lose Force Generating Capacity
- A Rare Case of Bilateral Xanthomatosis of the Achilles Tendon
- Does Kinesio Tape Negatively Affect Treatment of Plantar Fasciitis
- HIIT Appears to Temper Metabolic Syndrome in 8-year Study
- Association of Vit D with Sarcopenic Obesity Risk
- Low-Intensity Focused Ultrasound for Pain Relief in DPN?
- Associations Between Female Sex Hormones and Skeletal Muscle Ageing
- Plantar Pressure As Tool For Assessing Risk of Scoliosis

AD INDEX

39 GET CONTACT INFO FOR ALL OF OUR ADVERTISERS

NEW & NOTEWORTHY

40 PRODUCTS, ASSOCIATION NEWS & MARKET UPDATES

COVER STORY

24 HOW BIOMECHANICS HELPED ME RUN MY 1ST HALF MARATHON AT AGE 60

This physical therapist used his knowledge of muscle activation, range of motion, and neuromotor training to prepare himself for his first half marathon at age 60

By Christopher K. Wong, PT, PhD

LEREXPO CONVERSATIONS

17 NON-UNIONS OF THE HIND FOOT

Non-unions of the hind foot represent a significant challenge due to the hind foot's role in weight bearing and mobility and the increased risk of infection.

By Zeeshan Husain, DPM, FACFAS, FASPSP

THE LAST WORD

44 EFFECTS OF PLYOMETRIC TRAINING ON KNEE BIOMECHANICS DURING LANDING

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FEATURE ARTICLES

20 CAGA 101: THE 12 DIRTY TRUTHS PLAYBOOK

DIRTY TRUTH #3: WHAT WE CAN'T SEE IS KEY

Many biomechanical characteristics can be seen by the naked eye but are better visualized and quantified with computers, which can capture the unseen.

By Jay Segel, DPM; Sally Crawford, MS

28 CIVILIAN LOWER EXTREMITY INJURIES RESULTING FROM FIRES IN THE UNITED STATES

Several thousand civilian lower extremity injuries are reported to the National Fire Incident Reporting System every year. This study characterizes the nature of those injuries.

By Mathias B. Forrester, BS

34 MACHINE LEARNING COMBINED WITH EXPLAINABLE ARTIFICIAL INTELLIGENCE FACILITATE ACCURATE BALANCE ABILITY CLASSIFICATION

Using computerized posturographic parameters provides a highly quantitative and objective measure without ceiling or floor effect as a classifier or predictor of falls.

By Huey-Wen Liang, Rasoul Ameri, Shahab Band, Hsin-Shui Chen, Sung-Yu Ho, Bilal Zaidan, Kai-Chieh Chang, and Arthur Chang

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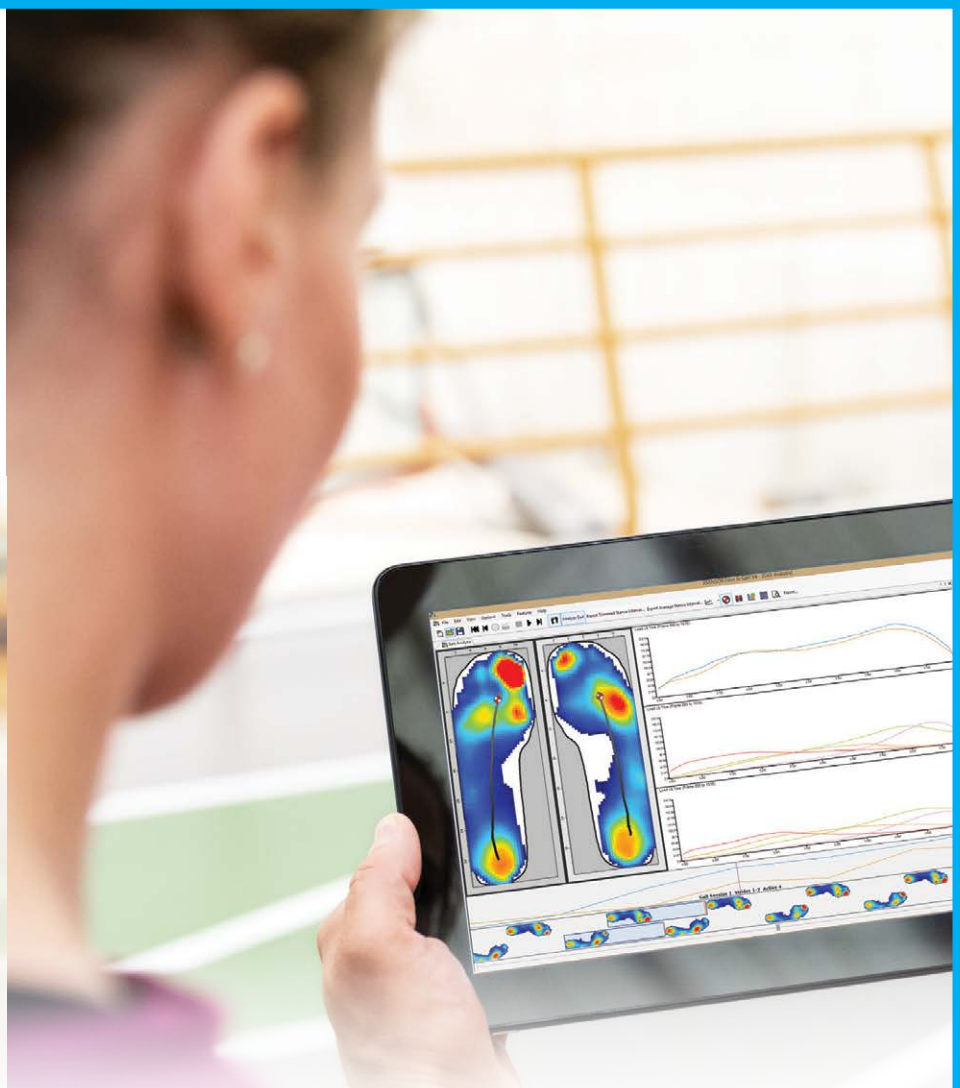

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Lower Extremity Review

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
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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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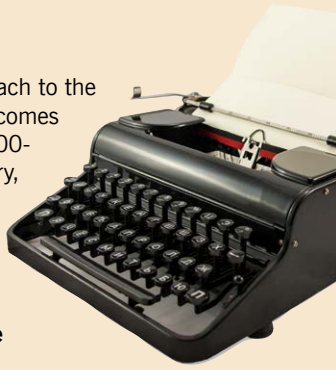

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MALES/FEMALES EXPERIENCE PAIN THROUGH DIFFERENT MECHANISMS

Pain—and how well pain treatments work—differs between the sexes. Females are more likely to experience chronic pain than males. Studies *have also shown that opioid painkillers are less effective in females.*

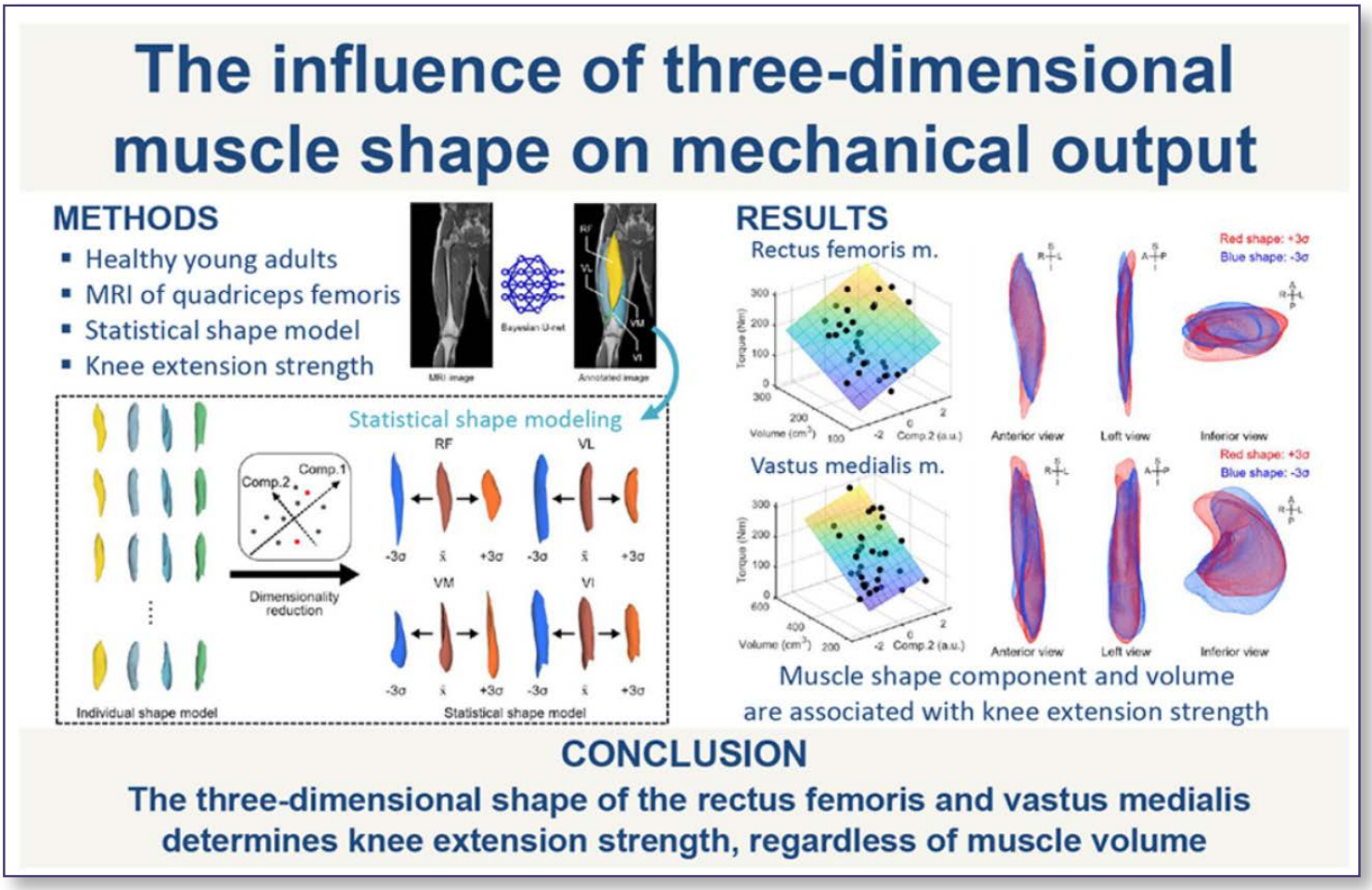
Several systems inside the body contribute to the perception of pain and the response to pain treatments. One of the most important is called the endogenous opioid system. Opioid-based medications work by tapping into this system.

To better understand whether sex-based differences in the endogenous opioid response contribute to differences in pain, researchers led by Fadel Zeidan, PhD, from the University of California, San Diego, analyzed previously collected data from 2 small, NIH-funded clinical trials. Both trials tested whether an endogenous opioid response was required for people to feel pain reduction during meditation. Past studies had shown that meditation techniques can help reduce some types of pain, including back pain, for some people.

One of the trials enrolled people with chronic back pain; the other enrolled people without chronic pain of any kind. A total of 98 people—51 females and 47 males—participated in the studies. In both trials, the researchers randomly assigned participants to learn either mindfulness meditation or another meditation technique that didn't focus on mindfulness. The volunteers then practiced their meditation during exposure to a painful but harmless heat source on their leg over 2 sessions.

After the participants underwent pain exposure, they randomly received either an infusion of the drug naloxone, which blocks the endogenous opioid system, or saline. They then underwent pain exposure again while practicing their meditation techniques.

All participants received both infusions over the 2 sessions without knowing which was which. They reported their levels of pain before and



Source: Umehara J, Taniguchi M, Yagi M, Li G, Soufi M, Otake Y, Sato Y, Fukumoto Y, Yamagata M, Nakai R, Ichihashi N. Skeletal muscle shape influences joint torque exertion through the mechanical advantages. J Appl Physiol (1985). 2025 May 1;138(5):1119-1132. doi: 10.1152/japplphysiol.00997.2024. Epub 2025 Apr 7. PMID: 40192188.

after the infusions. In the new study, Zeidan and his colleagues looked at whether changes in pain during meditation differed betweenthe sexes.

For males and females, both types of meditation significantly lowered levels of pain during saline infusion. However, in males, the pain relief from meditation disappeared when they received naloxone. This shows that the endogenous opioid system mediates the effects of meditation on pain in males.

In contrast, females had no substantial drop in pain relief during meditation when they received naloxone. This suggests that a different mechanism is responsible for controlling pain relief in females.

"There are clear disparities in how pain is managed between men and women, but we haven't seen a clear biological difference in the use of their endogenous systems before now," Zeidan said in a separate interview. "This study provides the first clear evidence that sex-based differences in pain processing are real and need to be taken more seriously when developing and prescribing treatment for pain."

More studies are needed to directly measure sex differences for other pain-reduction strategies. ler

Written by Sharon Reynolds of NIH Research Matters.

Source: *Dean JG, Reyes M, Oliva V, Khatib L, et al. Self-regulated analgesia in males but not females is mediated by endogenous opioids. PNAS Nexus. 2024;3(10):pgae453. doi: 10.1093/pnasnexus/pgae453.*

STUDY SHOWS OLDER SPRINTERS LOSE FORCE GENERATING CAPACITY

Both longitudinal and cross-sectional studies have demonstrated that muscle mass, strength and power are lost with ageing. Although longitudinal studies have shown changes in muscle morphology and function in sedentary, healthy active, and endurance-trained older people, less is known about such age-related changes in sprint athletes. It has been proposed that active older people may provide a better study of healthy ageing not confounded by factors of inactivity and other unhealthy behaviors. Given that the training regimens of masters sprinters consist of strength and sprint training that elicit gains in muscle force, power and mass, sprinters may not suffer from measurable decrements in muscle strength, functional performance or morphology over a 10-year period.

To investigate this, *m. vastus lateralis* (VL) biopsies were taken from 24 masters sprinters aged 48–85 years at baseline and 10 years later. Immunofluorescent staining of slides taken from these biopsies was used to assess fiber type composition, fiber cross-sectional area (FCSA) and capillarization. In addition, VL thickness was assessed using B-mode ultrasonography, maximum voluntary contraction (MVC) of knee extension was measured with an electromechanical dynamometer, and the flight time of a counter movement jump was determined with a contact mat. 60-m sprint times were measured using double-beam photocell gates connected to an electronic timer.

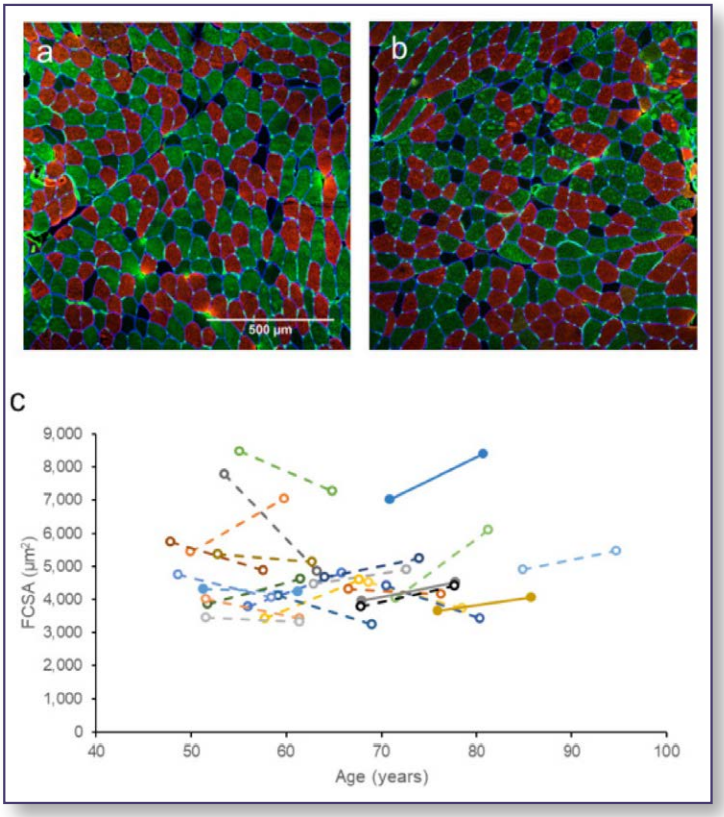


Figure. Histology of muscle biopsies. (a,b) Vastus lateralis muscle biopsy sections stained for Type I (red), Type IIa (green), Type IIx (unstained) and capillaries (green dots). (c) Mean fiber cross sectional area changes in masters sprinters at baseline and 10 years later. Each color and line indicate one individual.

The researchers found that FCSA, fiber-type composition, capillarization and VL thickness had not changed significantly after 10 years. The decrease in jump power (−9.5% ± 5.7, $P < 0.001$) was attributable to a concomitant decrease in knee extension MVC (−21.0% ± 20.4, $P < 0.001$), not slowing of the muscle. Athletes demonstrated reduced 60-m sprint performance after 10 years (+14.2% increase in sprint time ± 12.4, $P < 0.001$) with greater loss in performance found in older participants (stepwise regression $P < 0.004$). Similarly, the loss of jump power found in the follow-up measurement (−9.47% ± 5.7, $P < 0.001$) was larger in the older participants (stepwise regression $P < 0.001$). However, no changes in muscle function or performance were significantly related to years of training or training volume.

The group concluded that masters sprinters aged 48–85 maintained muscle histological characteristics over 10 years, but their training was unable to offset decrements in sprint performance and power that were attributable to a loss in force generating capacity, but not slowing of the muscle. ler

Source: *Hendrickse PW, Hutz B, Korhonen MT, Degens H. A 10-Year Longitudinal Study of Muscle Morphology and Performance in Masters Sprinters. J Cachexia Sarcopenia Muscle. 2025 Jun;16(3):e13822. doi: 10.1002/jcsm.13822.*

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A RARE CASE OF BILATERAL XANTHOMATOSIS OF THE ACHILLES TENDON

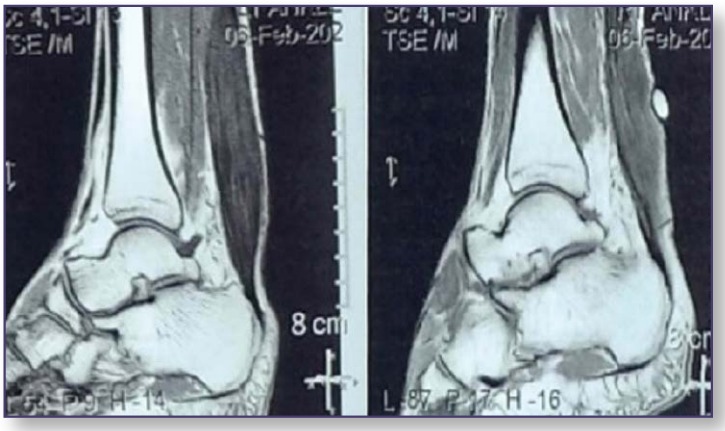


Figure. Magnetic resonance imaging of the left and right tendon of Achilles.

Xanthomatosis is an atypical pseudotumor of connective tissue characterized by the accumulation of lipid-laden histiocytes, often manifesting as encapsulated yellowish masses. It is commonly associated with familial hypercholesterolemia (FH). This case report aims to present a rare instance of bilateral xanthomatosis affecting the Achilles tendons in a 42-year-old male, which underscores the importance of identifying clinical and radiological findings of this condition to facilitate early diagnosis and intervention for related musculoskeletal and metabolic disorders.

A 42-year-old male presented with a 6-year history of asymptomatic swelling in the distal aspect of both legs. On examination, firm, non-tender, non-reducible, and non-mobile masses were observed without signs of inflammation, and the patient maintained full ankle joint mobility. Magnetic resonance imaging findings revealed diffusely bulky Achilles tendons with specific imaging characteristics consistent with xanthomatosis (Figure). Further evaluation of the lipid profile confirmed hypercholesterolemia and hyperlipidemia. Given the absence of pain or movement restrictions, the patient was managed conservatively with monitoring and treatment for his lipid abnormalities.

This case of bilateral xanthomatosis of the Achilles tendon highlights its rarity and the importance of imaging techniques in diagnosis. Early recognition is critical, as it serves as a potential indicator of underlying hyperlipidemia, necessitating appropriate management to prevent complications. In this instance, conservative treatment was deemed suitable due to the absence of significant symptoms, emphasizing the need for ongoing observation and treatment for the identified lipid disorder.

Source: *Thakare A, Bhandari H, Patwa B. A rare case of bilateral xanthomatosis of tendon of achilles: a case report. J Orthop Case Rep. 2025;15(5):75-79. doi: 10.13107/jocr.2025.v15.i05.5562. Use is per Creative Commons Attribution 4.0 International License.*

DOES KINESIO TAPE NEGATIVELY AFFECT TREATMENT OF PLANTAR FASCIITIS

Figure. Application of the kinesio taping.

Radial extracorporeal shock wave therapy (r-ESWT) is accepted as one of the most effective treatment modalities for plantar fasciitis (PF). Also, kinesio taping (KT) application is effective for the treatment of PF. However, there is not enough evidence about the effectiveness of the combination of these 2 modalities in the treatment of PF. This prospective randomized clinical trial was planned to investigate the acute effects of KT application in addition to r-ESWT application on pain, foot function, and flexibility.

The study was performed on 42 patients with unilateral PF, that were randomly assigned into 2 groups receiving 4 sessions of either r-ESWT or r-ESWT+KT treatment once per week. All patients performed home exercises. Patients' pain levels were evaluated via the Visual Analogue Scale (VAS), and foot function via the Foot Function Index (FFI). Flexibility was evaluated through gastro-soleus and plantar fascia flexibility tests. The evaluations were done before and 1 week after the final treatment. Two Way Analysis of Variance with Repeated Measures and Generalized Estimating Equations (GEE) methods were used in statistical analyses.

As a result, rest pain and activity pain decreased in both groups and there were no differences between the groups (respectively *P*: 0,831; *P*:0.331). FFI pain and disability subscores decreased and were also similar between the groups (respectively *P*: 0.304;*P*: 0.978). FFI activity limitation subscore decreased in the r-ESWT group more than r-ESWT+KT group (*P*: 0.002). Night pain, gastro-soleus and plantar fascia flexibility did not change in both goups (respectively *P*: 0.713; *P*: 0.413; *P*: 0.475).

The authors concluded that adding KT to r-ESWT application did not create an additional pain-relieving effect, on the contrary, resulted in less improvement in activity limitation. This may be related to the fact that KT application to the sole and heel region creates a hard surface on the heel. r-ESWT application may be more beneficial in PF where activity limitation is prominent.

Source: *Kocahan T, Örsçelik A, Günaydın H, et al. Can kinesio tape negatively affect the treatment by creating a hard floor in plantar fasciitis treatment? A randomized clinical trial. PLoS One. 2025;20(5):e0322397. Doi: 10.1371/journal.pone.0322397.*

HIIT APPEARS TO TEMPER METABOLIC SYNDROME IN 8-YEAR STUDY

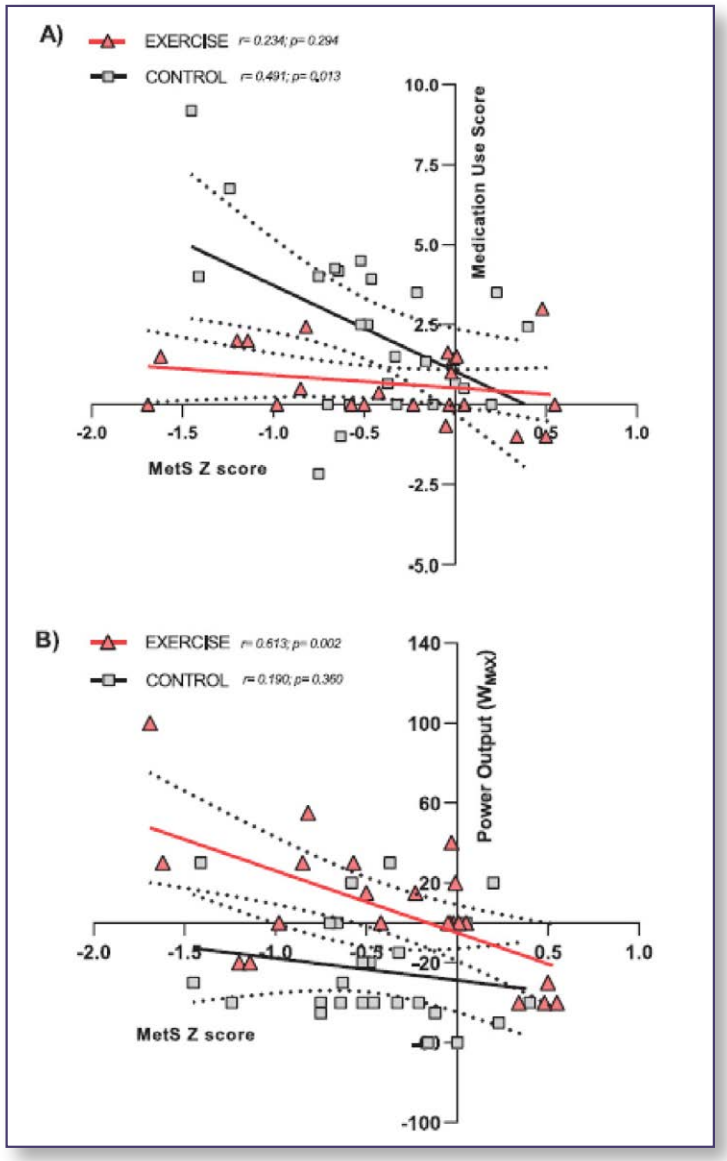


Figure. Pearson correlation between improvements in MetS *Z* score (Δ MetS *Z* score) after 8 years of follow-up and changes in medication use score (Δ medication use score [A]) and W_{MAX} (Δ power output [B]) in the EXERCISE and CONTROL.

Metabolic syndrome (MetS) is a set of 5 cardiometabolic risk factors including obesity and Type 2 diabetes, that typically worsen with age. One exercise-training program is effective at improving those factors in middle-aged individuals with MetS. This study determined the effectiveness of a periodized exercise training program for individuals with MetS after a follow-up period of 8 years.

Forty-seven individuals with MetS were block-randomized into an EXERCISE (n = 22, 52 ± 8 years old, 23% women) or a CONTROL group (n = 25, 53 ± 8 years old, 32% women). Both groups received standard health care, including medical counselling and lifestyle advice at least every 6 months, while participants in EXERCISE also underwent a supervised exercise program. The intervention lasted 8 years and consisted of 4 months per year (November to March) of high-intensity interval training thrice weekly. At baseline, and after 4 and 8 years of treatment, researchers assessed body composition, MetS components (ie, MetS ≥ score), medication use, cardiorespiratory fitness (CRF; assessed by VO_{2MAX}) and maximal leg cycling power output (W_{MAX}).

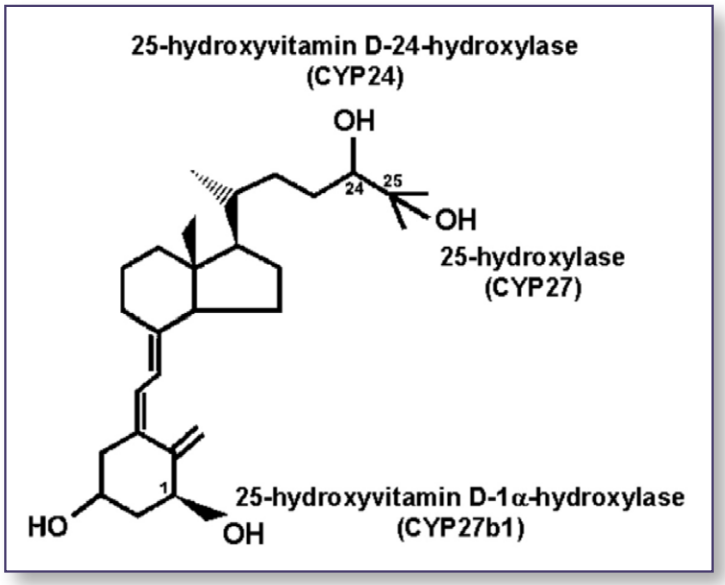
Results: Paradoxically, MetS *Z* score and body weight were reduced after 8 years (participants aged from 52 to 60 years old) in both groups (time effect $P < 0.001$ and $P = 0.008$; time × group interaction $P = 0.253$ and $P = 0.130$). However, in those 8 years, the medicine use score increased threefold in CONTROL (137% increase; from 1.7 to 3.9; $P < 0.001$) while it did not change in EXERCISE (33%; from 2.0 to 2.7; $P = 0.066$). In 8 years, CRF and W_{MAX} increased in EXERCISE by 14% (3.4 ± 5.6 mL±kg^{-1}• min^{-1}) and 4% (7 ± 37 W) while decreasing in CONTROL by −7% (−1.6 ± 3.4 mL±kg^{-1}• min^{-1}) and −14% (−24 ± 27 W) being different between groups after 4 and 8 years (both time × group interaction $P = 0.002$). Pearson correlations showed that MetS *Z* score improvements were significantly associated with increases in medication use score in the CONTROL group $r = 0.491$; $P = 0.013$) and with W_{MAX} enhancement in the EXERCISE group ($r = 0.613$; $P = 0.002$).

On closer analysis, the researchers concluded that the data revealed that the nonexercising CONTROL group reduced their MetS *Z* score at the expense of tripling their oral medication. This provides evidence of a worsening of their disease that had to be compensated by increasing pharmacological therapy. On the other hand, the EXERCISE group did not need to increase medication in 8 years to improve their MetS. The factor that better predicted MetS evolution was leg cycling power in the EXERCISE group while it was medicine use score in the CONTROL group (Figure). In summary, this data suggest that individuals with cardiometabolic disease, who do not exercise regularly as they age, render the control of their disease to pharmacological treatment alone. Lastly, our data suggest that exercise training has similar clinical power to tripling oral medication to control MetS as individuals age 50 to 60 years.

Source: *Morales-Palomo F, Moreno-Cabañas A, Alvarez-Jimenez L, Mora-Gonzalez D, Mora-Rodriguez R. Long-term effects of high-intensity aerobic training on Metabolic Syndrome: an 8-year follow-up randomized clinical trial. J Cachexia Sarcopenia Muscle. 2025;16(2): e13780. Doi: https://doi.org/10.1002/jcsm.13780*

Continued from page 15

ASSOCIATION OF VIT D WITH SARCOPENIC OBESITY RISK



Sarcopenic obesity (SO), a relatively new category of obesity and a high-risk geriatric syndrome in the elderly, is associated with numerous adverse health consequences such as frailty, falls, disability, and increased morbidity and mortality. This study, done by researchers in China using longitudinal data from the UK Biobank cohort (N=46,535), examined the association of serum 25-hydroxyvitamin D (25[OH]D) concentration with the risk of SO incidence. Cox proportional hazards models were used to estimate the hazard ratios (HRs) and 95% Confidence Intervals (CI) between serum 25(OH)D concentration and risk of SO incidence by sex.

With a median follow-up of 8.74 years, 1086 incident SO cases were identified. After multivariable adjustment, compared with the lowest quartile group, the HRs (95% CI) for the second, third, and fourth quartile of 25(OH)D concentration in female individuals were 0.66 (95% CI: 0.53–0.82), 0.53 (95% CI: 0.41–0.67), and 0.43 (95%: 0.33–0.55), respectively ($P_{trend} < 0.001$). Similarly, in male individuals, the HRs (95% CI) for the second, third, and fourth quartile of 25(OH)D concentration were 0.86 (95% CI: 0.66–1.10), 0.68 (95% CI: 0.56–0.92), and 0.40 (95% CI: 0.29–0.54), respectively ($P_{trend} < 0.001$). A nonlinear association between serum 25(OH)D concentration and risk of SO incidence was observed in female ($P_{nonlinear} = 0.043$) and male ($P_{nonlinear} = 0.008$) individuals using restricted cubic spline analysis.

The authors concluded that higher serum 25(OH)D concentration was significantly associated with a lower risk of SO incidence in a dose–response relationship.

Source: *Xu Q, Bu F, Song ZT, et al. Association of serum 25-hydroxyvitamin D with sarcopenic obesity risk: a longitudinal observational study from the UK Biobank. Obesity (Silver Spring). 2025 May 1. doi: 10.1002/oby.24286. Image from Anderson & May. Clin Biochem Rev. 2003;24(1):13-26.*

LOW-INTENSITY FOCUSED ULTRASOUND FOR PAIN RELIEF IN DPN?

In an interesting, but small, study out of China, researchers evaluated the efficacy of low-intensity focused ultrasound (LIFU) in alleviating pain in patients with painful diabetic peripheral neuropathy (PDPN).

Fifty participants were randomized to either LIFU or placebo therapy for 7 days . Compared to placebo therapy, patients in the LIFU group ($n = 25$) demonstrated significantly lower numeric pain rating scale scores (3.96 ± 1.07 versus 2.76 ± 1.79, $P < .05$). Additionally, significant improvements in neuropathic symptoms, as measured by neuropathy symptom score, were observed in the LIFU group post-treatment. Notably, LIFU therapy did not alter the conduction velocities or amplitudes of the bilateral peroneal, tibial, and sural nerves as measured by electromyography.

The authors concluded that LIFU therapy was effective in reducing pain and improving neuropathic symptoms in patients with mild-to-moderate PDPN and called for future studies to investigate the long-term effectiveness and sustainability of this novel therapeutic approach.

Source: *Zhang X, Wang Y, Peng W. Explore the effect of low-intensity focused ultrasound on pain relief in patients with diabetic peripheral neuropathy. A pilot randomized trial. J Ultrasound Med. 2025 May 5. doi: 10.1002/jum.16716.*

ASSOCIATIONS BETWEEN FEMALE SEX HORMONES AND SKELETAL MUSCLE AGEING

This study highlights the significant role of circulating sex hormones in the aging process of female skeletal muscles. Prior research has primarily focused on distinct age groups, often comparing only young versus old, or pre-menopausal versus post-menopausal women, thereby neglecting the

transitional phase from high to low oestrogen levels. This research aimed to explore both cross-sectional and longitudinal relations between sex hormones and muscle mass and function using data from the Baltimore Longitudinal Study of Aging.

In the analysis, multiple and binomial linear regression methods were applied to a sample of healthy women aged 24 to 89 years. The study assessed hormones such as oestradiol (E2), free oestradiol index (FEI), total and bioavailable testosterone (TT and BioT), and their influence on skeletal muscle mass and other related parameters. Key findings from the cross-sectional analysis revealed positive associations between E2 and FEI with relative appendicular lean mass and thigh muscle percentage, while they negatively correlated with total body fat percentage. Conversely, BioT showed a positive link with absolute appendicular lean mass and total body fat, whereas TT did not.

In terms of longitudinal data, results demonstrated that declines in E2 and FEI correlated with decreases in lean muscle mass and handgrip strength over a 4-6 year period. Moreover, reductions in TT and BioT were linked with increased total body fat.

The findings suggest the need for a detailed examination of hormone fluctuations to better understand female muscle aging, highlighting the nuanced role of sex hormones across a broad age continuum. ler

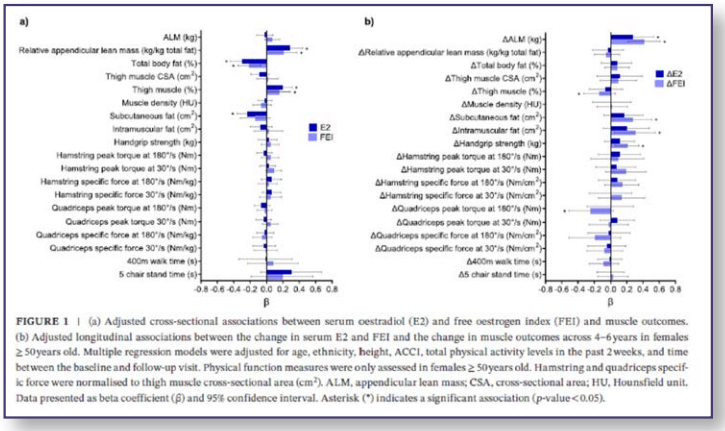


FIGURE 1 | (a) Adjusted cross-sectional associations between serum oestradiol (E2) and free oestrogen index (FEI) and muscle outcomes. (b) Adjusted longitudinal associations between the change in serum E2 and FEI and the change in muscle outcomes across 4–6 years in females ≥ 50 years old. Multiple regression models were adjusted for age, ethnicity, height, ACCI, total physical activity levels in the past 2 weeks, and time between the baseline and follow-up visit. Physical function measures were only assessed in females ≥ 50 years old. Hamstring and quadriceps specific force were normalised to thigh muscle cross-sectional area (cm^2). ALM, appendicular lean mass; CSA, cross-sectional area; HU, Hounsfield unit. Data presented as beta coefficient (β) and 95% confidence interval. Asterisk (*) indicates a significant association (p-value < 0.05).

Source: *Critchlow AJ, Alexander SE, Hiam DS, Ferrucci L, Scott D, Lamon S. Associations between female sex hormones and skeletal muscle ageing: The Baltimore Longitudinal Study of Aging. J Cachexia Sarcopenia Muscle. 2025 Jun;16(3):e13786. doi: 10.1002/jcsm.13786. Use is per CC BY.*

PLANTAR PRESSURE AS TOOL FOR ASSESSING RISK OF SCOLIOSIS

Idiopathic scoliosis (IS) caused by an unknown etiology is prevalent in primary and secondary school students. Early detection and prevention are challenging because of the limited knowledge about controllable risk factors and imbalances in body mechanics. These authors examined the potential causative factors of IS and its correlation with foot

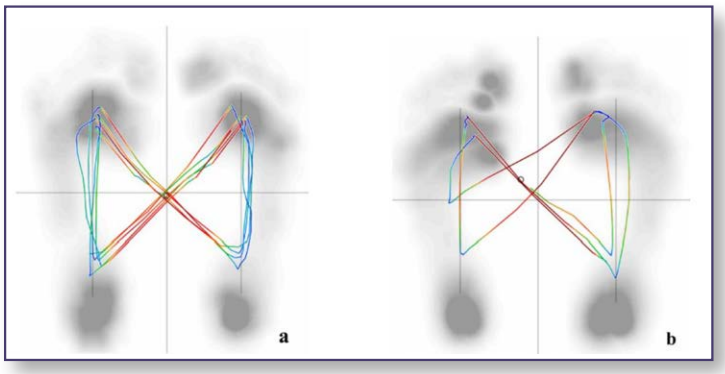


Figure. The butterfly diagram formed by the movement of the body center of gravity during walking. (a) Butterfly diagram of a healthy subject with a regular butterfly pattern and smooth gait, with the body center of gravity centered at the center of the butterfly. (b) Butterfly diagram of an IS patient (the patient's spine curves to the left); the butterfly pattern tends to be disordered, gait is severely imbalanced, and the body center of gravity is concentrated on the left front side.

mechanics among 7–14 year-old students in northern Jiangsu Province, China. Based on a stratified whole cluster sampling, 4387 students were examined, of whom 165 were diagnosed with scoliosis. Through logistic regression analysis, the following risk factors were identified: age group, female gender, thinness, unsuitable desk and chair heights, heavy schoolbags, backpack carried on one shoulder, daily sedentary time ≥10 h, daily playing electronic products time ≥2 h, daily physical activity time <1 h, sports programs with unilateral limb power, lumbar and back fatigue, unequal thickness of worn soles on both feet, and flat foot.

When compared to healthy people, IS patients exhibit foot biomechanics characterized by a diagonal distribution of bilateral weight-bearing and walking instability, as well as poor balance function if they have an abnormal foot type, as in the case of flat foot. This study revealed that the detection rate of scoliosis in primary and secondary school students in northern Jiangsu Province, China, is relatively on the high side, so it is necessary to strengthen education and screening, concentrate on female students, and provide guidance on how to develop a healthy lifestyle and learning habits. Assessment of plantar pressure distribution and postural symmetry is an effective means of predicting scoliosis. Plantar pressure analysis can serve as an additional tool for assessing the risk of scoliosis. ler

Source: *Sun P, Zhou Y, Xie Y, et al. Risk factors and foot biomechanical characteristics of idiopathic scoliosis: a cross-sectional study. Sci Rep. 2025;15(1):16953. doi: 10.1038/s41598-025-01170-4.*

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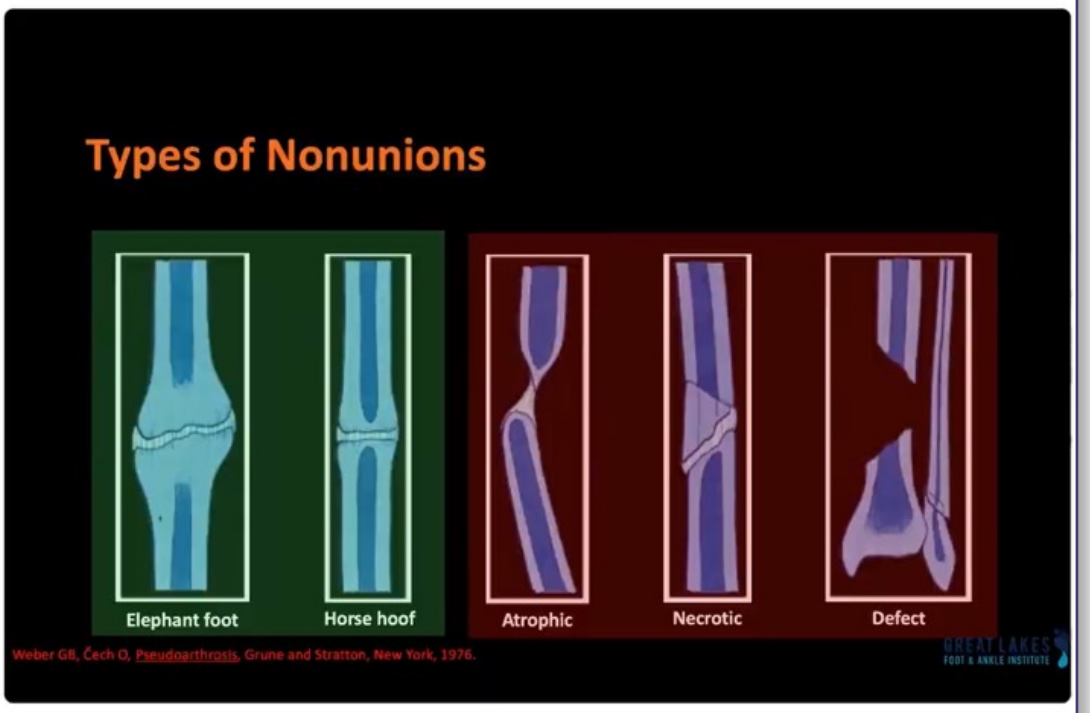
Non-Unions of the Hind Foot



By Zeeshan Husain, DPM, FACFAS, FASPS

Hind foot non-unions are a complex orthopedic challenge that clinicians face, particularly due to the unique anatomy and weight-bearing responsibilities of this part of the foot. Non-unions occur when a fracture fails to heal nine months after injury or shows no radiographic improvement over a consecutive 3-month period. This condition is not only painful but can also severely impact mobility and quality of life. Understanding non-unions in the hind foot involves examining various contributing factors such as host medical status, presence of infection, and prior surgical interventions. These factors all play a significant role in the healing process and can complicate treatment, making comprehensive management strategies essential.

Non-unions occur when a fracture fails to heal within the expected timeframe. Specifically, a fracture is considered a non-union if there is no healing within 9 months or no radiographic improvement over a period of 3 consecutive months. Causes for non-unions include poor vascularity, traumatic injuries, and infections. Often, these factors disrupt the natural bone healing process, making recovery challenging without proper intervention.

Several host factors can increase the risk of non-unions. Patients with vitamin deficiencies, particularly vitamin D, as well as those with poor nutritional status, may face difficulties in bone healing. Smoking and non-compliance with medical advice can also impede recovery. Additionally, diabetic patients, especially those with high hemoglobin A1C levels, are at a greater risk for complications, including infections that may lead to non-unions. Effective management often requires addressing these underlying health concerns through multidisciplinary approaches.

Challenges in Treating Hind Foot Non-Unions

Infection Risks: Infections remain a significant challenge when treating hind foot non-unions. Infection not only contributes to the development of non-unions but also complicates the healing process. Effective treatment necessitates

This article is a summary of Dr. Husain's presentation titled, "None of the Joints I Fused healed, Now What?," from the APMA Surgical Complications Virtual Seminar, January 18, 2025 hosted by lerEXPO.com. To view the slide presentation which includes 2 complex case studies with questions and answers, visit https://apmasurgical.lerexpo.com/. Continuing education credits are available for many lerEXPO.com programs

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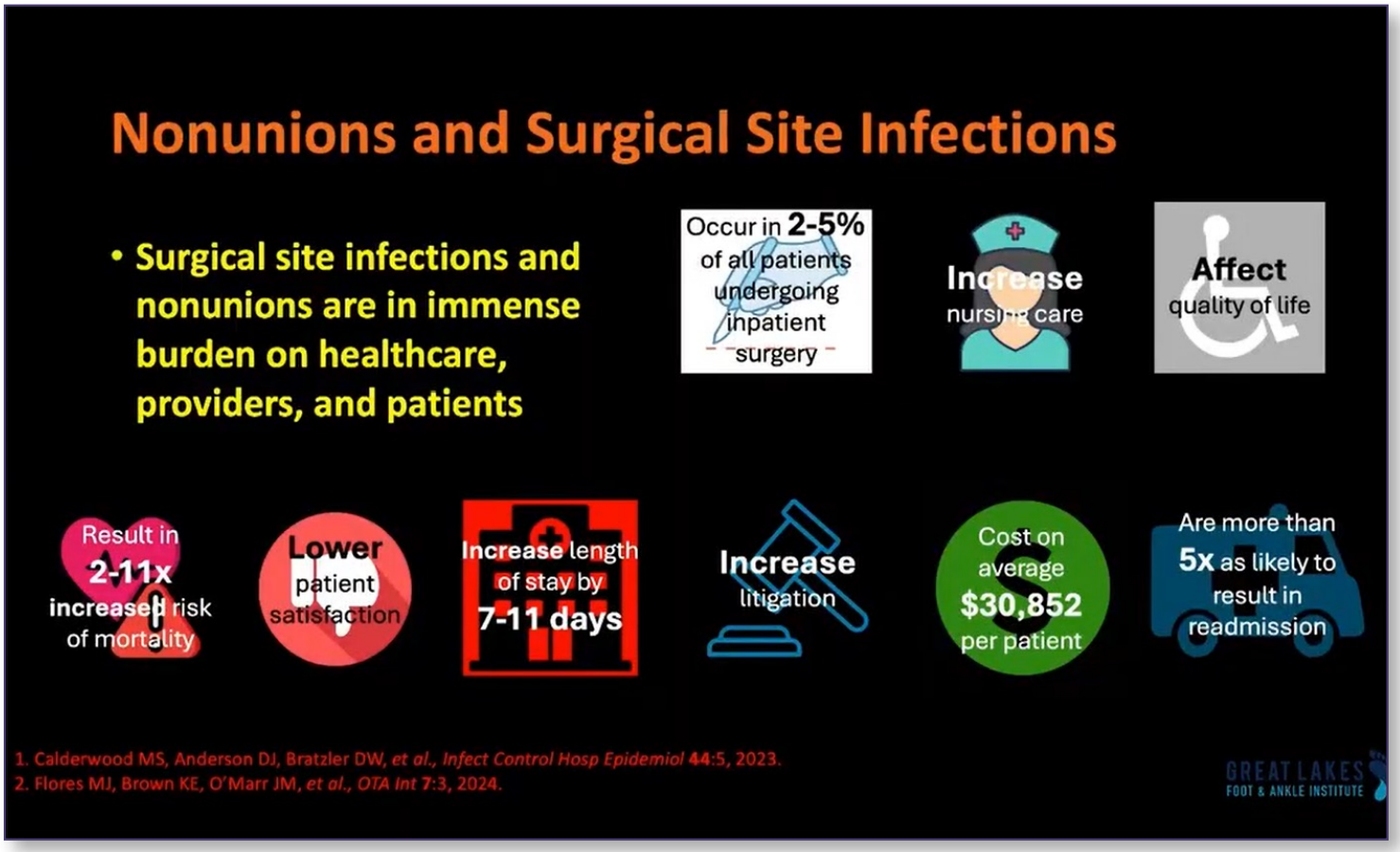

thorough debridement and often involves a multidisciplinary team including surgeons, infectious disease specialists, and clinical pharmacists to manage care and tailor antibiotic therapies.

Weight Bearing Implications: The hind foot's role in bearing weight complicates the treatment of non-unions. Unlike the forefoot, the hind foot must support significant body weight, which can lead to severe implications for the patient's quality of life. Non-unions in the hind foot can result in prolonged periods of restricted mobility, increased rehabilitation times, and higher risks of re-injury.

Costs and Patient Satisfaction: Addressing hind foot non-unions can be costly, with expenditures encompassing medical procedures, prolonged treatments, and potential litigation from dissatisfied patients. The complexities of these conditions can lead to lower patient satisfaction, as individuals endure lengthy recovery processes that demand compliance and lifestyle adjustments. Managing these factors is critical to improving outcomes and reducing the financial burden associated with non-unions.

Risk Factors and Diagnostics

Poor Vascularity and Trauma: Hind foot non-unions often occur due to several underlying factors, including poor vascularity and trauma. Trauma, particularly high-impact injuries or fractures, can significantly impair blood flow to the affected area, leading to delayed or incomplete bone healing. Moreover, poorly vascularized bone tissue struggles to receive the necessary nutrients and oxygen crucial for bone regeneration, thereby increasing the risk of non-union.

Compliance and Lifestyle Factors: Patient compliance and lifestyle choices also play a pivotal role in the development of non-unions in the hind foot. Non-compliance with post-operative care, such as failure to adhere to weight-bearing restrictions, can compromise healing. Lifestyle factors, such as smoking and poor nutrition, further exacerbate the risk, as they can impair the body's ability to repair itself effectively. A high hemoglobin A1C level, especially above 7.7%, can increase susceptibility to infections and complications, further complicating the healing process.

Collaborative Care: Infections are a significant contributor to non-unions and can lead to bone resorption. Accurate diagnosis requires a comprehensive approach, utilizing thorough imaging and microbiological testing. A multidisciplinary team consisting of surgeons, infectious disease specialists, and clinical pharmacists can ensure appropriate management. This team collaborates to design targeted antibiotic therapies and effective intervention plans, often involving surgical debridement and extended follow-up care.

Management Strategies for Non-Unions

Non-Surgical Approaches: Managing non-unions of the hind foot often begins with conservative strategies. These include nutritional optimization and lifestyle modifications to

bolster the patient's overall health and enhance bone healing potential. Addressing vitamin deficiencies, particularly vitamin D, plays a critical role in supporting bone health. Use of bone stimulators, such as ultrasound or electromagnetic devices, can promote healing by stimulating the bone's natural regenerative processes.

Surgical Techniques and Grafting: When non-surgical efforts prove insufficient, surgical intervention becomes necessary. Techniques often involve stabilization with rigid fixation using plates, screws, or intramedullary nails. Bone grafting is another cornerstone treatment, using autografts or allografts to provide osteogenic, osteoinductive, and osteoconductive properties to the healing site. Meticulous surgical planning and execution are paramount to improving outcomes and minimizing complications.

Supplements and Bone Stimulators: Supplementation with calcium, vitamin D, and vitamin K can enhance bone formation and density, thus aiding recovery. Additionally, bone stimulators are valuable adjuncts in the management of non-unions. These devices generate electrical or electromagnetic fields to augment bone healing processes. By integrating these therapeutic strategies, healthcare professionals can effectively address hind foot non-unions, optimizing patient recovery and long-term foot health.

Conclusion

In conclusion, understanding and addressing non-unions of the hind foot require a comprehensive approach that encompasses the identification of underlying causes, informed diagnosis, and a multidisciplinary treatment plan. Factors such as poor vascularity, infection, vitamin deficiencies, and patient non-compliance must be carefully managed to improve bone healing outcomes. Surgical interventions may include stabilization with various fixation techniques and bone grafting, while non-surgical therapies such as nutritional supplementation and lifestyle modifications play crucial roles. Collaborative care with infectious disease specialists and clinical pharmacists can ensure accurate diagnosis and effective treatment pathways, ultimately enhancing patient outcomes and quality of life. Properly addressing these complex cases requires not only technical expertise but also an awareness of patient-specific factors that may influence healing and recovery.

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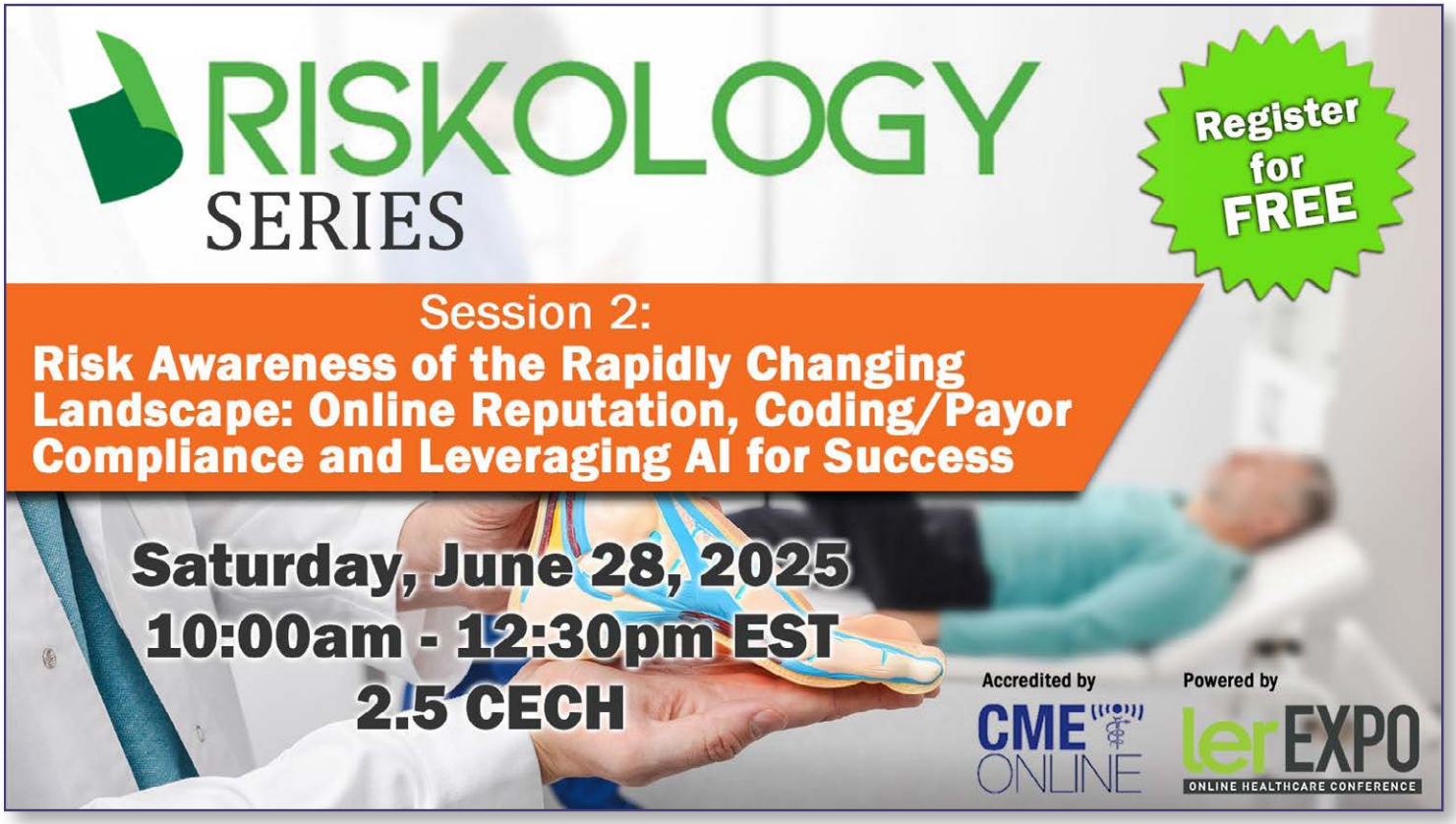

CAGA 101: The 12 Dirty Truths of Foot Mechanics

Dirty Truth #3: What We Can't See Is Key

By Jay Segel, DPM; Sally Crawford, MS

In the last 2 installments, we talked about our problematic foot anatomy and what happens to the structure during weightbearing and activity. Much like how a mousetrap precisely captures its target, analyzed computer-aided gait analysis (CAGA) reports accurately "mousetrap" and track the unseeable, providing valuable insights and objective data.

Consider the common biomechanical and structural foot problem, equinus. Many sources describe equinus in gait terms by noting an early heel off, such as a heel leaving the support surface at 55% of the gait cycle. Through visual gait observation, we may note that the heel indeed leaves the ground early, but we cannot assign a quantitative percent value, thus deciding the severity of the equinus deformity without CAGA: mild, moderate, and severe.

Delving further into diagnostic nuances, early metatarsal onset times also point to dropfoot. So, how do we differentiate between these 2 conditions? CAGA offers the precision required to distinguish Dropfoot and Equinus as an example. Near-instantaneous start times suggest dropfoot, while times falling between near-instantaneous and normative values lean toward an equinus diagnosis (Figure 1).

The ability to monitor and document baselines and progress objectively is an obvious advantage of CAGA. However, the greatest value may be in leveraging the data as treatment planning (Figure 2). In the clinical setting, CAGA is our main tool in creating comprehensive treatment plans. Let's examine another serious issue: the diabetic ulcer. Without a precise solution, diabetic ulcer recurrence can range upwards of 71.2% as determined in a recent study.[1]

In podiatric care clinics like Johns Hopkins, the use of CAGA extends beyond identifying at-risk areas and designing precise offloading solutions like custom orthotics to prevent or treat diabetic ulcers and even ulcer recurrence. CAGA brings to light device efficacy and guides adjustments for improved care. Additionally, CAGA empowers patients with a deeper understanding of their progress, and in turn, this enhanced comprehension fosters greater adherence and compliance with plans.

What We Can't See Is Key: Many biomechanical characteristics can be seen by the naked eye but are better visualized and quantified with computers, which can capture the unseen.

As one can imagine, with over 255 temporal-spatial parameters and graphs, combined with the period of foot disorders, we could go on all day, but there is one last point to highlight in this "dirty truth": symmetry and normality. You can't create a good plan without the CAGA data and the normative data comparison and asymmetry scores (Figure 3, page 22).

An ideal analogy to the understanding and cost of asymmetry between limbs is that of car axles and tires. Car tire-wear is not even from left to right or from inside and outside in a specific tire. Left untreated, that asymmetric wear will not only cause problems with the rubber tires, but with the axles and eventually the whole car structure, not to mention drivability. We experience the same types of wear and tear, but unfortunately, we can't just change our feet as we can the tires of the car. Instead, we must be particularly focused on asymmetry wear and tear, which leads to heat, fatigue, inflammation, arthritis, deformation, and eventually pain coupled with limitation of ambulation. Fortu-

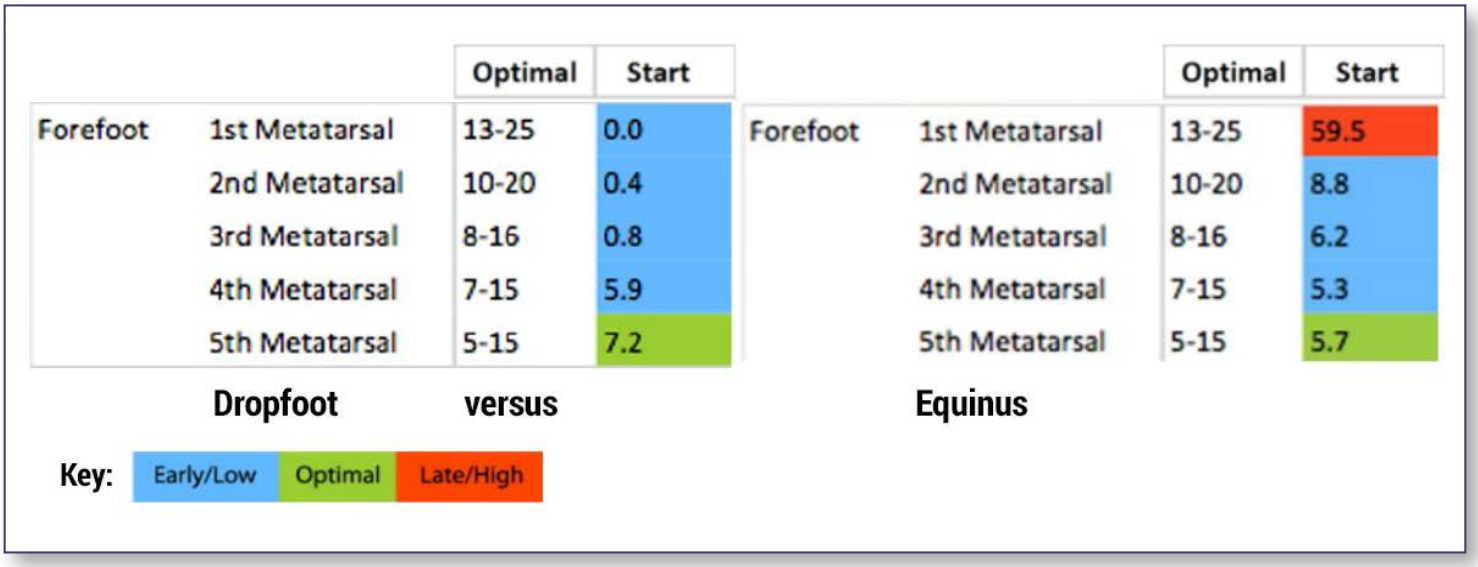

Figure 1: CAGA as diagnostic tool. When evaluating the "unseen" aspects of this equinus deformity case, the interplay between heel-strike and mid-stance gait phases is noteworthy. Consequently, we can view "early Mets on" as an additional element in CAGA. The onset timing of pressure under the metatarsal heads (early Mets on) serves as a dependable marker for this deformity, though one might observe the trait without quantifying it precisely.

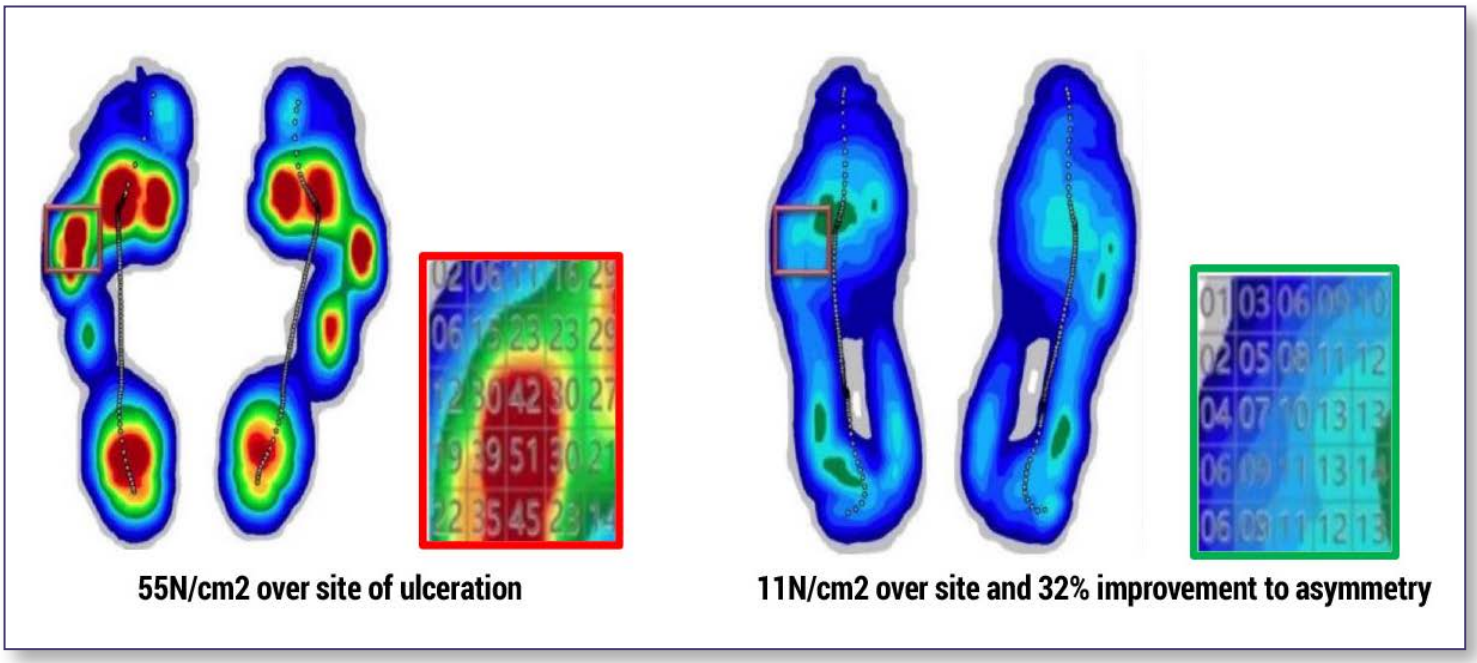

Figure 2: CAGA as treatment planning tool. Identify areas at risk with specificity and design offload mechanisms, such as those built into an orthotic, to protect these areas of concern. After creating such solutions, we can also objectively judge their efficacy and make any corrections needed to the device (78.43% reduction in pressure achieved with 32% improvement in asymmetry).[1]

nately, we have a tool that allows us to catch asymmetry in the earlier stages and intervene with a targeted treatment protocol to arrest this erosive problem: yes, it's CAGA analysis. These detailed reports lay bare to the trained eye, medial-to-lateral and left-to-right asymmetries for treatment consideration. A useful adage to consider when thinking about intervention is, "Change your orthotics, not your joints." So, we think it's clear that what we can't see is key, or maybe what we should say is, what we can see with CAGA is key.

Reference

1. Kochar K, Priesand S, Yosef M, Schmidt BM. Diabetic foot infection severity as a predictor of re-ulceration following partial forefoot amputation. J Foot Ankle Surg. 2025;64(3):238-242. doi: 10.1053/j.jfas.2024.10.012.

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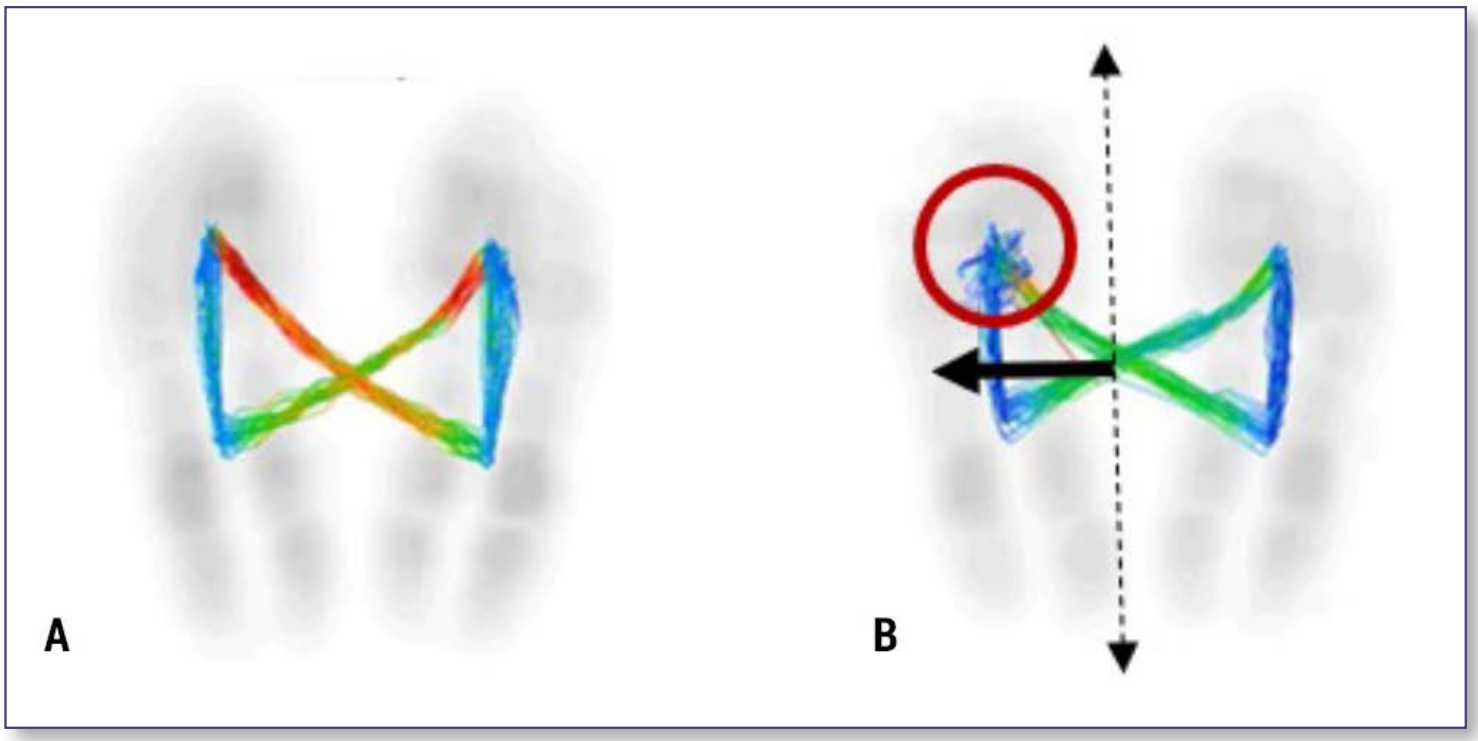

Figure 3: Comparison of A) Balanced single support phase center of pressure with Lateral Shifting at 0mm, perfect alignment, versus B) Unbalanced single support phase center of pressure intersection with variability and >8mm lateral shifting and malalignment.

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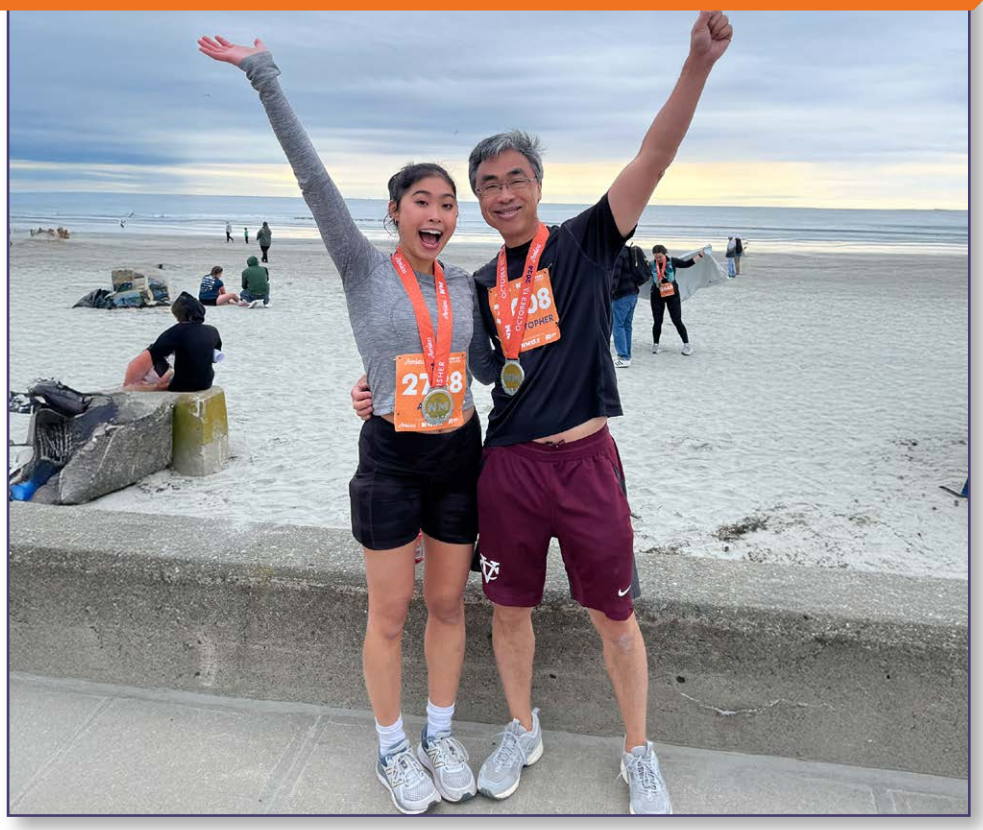
How Biomechanics Helped Me Run My 1st Half Marathon at Age 60

By Christopher K. Wong, PT, PhD

With a focus on muscle activation, range of motion, and neuromotor training, this 60-year-old went from not being a runner to a half marathon in just a few months.



The author with his daughter after completing the half marathon. The author is a physical therapist, board certified as an orthopedic clinical specialist by the American Board of Physical Therapy Specialties, in practice for over 30 years and dedicated to academic scholarship and professional education currently at Columbia University.

I have never been a runner. The furthest I had ever run was the 7.5-mile Bay to Breakers race across San Francisco, 40 years ago while in college. A few years ago, I started running 1 mile per week to maintain my health for my family, my fitness, and for myself. As a physical therapist and professor, I also serve as a role model for my students and patients—some of whom are competitive runners. I am not competitive, however, and find running 2-3 miles/week has been sufficient to maintain my overall health. But when I was asked to run a half marathon by my daughter (who I had once pushed to run until she collapsed before we knew she had a rare disease called APS1 that made running difficult), I couldn't say no.

Minimal Training

My main goal was to finish without injury and be able to walk the next day. I knew many running injuries are related to training,[1] so I wanted to be smart about training. Cardiopulmonary endurance can reduce injury risk[2] and mine would have to improve, though I anticipated having minimal training time since I work 2 jobs. A gradual increase in running distance fit my schedule, which was good since injuries occur most when habitual running distance or intensity increases by 15% or more.[3] The result was that before the race, I had only run 13 total miles in a week's time twice: once split over 3 days, once split over 2 days. Would that be enough? I received skeptical looks from family, runners, and colleagues alike.

Biomechanics

My plan was to optimize my movement potential as I do for my athlete patients so that my body could be as efficient as possible. The first of the 3-step plan was to ensure movements were not limited by fibrosis, often thought of as adhesions or scar tissue, that forms in response to injury but also immobility and affect ***passive*** structures such as nerve, joints, and myofascia—the fascia that surrounds all muscle.[4] For example, when nerves exiting the spine are restricted, full innervation can be affected and the target muscles weakened; but nerves can be easily mobilized by maintaining spine range-of-motion.[5] Joints can be kept healthy by maintaining full range-of-motion and myofascia maintained flexible with simple stretching (Figure 1).[6] Joints and fascia can sometimes be addressed together, such as ankle joint dorsiflexion with soleus muscle stretch or knee joint flexion with ankle and midfoot joint plantarflexion and shin muscle stretch. As a physical therapist, I mobilized my joints and muscle fascia by maintaining firm pressure on stiff areas while moving the surrounding joints. Obtaining full joint range-of-motion and muscle flexibility can sometimes be difficult, which is a good reason to consult a skilled manual therapy focused physical therapist.

Optimizing full passive range-of-motion is important because the available motion determines the active motion and power that is produced in running. Power is the work performed in a specified time (P=W/t); and Work is the

Figure 1: Stretches to minimize ***passive*** restraints to movement from restricted nerve, joints, and myofascial. **A)** arm clock stretch to maintain spinal mobility and prevent myotomal weakness. **B)** what the author calls a tea ceremony stretch to maintain knee, ankle, and midfoot joint mobility while also stretching quadriceps and anterior shin muscles. **C)** ankle dorsiflexion with soleus stretch because limitation will also affect knee and hip function. **D)** lunge stretch for the hip flexors and calf muscles recommended by the author for life as the antidote to the sitting we all do.

energy required to move a force through a particular distance (W=Fd) with a related formula for torque through a joint angle. When motion (the distance moved) is limited, the power that can be produced will always be limited when the force applied is the same. Ankle plantarflexion and knee extension enables power generation at push off to propel one forward, while ankle dorsiflexion and knee flexion absorb the shock of impact upon landing. So optimizing my range-of-motion would take advantage of both elements of the Work equation, in case my muscles couldn't produce substantially more force in the few months I had to prepare knowing that for older people strengthening can take months.[7]

Active Training

The second step was to ensure that all muscles were ***active*** and strong throughout the full range-of-motion, which can be checked by simply holding for 10 seconds at all points, especially at the ends of the range-of-motion. I made sure to hold at whatever position I sensed weakness in the form of muscle ache, instability, or trembling. After all, if I couldn't activate the muscle sufficiently when focused on trying, how could I expect the muscle to work automatically when I wasn't specifically trying? Then I continued developing strength in the relevant muscles until the weakness went away by spending focused effort, yet minimal time, integrated into my daily life: holding at a certain angle of knee bending when I descended my stairs, reaching the highest point of the heel-raises I did at the kitchen sink when I made coffee, and getting to the lowest point of the split squats and side lunges I did while I brush my teeth.

The third step was integrating my range-of-motion and strength in running through neuromotor training so that all the muscles and joints worked together. Neuromotor training can be considered the coordination that enables efficient use of all the parts—as critical to success as the baton pass in a 4x4 relay. As I tell patients, just because your legs have normal motion and strength doesn't mean you can dance. Since running steps are so fast, ***neuromotor*** training was easiest during walking. Four keys address important points of the gait cycle: 1) extending the trailing or back knee straight behind me ensured gluteus maximus activation, 2) feeling the trailing foot roll over the ball of the feet ensured muscle activation of the calf muscles, 3) engaging the abdominals as the swinging leg advances and generates momentum, and 4) allowing the front knee to bend upon contact to make sure the quadriceps play their role in absorbing impact. Extending the trailing leg allows longer step lengths without the jarring horizontal braking force that occurs with over striding. While some suggest shortening step length, gait speed is the simple product of step length and cadence, so reducing either will slow a runner down. And though my primary goal was to finish, I didn't want to run slower. Training new neuromotor patterns into any ***activity*** takes time, but long runs provide the time.

Accounting for Real Life

I ran using these tips to optimize my running body mechanics but had to build up my endurance or cardiopulmonary ***capacity*** over the couple months before the race. Afterall, many can run to the corner, but few can run a marathon. I emphasized rest and recovery, which meant not running every day and attending to various aches and pains as they occurred with the

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self-stretches and joint mobilizations described above. With a goal of at least a couple long runs of 10 miles before the race, I stuck with a regimen of a couple short runs and a longer run each week. Since my goal was to finish without injury, I didn't fret if I had to walk briskly during a long run—the same advice I have often given to patients as they recover and return to running. As the race approached, I tried not to walk but walked as fast as possible for as short a time as possible when I did.

Then to account for the course topography, I made sure my running ***environment*** included hills to account for the elevation changes on the race map. Inclines are an efficient way to force abdominal muscles and the gluteus maximus to work as well as necessary for cardiovascular conditioning; declines challenge the quadriceps.[8] Counting for the adrenaline fueled psychological environment of a run with a crowd of people, I didn't bother to run more than 10 miles in training ever, figuring that the crowd of eager motivated peers would pull me over the finish line. The process spelled out here of working through ***Passive*** restraints to movement, ***Activating*** muscles in their specific positions, ***Neuromotor*** training to integrate into the ***Activities*** of life, building sufficient cardiovascular ***Capacity*** to perform in real life ***Environments***, all while harnessing an ***Attitude*** for success, I describe with the acronym PANACEA for rehabilitation[9] (Figure 2).

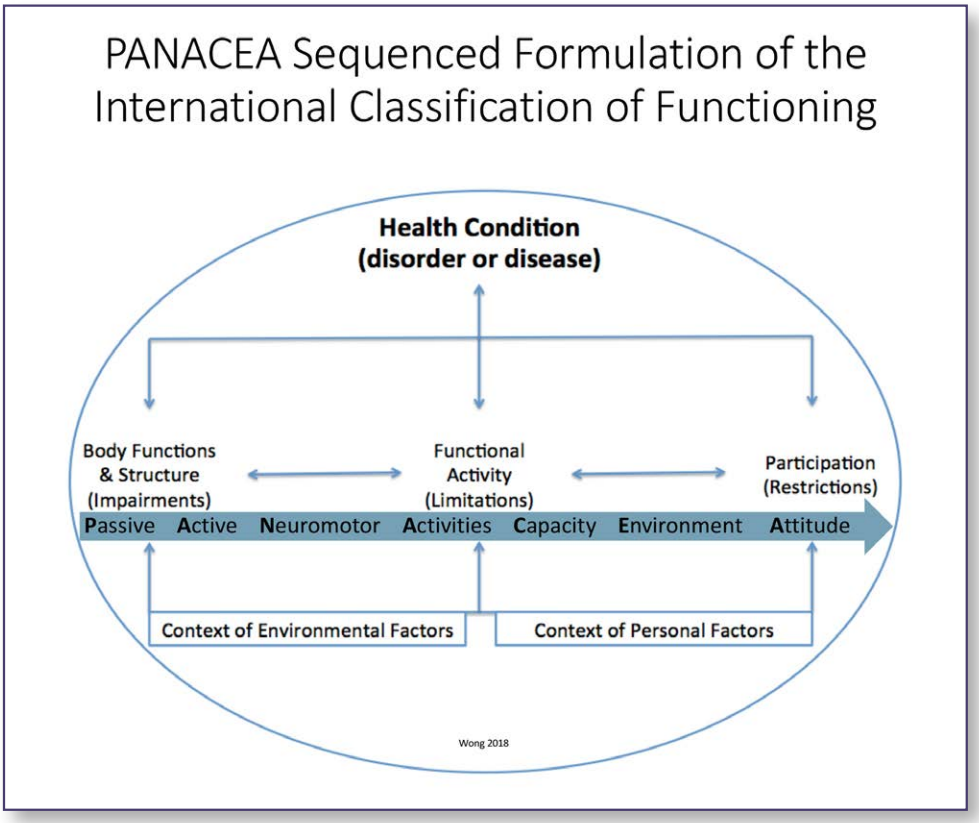

Figure 2: The International Classification of Functioning (ICF) model describes an individual's health condition considering personal and environmental factors that affect them in the context of their body's impairments, that lead to functional limitations, and can ultimately restrict full participation in life. The PANACEA sequence optimizes a person's participation by addressing all ICF elements in logical order from impairments to functional activities to requirements for life participation. Minimizing passive restraints to movement, activating musculature, and neuromotor coordination enables active participation in building the cardiopulmonary capacity needed for real life social and physical environments. Attitude is a personal factor that must be always addressed. *This figure is the author's adaptation from his prior work, Graham E, Johnson M, Wong CK. Return to running after rehabilitation for chronic 16-year cremaster strain: a case study. J Orthop Sports Phys The Cases. 2024;4(3):146-152. https://doi.org/10.2519/josptcases.2024.0007.*

Attitude

Biomechanical and physiological factors don't completely explain the success of people engaging in endurance sports.[10] Psychological traits, including motivation and ***attitude,*** are also critical aspects. Some need external motivation such as an impending goal, in my case just finishing the race. Some are intrinsically motivated by maintaining psychological and physical health.[11] I am always inspired by my many patients who have struggled through rehabilitation to return to running and also my friends who have overcome leg amputations to walk, run, and excel at world class paralympic levels.

For me, my biggest motivator was to run the half marathon with my daughter who I had once had to carry home after we tried to run too far before knowing that her health was compromised by APS1. Autoimmune polyglandular syndrome type 1 (APS1) affects multiple organs due to mutations of the autoimmune regulator AIRE gene.[12] While the various organs affected can be medically managed, there is no cure. So in the grand scheme of things, the ability to run the half marathon was just one health issue for my daughter to conquer, and a way for me to relieve my lingering unnecessary parental guilt.

Conclusion

Ultimately, we did complete the half marathon. I ran without causing injury, walked down my stairs the next morning, and went to work without pain. My daughter beat me to the finish line by 10 minutes and was happy and inspired to run more. Honestly, my best-case scenario. My only problem is that now she wants us to run another!

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Civilian Lower Extremity Injuries Resulting from Fires in the United States

By Mathias B. Forrester, BS

Background: In 2023, an estimated 13,350 civilian fire injuries were reported in the United States (US). The objective of this study was to characterize civilian lower extremity injuries resulting from fires in the US.

Methods: Data were obtained from the National Fire Incident Reporting System (NFIRS), which collects information on incidents to which fire departments respond in the US. Cases were civilian lower extremity injuries resulting from fires reported to NFIRS during 2014-2023. The distribution of cases was determined for patient characteristics, type of injury, and circumstances of injury.

Results: A total of 4,309 records of civilian lower extremity injuries resulting from fires were reported to NFIRS during 2014-2023. The most common symptoms were 48.7% burns only (thermal), 11.1% burns and smoke inhalation, 8.5% burns (scald), and 5.8% cut or laceration. The injury severity was 50.8% minor, 32.3% moderate, 11.1% severe, 2.3% death, 2.0% life threatening, and 1.4% undetermined. The disposition was 58.6% transported to emergency care facility, 1.3% no transport to emergency care facility, and 40.1% not documented.

Conclusion: Several hundred civilian lower extremity injuries resulting from fires were reported to NFIRS each year. The majority of these injuries involved some type of burn, and most of these injuries were classified as minor or moderate. Most of the patients with a known disposition were transported to an emergency care facility. The information in this study may be useful for creating strategies to prevent or manage such injuries.

In 2023, local fire departments responded to an estimated 1.39 million fires in the United States (US). These fires caused an estimated 3,670 civilian fire deaths and 13,350 reported civilian fire injuries.[1]

The objective of this study was to characterize civilian lower extremity injuries resulting from fires in the US.

Methods

This retrospective epidemiologic study used data from the United States Fire Administration (USFA) National Fire Data Center (NFDC), which collects information on incidents to which fire departments respond in the National Fire Incident Reporting System (NFIRS).[2] Participation in NFIRS is voluntary, and not all US fire departments participate.[3,4] However, as of 2023, over 22,000 US fire departments in all 50 states reported incident data to NFIRS.[2-4]

After responding to an incident, participating fire departments submit information on the incident to NFIRS. The information provided describes the kind of incident, the location of the incident, the resources used to mitigate the incident, and other information to understand the nature and cause of the fire, hazardous material, or emergency medical service (EMS) incident. Information is also collected on civilian or firefighter casualties and an estimate of property loss.[2,3] NFIRS consists of 11 modules (data subsets). Not all modules are completed for all incidents. Information is first sent to local agencies, who then forward the completed NFIRS formation to the state agency responsible for NFIRS data. The state agency combines the information with data from other fire departments into a statewide database and then electronically sends the data to the NFDC at the USFA.[3]

Each year the USFA compiles publicly released NFIRS incident data that were collected by the states during the previous calendar year into a public data release (PDR) that is publicly available free of charge.[5] Each annual database can be downloaded at:[6] https://www.fema.gov/about/openfema/data-sets/fema-usfa-nfirs-annual-data

Cases were civilian lower extremity injuries

Table 1. Civilian lower extremity injuries resulting from fires reported to the National Fire Incident Reporting System during 2014-2023 by diagnosis and severity

Variable	Number	Percent
Primary apparent symptom		
Burns only: thermal	2,099	48.7
Burns and smoke inhalation	477	11.1
Burn: scald	365	8.5
Cut or laceration	252	5.8
Fracture	190	4.4
Strain or sprain	181	4.2
Other	510	11.8
Not documented	235	5.5
Severity		
Minor	2,189	50.8
Moderate	1,391	32.3
Severe	479	11.1
Death	100	2.3
Life threatening	88	2.0
Undetermined	62	1.4
Disposition		
Transported to emergency care facility	2,523	58.6
No transport to emergency care facility	58	1.3
Not documented	1,728	40.1
Total	**4,309**	

resulting from fires reported during 2014-2023. These injuries were identified using the NFIRS Civilian Fire Casualty Module, which should be completed by a fire department whenever there are civilian casualties resulting from a fire. A fire casualty is a person who is injured or killed because of a fire. This includes injuries or deaths from natural or accidental causes sustained while involved in the activities of fire control, attempting rescue, or escaping from the fire. If a civilian injury is not directly related to fire, it may be reported using the EMS Module.[3] Injuries in the EMS Module were excluded from the study. Lower extremity injuries were identified by searching the Civilian Fire Casualty Module for those records where the Primary Part of Body Injured (BODY_PART) numeric field included the code for the lower extremity: 7 Lower extremities (includes legs and feet). The field does not include codes for more specific parts of the lower extremity (eg knee, ankle, foot).

The distribution of cases was determined for patient characteristics, type of injury, and circumstances of injury. Since the data are publicly available and de-identified, the study is exempt from institutional review board approval.

Results

A total of 4,309 records of civilian lower extremity injuries resulting from fires were reported to NFIRS during 2014-2023, representing 4.2% of the 102,483 total injuries. Table 1 shows the distribution of these injuries by diagnosis and

Continued on page 30

Continued from page 29

Table 2. Civilian lower extremity injuries resulting from fires reported to the National Fire Incident Reporting System during 2014-2023 by patient characteristics

Variable	Number	Percent
Patient age (years)		
0-5	101	2.3
6-12	148	3.4
13-19	313	7.3
20-29	749	17.4
30-39	736	17.1
40-49	662	15.4
50-59	699	16.2
60-69	483	11.2
70-79	266	6.2
80+	152	3.5
Patient sex		
Male	2,712	62.9
Female	1,597	37.1
Patient race		
White	1,933	44.9
Black	802	18.6
Asian	41	1.0
American Indian, Eskimo or Aleut	19	0.4
Native Hawaiian or other Pacific Islander	6	0.1
Other, includes multi-racial	152	3.5
Undetermined or not documented	1,356	31.5
Total	**4,309**	

severity. The most commonly reported lower extremity injuries were burns only (thermal), burns and smoke inhalation, burn (scald), and cut or laceration, accounting for 74.1% of all of the injuries. A burn of some sort (thermal, scald, chemical, electric, not stated) was reported in 2,967 (68.9%) of the injuries. When the injury severity was examined, 83.1% of the injuries were classified as minor or moderate. Most of the patients with a documented disposition were transported to an emergency care facility.

Table 2 presents the distribution of civilian lower extremity injuries resulting from fires by patient characteristics. The highest proportion of patients were aged 20-29 years followed by patients aged 30-39 years; the mean patient age was 42 years. Most of the patients were male. Of those patients with a documented race, the majority were White followed by Black. The patient ethnicity (not shown) was 285 (6.6%) Hispanic, 1,665 (38.6%) other, and 2,359 (54.7%) not documented.

The annual number of reported civilian lower extremity injuries resulting from fires ranged

Table 3. Civilian lower extremity injuries resulting from fires reported to the National Fire Incident Reporting System during 2014-2023 by circumstances of the injury

Variable	Number	Percent
Cause of injury		
Exposed to fire products	2,764	64.1
Jumped in escape attempt	330	7.7
Fell, slipped, or tripped	302	7.0
Struck by or contact with object	187	4.3
Other	363	8.4
Undetermined or not documented	363	8.4
Activity when injured		
Fire control	1,133	26.3
Escaping	998	23.2
Sleeping	221	5.1
Irrational act	160	3.7
Other	842	19.5
Undetermined or not documented	955	22.2
Location at time of incident		
In area of origin and involved	1580	36.7
In area of origin and not involved	898	20.8
Not in area of origin and not involved	607	14.1
Not in area of origin but involved	289	6.7
Other location	33	0.8
Undetermined or not documented	902	20.9
Total	**4,309**	

between 436 and 495 (annual mean 477) during 2014-2019 and 337 and 376 (annual mean 362) during 2020-2023. There were 1,094 (25.4%) reported injuries during January-March, 1,124 (26.1%) during April-June, 1,073 (24.9%) during July-September, and 1,018 (23.6%) during October-December. The number of injuries varied little by day of the week (data not shown). The states with the highest number of reported injuries were 363 (8.4%) Florida, 290 (6.7%) Texas, 275 (6.4%) Ohio, 238 (5.5%) Illinois, 228 (5.3%) California, and 205 (4.8%) North Carolina.

Table 3 presents the distribution of civilian lower extremity injuries resulting from fires by the circumstances of the injury. The majority of injuries were caused by exposure to fire products. The most common activities when injured were fire control and escaping. Most of the patients were in the area of fire origin at the time of the incident.

Discussion

This study examined civilian lower extremity injuries resulting from fires reported to a national database during a recent 10-year period. Although lower extremity injuries comprised only 4% of the total injuries, several hundred civilian lower extremity injuries resulting from fires were reported each year.

The most commonly reported lower

Continued on page 32

Continued from page 31

extremity injuries were burns only (thermal), burns and smoke inhalation, burn (scald), and cut or laceration, accounting for 74% of all of the lower extremity injuries. Burns of any type accounted for 69% of the injuries. Half of the injuries were classified as minor, and an additional 32% were classified as moderate. Despite this, the majority of the patients with a documented disposition were transported to an emergency care facility.

Of the civilian lower extremity injuries resulting from fires, the highest proportion of patients were aged 20-29 years followed by patients aged 30-39 years, and 63% of the patients were male. This is consistent with NFPA research, which found that the highest proportion of patients with home fire injuries during 2015-2019 were aged 25-34 years, and 55% of the patients were male.[7]

The annual mean number of civilian lower extremity injuries resulting from fires was 477 during 2014-2019 and 362 during 2020-2023, a 24% decline in the latter part of the study period. A similar pattern was observed for firefighter lower extremities.[8] Between 2013 and 2022, residential building fires declined by 4%.[9] In addition, the COVID-19 pandemic that began in late 2019-early 2020, and the associated societal disruptions, may have affected the risk of people being injured in fires. One study found that, during January-June 2020, the number of cooking fires and residential fires increased in San Francisco but remained similar in New York City when compared to previous years.[10]

Florida reported the highest number of civilian lower extremity injuries resulting from fires, followed by Texas, Ohio, Illinois, California, and North Carolina. This may be due to geographic differences in the number of fires or the risk of civilian lower extremity injuries resulting from fires. Alternatively, it may be due to geographic differences in fire department participation in NFIRS.

Exposure to fire products accounted for 64% of the civilian lower extremity injuries resulting from fires. The most common activities when injured were fire control and escaping, and most of the patients were in the area of fire origin at the time of the incident. This information may be useful for the development of strategies to prevent civilian lower extremity injuries resulting from fires.

There are limitations to this study. Participation in NFIRS is voluntary. Thus, the NFIRS database does not include all incidents to which all US fire departments respond.[4] This particularly needs to be considered in the analysis of certain variables such as geographic region. Moreover, each record only documents a single primary apparent symptom and the associated primary part of body injured. An injury may involve multiple symptoms and/or multiple body parts. Thus, the number of lower extremity injuries included in the study should be considered a minimum number of such injuries. Furthermore, the Primary Part of Body Injured numeric field only includes a single code for the lower extremity; the field does not include separate codes for more specific parts of the lower extremity (eg, knee, ankle, foot).

In conclusion, this study found that several hundred civilian lower extremity injuries resulting from fires were reported to a national database each year. Although the majority of these injuries were considered to be mild or moderate, most of the patients with a documented disposition were transported to an emergency care facility. The information in this study may be useful for creating strategies to prevent and manage civilian lower extremity injuries resulting from fires. ler

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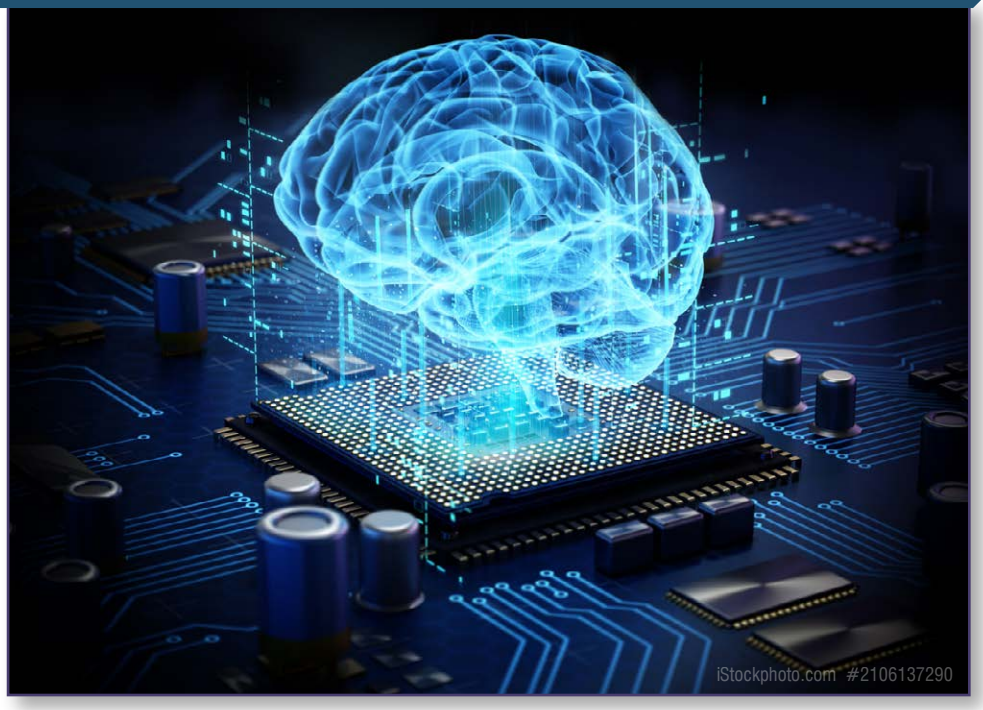
Machine Learning Combined with Explainable Artificial Intelligence Facilitate Accurate Balance Ability Classification

By Huey-Wen Liang, Rasoul Ameri, Shahab Band, Hsin-Shui Chen, Sung-Yu Ho, Bilal Zaidan, Kai-Chieh Chang, and Arthur Chang

Using computerized posturographic parameters provides a highly quantitative and objective measure without ceiling or floor effect as a classifier or predictor of falls.



The balance control problem is one of the major contributing factors to falls and may change with aging, medication, or acute illness. Computerized posturography obtained in standing conditions has been applied to classify fall risk for older adults or disease groups. Combining machine learning (ML) approaches is superior to traditional regression analysis for its ability to handle complex data regarding its characteristics of being high-dimensional, non-linear, and highly correlated. The study goal was to use ML algorithms to classify fall risks in community-dwelling older adults with the aid of an explainable artificial intelligence (XAI) approach to increase interpretability.

Methods

A total of 215 participants were included for analysis. The input information included personal metrics and posturographic parameters obtained from a tracker-based posturography of 4 standing postures. Two classification criteria were used: with a previous history of falls and the timed-up-and-go (TUG) test. The study authors used 3 meta-heuristic methods for feature selection to handle the large numbers of parameters and improve efficacy, and the SHapley Additive exPlanations (SHAP) method was used to display the weights of the selected features on the model.

Results

The results showed that posturographic parameters could classify the participants with TUG scores higher or lower than 10 seconds but were less effective in classifying fall risk according to previous fall history (Figure). Feature selections improved the accuracy with the TUG as the classification label, and the Slime Mould Algorithm had the best performance (accuracy: 0.72 to 0.77, area under the curve: 0.80 to 0.90). In contrast, feature selection did not improve the model performance significantly with the previous fall history as a classification label. The SHAP values also helped to display the importance of different features in the model.

Discussion

XAI represents a cutting-edge approach that seeks to establish transparency and trustworthiness in machine learning models. This study contributes to the field by documenting the influence of posturographic parameters derived from various stance conditions and personal metrics on the model's performance. The main advantage of using SHAP is the transparency to identify which features are driving a model performance

This article has been excerpted from "Fall risk classification with posturographic parameters in community-dwelling older adults: a machine learning and explainable artificial intelligence approach." Journal of NeuroEngineering and Rehabilitation (2024) 21:15. https://doi.org/10.1186/s12984-024-01310-3. Editing has occurred, including the renumbering or removal of tables and figures, and references have been removed for brevity. Use is per CC Attribution 4.0 International License.

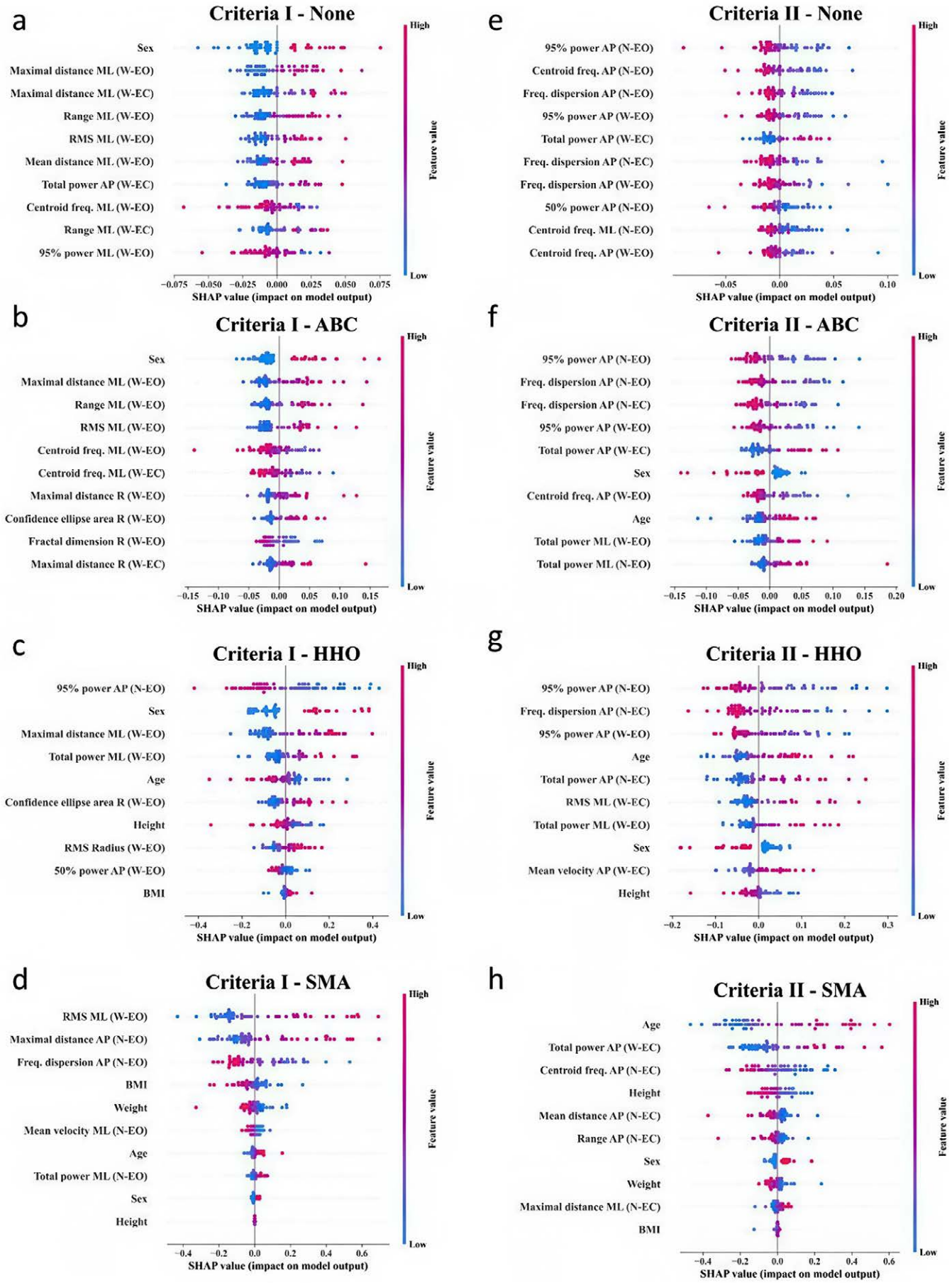


Figure: The SHAP summary visualization of the proposed model. The higher SHAP value of a feature corresponds to the higher prediction and feature importance for the different machine learning models were listed top-down.

Continued on page 36

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and how much each feature is contributing to the model. This study used posturographic data from 4 stance conditions from the combination of stance width and eyes open/closed; the results illustrated the significance of postural control strategies when individuals modify their stance width and rely on visual information cues. This investigation provides valuable insights into the role of these factors in shaping the model's decision-making process and enhances our understanding of the underlying mechanisms governing postural control in different contexts. Several posturographic and personal metrics demonstrated a high contribution to the fall risk classification, as determined by SHAP's output based on different feature selection approaches. It seemed that the posturographic parameters obtained during feet apart with eyes open (W-EO) and feet apart with eyes closed (W-EC) conditions attributed more weight to the output with criteria I. The parameters obtained during feet together (E-EC), the most challenging task, had higher attribution to the output with criteria II. It explained that a contribution of increased body sway in these challenging standing tasks, and a declined postural control could be classified effectively. The results highlight the potential utility of these features in classifying fall risk and provide guidance for the development of more robust and accurate fall classification models among community-dwelling older adults.

Conclusion

Posturographic parameters in standing can be used to classify fall risks with high accuracy based on the TUG scores in community-dwelling older adults. Using feature selection improves the model's performance. The results highlight the potential utility of ML algorithms and XAI to provide guidance for developing more robust and accurate fall classification models. The results highlight the potential utility of these features in classifying fall risk and provide guidance for the development of more robust and accurate fall classification models among community-dwelling older adults. ler

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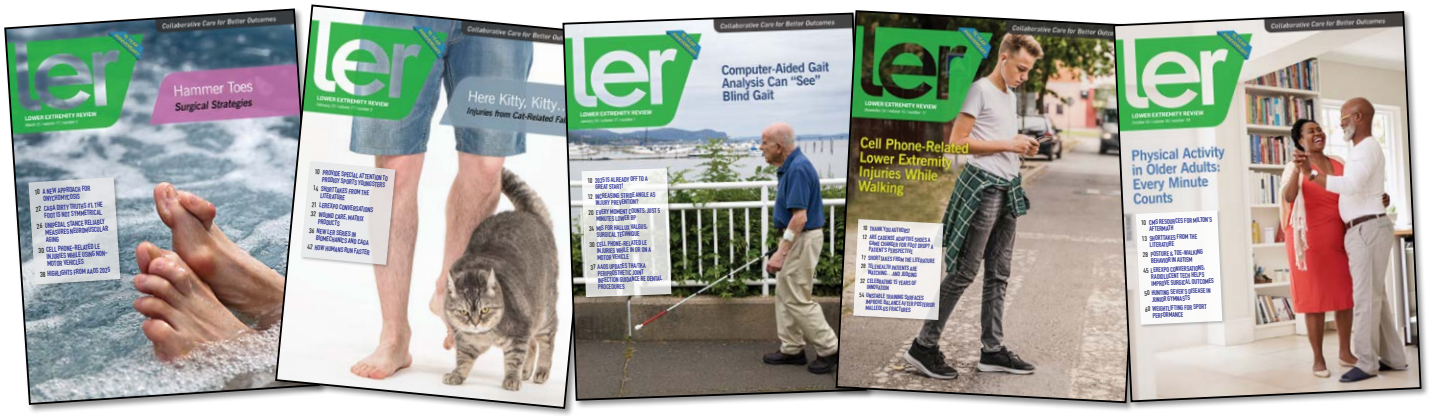

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New & Noteworthy

Noteworthy products, association news, and market updates

BUNION SCREW TECHNOLOGY

Voom™ Medical Devices's Revcon™ bunion screw technology is indicated for use in minimally invasive bunion surgery (MIBS). The patented dual-zone screw technology features alternating non-compressive thread pitches targeted to the cortical and cancellous regions of the metatarsal, helping to optimize fixation with a Single Screw™ and reduce operating room times. The system also includes a guide for best practices in performing the proprietary Transveron™ osteotomy, achieving correct screw placement, and navigating common challenges in MIBS. This system and the Single Screw™ technology allows correction of bunions of all sizes. The technology also cuts the learning curve and makes it easy for surgeons to replicate the procedure with confidence.

Voom Medical Devices
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SENSORY NEUROPROSTHESIS AIDS STUMBLE RECOVERY

A sensory neuroprosthesis (SNP) developed by researchers at Case Western Reserve University and the Louis Stokes Cleveland Veterans Affairs Medical Center has shown promise in improving balance and reducing fall risk for people with lower limb loss. High-density nerve cuff electrodes are installed around the peripheral nerves in the residual limb. Electrical stimulation through these electrodes elicits sensations that are perceived as originating from the participant's missing limb.

In 1 area of their work, this technology is incorporated into an SNP. An instrumented prosthesis detects and communicates the pressure profile applied to the prosthetic foot and the electrical stimulation is adjusted to match. With this system, the participant feels sensations corresponding to the foot-floor interactions.

They are also working to restore intuitive control to prosthesis users by interfacing with the remaining muscles in the leg. This is achieved by implanting intramuscular EMG recording electrodes within selected leg and hip muscles.

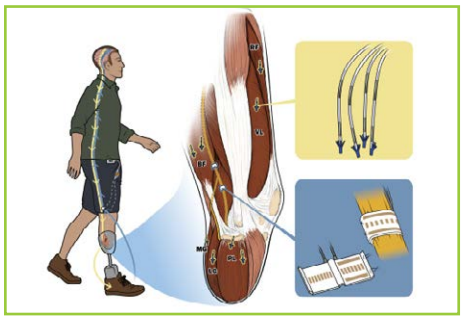

Image courtesy of the researchers.

By interpreting and integrating muscle activity data with a robotic prosthesis, the researchers can create a more intuitive way for users to control their prosthetic limbs. This leads to what they call a 'bidirectional neuroprosthesis', combining restored sensation of the foot with natural movement control. Through this reconnection of neural pathways, they can explore improvements in walking, balance, and the ability to handle uneven or challenging terrains. Ultimately, their goal is to enhance overall functionality and quality of life for prosthesis users.

The researchers are also working on quantifying the impact this neural sensory stimulation can have on the health of the residual limb (ie, if it can increase blood flow and oxygen perfusion), which is especially important for those with diabetes, peripheral neuropathy, or other vascular diseases.

VIBRATION STIMULATION FOR TENDINOPATHY

Tend-Deep is an easy-to-use, at-home wellness device that uses pinpointed direct vibrational stimulation with multiple patterns and settings to provide convenient at-home treatment for pain points and tendons. The device's direct vibration stimulation specifically targets any tendon or area that has pain, swelling, or stiffness, or needs circulation, with 6 vibration patterns and 4 speed settings. With a primary focus on tendons, the material surface and compact size of Tend-Deep works as a trigger point tool and trigger point release for targeting any area of pain on the body. It's waterproof, recharges in 2 hours, and is made out of body-safe recycled aluminum with a US Food & Drug Administration–grade silicone handle.

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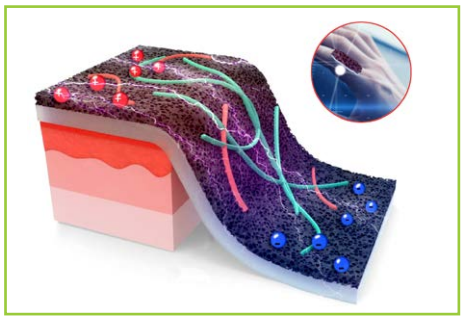
SMART SENSOR TAKES THE PAIN OUT OF WOUND MONITORING

Researchers from Pennsylvania State University (Penn State) and China's Hebei University



The flexible sensor, ideal for use in the human body, uses laser-induced graphene to simultaneously but separately measure temperature and strain, potentially enabling better wound healing monitoring by providing clearer insights into inflammation and recovery. Image courtesy of the researchers.

of Technology aimed to accurately measure temperature and strain signals without cross-talk by using laser-induced graphene (LIG), a 2-dimensional (2D) material. In doing so, they stumbled upon the fact that this material also has thermoelectric properties, said Huanyu "Larry" Cheng, James L. Henderson, Jr. memorial associate professor of engineering science and mechanics (ESM) at Penn State. Thermoelectric properties in a material refer to the ability to convert temperature differences into electrical voltage and vice versa, enabling such materials to be used for applications like energy harvesting and temperature sensing. According to Cheng, this newly identified thermoelectric property of LIG makes it easy to separate the 2 sensor measurements and ideal for healthcare applications such as a sensor embedded in a bandage.

"[B]y using this thermoelectric effect…we can look at the electrical resistance to get information about the strain, while also measuring the thermal voltage to determine the temperature," said Cheng. "This is why doctors could use it to track both temperature fluctuations and physical changes in the wound site and give a much clearer picture of how the healing is progressing."

He also noted that the sensor is highly sensitive, detecting temperature changes as small as 0.5 degrees Celsius. The material's design takes advantage of the way porous graphene and thermoelectric components work together, making it nearly 4 times better at converting heat into electricity. The sensor can also stretch up to 45%, as well as conform to different shapes and surfaces, without losing function.

Since the thermoelectric aspect of LIG also means it can generate electrical power when there is a temperature difference, LIG sensors are self-powered. This could be particularly useful for continuous monitoring in clinical settings and for other applications, such as helping to detect fires in remote locations.

In addition to refining the sensor, the team is developing a wireless system that will allow people to monitor the data from the sensor remotely. This will make it possible to track important information, such as temperature or strain, in real time using smartphones or other devices.

ELEVATING WALKER-CHAIR

The Zeen® is a groundbreaking "Elevating Walker-Chair" that supports mobility and autonomy for those whose lives are restricted due to a variety of physical limitations. Compared to traditional walkers and wheelchairs, the device continually supports users while seated or standing—all while providing an active lift through transitions. It is ideal for those who are at risk of falling while moving throughout their day, and for those who tire easily when walking due to disability, injury, age, or chronic condition. It offers unique social benefits, permitting individuals to rest and converse at eye-level height in "barstool mode" rather than in a low position with their heads at others' waist-height. Every Zeen comes standard with never-flat tires. For those who are limited to use of a single hand, one-handed controls are available. The device is indicated for users who weigh between 100 and 250 pounds, with a stand-over height between 22 and 36 inches.

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COMPRESSION CALF SLEEVES

The R2 3.0 compression calf sleeve by COMPRESSPORT® is designed to increase stability and reduce shocks. The seamless, multi-gradual compression, quick-drying fabric, and specially designed K-Protect band reduce impact. The new 3D weave activates the proprioceptors: improved balance and stability, especially when running downhill. Targeted areas stimulate microcirculation and reduce inflammation with the aim of limiting the risk of tendinitis and periostitis and improving lymphatic circulation. The targeted compression on the calves helps to absorb shock and reduce vibration for less muscle fatigue, tiredness, and cramping. The R2 3.0 calf sleeve is available in a variety of colors and 4 sizes.

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Clove Nursing Shoes are engineered to keep up with the rigorous demands of medical professionals, providing all-day comfort and stability. A 10mm heel drop and blister-preventing heel cup ensure maximum comfort during long shifts. ASTM-certified slip-resistant outsoles offer superior traction on slick surfaces. Fluid-repellent materials make it easy to clean spills and stains for a professional appearance. Removable OrthoLite® inserts combat bacteria and odors, promoting freshness shift after shift. Made with premium vegan Clarino™ fabric, these shoes deliver a stylish, leather-like finish while being environmentally conscious. The shoes are available in a variety of colors and styles. Clove Classic original design is available in men's, women's, and unisex fits, delivering lasting comfort and support. Clove Solo is a sleek, slip-on style. Clove Forte offers enhanced cushioning with dual-density foam. Clove Alto is lightweight and flexible, featuring a ripstop upper and SuperCush™ technology.

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TRIAL TO DETERMINE MOST EFFECTIVE TREATMENT FOR HIP FRACTURE IN OLDER ADULTS

A new $10.8 million multicenter clinical trial co-led by Gerard Slobogean, MD, MPH, an associate professor of orthopaedics and director of clinical research in the department of orthopaedics at the University of Maryland School of Medicine (UMSOM), will determine if hip arthroplasty produces better outcomes for patients age 60 and older who have sustained femoral neck fractures compared to simpler "internal fixation," which has been performed for decades. Their goal is to improve patient outcomes.

"We want to answer the question, 'When an older adult has this type of broken hip, does fixing the fracture or replacing the hip best reduce death, maintain their ability to walk, increase their time at home and improve their overall health?'" Slobogean said. "Currently, we have limited clinical research to help patients, caregivers and orthopaedic surgeons choose the best treatment for each patient."

The randomized controlled clinical trial is set to begin in the fall. They plan to enroll 600 patients age 60 or older who need surgery for minimally displaced femoral neck fractures, at 32 tertiary care and community hospitals in the United States, Canada, the United Kingdom, Spain, the Netherlands, and Norway. Patients will be randomly selected to receive either internal fixation or hip replacement surgery and investigators will follow them for 12 months.

"Evidence from head-to-head clinical trials will help surgeons advise patients on whether to choose an immediate hip replacement, which is more time-consuming and involves more blood loss, or an internal fixation procedure that may require another surgery later," said Mark T. Gladwin, MD, the John Z. and Akiko K. Bowers distinguished professor and dean of UMSOM, and vice president for medical affairs at University of Maryland, Baltimore.

NEW MATERIAL ALLOWS ADJUSTMENTS TO PROSTHETIC LIMB FIT THROUGHOUT THE DAY VIA SMARTPHONE

A new dynamically adaptive material, 'Roliner,' that was developed by researchers at the Imperial College London, department of bioengineering, offers amputees the power to change the shape, volume, and stiffness of the liner that is used to attach a prosthetic limb's socket to a residual leg. Amputees could make these tweaks using their smartphone in real-time, providing a more comfortable and personalized fit.

The solution enables individuals to manage their prosthetic limbs and give them more control over their condition; avoid chronic pressure ulcers; and remain more active and productive by enjoying pain-free daily lives. Image courtesy of Imperial College London.

The material can incorporate artificial intelligence so each liner can 'learn' the personal preferences of the user. It can automatically adjust its properties according to how the human body changes in response to variables such as the time of day, weight loss or gain, and hormonal fluctuations. An amputee's desired fit may also change due to the type of activity being undertaken. For example, they may prefer a looser fit while sitting and a tighter, more controlled fit when walking.

Roliner is made from silicone elastomers with channels that can be pressurized to change the material's properties, meaning its volume and shape can change. Its data-driven approach standardizes the quality of prosthetic fittings. The researchers also believe that the technology could have applications beyond prosthetics, because it could be used in any situation where rigid materials must touch the human body. For example, Roliner could be used to increase the flexibility of exoskeletons used in rehabilitation, to modulate the pressure points of hospital beds, or to improve the personalized fit and safety potential of protective gear such as ski boots and even wearables used by astronauts in space

IMPROVED SENSOR ALLOWS RESEARCHERS TO STUDY DAILY WALKING TO MITIGATE TRIPPING

Associate Professor Peter Adamczyk and PhD student Katherine Heidi Fehr, holding a prosthetic foot, in the UW BADGER Lab. Image courtesy of Tom Ziemer.

Using a wearable sensor similar to those used in smartwatches and fitness bands, University of Wisconsin-Madison (UW-Madison) engineers have developed a new, easy and low-cost method that goes beyond step counts: It allows researchers to see how a person walks in daily life.

In their method, people go about their daily activities with a small motion sensor attached to their shoe. Graduate student Yisen Wang developed an improved method for reconstructing the motion of that sensor accurately enough to measure the details of its 3D movement, including rotation and height. The researchers combine the sensor data of the foot's movement with a 3D scan of the person's shoe. The resulting model allows the researchers to reconstruct and analyze the movement of the whole foot. That's in contrast with other techniques that only consider the tip of the toe when the foot is swinging, providing a surrogate measure of foot clearance that might not be accurate.

Being able to analyze the movement of the whole foot provides a more accurate measurement of the real-world foot clearance and a better understanding of an individual's risk of tripping. In particular, the researchers measure foot clearance while in the swing phase of walking. That's crucial for understanding and reducing the risk of trip-and-fall incidents for people with gait difficulties.

The method also could draw on a single low-cost sensor and a phone with 3D scanning capabilities, making it widely accessible. The team is now using their method to study how different assistive devices help people with multiple sclerosis and how different prosthetic feet can improve users' gait.

SPS AWARDS O&P STUDENT SCHOLARSHIPS

SPS, Alpharetta, Georgia, a U.S. distributor of orthotic and prosthetic (O&P) products, has awarded 2 recipients—Gunnar Zellman, Concordia University, St. Paul, Minnesota, and Kate Menzer, University of Texas Southwestern Medical Center—with its 2025 SPS O&P Master's Scholarship, which is given to promising students pursuing a career in the O&P industry. The students were chosen based on their excellent leadership skills, academic achievements, and written essay submissions. Each will receive $2,500 toward their educational pursuits.

"Each year, getting a new prosthetic leg became a significant moment in my life, even though I didn't recognize it at the time," said Zellman. "I know firsthand how confusing and isolating it can be for a child to go through an amputation or feel different from their peers. Mobility challenges can be especially difficult for young people to navigate, which is why I am so dedicated to this field."

Menzer stated that she decided to pursue a career in O&P because she has witnessed the joy that results from a medical device that restores function. "I have had the opportunity to see people gain function and independence with the help of a certified prosthetist/orthotist, and they all have the similar features: a massive smile and the correct medical device to support their movement and hope."

For updates about the 2026 application process, please visit spsco.com/op-master-scholarship.

SEMI-FLEXIBLE LIGAMENT ORTHOSIS

As the newest addition to Bauerfeind's knee portfolio, the innovative SecuTec Genu Flex knee orthosis stabilizes the knee joint and relieves the ligaments. The device features a Flex-Link System that enables a precise and secure fit throughout each state of recovery for complex knee injuries; Flex-Links can be easily added or removed as therapy progresses, to accommodate for swelling or regaining of muscle mass. The semi-flexible frame design adapts to the circumference of the upper and lower leg while moving and stays security in position. Telescoping hinges with tool-free flexion/extension limitation provide individual fit and use. The lightweight, low-profile design with soft microfiber cushions offers high patient compliance. Code L1845/L1852 approved.

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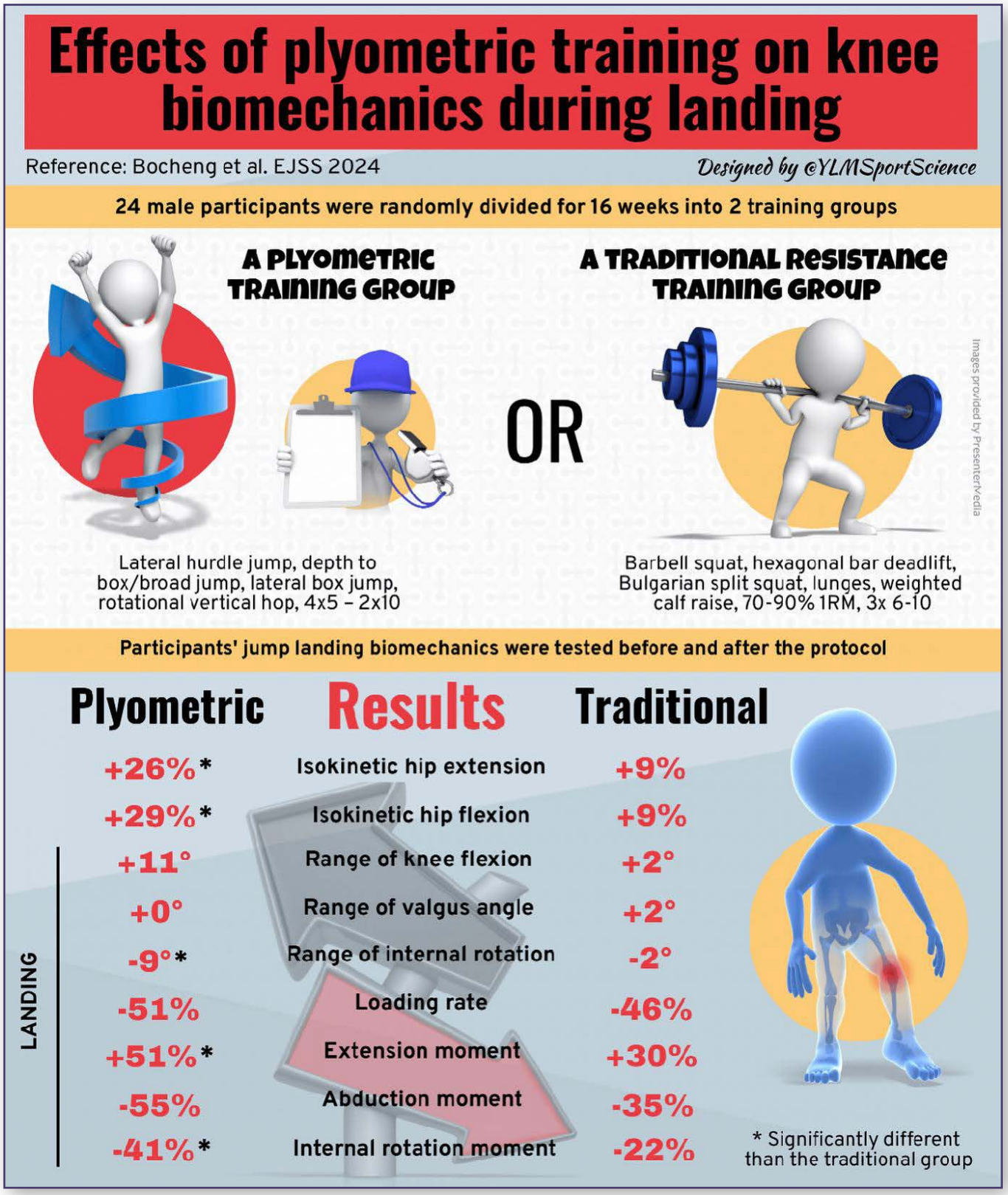

Source: Bocheng C, Ziyan Y, Jiaxin W, Wang G, Tiancheng Y. Effects of 16 weeks of plyometric training on knee biomechanics during the landing phase in athletes. Eur J Sport Sci. 2024;24(8):1095-1109. doi: 10.1002/ejsc.12174.

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