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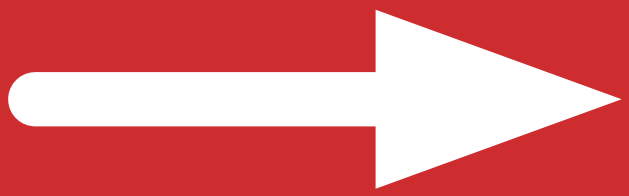

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Lower Extremity Review

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

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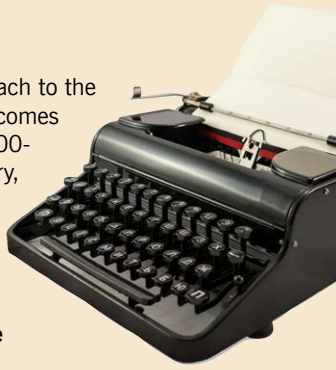

LER encourages a collaborative multidisciplinary clinical approach to the care of the lower extremity with an emphasis on functional outcomes using evidence-based medicine. We welcome manuscripts (1000-2000 words) that cross the clinical spectrum, including podiatry, orthopedics and sports medicine,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

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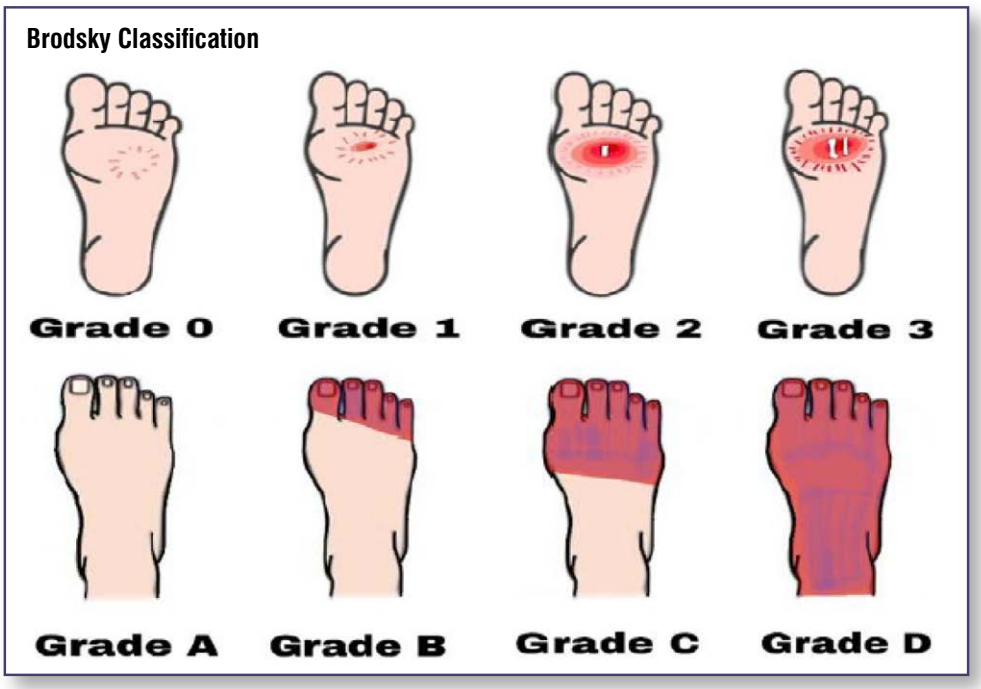
Factors Influencing Wound Healing in Diabetic Foot Patients

By Sang Heon Lee, Sung Hwan Kim, Kyung Bum Kim, Ho Sung Kim, and Young Koo Lee

Diabetic foot is defined as a foot affected by ulceration that is associated with neuropathy and/or peripheral arterial disease of the lower limb in a patient with diabetes. These authors focused on nutrition as a source of healing and examined the correlation between various trace elements and wound healing in patients with diabetic foot ulcers.

Diabetic foot stands out as one of the most consequential and devastating complications of diabetes. Many factors, including VIPS (Vascular management, Infection management, Pressure relief, and Source of healing), influence the prognosis and treatment of diabetic foot patients. There are many studies on VIPS, but relatively few studies on "sources of healing." Nutrients that affect wound healing are known, but objective data in diabetic foot patients are insufficient. We hypothesized that "sources of healing" would have many effects on wound healing. The purpose of this study is to know the affecting factors related to the source of healing for diabetic foot patients.



Diabetic foot ulcers based on Brodsky's classification. Grade 0 has no sign of ulceration, but persistent pain is present. Grade 1 is a superficial ulcer. Grade 2 indicates deep ulceration toward the bone. Grade 3 means exposure to severe infection (osteomyelitis). Grade A has no ischemia. Grade B indicates ischemia but no gangrene. Grades C and D are partial and complete gangrene infections with ischemia, respectively. Reprinted from Appl. Sci. 2022;12:11777. https://doi.org/10.3390/app12221177 7.

Methods

A retrospective review identified 46 consecutive patients who were admitted for diabetic foot management from July 2019 to April 2021 at our department. The wound size was measured manually using a ruler in operation rooms. Several laboratory tests were performed for influencing factor evaluation. We checked serum levels of total protein, albumin, vitamin B, iron, zinc, magnesium (Mg), copper (Cu), hemoglobin (Hb), HbA1c, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol. These values of diabetic foot patients were compared with normal values. Patients were divided into 2 groups based on wound healing rate, age, length of hospital stay, and sex, and the test values between the groups were compared.

This article has been excerpted from "Factors Influencing Wound Healing in Diabetic Foot Patients" by same authors as published in Medicina (Kaunas). 2024; 27;60(5):723. doi: 10.3390/medicina60050723. Editing has occurred, including the removal and renumbering of tables and figures, and references have been removed for brevity. Figures are reprinted from Ansari P, Akther S, Khan JT, et al. Hyperglycaemia-Linked Diabetic Foot Complications and Their Management using Conventional and Alternative Therapies. Appl. Sci. 2022;12:11777. https://doi.org/10.3390/app12221177 7. Use is per CC Attribution 4.0 International License.

Results & Discussion

The wound healing rate was measured using the initial wound size and the change of the wound size after 1 week of treatment. Wound healing rate (%) = [(Initial wound size − wound size after 1 week)/Initial wound size] × 100. The wound healing rate was divided into 2 groups based on a 20% threshold and the differences were compared in 2 groups. There were no differences in demographic characteristics based on wound-healing rate. There was no significant difference in age, American Orthopedic Foot and Ankle Society score, visual analog scale (VAS) score, or length of stay between the 2 groups.

The facts learned from this study are that levels of albumin (37%) and Hb (89%) were low in the diabetic foot patients; as for trace elements, levels of iron (97%) and zinc (95%) were low in these patients, but levels of magnesium and copper were usually normal or high. However, when compared to normal adult values, diabetic foot patients in our data exhibited significantly lower levels of Hb, total protein, albumin, iron, zinc, Cu, and HDL cholesterol. When compared based on age and length of hospital stay, hemoglobin levels were significantly lower in both the older age group and the group with longer hospital stays. Glycemic control, as indicated by the mean HbA1c of 7.90 (7.46, 8.35), was generally poor, which is not unexpected. The Table details average values of diabetic foot ulcer patients and comparison with normal values.

Table. Average Values of Diabetic Foot Ulcer Patients and Comparison with Normal Values

	Less than 2 Weeks (N = 27)	More than 2 Weeks (N = 19)	*p*-Value
HbA1C (%)	7.99 ± 1.73	7.78 ± 1.09	0.6261
Hb (g/dL)	10.98 ± 2.28	9.51 ± 1.71	0.0215
Total protein (g/dL)	7.10 ± 0.51	6.77 ± 0.70	0.0685
Albumin (g/dL)	3.53 ± 0.51	3.16 ± 0.51	0.0195
Fe (ug/dL)	36.44 ± 18.38	34.32 ± 17.84	0.6974
Mg (ug/dL)	2.17 ± 0.32	2.09 ± 0.33	0.4242
Zn (ug/dL)	57.08 ± 12.38	63.77 ± 17.94	0.1458
Cu (ug/dL)	137.62 ± 28.56	140.36 ± 20.71	0.7248
Vitamin B12 (pg/mL)	648.30 ± 513.52	838.32 ± 628.54	0.2662
HDL-cholesterol (mg/dL)	35.78 ± 8.50	34.68 ± 15.50	0.7598
LDL-cholesterol (mg/dL)	73.63 ± 32.32	61.32 ± 26.59	0.1789
Ages	58.93 ± 7.88	63.68 ± 8.20	0.0536

Less than 2 Weeks = Wound healing rate ≤20% (normal); More than 2 Weeks = Wound healing rate >20%.

While hypoglycemia has been linked to vascular complications in diabetes, the majority of the literature, including this section, concentrates on the adverse impacts of hyperglycemia in relation to the onset and advancement of diabetic foot ulcers. Hyperglycemia plays a role in the development of atherosclerosis, which in turn impedes the delivery of essential nutrients to wounds, thereby hindering the healing process. Additionally, in individuals with diabetes, hyperglycemia has been identified as a potential factor leading to dysfunction of endothelial cells, which are essential for the healing of diabetic foot ulcers through pressure-induced vasodilation, a response that typically serves as a protective mechanism for the skin. In addition to endothelial cells, hyperglycemia disturbs essential mechanisms crucial for re-epithelialization, such as the synthesis of proteins, migration, and proliferation of keratinocytes and fibroblasts. Another way in which hyperglycemia hampers wound healing is through the generation of free radicals due to decreased activity of antioxidant enzymes such as glutathione peroxidase and superoxide dismutase. This could partly elucidate why other research has indicated that prolonged uncontrolled hyperglycemia correlates with elevated levels of markers related to the skin-aging process, specifically advanced glycation end products (AGEs) and their receptors. Hyperglycemia can also induce the production of reactive oxygen species (ROS) through pathways including polyol, hexosamine, protein kinase C, and advanced glycation end products (AGEs). While reactive oxygen species are necessary for the initial phases of wound healing, an imbalance in their production has been demonstrated to be detrimental to the later stages of the healing process. In particular, heightened levels of reactive oxygen species can inflict damage on the blood supply, metabolism, and structure of peripheral nerves. This damage to nerves can result in sensory, motor, and/or autonomic dysfunction, with each impairment independently elevating the risk of developing a diabetic foot ulcer. Collectively, these alterations induced by uncontrolled hyperglycemia render the skin more vulnerable to injury and infection, thereby impairing the process of wound healing.

Anemia has been reported as a complication of DM and is associated with poor wound healing, amputation, and increased mortality. Recent studies have shown that anemia is prevalent among patients with DM, particularly in those with diabetic foot ulcers. A meta-analysis revealed that the severity of anemia was positively correlated with the severity of diabetic foot ulcers and could potentially serve as a predictor of amputation and mortality. Retrospective cohort studies, including research on 654 and 353 patients with diabetic foot ulcers, have identified anemia as significantly associated with larger, deeper ulcers, more severe infections, higher risk of amputation, and increased mortality rates, In the present study, hemoglobin (Hb) levels were significantly lower in diabetic foot patients compared to healthy individuals, particularly among those over 60 years of age and those hospitalized for 2 weeks or more. Addressing anemia will be crucial for promoting wound healing in diabetic foot patients. In this study, iron levels were significantly lowered in DM foot patients

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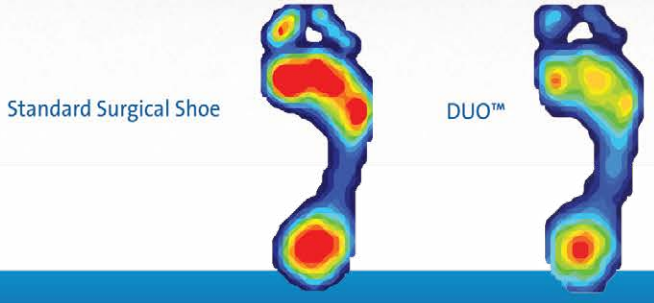

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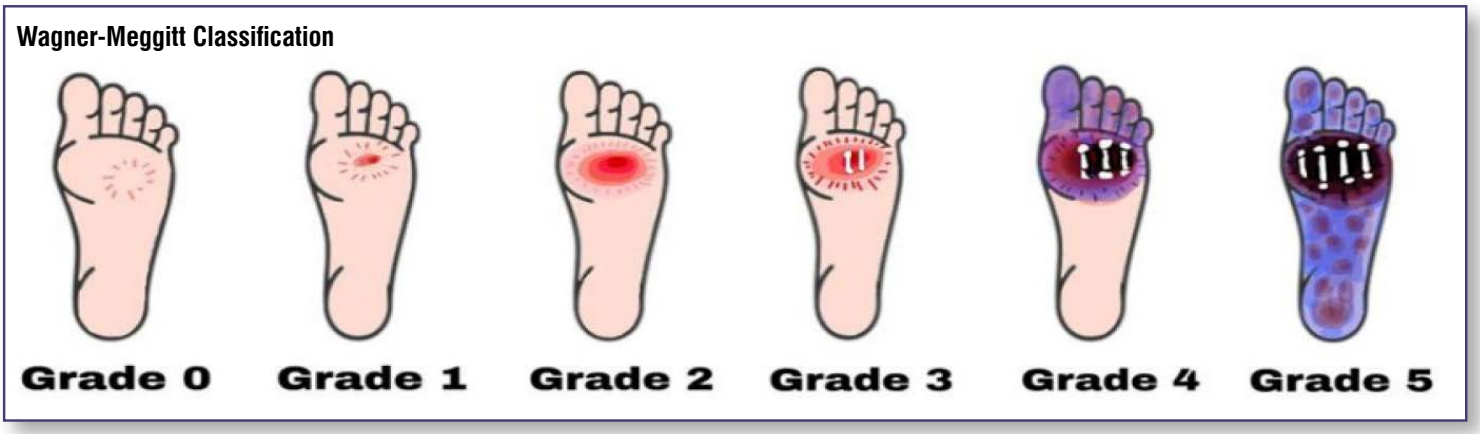

Diabetic foot ulcers are categorized using the Wagner–Meggitt classification. Grade 0 means no break in the skin. Grade 1 indicates a superficial ulcer. Grade 2 indicates a deep ulcer. Grade 3 shows the presence of osteomyelitis. Grade 4 is identified as forefoot gangrene. Grade 5 is recognized as complete foot exposure to gangrene. Reprinted from Ansari et al. Appl. Sci. 2022;12:11777. https://doi.org/10.3390/app12221177 7.

compared to healthy people. Iron supply will be important for the treatment of iron deficiency anemia, the main cause of anemia.

Albumin has the ability to maintain the function of endothelial cells. Albumin also improves microcirculatory blood flow and reduces inflammation and oxidative damage. Hypoalbuminemia is a risk factor for wound healing in diabetic foot ulcers. Recent studies of patients with a diabetic foot ulcer showed that serum albumin levels were significantly lower than that in diabetic patients without a diabetic foot ulcer and that low albumin level was an independent predictor for delayed wound healing. Similarly, in this study, albumin levels were significantly lowered in DM foot patients compared to healthy people. Also, the albumin level was measured to be low in patients who were hospitalized for more than 2 weeks. For wound healing, it is thought that albumin level correction and nutrition supply are important.

Magnesium plays an important role in carbohydrate metabolism as a cofactor of enzymes needed for the phosphorylation of glucose and is also required for glucose transport. Low intracellular levels negatively affect tyrosine kinase activity, glucose transport in cells, and post-receptor insulin action, which, in turn, accentuates hyperglycemia. Reza Razzaghi et al, in their randomized, double-blind, placebo-controlled trial, observed significant benefits in the reduction of ulcer length, width, and depth with Mg supplements for a period of 12 weeks in diabetic foot ulcer patients. A study by Martha Rodríguez-Morán et al showed a strong relationship between hypomagnesemia and foot ulcers in subjects with type 2 diabetes. Magnesium, which was thought to affect wound healing in previous studies, did not differ between the DM foot patients and healthy people in this study.

Zinc (Zn) is involved in insulin secretion, transport and receptor sensitivity, protection against free radicals, and as a cofactor for enzymes of wound healing. Zinc is the second most abundant trace element in the human body after iron, and its primary sources include animal products and seafood. It is an essential trace element vital for the function of over 300 enzymes and plays a critical role in cellular processes such as cell division and apoptosis. Zinc plays a crucial role in wound healing as it acts as a cofactor in various transcription factors and enzyme systems, including zinc-dependent matrix metalloproteinases. Matrix metalloproteinases constitute a group of calcium-dependent zinc-containing enzymes responsible for degrading the extracellular matrix.

Metalloproteinases and their inhibitors play a crucial role in regulating the degradation and deposition of the extracellular matrix during wound repair. Mansooreh Momen-Heravi et al, in their randomized, double-blinded, placebo-controlled trial, observed significant benefits in the reduction of ulcer length and width with zinc supplements for a period of 12 weeks in diabetic foot ulcer patients. The Charu Yadav et al study showed a statistically significant decrease in the serum levels of zinc in diabetic foot ulcer cases as compared with subjects without ulcers. As with other previous studies, in this study, zinc levels were significantly lowered in DM foot patients compared to healthy people.

Copper is essential for the crosslinking of elastin and collagen and mediates angiogenesis via the induction of pro-angiogenic factors, with innate immunity and protection against free radicals. It plays a crucial role in skin regeneration and the formation of new blood vessels, accelerating the healing process by stimulating the production of vascular endothelial growth factor (VEGF) and angiogenesis via the action of hypoxia-inducible factor 1-alpha (HIF-1α). Charu Yadav et al noticed a significant decrease in the serum levels of Cu in the diabetic foot ulcer group. However, in this study, Cu in DM foot patients was significantly higher than in healthy people.

Vitamin B12, also known as cobalamin, is a vitamin essential to the proper functioning and development of the central and peripheral nervous systems, ensuring effective nerve-impulse transmission. The Mohammed Badedi et al study showed that vitamin B12 deficiency was associated with diabetic foot ulcer development in patients with Type 2 Diabetes Mellitus (T2DM) in Jazan, Saudi Arabia. However, in this study, there was no significant difference in

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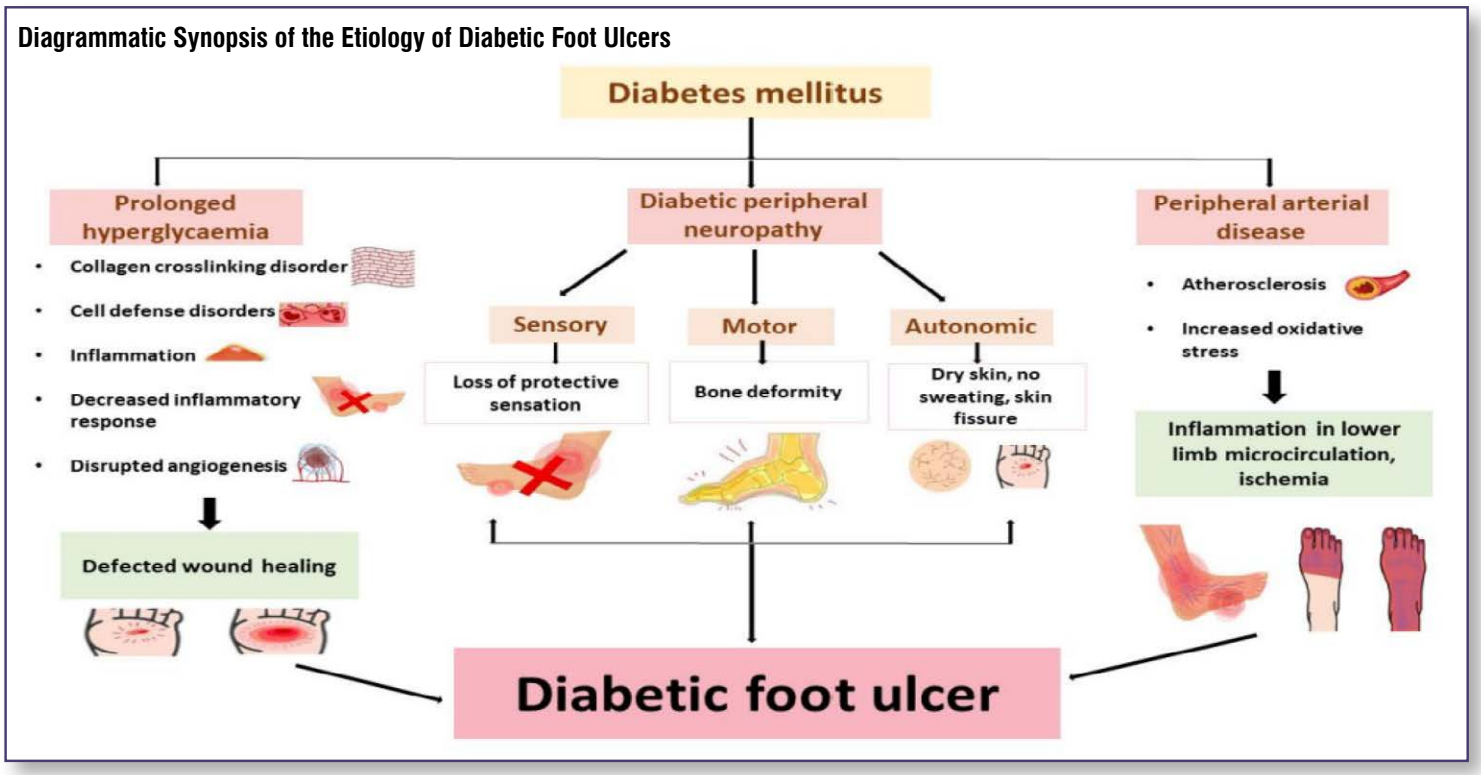
Diagrammatic Synopsis of the Etiology of Diabetic Foot Ulcers



Diagrammatic synopsis of the etiology of diabetic foot ulcers involving prolonged hyperglycemia, diabetic peripheral neuropathy, and peripheral arterial diseases. The sustained hyperglycemia impairs the wound-healing process via collagen crosslinking disorder, cell defense disorders, decreased inflammatory response, and disrupted angiogenesis; peripheral neuropathy affects the sensory, motor, and autonomic nervous systems, causing protective sensation loss, bone deformation, dry skin, skin fissures, and infections; peripheral arterial diseases such as ischemia, inflammation in lower limb microcirculation, and high plantar pressure in the foot can occur from atherosclerosis and elevated oxidative stress. Reprinted from Ansari et al. Appl. Sci. 2022;12:11777. https://doi.org/10.3390/app12221177 7.

vitamin B12 levels in DM foot patients compared with healthy people.

High-density lipoproteins (HDL) are circulating particles composed of phospholipids, cholesterol, and proteins. HDL has attracted lots of attention mainly because of its protective effect against the development of atherosclerosis. Lower levels of HDL cholesterol were associated with increased risk for foot ulceration in patients with diabetes (odds ratio 0.427, 95% confidence interval [CI] 0.228–0.799, P = 0.008). No significant associations were found between diabetic foot and LDL cholesterol. In this study, HDL cholesterol was significantly lowered in DM foot patients compared to healthy people. In the case of LDL cholesterol, there was no difference in DM foot patients compared with healthy people.

Study limitations include: single institution, limited sample size, and lack of long-term research on the effects of trace elements. Based on the results of this study, it was found that trace elements can affect diabetic foot ulcers, and additional research is needed on this.

Conclusion

Compared with healthy foot patients, the levels of albumin, Hb, iron, and zinc were low in diabetic foot ulcer patients in our study. In the prognostic assessment and treatment of diabetic foot ulcers, the VIPS classification, which emphasizes vascular, infection, and pressure, as well as nutrition and trace elements as a source of healing, is crucial. Low levels of these parameters can negatively impact wound healing; thus, correction should be considered in the treatment of diabetic foot ulcers.

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Author Kyung Bum Kim is with the Department of Orthopaedic Surgery at the NEW Korea Hospital, in Gyeonggi-do, Republic of Korea.

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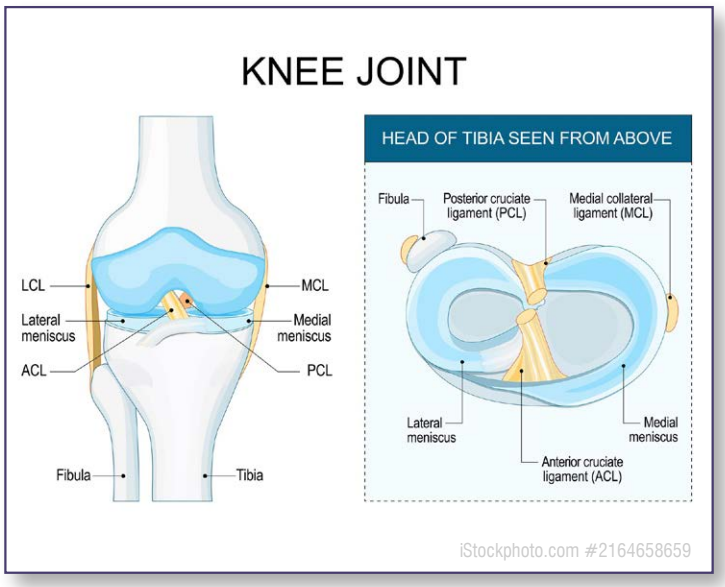
RECENT PRIOR CORTICOSTEROID INJECTIONS INCREASE MENISCUS REPAIR FAILURE



Meniscal tears are common knee injuries with limited endogenous healing capacity. This study aimed to investigate the association between the timing and administration of preoperative intra-articular corticosteroid injections (CSIs) and the risk of subsequent meniscectomy following meniscus repair.

Using a national insurance claims database, patients age 18-40 years undergoing meniscus repair within 6 months of tear diagnosis were studied. Patients were categorized based on whether they received preoperative CSIs within 3 intervals prior to repair. Multivariable logistic regression was used to analyze the risk of follow-up meniscectomy while controlling for various patient-related variables.

Among 5,390 patients meeting inclusion criteria, 201 received preoperative CSIs. The CSI group was older and had higher rates of diabetes, obesity, and knee osteoarthritis. The overall rate of follow-up meniscectomy did not differ between groups. However, CSIs performed within 1 month prior to repair were associated with significantly higher odds of subsequent meniscectomy compared to CSIs performed between 3 and 6 months prior. Obesity, tobacco use, and knee osteoarthritis were also independently associated with higher risk, while increasing age was associated with lower risk.

In conclusion, the study highlights an increased risk of repair failure requiring follow-up meniscectomy for patients receiving intra-articular CSIs within 1 month prior to meniscus repair. These findings suggest caution when considering CSIs as a treatment option for patients scheduled for meniscus repair. Further research is needed to establish optimal timing guidelines for CSIs in relation to meniscus repair and to understand the underlying mechanisms. (ler)

Source: *Zhang D, Baker HP, Lee CS, Pathuri M, Reddy S, Strelzow J. Corticosteroid injection of the knee within one month prior to meniscus repair increases the risk of repair failure requiring meniscectomy. Phys Sportsmed. 2024 Aug;52(4):369-373. doi: 10.1080/00913847.2023.2268604.*

PATIENTS WITH DPN SHOW WORSENING MUSCLE QUALITY OVER TIME

Muscle volume loss may progress in parallel with muscle-associated adipose tissue (MAAT) accumulation, impacting contractile performance in individuals with diabetic peripheral neuropathy (DPN), according to an article recently published in the journal *Gait & Posture*.

Researchers from Washington University in St. Louis, Missouri, wanted to understand the muscle quality (normal, abnormal muscle, and adipose volumes) of the DPN foot intrinsic compartment, how it changes over time, and whether muscle quality is related to gait and foot function.

In their study, 45 patients with DPN (mean age 67 yrs) had computed tomography (CT) performed on the intrinsic foot muscle compartment; the CT was repeated at approximately 3.6 years. Each time, images were processed to obtain volumes of MAAT, highly abnormal, mildly abnormal, and normal muscle. Annual rates of change were

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calculated for each category and paired t-tests were conducted at baseline and follow-up. 3D motion analysis and the Foot and Ankle Ability Measure (FAAM) were used to assess foot function, and Pearson's correlations were used to analyze correlations between muscle compartment and foot function during gait.

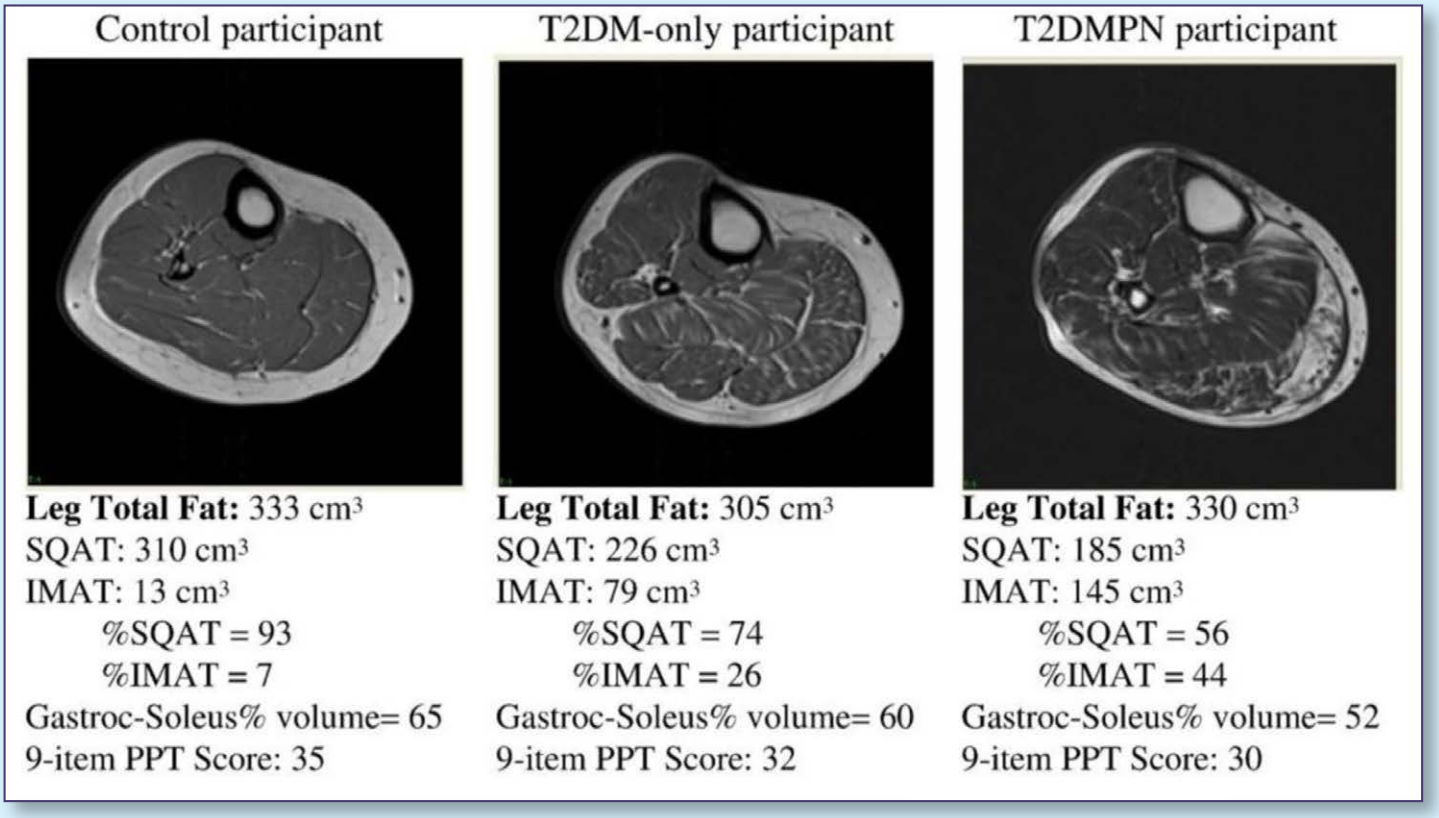
The researchers reported that total muscle volume decreased, driven by a loss of normal muscle and mildly abnormal muscle ($P < 0.05$). MAAT and the adipose-muscle ratio increased. At baseline, 51.5% of the compartment was abnormal muscle or MAAT, increasing to 55.0% at follow-up. Decreased total muscle volume correlated with greater midfoot collapse during gait (r = -0.40, $P = 0.02$). Greater volumes of highly abnormal muscle correlated with a lower FAAM score (r = -0.33, $P = 0.03$).

In other words, patients with DPN showed impaired muscle quality that worsened over time.

The authors concluded that muscle quality, not adipose tissue, is related to foot function during gait. Muscle volume loss may progress in parallel with MAAT accumulation, impacting contractile performance in individuals with DPN. Only 48.5% of the DPN intrinsic foot muscle compartment consists of normal muscle and greater abnormal muscle is associated with worse foot function. These changes identify an important target for rehabilitative intervention to slow or prevent muscle deterioration and poor foot outcomes.

Source: *Kaszyk EM, Commean PK, Meyer GA, et al. Use of computed tomography to identify muscle quality subgroups, spatial mapping, and preliminary relationships to function in those with diabetic peripheral neuropathy. Gait Posture. 2024 Jul;112:159-166. doi: 10.1016/j.gaitpost.2024.05.016.*

VISUALIZING DECLINING MUSCLE QUALITY



T1 cross-sectional images of the legs of a control, a patient with Type 2 diabetes (T2DM), and a Type 2 diabetes patient with peripheral neuropathy (T2DMPN). These images exemplify the progression of obesity (control) to T2DMPN and the accompanying loss of subcutaneous adipose tissue (SQAT), accumulation of leg intermuscular adipose tissue (IMAT), loss of muscle volume (gastroc-scoleus% vol.), and reduced physical function as assessed by the Physical Performance Test (PPT). Reprinted from Bittel DC, Bittel AJ, Tuttle LJ, et al. Adipose tissue content, muscle performance and physical function in obese adults with type 2 diabetes mellitus and peripheral neuropathy. J Diabetes Complications. 2015;29(2):250-7. doi: 10.1016/j.jdiacomp.2014.11.003. Reprinted with permission from Elsevier. All rights reserved.

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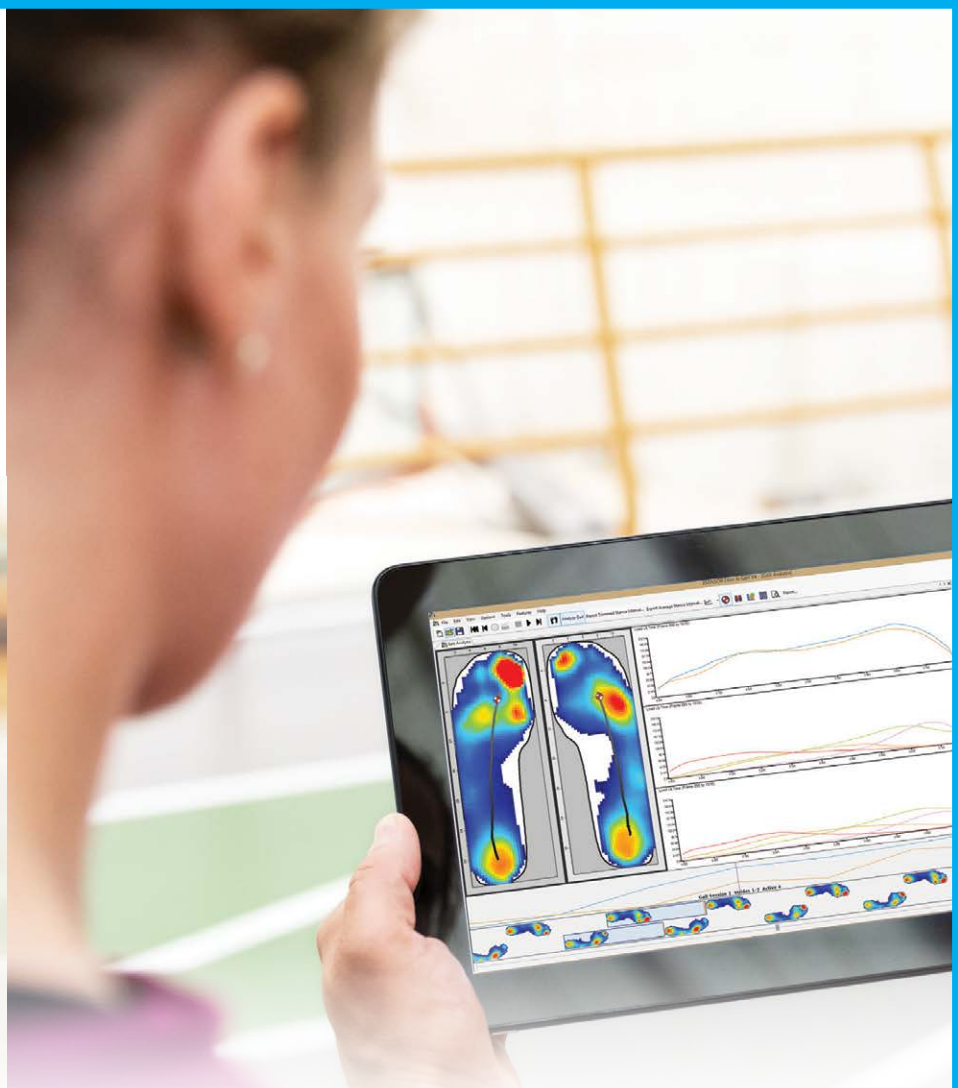

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RINGSIDE PHYSICIANS DISCOURAGE USE OF CANNABIS

With the twin goals of promoting safety of combat sports athletes and striving for the advancement of clean sport, the Association of Ringside Physicians (ARP) recently issued a position statement based on the available body of evidence regarding cannabis. ARP members oversee combat sports including boxing, kickboxing, wrestling, mixed martial arts, fencing, pro-wrestling, judo, karate, taekwondo, and jiu-jitsu.

- Use of marijuana or synthetic cannabinoids (CBD) by combat sports athletes is discouraged due to unproven benefits and many known adverse effects. Acute use can impair cognition and complex motor function, which likely leads to reduced performance in combat sports. Chronic use can increase risk for heart and lung disease, several cancers, schizophrenia, and can reduce testosterone in men and impair fertility. Benefits from cannabis in most contexts, including athletic performance, have not been proven.
- Use of topical purified CBD is neither encouraged nor discouraged.
- Since acute cannabis intoxication can impair complex cognitive and motor function, any athlete suspected of acute intoxication at the time of competition–based on clinical judgment–should be banned from that competition.
- Wide-scale regulation of cannabis based on quantitative testing has limited usefulness in combat sports, for the following reasons:
    - Cannabis is not ergogenic and is likely ergolytic.
    - Concentrations in body fluids correlate poorly with clinical effects and timing of use.
    - Access to testing resources varies widely across sporting organizations. ler

Source: *Stellpflug SJ, Stolbach A, Ghorayeb J, et al. Cannabis in combat sports: position statement of the Association of Ringside Physicians. Phys Sportsmed. 2024 Jul 9:1-12. doi: 10.1080/00913847.2024.2375788.*

LOWER EXTREMITY INJURIES IN MARTIAL ARTS ATHLETES

With the advent of mixed martial arts (MMA) growing in popularity, there has been a described increase in its participation. The term MMA generally describes the hybridization of combat disciplines including but not limited to: karate, judo, jiu-jitsu, wrestling, taekwondo, boxing, kickboxing, and Muay Thai. With increased participation in MMA and martial arts, differing physical demands are placed on participants.

Unique physical demands are placed on participants compared to traditional sports given the complex interdisciplinary demands of martial arts and the merging of different styles. Martial arts styles such as karate, taekwondo, kickboxing, and Muay Thai involve striking with punches and kicks while competitors remain standing and aim for knock downs. Wrestling, judo, and jiu-jitsu involve competitors utilizing standing and ground fighting without strikes to submit and subdue opponents. Each unique style carries a different risk profile given the inherent demands of the individual sport.

Due to the physical nature of combat sports, there are injuries associated with participation. The purpose of this study is to report the incidence and characteristics of injuries seen from various martial art disciplines presenting to U.S. emergency rooms in order to educate participants and providers alike about risks assumed with participating in martial arts.

The National Electronic Injury Surveillance System (NEISS) database was queried for martial arts–related injuries from 2009 to 2019. Cases were examined and data including patient age and gender, injury type and location, hospital disposition, and type of martial arts practiced were extracted.

A total of 8,400 injuries were recorded, leading to a national estimate of 310,143 martial arts–related injuries over the 11-year period of 2009–2019 (95% CI 239,063–381,223). The most common types of injuries were strains/sprains (n = 2664, 31.7%), fractures (n = 1,575, 18.8%), and contusions/abrasions (n = 1,698, 20.2%). There were 260 dislocations, with shoulder dislocations being most common (n = 96, 36.9%). Lower extremities were affected more frequently than upper extremities (n = 3566, 42.5% versus n = 3026, 36.0%), with the knee being the single most common location of injury (n = 811, 9.7%). Males more commonly sustained fractures (19.7 % versus 17.4%, p = 0.03) and dislocations (3.5% versus 2.4%, p = 0.01) when compared to females. Ankle injuries were more common in females than males (10.4% versus 6.0%, p < 0.001). Only 2.2% of patients required admission to the hospital. Risk factors for admission included patients >35 years of age and male sex. ler

Source: *Bickley RJ, Hazim NY, Sy JW, Nute DW. An epidemiological study of martial arts injuries in patients presenting to US emergency rooms. Injury. 2023 Dec;54(12):111089. doi: 10.1016/j.injury.2023.111089. Copyright ©2023. Reprinted with permission from Elsevier; all rights reserved.*

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PERI-ANKLE MUSCLES ARCHITECTURE & PERFORMANCE CHANGES IN CAI

This study aimed to identify changes in the architecture and performance of the peri-ankle muscles in patients with chronic ankle instability (CAI) and investigate the relationship between them.

Inclusion criteria for the study included: (1) age ≥18 years or older; (2) previous history of ≥1 severe ankle sprain that caused pain, swelling, limited weight bearing, or complete immobility for ≥3 days; (3) failure to return to pre-injury functionality; (4) repeated episodes of ankle sprain; and (5) self-reported ankle dysfunction score of ≤24 on the Cumberland Ankle Instability Tool (CAIT), classified as a noticeable or pathologic condition. Exclusion criteria were as follows: (1) experienced an injury within the 3 months prior to first outpatient visit; (2) history of surgery on their bones, joint structures, or nerves in either lower limb; (3) previously experienced fracture in either lower limb; (4) acute injury to musculoskeletal structures in lower extremities within previous 3 months that impacted their joint function and resulted in ≥1 day of interrupted physical activity; (5) experienced current and/or intermittent pain; and (6) systemic musculoskeletal disease.

This retrospective cross-sectional study used data from the electronic medical records of patients with CAI who visited a tertiary care hospital during a 2-year period. In total, 17 subjects were evaluated retrospectively. Each subject underwent anthropometric and isokinetic test, and peroneus longus (PL) and brevis (PB), medial gastrocnemius (MGCM), and tibialis anterior (TA) ultrasound imaging were performed at rest and maximum voluntary contraction (MVC) conditions (Figure 1).

Regarding muscle architectural variables, the pennation angle (PA) of the MGCM at rest and the PA of the TA, MGCM, and PL in MVC were significantly reduced on the injured side compared to the intact side. There were no significant differences in muscle thickness of PL, PB, MGCM, and TA observed between intact and injured side during both rest and MVC.

Regarding muscle performance parameters, significant decreases were observed in the muscle strength for both limbs in all 4 directions under the 2 different conditions. A secondary finding was that the rel-

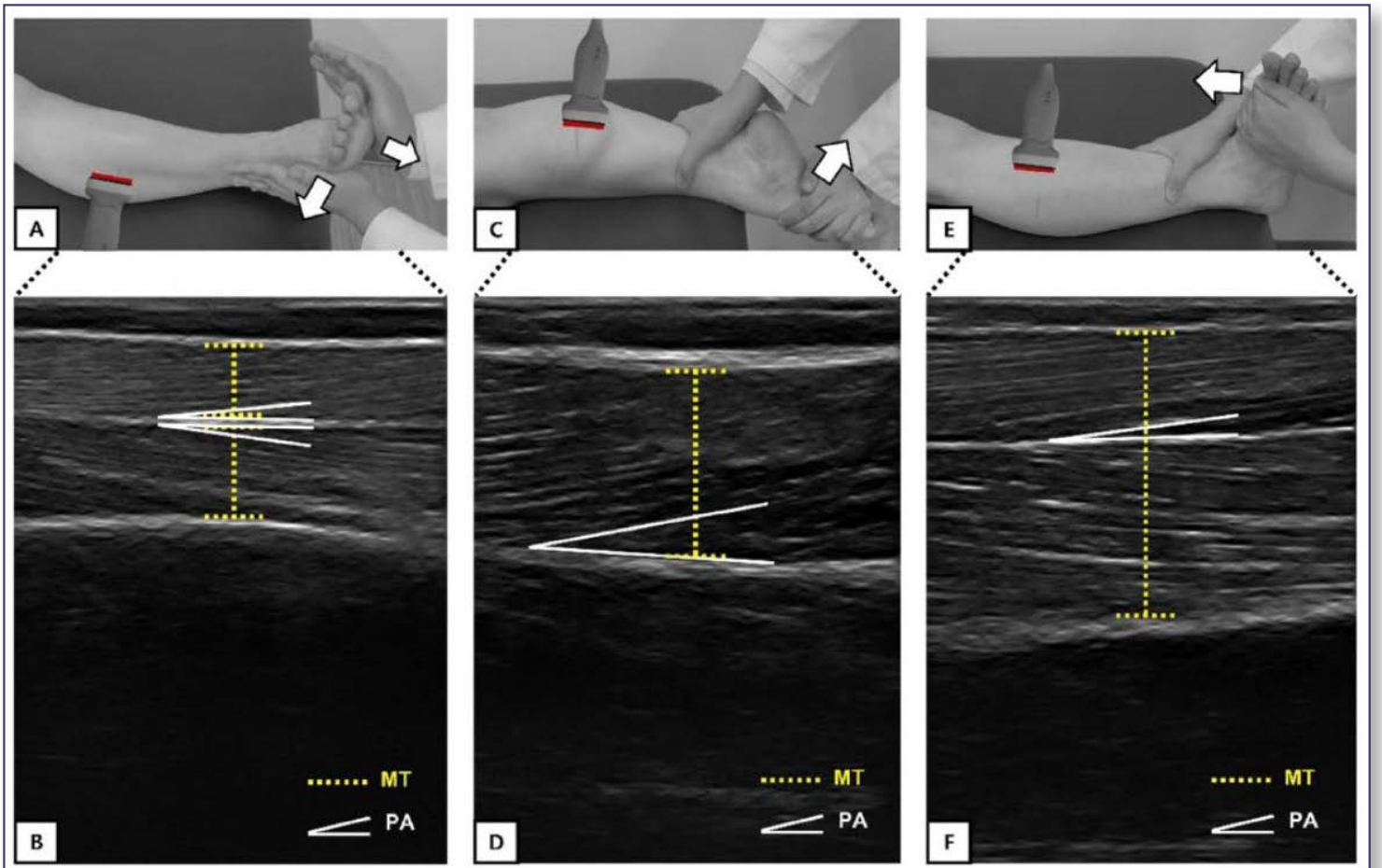

Figure 1. (A) Assessment of peroneal muscles at MVC; (B) ultrasound image of the peroneal muscles; (C) assessment of MGCM at MVC; (D) ultrasound image of the MGCM; (E) assessment of TA at MVC; (F) ultrasound image of the TA. MGCM, medial gastrocnemius; TA, tibialis anterior.

Continued on page 25

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Continued from page 22

ative PA ratio of the TA showed moderate correlation with the relative dorsiflexion ratio at 30°/s.

These findings can provide opportunities to better understand how injuries in patients with CAI may be related to changes in ankle and foot function.

Source: *Yu H, Yeo S, Lim JY, Kim I, Hwang J, Lee WH. Peri-ankle muscles architecture and performance changes in patients with chronic ankle instability: A retrospective cross-sectional study. J Foot Ankle Res. 2024;17(3):e12035. doi: 10.1002/jfa2.12035. Use is per Creative Commons License CC BY 4.0.*

VIBRATING INSOLE THERAPY FOR SENSORY PERIPHERAL NEUROPATHY

Sensory peripheral neuropathy is a common complication of diabetes mellitus and the biggest risk factor for diabetic foot ulcers. There is currently no available treatment that can reverse sensory loss in the diabetic population. The application of mechanical noise has been shown to improve vibration perception threshold or plantar sensation (through stochastic resonance) in the short term, but the therapeutic use, and longer-term effects have not been explored. In this study, vibrating insoles were therapeutically used by 22 participants, for 30 min per day, on a daily basis, for a month by persons with diabetic sensory peripheral neuropathy. The therapeutic application of vibrating insoles in this cohort significantly improved vibration perception threshold by an average of 8.5 V ($p = 0.001$) post-intervention and 8.2 V ($p < 0.001$) post-washout. This statistically and clinically relevant improvement can play a role in protection against diabetic foot ulcers and the delay of subsequent lower-extremity amputation.

Source: *Ennion L, Hijmans JM. Retention of improved plantar sensation in patients with Type II diabetes mellitus and sensory peripheral neuropathy after one month of vibrating insole therapy: a pilot study. Sensors. 2024;24:3131. https://doi.org/10.3390/s24103131. Use is per Creative Commons License CC BY 4.0.*

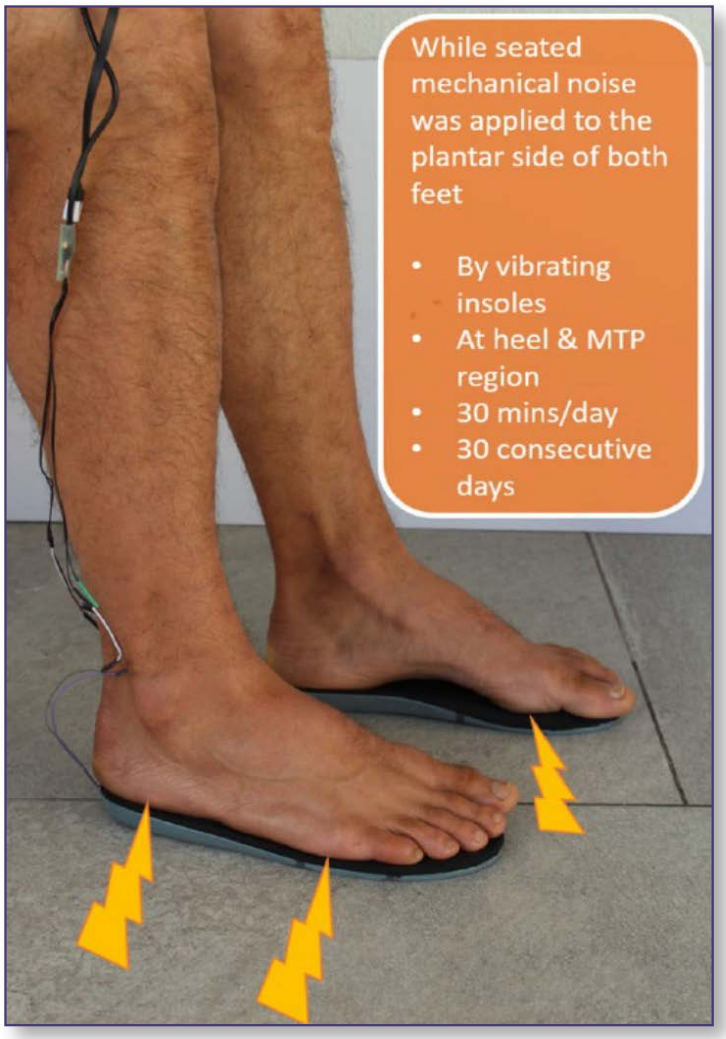

Figure. Overview of the intervention.

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Facts, Fictions, Fallacies of the Lapidus Bunionectomy

By Patrick DeHeer, DPM FACFAS, FFPM RCPS (Glasg)

The Lapidus bunionectomy, named after American orthopedic surgeon Paul Lapidus, has emerged as a highly popular surgical approach to correcting severe cases of hallux valgus, the deformity commonly known as a bunion. This procedure involves fusing the first tarsometatarsal joint to realign and stabilize the metatarsal bone, aiming to correct the deformity at its root and ideally prevent recurrence. A properly performed Lapidus procedure aims not only at straightening the metatarsal bone but also addressing any associated subluxation of the sesamoids to prevent recurrence. The Lapidus has gained traction among foot and ankle surgeons due to its potential to provide a long-lasting solution.

Despite its popularity, there are numerous misunderstandings surrounding the Lapidus bunionectomy. Key among them is the belief that the procedure guarantees a permanent solution without the possibility of recurrence. However, studies and clinical outcomes have shown variability, with recurrence rates reported in some reviews as high as 25%, though others present lower rates. This procedure is not a one-size-fits-all solution and does not guarantee long-term success and surgeons need to be honest about that. Success heavily depends on individual anatomical factors and the specific triplanar deformity, the surgeon's skill and attention to adjustments in all planes, and post-operative care adherence.

Pathophysiology of Hallux Valgus

Understanding the development of hallux valgus is crucial for addressing and preventing complications effectively.

The development of hallux valgus can be described in a 10-step process initially outlined by Perera et al in 2011 (see figures on next page):

Step 1 involves the failure of the medial structures of the medial collateral ligament, the metatarsal-sesamoid ligament, the flange sesamoid ligament. The integrity of the medial collateral structures is instrumental in maintaining the alignment and function of the first metatarsophalangeal joint. Strengthening or supporting these medial structures can slow the progression of the deformity, providing a pivotal target for therapeutic intervention. Failure or weakening of these structures leads to movement at the joint level with the displacement of the metatarsal over the fixed sesamoids.

Success heavily depends on individual anatomical factors and the specific triplanar deformity, the surgeon's skill and attention to adjustments in all planes, and post-operative care adherence.

Pronation of the first metatarsal and altered sesamoid position are significant contributors to Step 2. Studies have shown that there is notable pronation in affected individuals, which disrupts the normal biomechanical alignment and increases stress on the metatarsophalangeal joint. The sesamoids, which are supposed to protect and enhance tendon efficiency under the first metatarsal, when misaligned, exacerbate the malposition of the toe.

As the condition progresses, other changes including the valgus positioning of the phalanx (Step 3), erosion of the metatarsal head (Step 4), and formation of a bursa over the first metatarsal head (Step 5) occur.

Critical, yet underappreciated is Step 6, which involves the long extensor and flexor tendons. Under normal circumstances, these tendons help maintain the sagittal plane alignment of the first ray. However, in Step 6, we see the lateral translation of the long flexor and extensor tendons, which serves to further exacerbate the biomechanical deformity.

Step 7 is the hot topic everybody is

Continued on page 28

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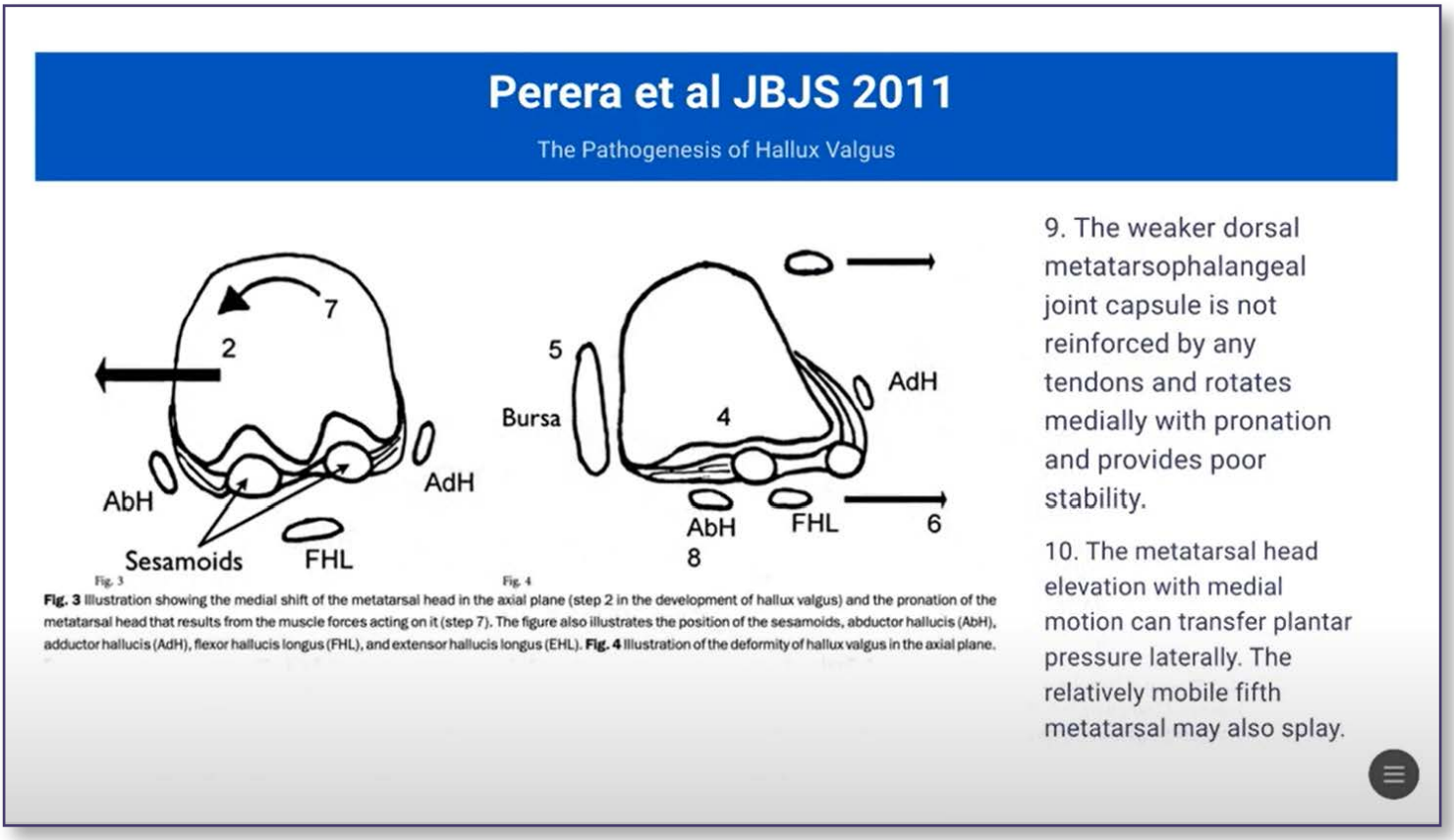


Fig. 3 Illustration showing the medial shift of the metatarsal head in the axial plane (step 2 in the development of hallux valgus) and the pronation of the metatarsal head that results from the muscle forces acting on it (step 7). The figure also illustrates the position of the sesamoids, abductor hallucis (AbH), adductor hallucis (AdH), flexor hallucis longus (FHL), and extensor hallucis longus (EHL). **Fig. 4** Illustration of the deformity of hallux valgus in the axial plane.

currently focused on: the pronation of the first metatarsal head.

The deformity culminates with metatarsal head rotation, causing instability and elevation, and ultimately resulting in lateral transfer pressure.

Surgical Techniques and Outcomes

Choosing the right corrective procedure for a Lapidus Bunionectomy involves understanding the specific anatomic deformities present in each case. Surgeons must consider the severity of the bunion deformity, the intrinsic stability of the foot within the context of the patient's lifestyle, and the presence of any co-existing conditions that might affect healing. The goal is to realign the metatarsal and phalangeal bones while restoring normal foot function, requiring a tailored approach for each patient.

Triplanar Correction: Achieving triplanar correction addresses deformities in all three anatomical planes: transverse, frontal, and sagittal. This comprehensive approach ensures that the correction is functional and durable. It involves meticulous surgical planning and execution, precise bone cuts, adequate management of soft tissues, and sometimes, supplemental procedures like lateral releases or tendon balancing to support the realigned structures.

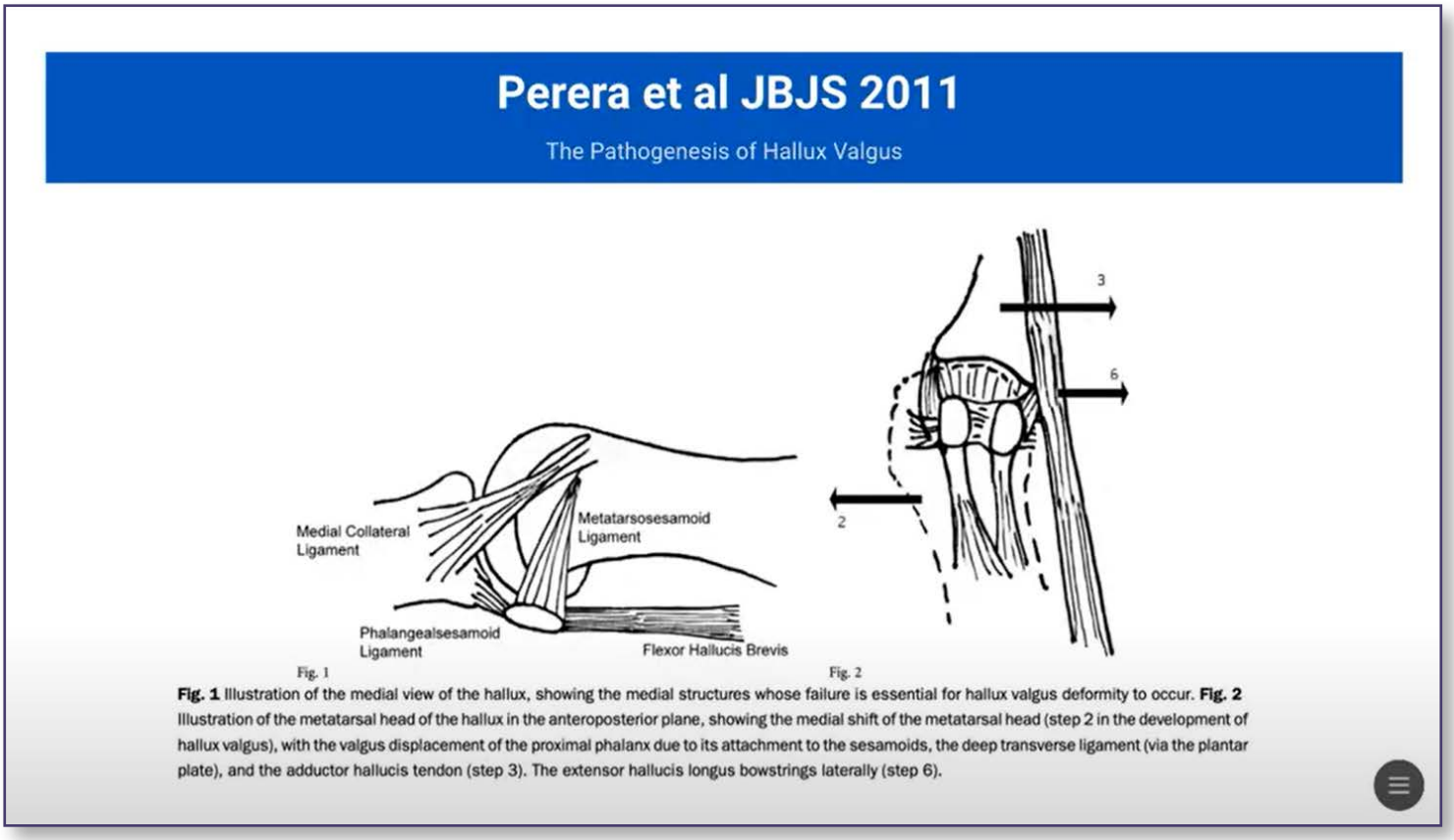
Lateral Release Techniques: Lateral release techniques are pivotal in the correction of hallux valgus during a Lapidus Bunionectomy. Complications arise when these techniques are either inadequately executed or omitted. Historically, experts noted recurrence of deformity when lateral structures weren't adequately released. Modern approaches now often include lateral release to ensure comprehensive correction of the toe's alignment, but this must be done judiciously to avoid destabilizing the toe and causing other complications such as reduced toe mobility.

Choosing the right corrective procedure for a Lapidus Bunionectomy involves understanding the specific anatomic deformities present in each case.

Long-term Effects: Surgical choices in any surgery can significantly impact patient outcomes. Therefore, long-term follow-up studies emphasize the importance of selecting surgical techniques that do not only correct the deformity but also mitigate the risks of recurrence. Strategies include ensuring stable fixation, respecting the inherent biomechanics of the foot, and preventing complications such as metatarsalgia and joint stiffness. By focusing on these elements, surgeons can enhance the procedure's success rate and improve patient satisfaction over the long run.

Complications and Their Management

Recurrence Rates: Literature on hallux valgus surgery shows a wide range of recurrence rates, from as low as less than 1% to more than 46%.



This variability could stem from differences in surgical methods, definitions of recurrence, and lengths of follow-up. Recognizing these discrepancies is vital for the surgical community to address and improve the long-term outcomes of bunion surgeries.

Torsional Adjustments: The Lapidus Bunionectomy, like any surgical procedure, has potential complications that need addressing through precise surgical techniques. One significant challenge involves torsional adjustments of the first metatarsal. Experts suggest that ignoring the innate torsion from base to head of the metatarsal during a bunionectomy can lead to suboptimal outcomes, including recurrence. Managing this torsion effectively ensures the correction remains stable long-term, hence emphasizing the need for meticulous structural realignment during surgery.

Managing Metatarsalgia: Metatarsalgia, or pain in the ball of the foot, can emerge as a troublesome postoperative complication. Its management is crucial for patient satisfaction and functional recovery. The key lies in respecting the anatomical architecture of the foot, particularly the metatarsal parabola. Surgeons must avoid excessive shortening of the metatarsals, which could shift the load distribution unfavorably, leading to increased pressure and pain under the lesser metatarsals. Post-surgery, careful monitoring and relevant adjustments in foot orthotics might be required to manage or mitigate this complication.

Future Perspectives on Lapidus Bunionectomy

As surgical techniques and technologies evolve, the Lapidus Bunionectomy will continue to be refined to improve outcomes and reduce complications. Future advancements may include more precise diagnostic tools like weight-bearing CT scans to assess foot biomechanics and deformities more accurately. Additionally, the development of enhanced surgical instruments and fixation devices could allow for more accurate bone cuts and stability, potentially decreasing the recurrence rate. Innovations in postoperative care and rehabilitation protocols could further enhance recovery times and long-term function of the foot. Emphasis on comprehensive preoperative planning and patient education will remain crucial in the successful management of hallux valgus deformities using the Lapidus technique.

To learn more about "Facts, Fictions, and Fallacies of the Lapidus Bunionectomy," see Patrick DeHeer's full lecture from the 38th Annual No-Nonsense Seminar, available at https://non-onsense2024.lerexpo.com/.

Patrick DeHeer, DPM FACFAS, FFPM RCPS (Glasg) is now Medical Director at Upperline – Indiana and Podiatric Residency Director at Ascension St. Vincent Hospital in Indianapolis.

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Varicose Veins of the Lower Extremities: A Primer Part I

By Angela Kelley, PA-C, MSM

Varicose veins (VVs)—those bulging, twisted blood vessels typically seen on the legs—are more than an esthetic issue. They can be painful and affect patients' quality of life; left untreated, they can lead to life-threatening chronic venous insufficiency and venous ulcers. And when seen or mentioned, will always warrant a clinician's attention.

VVs are a common occurrence noted in healthcare. This primer, which will appear as 2 articles, includes data published within the last 5 years with information in Part I not only on how to diagnose VVs, but also on the anatomy and pathophysiology related to development, risk factors for occurrence, clinical presentation, and differential diagnoses. Part II, which will appear next month, will include information on treatment, prevention, and complications of this condition. There are additional terms that will be explored such as chronic venous insufficiency (CVI), and chronic venous disease (CVD); however, it is important to note at the outset that these terms are not interchangeable with the term varicose veins.

Definitions

Varicose Veins

Varicose veins (VVs) are superficial veins that are dilated and bulging with diameters measuring 3 mm or greater that can progress to become more enlarged and more tortuous.[1] Patients with VVs can be either asymptomatic or have pain and even bleeding if progression occurs. VVs are the most common manifestation of CVD and usually manifest as stage C2 in the CEAP (see below).[2]

Chronic Venous Disease

Chronic venous disease (CVD) is a general term describing complications in the venous system caused by dysfunctional valves and venous reflux.[3] Differentials related to CVD should include causes of lower extremity edema including hypoalbuminemia, cardiac insufficiency, hypothyroidism, and more.[2,4]

Chronic Venous Insufficiency

Chronic venous insufficiency (CVI) is mainly caused by ambulatory venous hypertension due to abnormal blood flow from reflux of venous valves, obstruction of venous valves, or a combination of both.[1] The causes of CVI include VVs as well as reticular veins, telangiectasias, pigmentation, edema, lipodermatosclerosis, eczema, venous ulcers, and atrophie blanche. These additional exam findings are important to note to determine differential diagnoses that could cause venous abnormalities.[5]

CEAP Classification

VVs represent one aspect of venous disease, which is generally reported using the international standard known as CEAP: Clinical-Etiology-Anatomy-Pathophysiology Classification (Table 1).[2] CEAP, which is based on clinical manifestations of chronic venous disorders, helps to standardize diagnoses, improve communications among clinicians, and facilitates research. Class C0 represents no visible sign of venous disease; classes C1–3 typically denote CVD, while classes C4-6 are indicative of the more severe CVI.

Anatomy | Physiology | Pathophysiology

The venous system is just 1 part of the entire circulatory system that keeps blood and lymph fluids flowing in the body. The venous system is responsible for returning deoxygenated blood

Varicose veins affect nearly one third of the adult population and are considered early warnings of the more serious chronic venous insufficiency. Early recognition and prevention are key to suppressing potential life-threatening damage and maintaining patient quality of life.

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back to the heart. This is accomplished through an intricate network of perforating, superficial, and deep veins. In other words, venous blood is carried from the skin to the superficial veins, which are then channeled into the deep veins of the lower limbs. Typically, deep veins are located within the same vascular sheath as the artery of the same name, which allows arterial pulsations to aid venous return.

Using a system of internal valves and the pumping action of both the large lower limb muscles and the vascular smooth muscle cells within the veins themselves, these veins support the correct direction of blood flow throughout the entire venous system.[1] It is important that each of these components function properly to counter the pull of gravity and thus avoid pooling of blood in the lower extremities (pooling here means slower return to the heart, not stagnation).[6] (See Figure 1.)

Pressure within the entire circulatory system is affected by changes in postural position: venous pressure in the lower extremities is estimated around 90 mm Hg when standing and lessens to 30 mm Hg when lower extremities are elevated or while walking.[1] Walking activates a pumping action in the lower extremity muscles serving as a natural aid in blood flow. Although venous valves are typically bicuspid and unidirectional for the purpose of directing blood flow back to the heart, complications in these valves can lead to a reflux of blood in the opposite direction.[6-8] It is important to note that not all lower extremity veins contain valves (particularly in the feet),[1] which can affect venous return in patients with an incompetent venous system.

Although the pathogenesis of VVs is not fully understood, damaged or improperly working valves and changes that cause dilation and remodeling of the vessel walls as well as the loss of tone have been identified.[3,9] Those changes include hypoxia, inflammation, increased filling pressure in the veins, activation of the endothelium, and dysregulation of metalloproteinases and tissue inhibitors, as well as genetic factors and other underlying risk factors.[9,10] VVs have been identified as the first clinical evidence of CVD.[11]

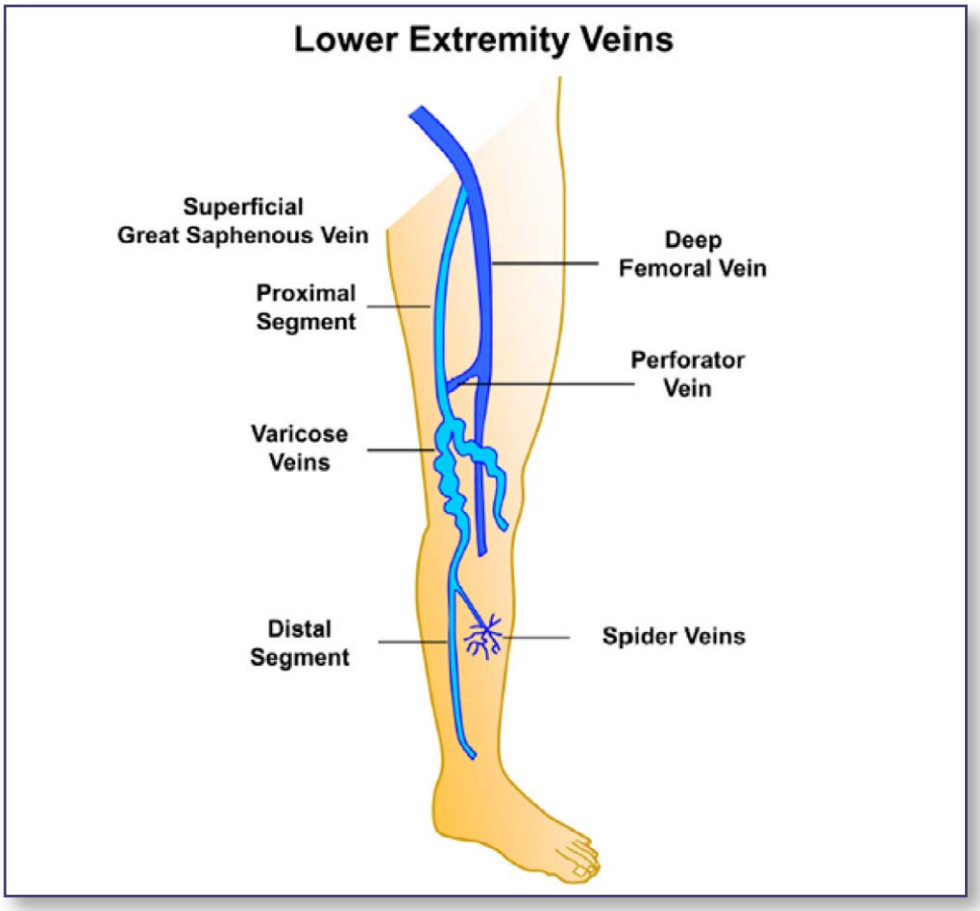

Figure 1. The lower extremity venous system, and changes to varicose veins. The lower extremity has an intricate system of superficial and deep veins connected by perforator veins. Excessive vein wall dilation and incompetent venous valves lead to superficial dilated spider veins or engorged and tortuous varicose veins. Image reprinted from Chen Y, Peng W, Raffetto JD, Khalil RA. Matrix Metalloproteinases in Remodeling of Lower Extremity Veins and Chronic Venous Disease. Prog Mol Biol Transl Sci. 2017;147:267-299. DOI: 10.1016/bs.pmbts.2017.02.003. Elsevier Copyright ©2017; all rights reserved.

Risk Factors

Environmental: Risk factors for the development of VVs are multifaceted:[1,3,5,6,9,10]

- Increasing age
- Standing for long periods of time
- Trauma to the lower extremity
- Obesity
- Smoking
- Family history
- Pregnancy and other states of elevated estrogen
- Sedentary lifestyle

Additional risk factors such as high systolic blood pressure,[10] Caucasian race,[6] chronic constipation leading to increased intra-abdominal pressure,[6] and decreased mobility[6] have also been recognized.

Genetic: A 2018 study published in *PLoS One*[9] that looked at genetic data on more than 408,000 European ancestry individuals reported finding the most likely causal genes as well as variants that related to hypertension and certain traits of blood cells. Additional findings indicated genetic correlation related to certain associations of VVs in individuals whose jobs require long periods of standing, those who have VVs and develop deep vein thrombosis (DVT), and other correlations, as well as indications from plasma protein levels that are related to size-proportional traits such as height, weight, waist circumference, and others. Additional genetic correlations have been found to increase the risk for VVs including

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Continued from page 27

Table 1. [2] Last Revision of CEAP Classification on CVD.

Table 1. Last revision of CEAP classification on CVD.

Clinical (C) Classification	Etiologic (E) Classification	Anatomic (A) Classification	Pathophysiologic (P) Classification
C0 No visible or palpable signs of venous disease C1 Telangiectasias or reticular veins C2 Varicose veins C2r Recurrent varicose veins C3 Edema C4 Changes in skin and subcutaneous tissue secondary to CVD C4a Pigmentation or eczema C4b Lipodermatosclerosis or atrophie blanche C4c Corona phlebectatica C5 Healed C6 Active venous ulcer C6r Recurrent active venous ulcer	Ep Primary Es Secondary Esi Secondary—intravenous Ese Secondary—extravenous Ec Congenital En No cause identified	As Superficial Old New Description 1. Tel Telangiectasia 1. Ret Reticular veins 2. GSVa Great saphenous vein above knee 3. GSVb Great saphenous vein below knee 4. SSV Small saphenous vein AASVAnterior accessory saphenous vein 5. NSV Nonsaphenous vein Ad Deep 6. IVC Inferior vena cava 7. CIV Common iliac vein 8. IIV Internal iliac vein 9. EIV External iliac vein 10. PELV Pelvic veins 11. CFV Common femoral vein 12. DFV Deep femoral vein 13. FV Femoral vein 14. POPV Popliteal vein 15. TIBV Crural (tibial) vein 15. PRV Peroneal vein 15. ATV Anterior tibial vein 15. PTV Posterior tibial vein 16. MUSV Muscular veins 16. GAV Gastrocnemius vein 16. SOV Soleal vein Ap Perforator 17. TPV Thigh perforator vein 18. CPV Calf perforator vein An No venous anatomic location identified	Pr Reflux Po Obstruction Pr,o Reflux and obstruction Pn No pathophysiology identified

CEAP: clinical–etiology–anatomy–pathophysiology; CVD: Chronic venous disease.

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30 novel genome loci related to blood pressure encoding and the development, integrity, and maturation of vascular channels.[3]

Prevalence

Presence of VVs has been noted in nearly one third of the population age 18–64,[6] with increased occurrences with age. Research shows VVs are present in 30% of adults in developed countries[9] and lower extremity VVs in particular are believed to be the 7th most common reason for physician referral in the United States.[12] The cost associated with VVs treatment was $290.59 million in the United States in 2016 and was expected to rise to $396 million by 2021.[10] Those same authors also noted that 1 out of every 65 patients have a VV treatment performed yearly.

History

The subjective history of varicose veins can be either an asymptomatic presentation or 1 with various levels of pain.[1] Often, patients present with an interest in treatment for cosmetic purposes.

Asymptomatic presentation could present with concerns for appearance, social impact related to relationships, restrictions related to leisure or physical activities, anxiety related to progressive deterioration into worsening conditions such as DVT or venous leg ulcers, or limitations in daily life.[12]

Symptomatic presentation has been shown to include the following:[5,6,12]

- Itching
- Pain
- Heaviness
- Leg cramps
- Numbness
- Tingling
- Skin changes
- Swelling
- Restlessness of the lower extremities

The level of pain can range from a slight discomfort to significant pain and cramping where the symptoms are worse after prolonged standing.[1,5] Often, many symptoms resolve after resting and elevating the lower extremities.[5]

A 2017 systematic literature review found that 5–15% of men and 2–29% of women worldwide experience VVs.[12]

Physical Exam Findings

Physical findings related to subjective concerns can vary based on patient presentation. An examination should be performed on bilateral lower extremities regardless of unilateral or bilateral subjective concerns.[6] Skin changes, such as eczema, hemosiderin deposits, lipodermatosclerosis, atrophie blanch, skin ulceration, lumps under the skin, and edema, can be signs of early or late disease related to VVs. VVs can also present as engorged and dilated masses[3] or simply enlargement of superficial veins.[11] Palpation of these atypical findings should occur to compare physical findings with subjective concerns, and to note the progression of the varicosities toward more chronic venous conditions. Palpation to assess the size of the veins and ankle mobility[5] are important as is palpating arterial pulses to determine the ankle-brachial pressure index[6] to evaluate if chronic conditions such as ulceration

Table 2. [1] Venous Clinical Severity Score

Attribute	Absent = 0	Mild = 1	Moderate = 2	Severe = 3
Pain	None	Occasional, not restricting daily activity	Daily, interfering but not preventing daily activity	Daily, limits most daily activity
Varicose veins	None	Few, isolated branch varices, or clusters, includes ankle flare	Confined to calf or thigh	Involves calf and thigh
Venous edema	None	Limited to foot and ankle	Extends above the ankle but below knee	Extends to knee and above
Skin pigmentation	None or focal	Limited to perimalleolar	Diffuse, over lower third of calf	Wider distribution above lower third of calf
Inflammation	None	Mild cellulitis, ulcer margin limited to perimalleolar	Diffuse over lower third of calf	Wider distribution above lower third of calf
Induration	None	Limited to perimalleolar	Diffuse over lower third of calf	Wider distribution above lower third of calf
Ulcer number	0	1	2	≥ 3
Ulcer duration	NA	< 3 mon	> 3 mon but < 1 yr	Not healed > 1 yr
Ulcer size	NA	Diameter < 2 cm	Diameter 2–6 cm	Diameter > 6 cm
Compressive therapy	Not used	Intermittent	Most days	Full compliance

An aggregate score for the limb is calculated by adding the individual component scores. The range of the total score is 0 to 30.
NA, not applicable.

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are beginning. Concern would be warranted if palpation of the vein indicates a hard lump that is tender as superficial thrombophlebitis should be ruled out. Although our focus here is on VVs of the lower extremities, clinicians should perform a more complete exam to determine if a rare pelvic or abdominal mass could be the etiology of varicosities that are present or other conditions.[6]

Diagnosis

VVs are typically diagnosed via a clinical presentation from the history and physical findings of a dilated vein of 3 mm or greater in diameter that is noted when the patient is in an upright position.[5] A concern for external hemorrhage of a VV leading to hemodynamically significant changes is rare but has been noted in the literature.[5,13] The additional evaluations suggested for the physical diagnosis are important to determine progression of the varicosity condition as VVs are noted to be a clinical feature of CVI.[1,10,11]

After taking a history and performing a physical examination, the CEAP classification (Table 1) may be used to determine the stage and or progression of CVD. If VVs are present, the clinical manifestations (C) will be noted at the level of C2, whereas CVI is diagnosed at levels C3–C6, noted from simply edema (C3) and dermatological changes (C4) to healed and active ulcers (C5 and C6, respectively).[2] Although the CEAP classification is helpful in determining etiology of VVs as primary, secondary, or congenital, and superficial, deep, or perforating, this classification system is static and not helpful for severity scoring.[1] An additional evaluation is provided in Table 2,[1] which standardizes the evaluation, assessment of severity, and treatment response.[1,14,15,16]

Differential Diagnoses and Tests

As discussed, differential diagnoses should be ruled out when considering the diagnosis of VVs. As noted, determining whether there is a larger underlying condition related to chronic venous disease other than VV presentation should be assessed. Determining whether varicose veins are the only manifestation of the genetic and environmental risk factors, or if the condition should be evaluated to determine progression to chronic venous insufficiency should be considered as well as ruling out more concerning differentials.

The diagnostic test of choice for VVs is venous duplex ultrasonography.[5,17,18] This diagnostic modality is a painless, easily accessible, and noninvasive method for evaluating venous junctions, venous reflux, incompetent veins, and can rule out superficial and DVT.[5] Other tests mentioned in the literature such as plethysmography, computed tomography, magnetic resonance venography,[1] intravascular ultrasound,[1] bloodwork for deep venous thrombosis, as well as genetic testing,[2,3] are reserved for venous disorders that progress toward CVI, those who have a past medical history that includes thrombosis,[9] or those who are preparing for surgical intervention.[1] ler

"Varicose Veins of the Lower Extremities: A Primer Part II" will appear next month and will cover treatment options and potential complications.

Angela Kelley, PA-C, is Associate Professor and

Continued on page 37

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Director of Didactic Education, Physician Assistant Program at Gannon University in Ruskin, Florida, and a Regional Director Health Coach with Optavia (www.optavia.com/us/en/coach/angela).

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SUGGESTED FURTHER READINGS

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   Bleeding associated with varicose veins is not uncommon and can be a sudden cause of death. This article includes a 1 page algorithm for managing bleeding in these patients.

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Comparing Aquatic-based and Land-based Exercises for Balance

By Ying Deng, Zheng Tang, Zhengting Yang, Qi Chai, Wenting Lu, Yunshi Cai, Yiting Luo, and Yongzhao Zhou

Aquatic-based exercises are used as an alternative to land-based exercises for older adults who have lower levels of physical activity or neuromuscular disorders that impact their balance function.

Balance plays a crucial role in the daily activities of older adults. Aquatic-based exercises (AE) are widely conducted as an alternative to land-based exercises (LE) for older adults who have lower levels of physical activity or neuromuscular disorders that impact their balance function. Previous studies have compared AE and LE as effective ways to improve balance and have yielded inconsistent results. Therefore, this review aimed to compare the effects of AE and LE on balance function in older adults.

Methods

Electronic databases, including PubMed, Web of Science, Scopus, and Embase, were searched. Randomized controlled trials published from January 2003 to June 2023 were included following predetermined criteria. Data extraction was carried out by 2 independent reviewers. Data synthesis was conducted using RevMan 5.3 software. The fixed-effect model or random-effect model was chosen based on the results of the heterogeneity test. Meta-analysis for the effect sizes of balance outcomes was calculated as standardized mean difference (SMD) with 95% confidence intervals (CI). The quality of the included studies was evaluated using the Physiotherapy Evidence Database (PEDro) scale.

Results

A total of 29 studies involving 1,486 older adults (average age of 66.2 years) were included. Among them, 6 studies included healthy subjects, 9 studies included patients with musculoskeletal disorders, 5 studies included patients with Parkinson's disease, 2 studies included patients with stroke, 3 studies included patients with chronic obstructive pulmonary disease (COPD), 2 studies included patients with heart failure (HF), 1 study included coronavirus disease 2019 (COVID-19) patients, and 1 study included sedentary lifestyle subjects.

Meta-analysis results indicated that AE could improve balance ability based on 2 tests: the Berg Balance Scale (BBS) and the 30-second chair stand test (30 CST). However, there were no significant differences between the AE group and the LE group in terms of the 6-minute walking test (6 MWT) and the Timed Up and Go (TUG) test

Thirteen studies assessed the effects of resistance training on the BBS. Data were extracted for 476 participants (AE group, n = 242; LE group, n = 234). Compared with the LE group, there was a significant increase

This article has been excerpted from "Comparing the effects of aquatic-based exercise and land-based exercise on balance in older adults: a systematic review and meta-analysis." Eur Rev Aging Phys Act 21, 13 (2024). https://doi.org/10.1186/s11556-024-00349-4. Editing has occurred, including the renumbering or removal of tables and figures, and references have been removed for brevity.

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in BBS in the AE group (SMD = 1.13, 95% CI 0.25 to 2.00, *P* = 0.01, I2 = 94%).

Eleven studies assessed the effects of resistance training on the 6-minute walk test (6 MWT). Data were extracted for 494 participants (AE group, n = 259; LE group, n = 235). The results indicated that there was no significant difference between the AE group and the LE group on the 6MWT (SMD = 0.13, 95% CI -0.16 to 0.43, *P* = 0.38, I2 = 62%).

Fourteen studies assessed the effects of resistance training on the Timed Up and Go (TUG) test. Data were extracted for 532 participants (AE group, n = 272; LE group, n = 260). The results indicated that there was no significant difference between the AE group and LE group on the TUG test (SMD = 0.44, 95% CI -0.04 to 0.91, *P* = 0.07, I2 = 85%).

Six studies assessed the effects of resistance training on 30-second chair stand test (30 CST). Data were extracted for 248 participants (AE group, n = 141; LE group, n = 107). Compared with the LE group, there was a significant increase in 30 CST in the AE group (SMD = 2.02, 95% CI 0.50 to 3.54, *P* = 0.009, I2 = 96%). See Figure 1.

Older adults with different health conditions have different gains in different balance measurements after AE intervention and LE intervention.

Publication bias can be visually displayed using funnel plots, which allow for the examination of small study effects and the assessment of funnel plot asymmetry through statistical testing. In the absence of publication bias, the funnel plot should exhibit a symmetrical shape, with smaller studies scattered widely at the bottom and larger studies more tightly spread. (Figure 1)

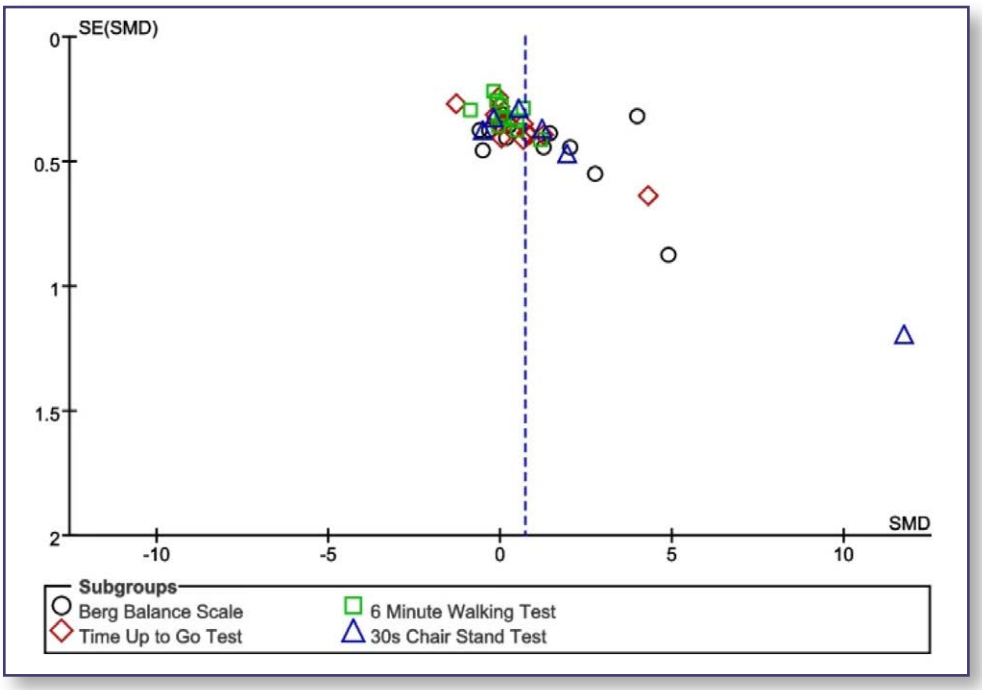

Figure 1: Funnel plot for all the meta-analyses

Discussion

With the increase of age and the influence of various chronic diseases, the physical function of older adults decreases significantly. Older adults' ability to accurately control body movements is limited due to the reduced central nervous system's ability to process information and significant degenerative changes in skeletal muscles, which ultimately leads to weakened balance ability. Balance plays a crucial role in the daily activities of older adults. The purpose of this meta-analysis was to compare the impact of AE and LE on balance in older adults. The results of our study indicated that AE had a more significant improvement in balance than LE. However, because the health status of the old individuals in the included studies varied, these results must be interpreted with caution.

Balance, coordination, and agility are often used to evaluate physical activity. Balance dysfunction can lead to an increased risk of falls among older adults, subsequently raising mortality and disability rates. A system review revealed that exercise can prevent falls in community-dwelling older people, and exercise programs that challenge balance and are of a higher dose have larger effects. Youngwook et al found that both AE and LE intervention demonstrated similar effects on dynamic balance in individuals age 65 years or older, and offered evidence supporting the use of AE as a viable substitute for LE in enhancing dynamic balance and potentially mitigating the risk of falls. Moreira et al demonstrated that compared to the LE intervention, AE intervention can be used as a preventive approach for the older adults at risk of falling, to enhance proprioception and increase awareness of fall risk. Patients with Parkinson's disease and stroke have obvious gait problems. When patients walk train in the water, the standing phase of the lower limbs of the affected side is prolonged due to the support of buoyancy, and the lower limbs of the unaffected side can relatively fully hip flexion, step, and buoyancy can reduce the difficulty of the lower limbs of the affected side in stride hip flexion, and improve gait symmetry. Veldema et al demonstrated that compared with LE interventions, AE showed superior effects in balance, walking, muscular strength, and cardiorespiratory fitness in patients with stroke.

In this study, BBS, 6 MWT, 30 CST, and TUG test are mainly used as indicators to evaluate balance ability. However, the subgroup analysis of this study found that compared to the LE group, AE can only improve BBS in patients with nervous system diseases. AE may offer a more suitable exercise option for older individuals with health conditions compared to LE. Bartels et al indicated that AE has clinically relevant effects on patient-reported pain and disability in people with knee osteoarthritis

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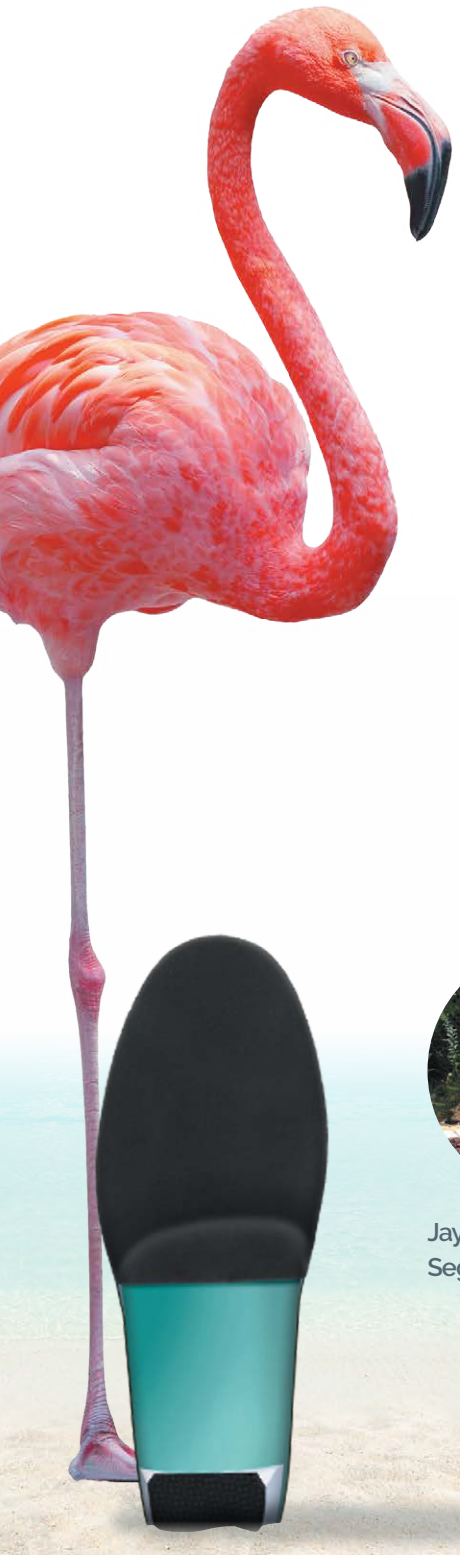

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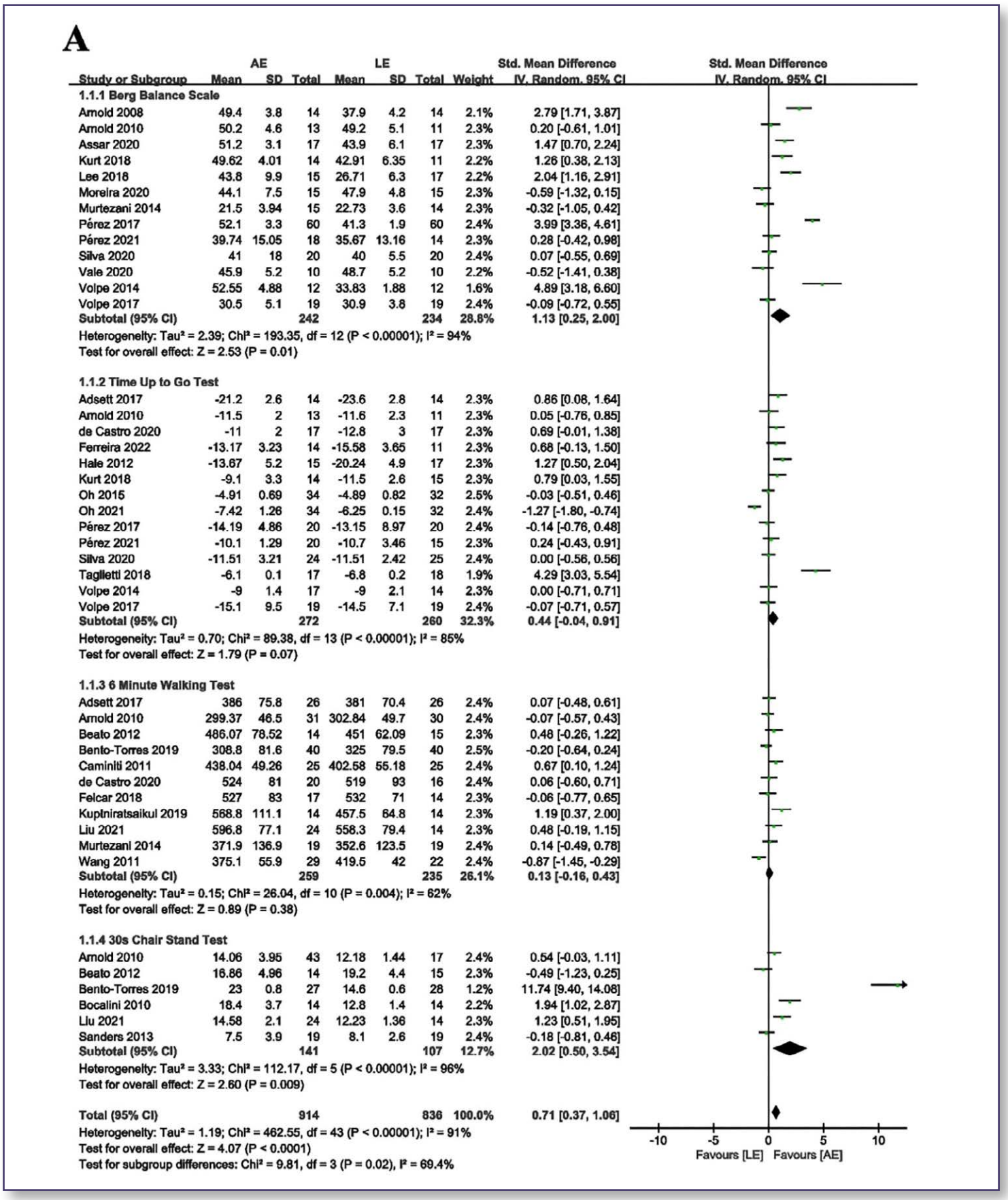

Figure 2. Meta-analysis of the aquatic-based exercise (AE) versus the land-based exercise (LE) on balance performance. CI: confidence interval; SD: standard deviation

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A comprehensive assessment of balance function may require a combination of different tests, clinical judgment, and consideration of individual factors.

and hip osteoarthritis compared to no intervention. However, the subgroup analysis in this study results revealed that AE only significantly improved BBS in patients with musculoskeletal disorders, and there was significant heterogeneity. This may be associated with musculoskeletal disorders that predispose to pain, thereby affecting dynamic balance function test results (ie, TUG test, 6 MWT, and 30 CST). The tests mentioned, namely BBS, are commonly used to evaluate balance ability. However, it is important to note that no single test can comprehensively assess all aspects of balance function. They may not fully capture all dimensions of balance function, such as anticipatory postural adjustments, reactive postural control, or balance during complex tasks. Additionally, individual factors, such as fear of falling or cognitive impairments, can influence test outcomes. Therefore, a comprehensive assessment of balance function may require a combination of different tests, clinical judgment, and consideration of individual factors.

A recent review indicated that AE is an effective physical intervention to enhance physical fitness in healthy adults and adults with chronic diseases. Comparison of balance challenges encountered in AE and LE revealed that LE may focus on static balance exercises, such as standing on 1 foot, whereas AE may involve dynamic movements, such as walking in water currents or maintaining stability on unstable surfaces, such as aquatic platforms. It was emphasized how the sensory feedback and proprioceptive demands differ between the 2 modalities, with the AE requiring adaptation to the unique stimuli of the aquatic environment. In the same way, the results of this study found that compared to the LE group, AE had more effects in improving balance ability in older adults with various health conditions. Further, the results of the present study indicated that AE could improve balance ability based on the BBS and the 30 CST. However, there were no significant differences between the AE group and the LE group in terms of the 6 MWT and TUG test. This heterogeneity may be caused by different populations. Subgroup analysis results of this study also found that compared to the LE group, the effects of the AE group on the improvement of balance function in patients with cardiopulmonary diseases was significant, and the heterogeneity was acceptable. The reason for the improved physical function in a water environment may be that the shift in the center of gravity induces more controlled movement and contributes to balance control during the task.

As individuals age, their balance and stability naturally decline due to factors such as decreased muscle strength and coordination. By incorporating exercises that offer a higher challenge, such as those performed on unstable surfaces or with dynamic movements, older adults can improve their balance and stability more effectively. By progressively increasing the challenge level of AE exercises, older adults can continue to make gains in their balance and prevent stagnation. Regularly exposing the body to new and more difficult balance demands helps to promote adaptation, strengthen muscles, and enhance the body's ability to maintain balance in various real-life situations. Older adults often have age-related conditions or disabilities that further compromise their balance. These may include conditions like osteoarthritis, Parkinson's disease, or stroke.

Providing a higher balance challenge through AE exercises can help stimulate the neuromuscular system, enhance the awareness of body position in space, and improve overall balance control, which is particularly beneficial for individuals with compromised balance abilities. However, it's critical to determine if these benefits transfer to LE training. Factors like task specificity, environmental similarities, and individual characteristics influence transfer effects. If AE exercises resemble dry land balance testing, transfer effects are likely. The importance of applying the principle of specificity to interventions aimed at improving balance ability was emphasized by Grabiner et al. Kim et al found that specific types of balance exercises had limited transfer effects to untrained balance tasks, and that even when these minimal training effects were maintained for several months, the intensity and specificity of the training was properly chosen, despite the relatively small total volume. Further research needs to consider the factors such as specificity, volume, and intensity of the training to maximize the time-effective transfer to real-world scenarios.

Conclusion

Although this study was influenced by participant health status, transfer effects, sample size, and other factors, AE offers better benefits than LE for improving balance function in older adults.

Study authors Ying Deng, Zheng Tang, Zhengting Yang, Qi Chai, Wenting Lu, Yunshi Cai, Yiting Luo, and Yongzhao Zhou are all affiliated with Sichuan University, West China Hospital, Chengdu, Sichuan, China.

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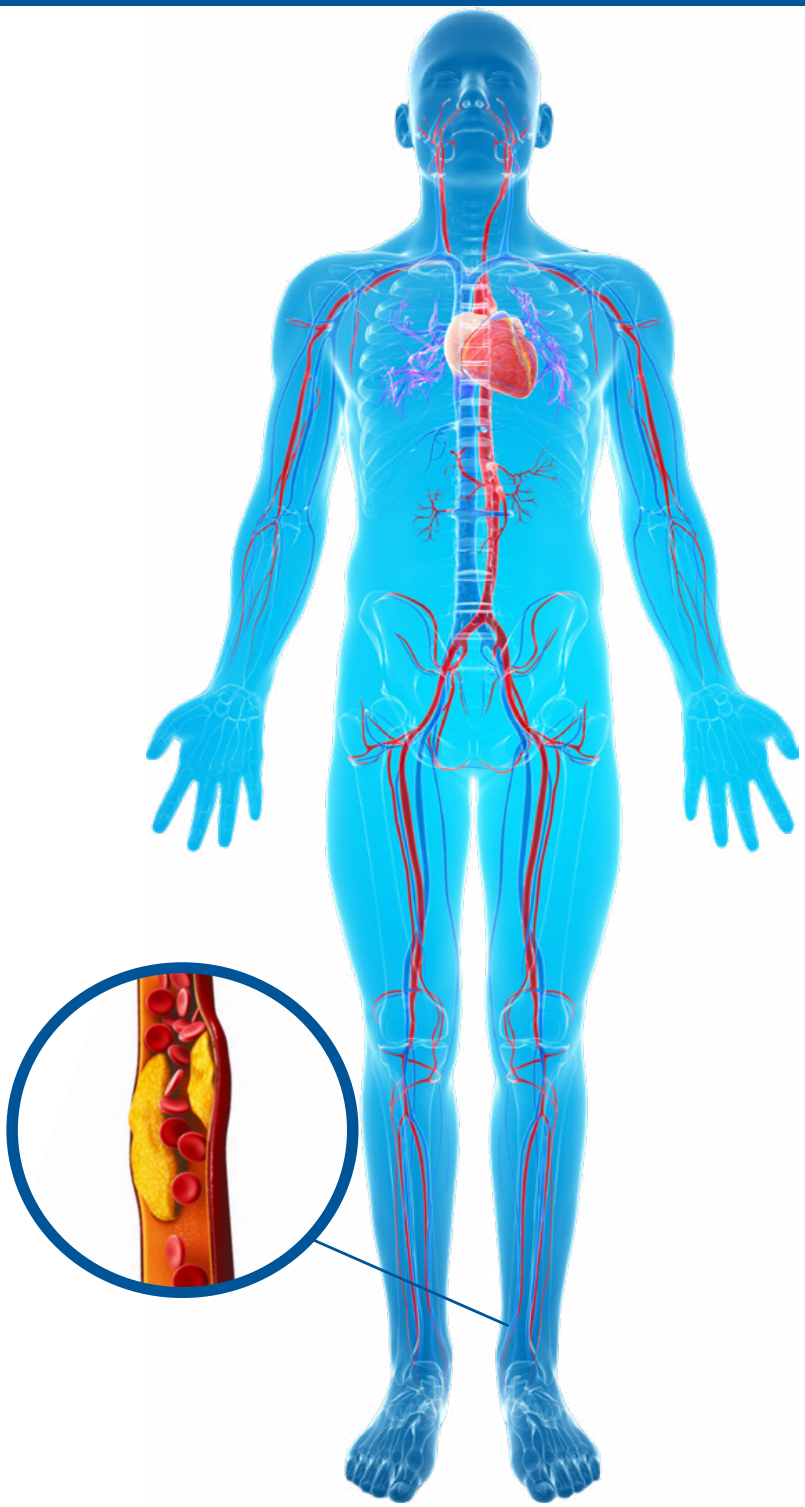

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A CASE REPORT

Hypertonia of the Big Toe Revealing Parkinson's Disease

By Houssam Mahla, Abdelilah Rhoul, Mohammed Gartit, Souhail Yachaoui, Ahmed Amine EL Oumri

Despite being less commonly discussed than other motor symptoms, such as tremors and bradykinesia, hypertonia of the hallux holds diagnostic and prognostic significance in Parkinson's disease (PD). This motor anomaly is dissected within the context of the broader clinical spectrum of PD symptoms, emphasizing its importance alongside its cardinal symptoms. This case report underscores the importance of accurate clinical assessment, especially thorough neurological evaluation in discerning hallux hypertonia, potentially enabling early disease recognition and intervention. By synthesizing these clinical insights, we trust that this case report contributes to an enhanced understanding of hypertonia of the hallux as a distinctive clinical presentation in PD fostering improved diagnostic precision.

Figure 1: Bilateral hallux hypertonia more pronounced on the right foot.

Hypertonia is defined as abnormally increased resistance to externally imposed movement about a joint. This can be caused by various conditions such as spasticity, dystonia, or rigidity, resulting in unusual postures, including foot deformities like striatal foot (SF), which is frequently observed in individuals with advanced Parkinson's disease (PD). These deformities could be developed not only in the later stages of PD but also in the initial phases of the disease and other Parkinsonian disorders. The likelihood of misdiagnosing SF deformities is notable, especially when they appear early in the absence of the cardinal signs of PD such as tremors. They could also be mistaken as primary dystonia, whether sporadic or hereditary, despite the fact that this condition rarely affects the feet. This case report highlights the importance of a complete clinical assessment and the consideration of PD in front of isolated toe dystonic cases.

Case Presentation

A 75-year-old woman presented to our Physical Medicine and Rehabilitation Department. Her chief complaints were walking difficulties that had started insidiously 1 year ago with a shuffling gait pattern and frequent trips (Video is available at DOI 10.7759/cureus.58203). She reported a personal history of hypertension, with no personal or familial history of neurologic disorders.

An initial clinical examination revealed a hypertonia of her big toes that was more significant on the right foot (Figure 1). This observation prompted us to conduct a more thorough neurological examination proving an akinetic-rigid syndrome with gait disturbance and axial rigidity. Upon evaluation, the Unified Parkinson's Disease Rating Scale (UPDRS) Part 3 score was determined to be 49, reflecting moderate to severe motor symptomatology. This assessment was indicative of substantial disease progression, as the Hoen and Yahr stage reached 3, highlighting moderate to severe functional impairment. Additionally, the Parkinson's Disease Questionnaire (PDQ-39) score of 25.7 revealed a moderate decline in PD-related quality of life.

Furthermore, standard X-ray imaging showed a bilateral dislocation of the first metatarso-phalangeal (MTP) joint more significant on the right (Figure 2). Additionally, a cerebral CT scan was performed and showed no abnormalities. Biological tests for rheumatic

This article has been excerpted from "Hypertonia of the Big Toe Revealing Parkinson's Disease: A Case Report." Cureus. 2024;16(4): e58203. DOI 10.7759/cureus.58203. Minor editing has occurred, including the removal of references for brevity.

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Continued from page 46

conditions were conducted, encompassing tests for rheumatoid factor and anti-cyclic citrullinated peptides antibodies (anti-CCP), both yielding negative results.

Confronted with this clinical presentation and the absence of any anomalies detected in the cerebral CT scan, we concluded the diagnosis of PD associated with focal dystonia. We recommended physical therapy sessions based on gait and balance training. The possibility of toxin injection for her big toes' dystonia will be evaluated after the completion of the rehabilitation sessions. The patient was then referred to the neurology department for complementary management.

Discussion

Several dystonic manifestations were reported in PD affecting different body parts, including focal and axial forms. SF is a focal dystonia form with a typical feature described as having a big toe extension, flexion of the other toes, equinovarus foot, and pain. This dystonic phenomenon could also be limited to the big toe only, realizing the striatal toe deformity which is the SF deformity without the equinovarus foot posture. These striatal deformities were reported in both advanced stages of PD and initial symptoms of PD. In our case, the patient presented an equinovarus foot with big toe adduction without claw feet deformities.

The prevalence of SF has not been systematically studied, with reports of 20% to 40% of foot dystonia development in PD patients receiving levodopa treatment. Nevertheless, approximately 2.4% of individuals within the PD population experience dystonia prior to treatment initiation. Furthermore, several studies reported different types of dystonic features including SF in untreated PD patients and even before the onset of Parkinsonism. In addition, dystonia is more likely related to the young onset of PD rather than late-onset PD.

SF is not a specific symptom of PD; other causes could also lead to this deformity, notably rheumatologic conditions such as rheumatologic arthritis (RA). In RA conditions, the great toe typically develops hallux valgus deformation characterized by subluxation of the phalanx at the MTP joint of the other toes that predominantly occurs dorsally. The context and clinical examination, in addition to paraclinical tests, generally help to guide the diagnosis. Furthermore, striatal toe deformity could also be seen in post-stroke spastic patients when the extensor hallucis longus muscle is affected. Other disorders with similar foot deformities including progressive supra-nuclear palsy, peripheral vascular disease, and lumbar canal stenosis were also reported.

Figure 2: An anteroposterior standard foot radiograph showing bilateral dislocation of the first MTP joint more significant on the right (white arrow).

> SF is a focal dystonia form with a typical feature described as having a big toe extension, flexion of the other toes, equinovarus foot, and pain.

Different management strategies for PD-related dystonia including pharmacological and procedural modalities were reported. Anti-Parkinsonism drugs have different degrees of response with positive results being reported; nevertheless, the response seems to be less predictable. Positive results with the use of anti-cholinergic and baclofen were also published. Botulinum toxin (BT) is another therapy to treat focal dystonia. Giladi reported positive results after injecting BT in the hallucis muscle of 3 patients. Several other studies supported the efficacy of the BT in the treatment of focal dystonia in PD especially in cervical and foot

Continued from page 44

dystonia. An ongoing double-blinded randomized clinical trial (RCT) aims to assess the safety and efficacy of the injection of BT in PD patients with foot dystonia (NCT04277247). The results from this RCT will highlight the role of this therapy in the management of SF.

Other therapies were also proposed, particularly deep brain stimulation which was used in segmental and generalized dystonia. However, high-evidence studies are still lacking with this therapeutic option.

Conclusions

In conclusion, while our case highlights the importance of considering PD in patients with atypical motor symptoms like hypertonia of the big toe, the findings are limited by the nature of our study. Future studies involving larger case series studies are needed to confirm the prevalence and clinical significance of hallux hypertonia as an early or atypical manifestation of PD. ler

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"BAREFOOT" SANDALS

The Camino™ barefoot sandal pairs flexible and minimal soling approach with classic rugged, durable oil-tanned leather uppers. The sandal was designed to meet the criteria of minimal footwear with a transitional flexible sole to safely build stronger, more functional feet. The shoe features a comfortable Poron® memory foam footbed to provide shock absorption and a secure heel strap to ensure optimal foot function. The unisex design features a wide toe box and an activewear outsole and is highly adjustable to accommodate a variety of foot shapes. For new wearers who spend most of their upright time in traditional shoes with arch supports, it is recommended that they transition gradually to minimal shoes over the course of several months, starting with 1 hour per day and increasing 1 hour each week. The sandals are 100% designed and crafted in the United States.

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AOPA ANNOUNCES 2024 HOWARD R. THRANHARDT AWARD RECIPIENTS

The American Orthotic and Prosthetic Association (AOPA) announced the recipients of the 2024 Howard R. Thranhardt Award are Andreas Kannenberg, MD (GER), PhD; Shane Wurdeman, PhD, CP, FAAOP (D); Tyler Klenow, MSPO, MBA, CPO, FAAOP; and Russell Lundstrom, MS. The award, established in 1996 by a gift from J.E. Hanger in memory of Howard R. Thranhardt, CP, has become 1 of the most distinguished honors in the orthotics and prosthetics profession, annually recognizing the strength in clinical research.

The lectures and awards will be given Saturday, September 14 at 8am in conjunction with the 2024 National Assembly in Charlotte, NC.

Kannenberg and Wurdeman will present "Assessing Outcomes with Microprocessor Knee (MPK) Utilization in a K2 Population (ASCENT K2): Findings from a Clinical Trial of 107 Individuals with Above-knee Amputation". The 2-arm randomized, controlled trial looked at 107 limited community ambulators with AKA (age: 73.7±5.6y). In the trial, 54 participants were assigned to wear an MPK and 53 wore a non-MPK. At 12 months follow-up, individuals with an MPK had on average reduced avoidance behavior from fear of falling, worried less about the consequences of falling, and experienced fewer fall events.

Klenow and Lundstrom will present "Reduction in Falls and Fall-Risk with Increased Walking Speed Found Following 1 Year of C-Brace® Use: Interim Results from the C-Brace® Registry". A prospective, multicenter registry was designed to gather real-world safety and effectiveness data from patients fit with a C Brace. Fifty-one orthotics and prosthetics clinics from the US and Europe are currently participating, enrolling 91 subjects and 42 subjects respectively and have completed the primary endpoint of 1 year. Use of the C-Brace resulted in improvements in fast walking speed and balance confidence while reducing falls and fall-risk measured by the Timed Up and Go test and the Activities-specific Balance Confidence Scale.

PRECISION® MIS BUNION SYSTEM

Paragon 28's PRECISION® MIS Bunion System was engineered to allow surgeons to complete a distal metatarsal osteotomy using a minimally invasive surgical (MIS) technique. The system features an outrigger designed for controlled triplanar correction including translation and derotation of the metatarsal head and adjustment of the distal metatarsal articular angle. Instrumentation is also provided to facilitate a free-hand technique. The system includes cannulated chamfer screws for fixation that allow alignment of the metatarsal head near the cortex of the first metatarsal. This minimally invasive technique is joint preserving, and the screw placement is designed to reduce the chance of soft tissue irritation.

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ROBOTIC HIP EXOSKELETON PROMISING FOR STROKE PATIENTS

Stroke survivors often experience walking asymmetry, where 1 step is shorter than the other. Now, new research from the University of Massachusetts (UMass) Amherst pushes forward the bounds of stroke recovery with a unique, portable robotic hip exoskeleton. Their work reveals that the robotic hip exoskeleton has the potential to effectively train individuals to modify their walking asymmetry, inviting the possibility of new therapies that are more

Meghan Huber, PhD, assistant professor of mechanical and industrial engineering, wearing the hip exoskeleton with Mark Price, PhD, and PhD candidate Banu Abdikadirova. Image courtesy of Derrick Zellmann.

accessible and easier to translate from practice to daily life compared to current rehabilitation methods.

The approach employed by the robotic exoskeleton is inspired by split-belt treadmills. Prior research has shown that repeated training on a split-belt treadmill can reduce walking asymmetry in stroke patients.

Wouter Hoogkamer, PhD, assistant professor of kinesiology, has spent the last decade studying split-belt treadmills. "Split-belt treadmill training is designed to exaggerate a stroke patient's walking asymmetry by running the belts under each foot at different speeds," he said. "Over time, the nervous system adapts, such that when the belts are set to the same speed, they walk more symmetrically."

This proof-of-concept study showed that applying resistive forces about 1 hip joint and assistive forces about the other with their exoskeleton mimicked the effects of split-belt treadmill training in neurologically intact individuals. Now that the research team has proven that the exoskeleton can alter gait asymmetry, they are eager to move their research into overground contexts that are more akin to the real world. The researchers also plan to expand their work by measuring the neural changes caused by walking with the exoskeleton and testing this new method on stroke survivors.

HANGER ANNOUNCES ACQUISITION OF O&P INSIGHT

Hanger, Inc., Austin, TX, announced that it has entered into an agreement to acquire orthotics and prosthetics (O&P) consulting firm O&P Insight, Las Vegas, NV.

"O&P Insight is uniquely focused on helping O&P businesses run profitable and compliant business operations, and brings an incredible amount of credibility, talent, and value," said Pete Stoy, Hanger's CEO. "Collaborating with O&P Insight in this capacity will enable us to place a greater focus on the services side of our business for the betterment of the profession…"

O&P Insight is a well-recognized and respected O&P consultancy providing comprehensive consulting and revenue cycle management services to independent O&P providers and manufacturers. The team offers over 250 years of combined experience.

The transaction is expected to close in the third quarter of 2024. Financial details of the transaction were not disclosed.

WOUND THERAPY DEVICE

The Wound Express advanced wound therapy device is designed to be used in conjunction with standard treatment techniques and has been shown to significantly reduce the size of both hard-to-heal wounds of venous and mixed etiology in some patients, and other wounds completely in just 8 weeks of use. This device uses intermittent pneumatic compression (IPC) to increase blood flow around the leg ulcer. The specially designed 3-chamber garment attaches to the pump, which has a patented timing cycle that augments venous and arterial blood flow. The Wound Express universal garment has also been designed to be placed on the thigh and not on the wound site. This device is ideally suited for patients to use at home, and includes a lightweight, portable, and quiet pump, which allows the 2-hour therapy cycle to be delivered while minimizing disruption to a patient's lifestyle and daily activities.

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ELECTRONIC SOCK DETECTS UNHEALTHY WALKING STYLE

An electronic sock that detects an unhealthy walking style linked with diabetes and poor circulation shows promise for preventing foot ulcers and amputation.

"Patients with diabetes tend to put pressure on the metatarsal area of the foot, rather than the heel," said researcher Ki Hong Lee, PhD, of Chonnam National University Hospital, Gwangju, Republic of Korea. "This way of walking encourages ulcers, which can become infected and lead to amputation. Identifying walking issues early using an electronic sock would enable patients to learn a healthy walking style and prevent serious foot problems."

This study examined whether a sock fitted with a ballistocardiogram (BCG) sensor could distinguish between healthy people and patients with diabetes. A BCG detects body motion as the heart ejects blood, and could potentially be used to measure heart rate and pressure exerted on the feet when walking.

The study enrolled 20 patients with diabetes and 20 healthy controls. All participants

wore the BCG sock for 40 seconds while standing and 40 seconds while walking to measure heart rate and to assess pressure distribution on the foot. At the same time as wearing the sock, participants had an electrocardiogram (ECG) assessment of heart rate.

The purpose of the heart rate measurement was to assess the accuracy of the BCG sock as a measurement tool relative to ECG, the gold standard method. The researchers found that the heart rate measurements by the BCG sock and ECG were almost the same.

Foot pressure distribution measurements were performed to discover whether the BCG sock could 1) detect differences between patients with diabetes and healthy controls, and 2) detect differences between patients with diabetes according to whether they had damage to the nerves or blood vessels.

Regarding the BCG comparison between patients and healthy controls, this showed that patients with diabetes exerted higher pressure in the metatarsal area of the foot while walking compared to participants without diabetes. The researchers also found that compared to patients without blood vessel damage, those with blood vessel damage exerted significantly greater pressure on the metatarsal area of the foot during walking and less pressure on the heel. There was no significant difference in foot pressure distribution measurements between patients with or without nerve damage.

"Taken together, the results suggest that the electronic sock could be an easy, non-invasive way to find patients with diabetes who could benefit from gait training to prevent foot complications," said Lee.

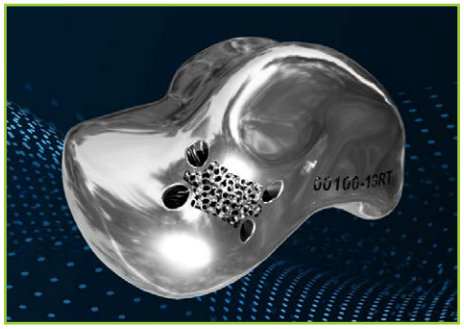
BONE HEALTH TECHNOLOGIES GRANTED 5TH PATENT FOR LOW BONE DENSITY TREATMENT

Medtech innovator Bone Health Technologies (BHT), Redwood City, CA, recently announced the company has been awarded a 5th patent for Osteoboost—the 1st and only US Food & Drug Administration–cleared prescription medical device to treat osteopenia.

The patent, titled 'Wearable Apparatus for the Treatment or Prevention of Osteopenia and Osteoporosis," describes the company's unique formula of precision-targeted vibration therapy, clinically proven to reduce the loss of bone density and strength in the lumbar spine in postmenopausal women.

"More than half of the devastating, life-altering fragility fractures happen to the 52 million patients with osteopenia who, prior to Osteoboost, had limited treatment options," said Laura Yecies, CEO at BHT. "Early intervention at the osteopenia stage to stop the loss of bone is critical to enabling women to stay strong, active, and fracture-free as they age. This patent recognizes the unique approach of our vibration therapy, and will further help us bring Osteoboost to market later this year."

PATIENT-SPECIFIC TALUS REPLACEMENT



The restor3d Total Talus Replacement implant is a 3D-printed and polished implant designed and made individually for each patient using data from computed tomography (CT) scan. The implant is intended to reduce pain, increase physical function, and maintain range of motion by avoiding amputation or loss of joint mobility (fusion). It is designed to match the patient's specific anatomy and is additively manufactured from a medical grade cobalt chromium metal alloy. This replacement allows the patient to maintain ankle joint movement between the distal tibia and the restor3d Total Talus Replacement implant, which imitates the anatomical talus in shape and size. As the diseased talus is replaced, pain is reduced. Optional soft tissue attachment sites may be requested and used by the surgeon to attach the patient's related ligament(s) to the implant.

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UNIVERSAL CONTROLLER COULD PUSH ROBOTIC PROSTHESES, EXOSKELETONS INTO REAL-WORLD USE

Aaron Young makes adjustments to an experimental exoskeleton worn by then-PHD student Dean Molinaro. The team used the exoskeleton to develop their unified control framework for robotic assistance devices. Image courtesy of Candler Hobbs, Georgia Tech.

Researchers are working on real-life robotic assistance that could protect workers from painful injuries and help stroke patients regain their mobility. So far, they have required extensive calibration and context-specific tuning, which keeps them largely limited to research labs. Mechanical engineers at Georgia Institute of Technology may be on the verge of changing that, allowing exoskeleton technology to be deployed in homes, workplaces, and more.

A team of researchers in Aaron Young's lab have developed a universal approach to controlling robotic exoskeletons that requires no training, no calibration, and no adjustments to complicated algorithms. Instead, users can don the device and go. Their system uses a

kind of artificial intelligence called deep learning to autonomously adjust how the exoskeleton provides assistance, and they've shown it works seamlessly to support walking, standing, and climbing stairs or ramps.

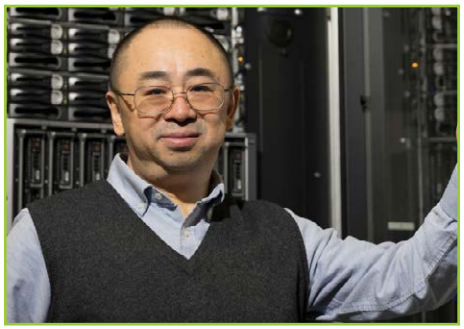
"The goal was not just to provide control across different activities, but to create a single unified system. You don't have to press buttons to switch between modes or have some classifier algorithm that tries to predict that you're climbing stairs or walking," said Young, PhD, associate professor in the George W. Woodruff School of Mechanical Engineering.

Most previous work in this area has focused on 1 activity at a time, like walking on level ground or up a set of stairs. The algorithms involved typically try to classify the environment to provide the right assistance to users. The Georgia Tech team, however, focused on the human—what's happening with muscles and joints—which meant the specific activity didn't matter.

With the controller delivering assistance through a hip exoskeleton developed by the team, they found that users expended less energy and their joints didn't have to work as hard compared to not wearing the device at all, even with the extra weight added by the device itself. The control system in this study is designed for partial-assist devices, which support movement rather than completely replacing it.

RESEARCHERS FIND BETTER WAY TO DETECT WHEN OLDER ADULTS FALL AT HOME

New research from Binghamton University, State University of New York, aims to cut reaction times with a human action recognition (HAR) algorithm that uses local computing power to analyze sensor data and detect abnormal movements without transmitting to a processing center offsite. Professor Yu Chen, PhD, and PhD student Han Sun from the Thomas J. Watson College of Engineering and Applied Science's Department of Electrical and Computer Engineering, designed the Rapid



Yu Chen, a faculty member in the Department of Electrical and Computer Engineering at the Thomas J. Watson College of Engineering and Applied Science, in the Data Center of the Engineering and Science Building at Binghamton University's Innovative Technologies Complex. Image courtesy of Jonathan Cohen.

Response Elderly Safety Monitoring (RESAM) system to leverage the latest advancements in edge computing.

Their work shows that the RESAM system can run using a smartphone, smartwatch, laptop or desktop computer with 99% accuracy and a 1.22-second response time, ranking among the most accurate methods available today.

Chen said the research is important for an underserved population—senior citizens—who need more help but normally do not have sufficient resources or the opportunity to tell high-tech developers what they need. By using devices already familiar to older people, rather than a full smart home setup, he thinks it gives them a better sense of control over their health—without the need to learn new technology for the system to be effective.

Also, to protect people's privacy, RESAM reduces the monitored images to skeletons, which still allows analysis of key points such as arms, legs, and torso to determine if someone has fallen or suffered a different accident that could lead to injury.

Chen sees the RESAM system as a cornerstone for a wider concept he's calling "Happy Home," which could include thermal or infrared cameras and other sensors to remotely assess other aspects of a person's environment and well-being. "Adding more sensors can make our system more powerful, because we are not only monitoring someone's body movements—we can monitor someone's health with 1 more dimension, so we better predict if something's going to happen before it happens," he said.

NEW KNEE BRACE LINE WITH JOINT-ASSISTANCE HINGE SYSTEM

McDavid has launched the Wrap and NRG Knee Brace, a hinge technology recovery solution that stores energy when flexed and rebounds with the body's natural movement, thereby reducing stress on knees up to 25% (based on wearing 1 NRG Knee Brace per knee). The NRG Knee Braces balance lightweight construction with serious support. The spring hinge, which is 60% lighter than a traditional metal hinge, is made with a high-strength polymer that helps offload stress from the wearer's muscles and knees. The design provides both lateral and medial knee support, making it an ideal solution for those dealing with joint instabilities, sprains, strains, or post-surgery rehabilitation. Spring Hinge Joint Assist technology is available in 2 new braces from McDavid: the NRG Over Knee Wrap, which is a versatile solution for strapping over pants, and the NRG Knee Brace, which delivers maximum support in a slip-on design.

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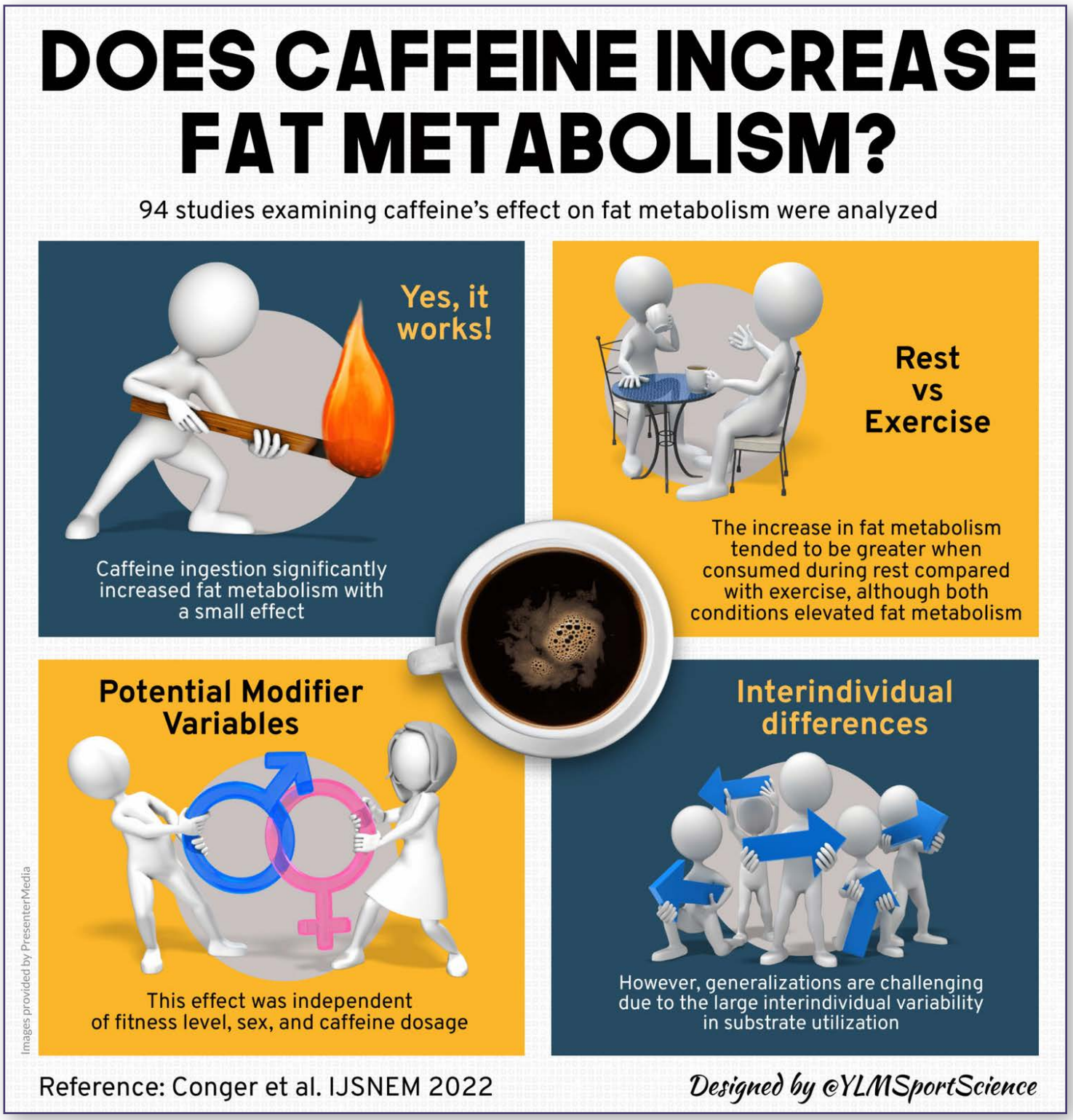

Source: Conger SA, Tuthill LM, Millard-Stafford ML. Does caffeine increase fat metabolism? A systematic review and meta-analysis. Int J Sport Nutri Exerc Metab. 2023;33(2):112-120. doi:10.1123/ijsnem.2022-0131

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