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LOWER EXTREMITY REVIEW

January 22 / volume 14 / number 1

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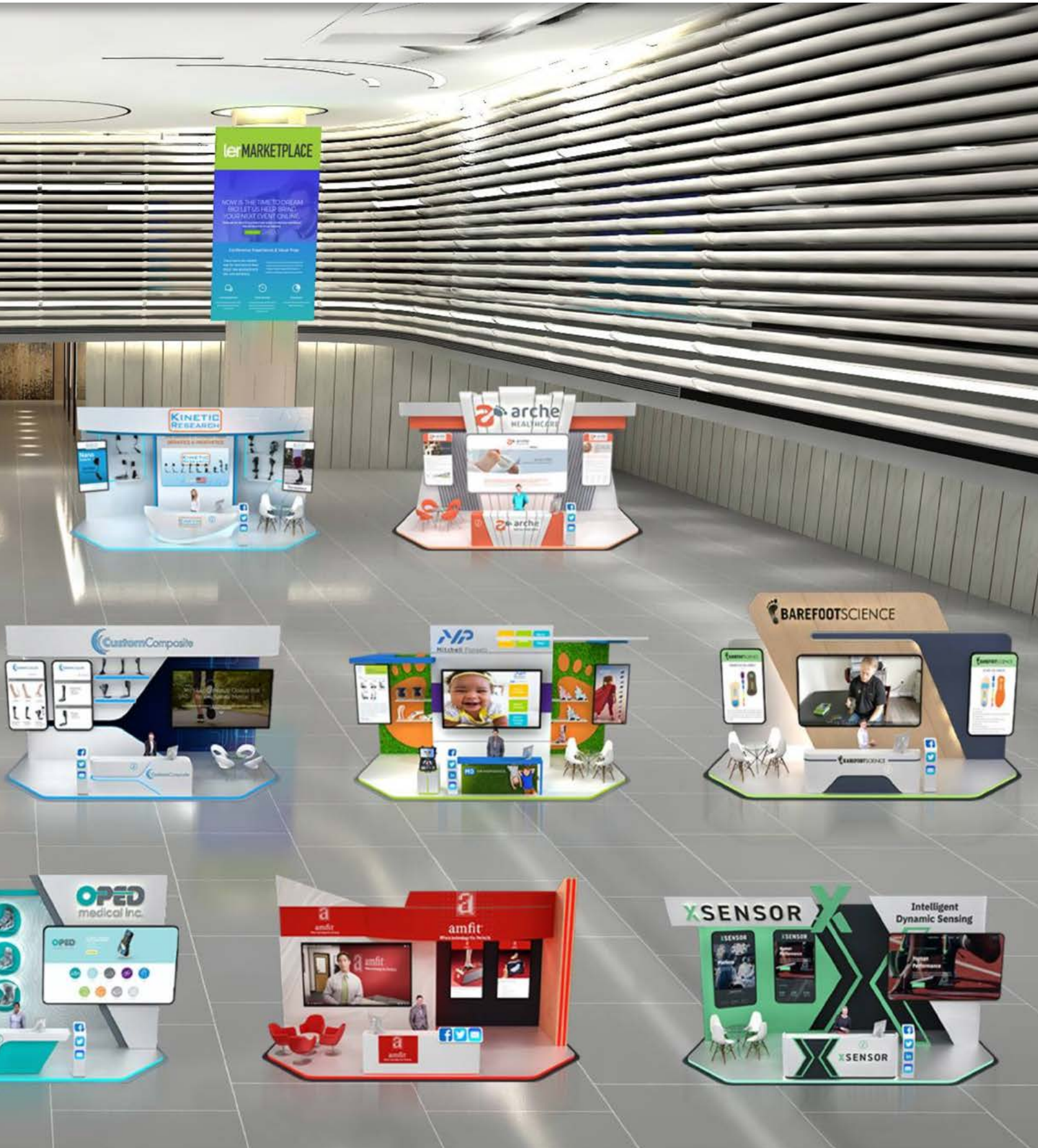

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January 2022 contents

PUBLISHER MEMO

As I write this Publisher's Memo, yet another in-person conference has been canceled due to Covid-19. While I thought we were making progress with more events going back to live, Covid-19 has once again reared its ugly head, dampening the demand for in-person meetings and increasing the desire to go virtual…at least for now.

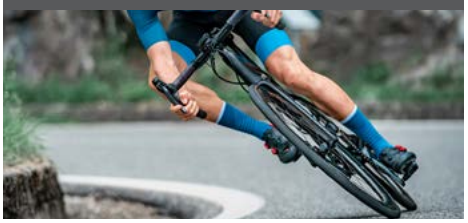
By Rich Dubin, Publisher

MEETING HIGHLIGHTS

AD INDEX

NEW & NOTEWORTHY

COVER STORY



The correct crank arm length is so critical that a bike fit cannot be performed until the bicycle is equipped with the correct crank arm length for the cyclist.

By Rick Schultz

WOUND CARE UPDATE

Dressings containing collagen enhance new tissue growth by improving fibroblast migration into the wound helping to promote angiogenesis and re-epithelialization.

By Windy Cole, DPM, CWSP

SHORTTAKES FROM THE LITERATURE

FEATURES

Technology is changing the way orthotics are designed and manufactured…and the evolution is ongoing. In this *lerEXPO Conversation*, leading experts offer their insights on the design process and today's manufacturing options.

By Keith Loria

Losing weight is hard. Keeping it off, even harder. Using data from the National Weight Control Registry, the author has identified 6 habits for the maintenance of weight loss, one of the most elusive patient outcomes in today's world.

By Jason R. Karp, PhD

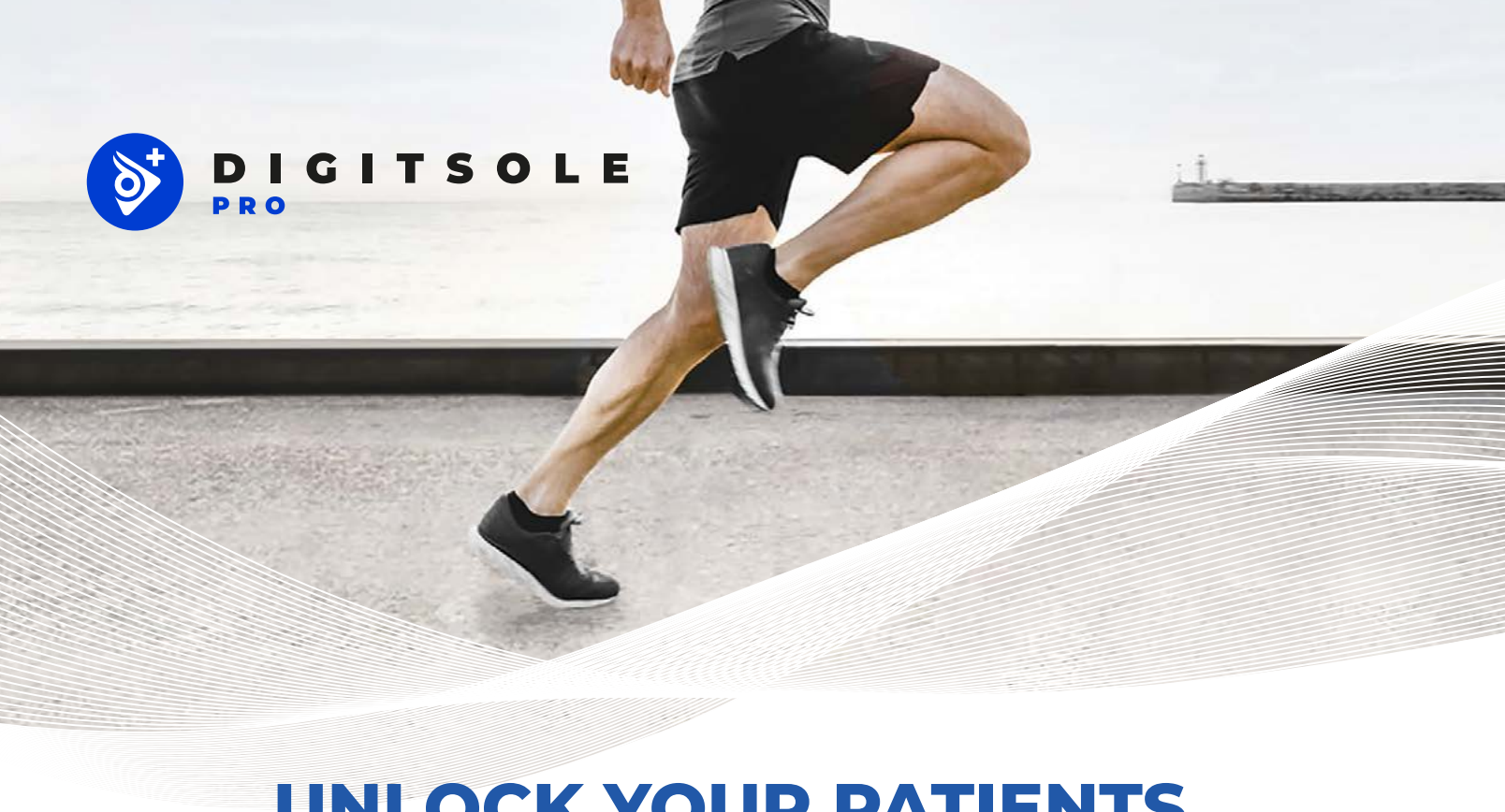
A tip sheet for clinicians to give to patients.

Foot orthoses that shift plantar load may alter the mechanical work required of internal structures and change the size of muscle and connective tissues. This study challenges the notion that FOs make muscles smaller.

By Joanna Reeves, Richard Jones, Anmin Liu, Leah Bent, Ana Martinez-Santos, and Christopher Nester

THE LAST WORD

DIGITSOLE PRO



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LOWER EXTREMITY REVIEW

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Lower Extremity Review

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Lower Extremity Review Mission

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

EDITORIAL PILLARS

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

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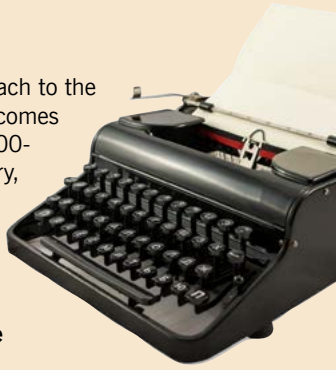
INFORMATION FOR AUTHORS

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



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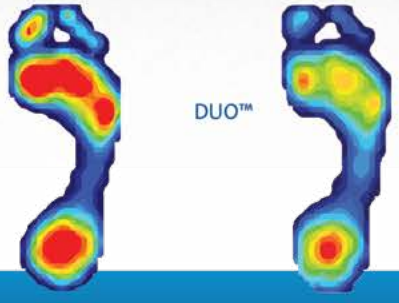

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Publishers Memo

Here's to a Prosperous 2022!

By Rich Dubin

As I write this Publisher's Memo, yet another in-person conference has been canceled due to Covid-19. While I thought we were making progress with more events going back to live, Covid-19 has once again reared its ugly head, dampening the demand for in-person meetings and increasing the desire to go virtual…at least for now.

Despite the hardships the pandemic has brought many, I am grateful for the past year as the LER brand is now fully entrenched in the virtual space. As with LER's introduction into the marketplace in the down times of 2008-2009, lerEXPO was in the right place at the right time and has provided more than 22 online events since the start of the pandemic for a variety of manufacturers and associations offering CEUs and CMEs for attendees. We have delivered online education to over 5000 attendees and have generated thousands of qualified quality leads for manufacturers large and small who have been struggling to gain traction during these trying times. As we look to 2022 and beyond, we have partnered with Advanced Physicians in Wound Health, North Central Ohio Academy of Podiatric Medicine, Western University of Podiatric Medicine, and Pedorthic Footcare Association to provide online CME and CEU events that will serve the many healthcare professions that treat the lower extremity.

The magazine's editorial will continue to address the complex care that many lower extremity patients need with a focus on collaborative care and its role in improving outcomes. We are already working with multidisciplinary authors to provide content that tackles larger topics such as diabetic foot ulcers, peripheral neuropathy, and the many challenges of aging, including falls prevention. And we will continue to look at sport-related injuries and how to prevent them with both exercise and technology.

With over 30 years in the multidisciplinary lower extremity space, we understand the market like no-one else. Our online visibility and tremendously supportive and loyal following, combined with the value we place on evidenced-based content, make our events the most successful around. We are committed to building a community of learning that bridges the gap among clinicians, manufacturers, and associations. The times have definitely changed and we need to adapt accordingly. lerEXPO's engaging platform makes our events the closest to being in-person. How do we know? Attendees have told us with comments such as these:

- "This online format was fantastic. Best seminar in 40 yrs."
- "By far the best No Nonsense seminar I have attended and I have attended since the 1980's. Great job"
- "This is truly the best overall material and presentation of any seminar I've attended in the last thirty years."
- "I have to admit I participated in more of the content this year by having it virtually. Tremendous, tremendous job!!!"
- "Well done and more effective learning process then [sic] in person"
- "Actually, best seminar in years."
- "Please continue to offer virtual, even if we return to in person seminar! This was an awesome experience!"

Our deep understanding of the market makes us an ideal education partner and only enhances the success of these "virtual" events for everyone involved: clinicians, manufacturers, associations, and ultimately, patients. In addition, we will be building our own LER events around specific topics such as biomechanics, wound care, diabetes, bracing, materials, technology, and more—and LER's readers will be the first to know.

To further cement our position in this new world, we have launched lerMARKETPLACE.com. This dynamic, 3D interactive, tradeshow offers clinicians a new way of receiving information and unique offers from self-selected manufacturers while providing manufacturers a way to generate new leads. We have been up and running for several months and have yielded over 77,000 pageviews for the vendors while providing thousands of leads and giving clinicians

Continued on page 10

Continued from page 9

valuable up-to-date product information at the moment they were searching for it.

I want to send personal thanks out to our incredible team of designers, editors, writers, marketers, consultants, and more. Without all of you, none of this would be possible. Another big thank you goes out to the readers and clinicians, manufacturers, and associations that have put their faith and trust in what we do and are a part of this ever-growing community.

Here's to a collaborative 2022–for all of us.

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LIMB PRESERVATION AT STUDENT-LED FREE CLINIC

Uninsured patients with diabetes are at high risk for amputations. This case series illustrates that the medical and specialty services provided by a free interprofessional student clinic were of a vital necessity in healing diabetic foot ulcers and preventing amputations in an uninsured population.

Methods: This case series includes uninsured patients seen by podiatry services at the Interprofessional Community Clinic (ICC), a suburban student-led free clinic at the Rosalind Franklin University Health Clinics (RFUHC) in Illinois. Patients were screened from the ICC's inception in 2014 through June 2021. Inclusion criteria included females or males age 18 and over with a diabetic foot ulcer. Patients were excluded if they were lost to care (n=2), which was defined as a gap in care lasting over six months. Information on medical and social history, wound characteristics, glycemic control, local wound care, and offloading modalities were recorded.

	Patient One	Patient Two	Patient Three
Demographics	47-year-old male, Hispanic	44-year-old male, Hispanic	51-year-old female, Hispanic
Medical history	Type 2 DM, peripheral neuropathy, hypertension, chronic kidney disease	Type 1 DM, peripheral neuropathy, PAD	Type 2 DM, peripheral neuropathy, Charcot neuroarthropathy
Surgical history	Multiple toe and partial ray amputations bilaterally	Left hallux amputation, left lower extremity revascularization	None
Ulcer characteristics	W1 ulcer, sub-3rd met head, left foot	W2 ulcer, lateral 5th met head, left foot	W1 ulcer, plantar-lateral midfoot, left foot
HbA1c	9.2% → 7.9%	7%	9.7%
Primary treatments	Debridement, patient education, diabetic shoes at reduced price	Debridement, patient education, accommodated orthoses	Debridement, patient education, felt padding and walking boot
Recurrences or amputations	First recurrence at ~7 weeks (W1) Second recurrence at 29 weeks (W1) No recurrence or new amputation at 30 weeks post 2nd recurrence	No recurrence or new amputation at ~20 weeks	No recurrence or new amputation at 7 weeks
Healing time	10 weeks (6 visits), 1 week (1 visit) Total 11 weeks (7 visits)	29 weeks (7 visits)	10 weeks (6 visits)

Note: DM= diabetes mellitus; PAD= peripheral artery disease; W1= Wagner grade 1; W2= Wagner grade 2; HbA1c= hemoglobin A1c

Results: Three patients, one female and two males, met the criteria. Average age was 47. All patients had a history of diabetes mellitus and peripheral neuropathy, and two had peripheral artery disease. No amputations were necessitated following initiation of care at the ICC. Patient 1's Wagner grade 1 ulcer healed in 10 weeks (6 visits). Patient 2's Wagner grade 2 ulcer healed in 21 weeks (7 visits). Patient 3's Wagner grade 1 ulcer recurred twice but most recently healed 60 weeks (12 visits) after first initiating treatment at the ICC. Wound care included regular wound debridement (via sharp and chemical techniques), home dressing changes, and offloading. The importance of glucose control was discussed with each patient. Offloading modalities included felt padding, surgical shoes, and therapeutic shoes. All patients lived in Waukegan, a low-income community in close proximity to RFUHC. Patients received primary care and other specialty services outside of the ICC.

ALPS SEEKS STUDENT CHAPTER MEMBERS

The American Limb Preservation Society (ALPS) serves as an interdisciplinary bridge between varied groups and organizations with respective roles to play in lower limb preservation. As part of its collective goal to eliminate preventable amputations, it is actively working to identify, develop, and mentor the next generation of clinicians, scientists and clinician scientists in this field. Accordingly, the organization is actively promoting the formation of ALPS Student Chapters.

The first such chapter was formed at Rosalind Franklin University of Medicine and Science (RFUMS), an institution renowned for its emphasis on the practice of interprofessional health care. The ALPS Student Chapter at RFUMS is focused on enhancing limb salvage for the diabetic population and emphasizes that each healthcare discipline plays an important role in limb preservation. Podiatric medical student Khanh Phuong Tong initiated the formation of the chapter in 2020, and present officers include Angela Garcia, Christine Jones, Emma Sorrentino, and Aashi Modi.

One of the key initial accomplishments of the RFUMS ALPS Student Chapter was the hosting of a webinar with the parent organization's President, David Armstrong, DPM, PhD, MD. Students from across the United States actively participated in the event. Another early success of the RFUMS chapter was its poster presentation Limb Preservation Success Stories from a Student-Led Free Clinic at DFCon 2021 (page 13). Chapter leaders are currently working on further research initiatives and are striving to help establish ALPS student organizations nationwide to unite future professionals in-training and create an interprofessional networking platform for enhancing limb preservation.

The testimonies of student leaders are evidence of the tremendous impact of ALPS on future professionals:

"Being the chapter president of ALPS has opened my eyes to the subtleties of properly examining patients in the diabetic community. Through ALPS, it is understood that we as podiatrists are not alone in the care of this particular demographic, as it provides a platform for interprofessional care of limb preservation."

— Angela Garcia, President, RFUMS ALPS Student Chapter

"Involvement in the ALPS student leadership team has deepened my aspirations of providing preventative podiatric medicine and limb-preserving care in collaboration with my future colleagues across healthcare disciplines. I look forward to seeing the ALPS legacy continue at RFUMS and schools across the nation."

— Emma Sorrentino, Secretary, RFUMS ALPS Student Chapter

More details about student chapters, including how to form a new chapter, are available at https://limbpreservationsociety.org/student-chapters/.

Continued on page 14

Don’t bury your head in the past

The future is far too bright

Continued from page 12

Conclusions: Podiatry clinics offer the essential preventative and specialty services needed for limb salvage for uninsured individuals. When such clinics are housed in interprofessional settings, patients are likely to benefit from greater coordination in care. Policy makers should support and encourage development of free limb preservation services in high need areas.

Source: *Tong KP, Garcia A, Jones C, et al. Limb Preservation Success Stories from a Student-Led Free Clinic. Available at https://www.dfcon.com/posters/.*

IMPACT OF FRAILTY ON WOUND HEALING

Few studies suggested that frailty may increase inflammation, which in turn may negatively impact tissue repair in people with significant tissue loss. This study aims to shed light on potential impact of frailty on outcomes of skin-substitute placement in patients with chronic diabetic foot ulcers (DFU).

Methods: Patients with chronic diabetic wounds ≥ Grade 2 Wagner class who underwent skin-substitute placement (i.e., acellular dermal matrix, bilayer cross-linked bovine matrix) were recruited. Using a validated trauma-specific frailty index questionnaire, patients with a score of >0.27 were classified as frail; all others as non-frail. Wounds were biweekly monitored for a 4-month period or until successfully closed. Primary outcome was successful granulation (defined as 100% of granulated tissue at the DFU site), and secondary outcome was wound tissue oxygen saturation (SatO2) at the study endpoint.

Results: Thirty-four patients with chronic DFUs (age: 58.2±11.6 years, 70.6% male, 55.9% Frail) were recruited. At the study endpoint, the successful granulation was significantly higher among non-frail than frail (53.8% vs. 8.3%, p=0.015) patients. The non-frail patients showed a trend for increased SatO2 (Baseline: 70.2 ± 13.6% vs Endpoint: 76.5 ±12.4%, p=0.17), as opposed to the frail patients (Baseline: 69.2 ± 11.4% vs Endpoint: 65.3 ± 21.9%, p=0.28). In addition, the magnitude of change in SatO2 at Endpoint compared to baseline showed a trend (p=0.13) for increased values in the non-frail patients (22% higher), in contrast to the frail patients (45% lower).

Conclusions: These findings support the hypothesis that frailty affects tissue granulation in patients with DFUs treated with skin-substitutes. The results are in agreement with prior studies suggesting that frailty may lead to increased inflammation and decreased tissue regeneration. This observation should be validated in a larger sample size.

Source: *Zulbaran A, Park C, Ross J, Lepow B, Najafi B. The Impact of Frailty on Wound Healing in People with Chronic Diabetic Foot Ulcers Treated with Skin Substitutes. Available at https://www.dfcon.com/posters/.*

DPN FOUND IN 4/5 PATIENTS IN SAUDI STUDY

This study aims to evaluate the prevalence of such a common and morbid neuropathy complication in a sample of Saudi diabetic patients.

Methods: A descriptive questionnaire-based cross-sectional survey was conducted on a sample of all diabetic patients who attend the specialist diabetes and endocrine center in Prince Mansour Military Hospital in Taif, Saudi Arabia. A monofilament test was used to identify diabetic peripheral neuropathy (DPN) cases, whereas its associated factors were identified through generalized linear

logistic regression analysis.

Results: The study included (n=343) diabetic patients. The prevalence of DPN was 84.8% of patients (n=291). Dyslipidemia increased the risk for DPN by 98.4% (p=0.04614). An interaction existed between the duration of diabetes and HbA1c levels in terms of their effect on DPN. When the interaction term is included, a positive association between DPN and both HbA1c (increased risk by 46.2%, p=0.03222) and DM duration (increased risk by 19.6%, p=0.04497). Cardiovascular disease reduced DPN risk by 62.1% (p=0.03516) and retinopathy reduced DPN risk by 60.9% (p=0.00782).

Conclusions: Over four out of every five patients have peripheral neuropathy. This is because our study was conducted among a high-risk group of attendees at the specialist diabetic center. Dyslipidaemia, poor glycaemic control, and longer diabetes duration were associated with peripheral neuropathy in our participants, confirming a direct nerve-damaging effect for high levels of lipoproteins, glucose and lipids in the blood.

Source: *Alfaez S, Alsalmi T, Alfeer R, Alghamdi E, Almalki B, Alfadhly A. Prevalence of Neuropathy and its Associated Factors Among Patients with Diabetes Presenting to the Specialist Diabetes and Endocrine Center in Taif, Saudi Arabia. Available at https://www.dfcon.com/posters/.*

Continued on page 16

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Continued from page 14

PREDICTING HEALING OF DFUS WITH MULTISPECTRAL IMAGING

Guidelines recommend adjunctive therapies for diabetic foot ulcers (DFUs) without >50% wound area reduction after 4 weeks of standard care. This delays advanced care in nearly 50% of DFUs. We sought to evaluate the ability of a multispectral imaging to predict DFU healing potential at the initial assessment.

Methods: Patients with a new DFU were enrolled in this multicenter, prospective trial after providing informed consent. Multispectral images of the DFU were obtained at initial evaluation using a novel wound imaging system. Clinicians were blinded to imaging data. A standardized DFU healing assessment was performed by physical exam after 30 days of standard care to determine whether ≥50% wound area reduction was achieved. A machine learning algorithm analyzing multispectral imaging features was trained and tested using cross-validation to measure the imaging system's accuracy of predicting DFU healing potential at the initial evaluation.

Results: Thirty-six patients (mean age 64±11 years; 84% male) with 48 DFUs were enrolled. Mean HbA1c was 7.6% ± 1.6%; 34 (66%) patients were prescribed insulin, 17 (47%) had prior lower extremity amputation, 7 (19%) had prior lower extremity revascularization, and 26 (72%) were current/former tobacco users. Standardized wound healing assessment identified 32/48 (67%) wounds that failed to achieve ≥50% wound area reduction. Using cross-validation, the overall accuracy for prediction of wound healing potential (likelihood wound would demonstrate ≥50% wound area reduction after 30 days of standard wound care) of the multispectral wound imaging system was 91.7% (95%CI: 83.3– 100%), with 96.9% (95%CI: 89.7–100%) sensitivity and 81.3% (95%CI: 61.5–100%) specificity; area under the curve (AUC) was 0.94, suggesting excellent performance of the classifier.

Conclusions: This study suggests that this novel wound imaging system has the potential to predict DFU healing potential upon initial assessment with a very high degree of accuracy. This wound imaging system would in turn allow clinicians to initiate additional diagnostics, specialist referrals, and advanced wound therapies in appropriately selected patients more quickly, with the potential to save costs and return patients to a higher quality of life with greater expediency. Independent validation of the wound imaging system is warranted. ler

Source: *Bastawros D, Squiers J, Thatcher J, et al. Machine Learning Analysis of Multispectral Imaging Data to Predict Healing Potential of Diabetic Foot Ulcers with Standard Therapy. Available at https://www.dfcon.com/posters/. Publication is pending in the* Journal of Vascular Surgery.

E-STIM FOR PREVENTION OF ICU-ACQUIRED WEAKNESS IN COVID-19 PATIENTS

Prolonged immobilization may inevitably lead to complications such as muscle dysfunction and consequently, intensive care unit-acquired weak-

ness (ICUAW) among critically ill COVID-19 patients. This pilot-study examined the effectiveness, feasibility and acceptability of lower-extremity electrical stimulation (E-stim) to prevent these complications.

Methods: COVID-19 patients admitted to ICU due to acute respiratory failure were randomly assigned to control (CG) or intervention (IG) groups. Participants and care providers were blinded to the group allocation. Both groups received daily E-stim (1-hour per session) up to 9-days on both gastrocnemius muscles (GNM). The device was functional in the IG and non-functional in the CG. The primary outcomes included ankle strength (Ankles) and muscle strength (GNMs) measured respectively by an ankle dynamometer and surface-electromyography (sEMG). Muscle endurance (GNMe) in response to E-Stim was also determined by sEMG. Outcomes were assessed at baseline, 3 days, and 9 days.

Results: Thirty-eight (IG=18, CG=20) lower-extremities were independently assessed. There were no significant differences in demographics and clinical characteristics between the groups ($p>0.05$). The mean time between ICU admission and delivery of E-Stim therapy was 2.2±1.9 days. The IG had higher GNMe at 3 ($p=0.04$) and 9 ($p=0.01$) days compared to the CG. While all outcomes were stable in the IG, the CG showed a decline in GNMe ($p<0.01$) and GNMs ($p=0.046$) at 3 days compared to baseline.

Conclusions: This study supports proof-of-concept effectiveness of E-stim to prevent muscle dysfunction in critically ill COVID-19 patients. If confirmed in a larger sample, E-Stim may be used as a practical adjunctive therapy to prevent ICUAW among this population. ler

Source: *Zulbaran A, Mishra R, Rodriguez N, et al. Effectiveness of Electrical Stimulation Therapy to Prevent Intensive Care Acquired Weakness in Critically Ill COVID-19 Patients – A Proof of Concept Double-Blinded Randomized Control Trial. Available at https://www.dfcon.com/posters/.*

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NEW TOOL PROVIDES CLINICAL SUPPORT FOR EXERCISE PRESCRIPTIONS

Exercise is recognized as the most efficient, cost-effective, and accessible "polypill" to prevent and treat more than 35 chronic diseases and health conditions that include cardiovascular disease (CVD) and its major risk factors (hypertension, diabetes mellitus, dyslipidemia, obesity, and physical inactivity). Yet, 82% of adults in the United States do not engage in the recommended amounts of exercise to achieve these health benefits. It has been proven that a physician's recommendation is a strong incentive for patients to exercise, but only 30% of physicians recommend exercise to their patients. Clinicians lack guidance on how to design an exercise prescription (ExRx) for patients with multiple CVD risk factors. To address this unmet need, we developed a novel clinical decision support system to prescribe exercise (prioritize personalize prescribe exercise [P3-EX]) for patients with multiple CVD risk factors founded upon the evidenced-based recommendations of the American College of Sports Medicine (ACSM) and American Heart Association. To develop P3-EX, we integrated (1) the ACSM exercise preparticipation health screening recommendations; (2) an adapted American Heart Association Life's Simple 7 cardiovascular health scoring system; (3) adapted ACSM strategies for designing an ExRx for people with multiple CVD risk factors; and (4) the ACSM frequency, intensity, time, and time principle of ExRx. We have tested the clinical utility of P3-EX within a university-based online graduate program in ExRx among students that includes physicians, physical therapists, registered dietitians, exercise physiologists, kinesiologists, fitness industry professionals, and kinesiology educators in higher education. The support system P3-EX has proven to be an easy-to-use, guided, and time-efficient evidence-based approach to ExRx for patients with multiple CVD risk factors that has applicability to other chronic diseases and health conditions. Further evaluation is needed to better establish its feasibility, acceptability, and clinical utility as an ExRx tool.

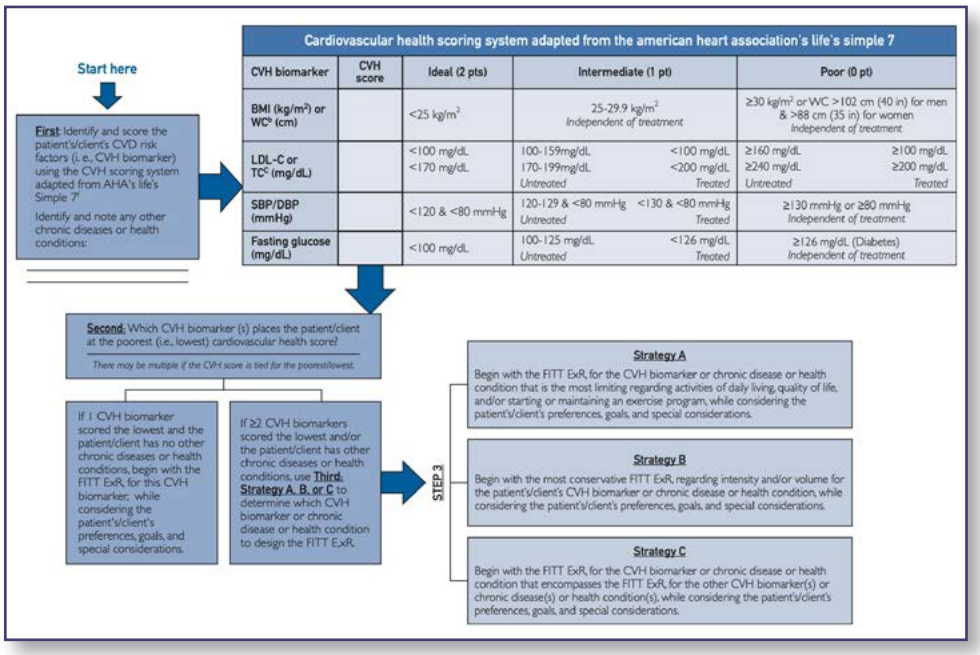

Figure. Clinical decision support system for prioritizing the cardiovascular risk factor or chronic disease or health condition to design the FITT ExRx.
AHA = American Heart Association; BMI = body mass index; CVH = cardiovascular health; CVD = cardiovascular disease; DBP = diastolic blood pressure; ExRx = exercise prescription; FITT = frequency, intensity, time, and type; SBP = systolic blood pressure; WC = waist circumference.

Excerpted from: *Pescatello LS, Wu Y, Panza GA, Zaleski A, Guidry M. Development of a novel clinical decision support system for exercise prescription among patients with multiple cardiovascular disease risk factors. Mayo Clin Proc Inn Qual Out 2021;5(1):193-203. Use is per CC BY 4.0.*

CLEVELAND CLINIC PRODUCING 3D-PRINTED GUIDES FOR ARTHROPLASTY

According to Alan Davis, MD, orthopedic surgeon from the Cleveland Clinic, when patients present with end-stage bone-on-bone arthritis, surgeons have 2 choices. Ankle fusion (arthrodesis) is recommended for patients who are younger or have large deformities, poor bone stock, or inadequate ligament or tendon function. The other option is total ankle arthroplasty. This option is for patients who have not had success with conservative treatment of ankle arthritis, have good bone stock, retain reasonable range of motion and good tendon/ligament function, and have no serious deformity below the ankle.

The Clinic is now using pre-operative 3D scanning to create 3D-printed surgical guides, customized to each patient; these help ensure tailored sizing and alignment during the procedure. As a result, according to Davis, they have seen higher success rates and greater longevity of ankle replacements.

Source: *Davis A. When Is Total Ankle Replacement the Best Treatment Option? Cleveland*

Continued on page 21

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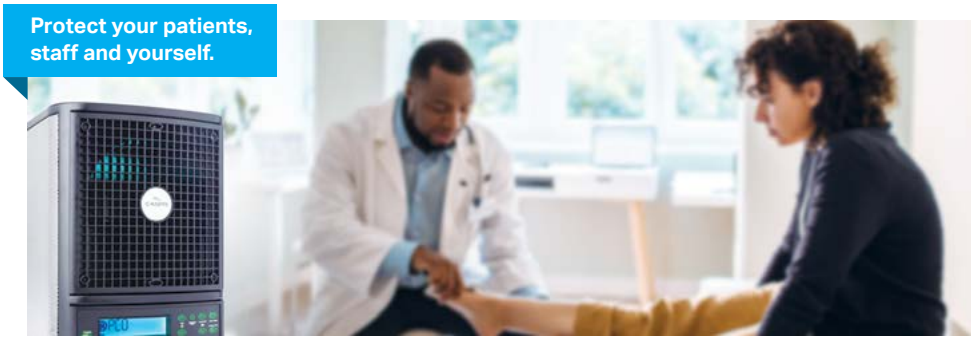

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Continued from page 19

Clinic Foundation. Consult QD Blog. Published Oct. 25, 2021. Available at https://consultqd.clevelandclinic.org/when-is-total-ankle-replacement-the-best-treatment-option/. Accessed Dec. 15, 2021.

FOOTPRINTS ID 2ND HUMAN ANCESTOR FOUND AT LAETOLI, TANZANIA

Bipedal trackways discovered in 1978 at Laetoli site G, Tanzania and dated to 3.66 million years ago are widely accepted as the oldest unequivocal evidence of obligate bipedalism in the human lineage. Another trackway discovered two years earlier at nearby site A was partially excavated and attributed to a hominin, but curious affinities with bears (ursids) marginalized its importance to the paleoanthropological community, and the location of these footprints fell into obscurity. In 2019, we located, excavated, and cleaned the site A trackway, producing a digital archive using 3D photogrammetry and laser scanning. Here we compare the footprints at this site with those of American black bears, chimpanzees and humans, and we show that they resemble those of hominins more than ursids. In fact, the narrow step width corroborates the original interpretation of a small, cross-stepping bipedal hominin. However, the inferred foot proportions, gait parameters, and 3D morphologies of footprints at site A are readily distinguished from those at site G, indicating that a minimum of 2 hominin taxa with different feet and gaits coexisted at Laetoli. ler

Abstract from: *McNutt EJ, Hatala KG, Miller C et al. Footprint evidence of early hominin locomotor diversity at Laetoli, Tanzania. Nature. 2021;600:468–471. Use is per CC BY 4.0.*

EFFECTIVENESS OF VR ON ANXIETY AND PERFORMANCE IN SPORT

With the increased use of technology, relaxation interventions are finding their way into technology devices like virtual reality head-mounted displays (VR HMDs). However, there is a lack of evidence on the efficacy of VR relaxation interventions to reduce anxiety in athletes and how that is portrayed in their movement patterns. The purpose of the current study was to examine how a VR relaxation intervention affected perceived anxiety levels and penalty kick performance of female soccer players. Thirteen female soccer players took 5 penalty kicks in baseline, stress induced, and VR relaxation conditions. Perceived levels of anxiety, self-confidence, mental effort, heart rate (HR), accelerometry of the lumbar spine and thigh, and performance in each condition was obtained. Results indicated that the VR intervention significantly reduced cognitive anxiety and somatic anxiety from baseline ($p = 0.002$; $p = 0.001$) and stress ($p < 0.001$; $p < 0.001$) with large effect sizes (Kendall's W = 0.72; 0.83). VR significantly increased self-confidence from baseline ($p = 0.002$) and stress ($p = 0.001$) with a large effect size (Kendall's W = 0.71). Additionally, all participants felt that VR helped them relax. Mental effort was significantly higher in the stress condition compared to that in baseline ($p = 0.007$) with moderate effect size (Kendall's W = 0.39). Peak acceleration and performance were not significantly influenced by stress or VR. This study serves as an initial step to evaluate VR relaxation interventions on performance in female soccer players. ler

Abstract from: *Harrison K, Potts E, King AC, Braun-Trocchio R. The effectiveness of virtual reality on anxiety and performance in female soccer players. Sports. 2021; 9(12):167. Use is per CC BY 4.0.*

IMPACT OF OVERLOADED SCHOOL BACKPACKS

…Carrying a backpack can increase reactive forces on the soil and plantar pressure, and this increase can be conditioned by the child's educational level. The increase in ground reaction force (GRF) was noted while children carried a backpack weighing only 7.5% of their body weight. Thus, the increased GRF may be responsible for the higher level of knee flexion observed at further distances and may be a strategy to compensate for the inability of the ankle dorsiflexors to attenuate the impact forces. In fact,

Continued on page 22

Continued from page 21

such protective behavior, when carrying a backpack, can generate smaller relative magnitudes of impact and propulsive forces when compared to the 'no-load' condition. The changes in walking speed and double support time described above could be used to not only maintain stability but also assist in shock absorption.

When carrying a backpack on a single shoulder, despite changes induced in the posture, the body adapts to the asymmetric placement of the load, finding a new dynamic balance that is not significantly different compared with the use of 2 handles. These adaptations cancel out a possible increase in the loading rate, even in children with scoliosis.

The analysis of GRF based on backpack use is of substantial importance because high levels of GRF are commonly associated with several health problems, such as lower limb injuries, degradation of articular cartilage, and injuries at the spine level. Mechanical forces influence spinal growth, and high loading rates can negatively affect bone health. These potential influences have gained emphasis because it is children of growing age who primarily use backpacks on a daily basis… (ler)

Excerpted from: *Barbosa J, Marques MC, Neiva HP, et al. Impact of overloaded school backpacks: an emerging problem. Open Sports Sciences J. 2021;14:76-81. DOI: 10.2174/1875399X02114010076. Use is per CC BY 4.0.*

FUNCTIONAL BRACING IS SAFE, COST EFFECTIVE FOR WEBER B FRACTURE

Despite the current recommendations that stable Weber B ankle fractures can be treated with functional bracing and weightbearing as tolerated, some reluctance exists among trauma surgeons to follow these recommendations. This paper reports on our institution's experience in managing these injuries and compare it to the national guidelines.

Patients and methods: This is a retrospective cohort study. Con-

secutive patients with isolated Weber B fractures referred to the local outpatient clinic over the period of 6 months were included in the study. Radiographs and clinic letters were examined, the patients were interviewed via telephone to obtain outcome scores [Olerud and Molander score]. Method of immobilization, weight-bearing status, radiological fracture union, clinical outcomes and complications were all assessed and analyzed.

Results: One hundred and twenty-three patients with isolated Weber B fractures were identified. This cohort of patients did not show clinical or radiographic evidence of instability, they were deemed stable and were initially treated non-operatively. Minimum follow-up period was 6 months. Sixty-two patients were treated in plaster and were non-weight bearing on the affected limb, while 61 were treated with functional bracing in a boot and were allowed early weight bearing. Three patients showed displacement requiring surgical fixation. All fractures progressed to union and patients were discharged irrespective of the method of immobilization or weightbearing status during treatment. There was no statistically significant difference in the functional outcome measures between the two groups. The protocol of functional bracing and weight bearing was associated with fewer outpatient clinics and a reduced number of radiographs obtained in the clinic and fewer complications.

Conclusion: Isolated trans-syndesmotic Weber B ankle fractures, that are clinically and radiologically stable, can be safely treated with functional bracing in a boot and weight bearing as tolerated.

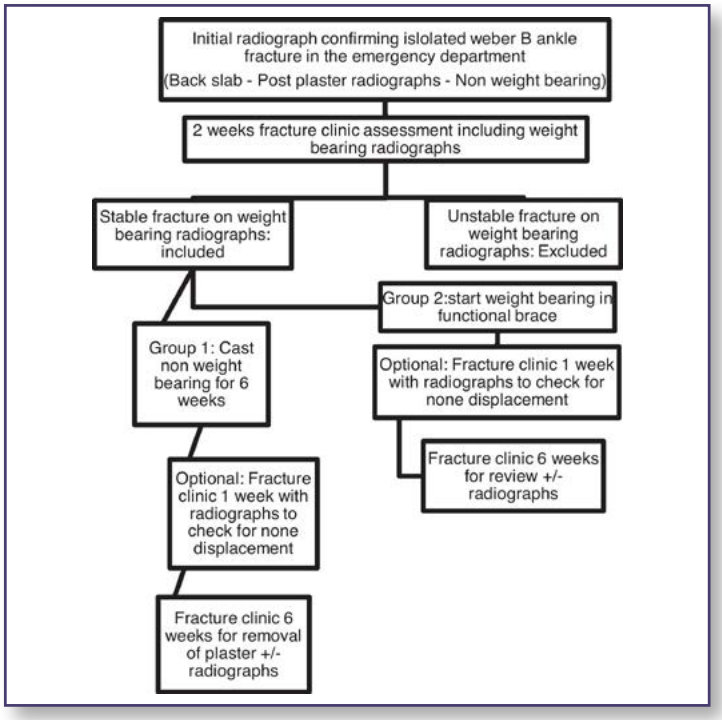

Figure. Treatment pathways for isolated Weber B fractures.

Abstract from: *Abdelaal A, Elnikety S. Functional bracing is a safe and cost effective treatment for isolated Weber B fracture. The Foot. 2021;49:101839. Use is per CC BY 4.0.*

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Wound Care Technology Expert Panel

By Keith Loria

The development of foot orthotics—both their prescription designs and their manufacturing processes—is continuously evolving as new materials and new manufacturing technologies arise to meet the changing demands of today's medical and sport performance needs. Just as medical practitioners have pushed the range of foot and lower limb pathologies for which these medical devices can be used, so too have manufacturers pushed the technology to improve the technical aspects of the product as well as the speed of manufacturing.

At a recent lerEXPO virtual event, "Orthotic Treatment Through the Ages" sponsored by ARIZE, authorities in the field of orthotics offered their thoughts on the processes for designing and manufacturing of today's orthotics.

Prescription Design

First up was Craig Payne, DipPod, MPH, a podiatrist and noted university lecturer from Australia, who focused on the various steps available to get "from the foot to the orthotic" and how those have evolved.

"I look at it as a clinical decision-making process," he said (Figure 1). "Once you make a diagnosis (eg, posterior tibial tendon dysfunction or plantar fasciitis), somewhere around that diagnosis a foot orthotic is indicated." To determine the specific needs, assessments are performed, such as gait analysis or postural alignment. These assessments, he explained, are done to look for "prescription variables."

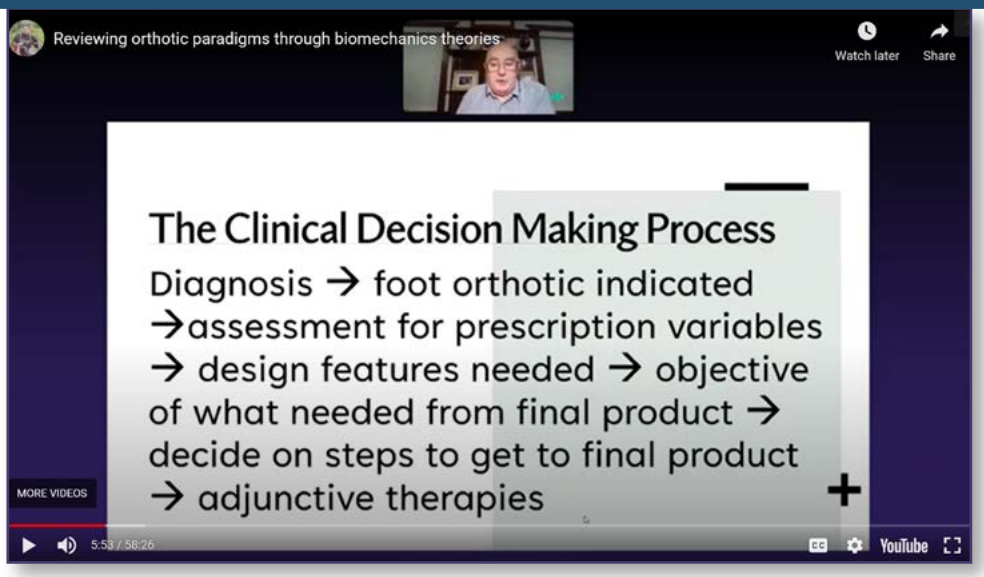


Figure 1. The Clinical Decision Making Process for foot orthotics.

Once those are known, design features of the orthotic are identified "to get the result of what we want."

"Then we have to decide on the steps to get to the final product, and those are the steps we'll go through" he said, adding, "of course, we'll do the necessary adjunctive therapies (eg, stretching or muscle rehab)…but I'm going to focus on deciding on the steps for how we get to the final [foot orthotic] product."

"We start with making a negative model," he said (Figure 2). "in the past, we called it a cast."

There are countless challenges with the negative models including: weightbearing versus non-weightbearing versus partial weightbearing; foot positioning (STJ neutral, MASS, facilitate windlass, etc.); prone or supine; forefoot varus or supinatus; capture rear of calcaneus; hands on or off the foot; and alignment/posture vs kinetics/loads. While acknowledging that the debate continues to rage, Payne was clear that for the last item, at least, he believes kinetics/load are most important.

He then described the many methods available to obtain the negative model, noting the many "new" technologies that have come and gone:

- eyeballing ("this is really just looking at the foot")
- plaster cast (depends on the skill of the technician)
- STS sock ("similar to the plaster cast but less greasy")
- foam box
- optical scanners ("many of today's models

"In reality, as we go into the future, the keys are understanding stiffness, thickness, texture, and structure," Williams said. "The goals are obviously to have a lighter device, and a thinner device so patients have more room in their shoes, and if we can improve the fit, that's always a great goal."

Continued on page 26

Continued from page 25

connect with iPads or iPhones, but there remain issues with holding the foot in proper position)

- photogrammetry ("involves taking several 2D photographs of the foot and providing measurements such that an algorithm can translate into a 3D image of the foot from which you can create a model… The evidence is pretty good")
- dilatancy-based systems (dilatancy is defined as the volume change observed in granular materials when they are subjected to shear deformations)
- weight-bearing systems ("these allow you to change the alignment of the foot in real time")
- pin matrix systems ("in these, non-sharp pins come up from below to capture the shape of the arch and the foot")
- extrapolation based systems (which are not as common today, "do not collect any volumetric data, they collect pressure data, and they rely on an algorithm to extrapolate that 2D pressure data and somehow create a foot orthotic.")

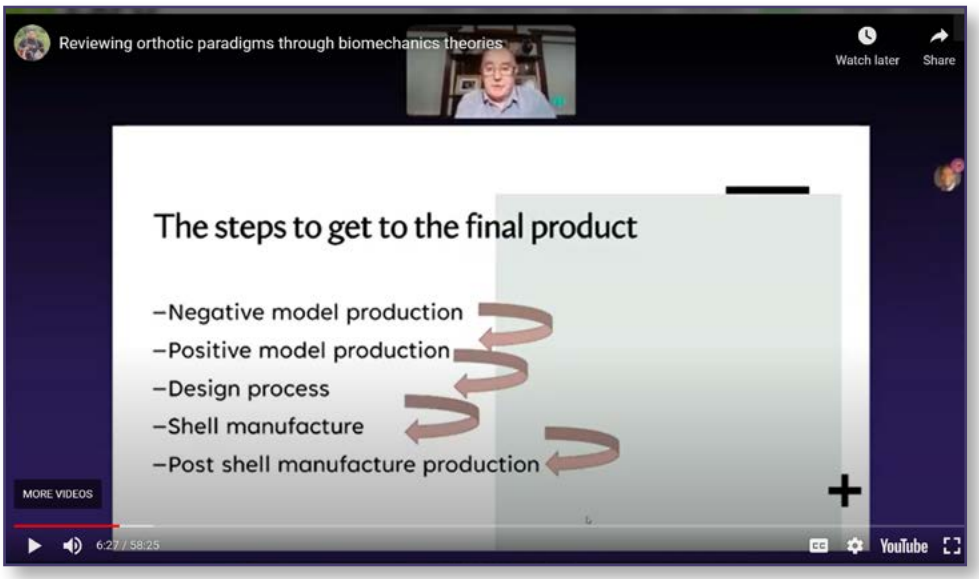
Payne cited data from a 20-year-old study showing the cost benefit analysis of using scanning (total costs $3.30–10.00) versus casting ($27.94–$49.60). "Optical scanning was a total no-brainer," he said.

"Which is the best way [to create a negative model]? It comes down to personal preferences and logical fallacies, there are lots of opinions," Payne said. "There's no evidence that any one way is better than another."

The key question he asks is this: "Can you get the segments of the foot in the position that you need?"

The next step involves the decision to use a prefabricated shell or a library device and produce a digital negative model for use by inhouse designers or to be sent out to lab.

"If we have a physical model from plaster, we can then manufacture ourselves, or we can ship it to the lab, or we could scan it and send it to the lab and they will scan it, and then have a digital negative model," he said.



One of those options is a 3D-printed physical positive model.

"The thing about 3D printing is that once the design process is finished, the lab can print it and send it back to you as a finished product," Payne said. "Some labs are actually outsourcing the 3D printing to facilities that have multiple machines."

He concluded by noting that at the end of day, it doesn't matter what system one uses, or what method, the shape of the final product should be the same if the prescription was followed by the lab.

"Use the method that allows you to manipulate the thickness of the foot into the position that you need, so that you can deliver the design features that are needed to get the outcomes that you want," Payne said.

The thing about 3D printing is that once the design process is finished, the lab can print it and send it back to you as a finished product.

3D: Manufacturing the Future

The second session started with commentary by Bruce Williams, DPM, a Chicago-area podiatrist and consultant with Arize Orthotics, who explained how 3D printing could be best applied to orthotics manufacture, describing how 3D printing technology works, the materials available, and the new design possibilities enabled by additive manufacturing.

"3D printers are here, and have been for a while," Williams said, noting the COVID-19 pandemic was one of the best things to happen to the 3D printer industry, because more people explored working with them due to manufacturing and shipping issues.

The biggest pushback he's seen with the use of 3D printers for orthotics comes from those who were using materials that weren't polypropylene or polypropylene-like, and so they would come out hard and didn't have a lot of flexibility. Or, if they did have flexibility, they were brittle.

Williams noted that labs are getting to the point where the materials they use are no longer a problem, with a higher use of polypropylene or PA-12 (also called Nylon-12) or something similar that could mimic polypropylene.

"At HP, we use PA-12, and overall, the dimension, the dynamic stiffness, energy recovery, everything is great," he said. "It's really

Continued on page 29

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Continued from page 26

difficult to break the thing from a traditional device mounted extension."

Williams also sees the potential for orthotic devices to be better because of the advanced design potential.

When printing as prescribed, 3D printing allows for prescription modifications to be programmed as needed, at minimal to no additional cost for modification of 3D printed shells that are then is ready to dispense with the addition of a top cover.

"In reality, as we go into the future, the keys are understanding stiffness, thickness, texture, and structure," he said. "The goals are obviously to have a lighter device, and a thinner device so patients have more room in their shoes, and if we can improve the fit, that's always a great goal."

When Williams concluded, Melanie Shelton, Arize product manager at HP with a near 20-year history in orthotics manufacturing, talked further about the 3D capabilities and how to take the concepts and turn them into a solution.

She explained that HP's approach with the Arize solution was to offer enough standardization that it would be very easy for clinicians to adopt into a clinic but also provide enough innovation and value that it would be significantly better than some of the other solutions that are out there.

"Design consistency and repeatability, that is 100 percent something that we can provide to you," Shelton said. "That's something that a 3D printing end-to-end solution can absolutely do for you in ways that cannot be done with these legacy manual processes that you all have experienced."

Currently, the timeframe to 3D manufacture an orthotic is under 2 weeks and the goal is to continue to get that turnaround time faster and faster.

"Patient outcomes are really important to us and we want happy patients," Shelton said.

The way it works is a 3D preview of the orthotic design is created so while someone is working with the software and prescribing the orthotic, the design engine is already designing the orthotic at one's desktop. It takes less than 5 minutes.

"We are able to control thicknesses—thickness on certain modifications and also even able to control thicknesses of the shell itself," Shelton said. "We're lucky that in 3D printing, we're not limited to one-millimeter sheet-stock increments like in legacy processes."

That means, there can be an orthotic where the arch is a little bit thicker, but under the heel it's a little bit narrow or shallow, and it also allows for a much lighter weight and a much lower profile orthotic.

Consistency and repeatability of the end-to-end solution were key to building the Arize solution, as was attention to clinician workflow. The goal, Shelton said, "was to ensure that the data is carried all the way through so the orthotic is repeatable and consistent, which is what patients and clinicians want."

To hear the talks in their entirety, visit lerEXPO.com and go to Events in the top tool bar and search for Orthotic Treatment Through the Ages. While there, scroll through lerEXPO's other events, all are available for free.

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The Role of Collagen Dressings in Wound Management

By Windy Cole, DPM, CWSP

Collagen is the most abundant protein in the human body. It acts as a support structure, giving the skin strength and elasticity. Collagen also plays an essential role in wound healing.[1] During the proliferative phase, fibroblasts migrate into wounded tissues and lay down new collagen to support the extracellular matrix (ECM), fill in the wound with granulation tissue, and aid in wound contracture. Acute and chronic wounds also contain matrix metalloproteinases (MMPs). These enzymes regulate degradation and deposition of the ECM. When present in excess, MMPs can lead to disorganization of the ECM, disrupt collagen deposition, and prolong wound healing.[1]

Dressings containing collagen have utility in chronic wound management. These biomaterials enhance new tissue growth by improving fibroblast migration into the wound helping to promote angiogenesis and re-epithelialization.[2] Collagen dressings also support wound healing by binding with and inactivating excessive MMPs. In these instances, the collagen in the dressing acts as a sacrificial substrate so that the ECM is spared.[2] Collagen dressings are also impermeable to bacteria.[2]

Collagen dressings are commercially available in sheets, powders, and gels. Common sources include bovine, equine, porcine, avian, or piscine. Collagen products are to be used as primary dressings, meaning they need to contact the wound bed to be effective. The wound bed should be free of necrotic tissue and large quantities of adherent fibrin or slough. Collagen dressings also promote a moist wound healing environment by absorbing mild to moderate exudate.

The utility of collagen dressings has been well documented in the wound management literature. A comparative study by Singh et al[3] found that healthy granulation tissue was present at a statistically significant level in the patient cohort treated with collagen versus those that received conventional care dressings. The researchers also noted that patients treated with collagen dressings also exhibited a lower need for skin grafting. Collagen dressings were also shown to be very easy to apply.

The Future of Collagen Dressings

A recent study from the *Bosnian Journal of Basic Medical Sciences*[4] investigated the efficacy of a novel carbodiimide cross-linked freshwater fish collagen sponge containing vancomycin in the treatment of infected wounds in a rat model. The researchers noted a decrease in the number of methicillin-resistant *Staphylococcus aureus* CFUs in the infected site following the local administration of the vancomycin-releasing cross-linked collagen sponge.

A recent literature review in the *Journal of Biomedical Materials Research Part A*[5] focused on the advances of electrospun collagen materials for chronic wound management. Breakthroughs in tissue engineering technology are giving rise to exciting new collagen blends and innovative nanofiber technologies.

When making product selections, clinicians should choose biomaterials that are natural, non-immunogenic, non-pyrogenic, hypo-allergenic, and pain-free. Collagen dressings check off all of these boxes.

Windy Cole, DPM. CWSP, is an adjunct professor and Director of Wound Care Research at Kent State University College of Podiatric Medicine. Dr Cole also serves as the National Director of Professional Development and Clinical Education for Woundtech. She is board certified by the American Board of Foot and Ankle Surgery and the American Board of Wound Management. She has been a dedicated wound care advocate for two decades with interests focused on medical education, diabetic foot care, wound care, limb salvage, and clinical research. Her passion to help others has led her to participate in humanitarian efforts around the world. Dr. Cole has published numerous peer-reviewed and industry articles on these topics and is a sought-after speaker both nationally and internationally. She is a feature writer for Podiatry Management and Today's Wound Clinic as well as a contributing writer for Podiatry Today. She is an Editorial Board member of Wound Management and Prevention, Podiatry Today, The Foot Journal, and Lower Extremity Review. She is also the Podiatry Section Editor for the ePlasty Journal. She is a wound care advocate on the forefront of wound research and was the 2020 World Union of Wound Healing Silver Medal Award recipient for her work in Technology-driven Research. She sits on the advisory board of multiple emerging biotech companies and has been integral in collaborating on innovative research protocols in the space.

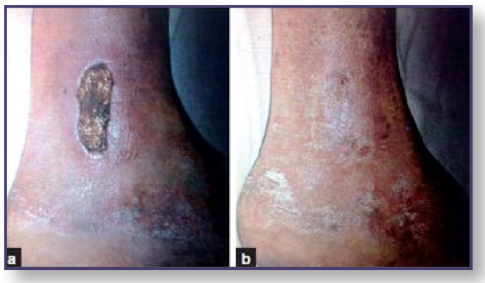

Figure. A deep wound on leg before (a) and after 28 days (b) of collagen dressing. Image from Singh O, Gupta SS, Soni M, Moses S, Shukla S, Mathur RK. Collagen dressing versus conventional dressings in burn and chronic wounds: A retrospective study. J Cutan Aesthet Surg. 2011;4:12-6.

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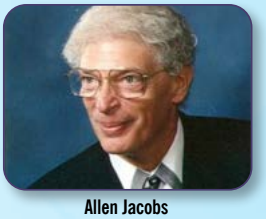

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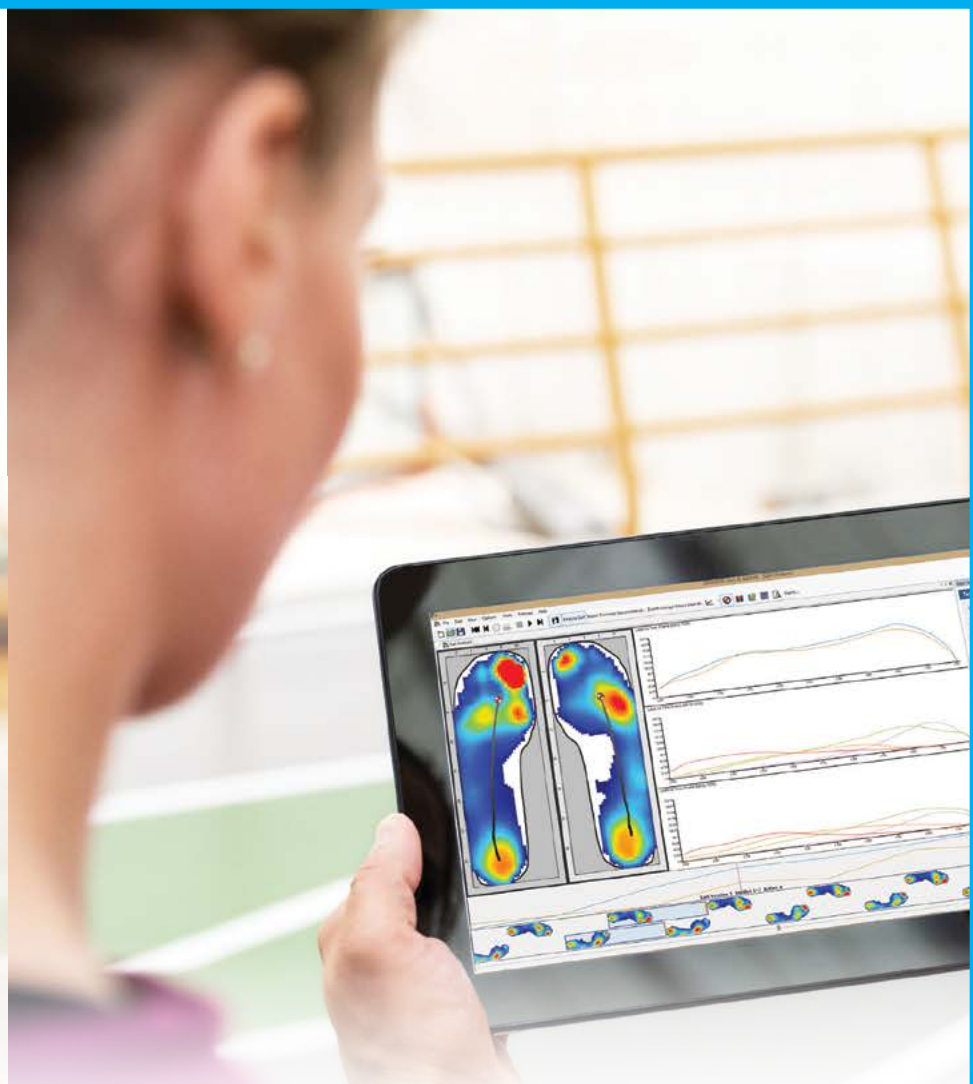
AGENDA (CHECK BACK FOR UPDATES)

- SURGERY: MIS Bunionectomy
- SURGERY: The Role of Foot Function and Biomechanics After Surgery?
- BIOMECHANICS: Biomechanical Assessment & Orthotic Prescription
- BIOMECHANICS: How Do Foot Orthoses Work
- BIOMECHANICS: Longitudinal Arch Load-Sharing System of the Foot
- BIOMECHANICS: The World of Science is Staring Up at Us
- POD MED: Limb Salvage Expert Panel Discussion
- POD MED: Onychodystrophy Is NOT Always Onychomycosis - Best Practices for Testing and Treatment
- POD MED: How to Manage the " No Option" Patient with PAD
- POD MED: Billing Hurdles for AFOs and Therapeutic Footwear
- POD MED: Gout Arthritis - The Time is Now for Remission and Cure
- POD MED: Oral ABX for Management of Osteomyelitis
- WOUND CARE: Didn't Heal - Recognizing Barriers to Wound Healing
- WOUND CARE: The ABCESS System for Chronic Wound Management: A New Acronym for Lower Extremity Wound Management
- WOUND CARE: The Challenges of Multidisciplinary Limb Salvage Team in a Safety Net Hospital
- WOUND CARE: Sclerotherapy Overview, When Things Go Wrong—with case studies



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A Perfect Bike Fit Starts With the Correct Crank Arm Length

By Rick Schultz

Having performed thousands of bike fits, I now believe that the bicycle's crank arm length is the most important factor when performing a bike fit. Every other anatomical dimension and joint angle is based upon the length of the crank arms; therefore, this is the first factor to address when performing a bike fit.

Having been a professional bike fitter for the past 12 years, I have seen and fit cyclists of every size and shape. As a result, I can assure you that every cyclist needs a custom bike fit because no 2 cyclists are the same. Even at the same overall height, each cyclist will have a slightly different torso-to-leg length ratio and maybe even a slightly different femur-to-tibia length ratio, so it is absolutely necessary that each cyclist undergo a fit that starts with evaluating their leg length. Like medical professionals everywhere, top-tier bike fitters follow the motto: *"first, do no harm."* Afterall, once a cyclist has gone through a comprehensive professional bike fitting process, they should be at least as comfortable and safe on the bike as they were before they came in.

This paper will focus on road, gravel, and especially triathlon/time trial (Tri/TT) bicycles, and the importance of crank arm length versus frame size. Why? Up to a point, frame size can be 'modified' by moving the saddle up or down, substituting a longer or shorter stem, changing the type, shape, or even the rotation of the handlebars. Tri/TT bikes are even more adjustable by changing the reach, angle, twist and/or, rotation of the aero bars. by changing the reach, angle, twist, and/or rotation of the aero bars. Crank arms, on the other hand, come in fixed sizes and cannot be changed, meaning that a typical crankset comes with a set of crank arms of a single size. Crank arms are the levers to which the pedals are attached. While there are some aftermarket solutions, these are not part of the standard crankset provided by the component manufacturers. For the past several seasons, I have seen the same one-size-fits-all crank arms on almost every road bike regardless of frame size. As we wrote in our July 2019 article,[1] crank arms that are too long can be a leading contributor to chronic knee and hip pain.

Bicycle Riding = Physics

The next item that became clear was that while every cyclist who came into the fit studio had their own reason for a bike fit, a large number of these cyclists came in due to pain experienced during cycling. Complaints were expressed about hand numbness, neck pain, shoulder pain, lower back pain, foot pain and, toe numbness, but the greatest number of cyclists complained of knee pain. Looking further into why, we found that crank arm length played a crucial factor.[1]

Propelling a bicycle forward requires Power which is made up of Force and Velocity. The Power formula is P=F×V, where F=the amount of Force, i.e., how hard the cyclist is pushing down on the pedals/crank arms, and V=Velocity, i.e., cadence, how fast the cyclist is spinning the pedals. A high F–low V draws more on the body's neuromuscular system to propel the bicycle forward and is normally associated with LONG crank arms, while a low F–high V draws more on the body's cardiovascular and respiratory systems[2] to propel the bicycle forward, and this is normally associated with SHORT(er) crank arms. It is interesting to note that the same amount of power can be output from each of the above. For example, a cyclist wants to output 10 units of power. They can generate the 10 units by 5F × 2V or 2F × 5V. Using either, the cyclist is still putting out 10 units of power. It's just which 'energy system' the cyclist wants to use. But there are 2 things to consider using this formula.

1. The formula falls apart at the extremes, eg:

   a. As the crank arms become shorter, they

Continued on page 36

Continued from page 35

TABLE 1. COMMON CAUSES OF KNEE PAIN

Lateral / Outside	Medial / Inside	Anterior / Kneecap	Posterior / Back
Lateral Ligament	Medial Cruciate Ligament	Patellofemoral Pain	Bakers Cyst
Lateral Meniscus Tear	Medial Meniscus Tear	Articular Cartilage	Hamstring Tendonitis
Lateral Cartilage	Pes Anserine Bursa	Anterior Cruciate Ligament	
Iliotibial Band Syndrome	Medial Plica Irritation	Posterior Cruciate Ligament	

can spin faster—to the point that you are losing leverage (Force) faster than cadence is increasing. You will eventually get to a point where they cannot spin any faster.

b. As the crank arms become longer and longer, you are gaining leverage up to the point that you are losing cadence faster than you are gaining leverage.

2. If the crank arms become longer, the leg at the 12 o'clock position experiences higher shear and compressive forces at the patellofemoral and tibiofemoral joints with accompanying structures. Prolonged cycling on crank arms that are too long can be a contributor to injury and potentially premature knee surgery/knee replacement.

How does it feel when the crank arm is too long?

Most road bicycles, triathlon bicycles, and mountain bikes come with crank arms that are too long for the average cyclist. Regardless of frame size, from what we have seen, most manufacturers are putting 172.5mm crank arms onto most road and triathlon bikes, and 175mm crank arms on most mountain bikes (Figure 1).

Through many post-bike fit interviews, cyclists tell me that riding with crank arms that are too long feels like they (a) just can't get the bike going, or (b) believe something is wrong with the bike, or (c) are exerting lots of force, but the bike just isn't responding. In summary, they can't get on top of the gear, and they end up 'fighting' the bike the whole ride. This takes all the fun out of riding, not to mention increases stress to the joints of the knee (Table 1). Once correct crank lengths are installed, the most common reply I've heard is, "I can't believe the bike is this easy to ride!"

Figure 1. Common crank arm sizes installed on today's road (172.5mm) and mountain (175mm) bikes. Credit: bike.shimano.com

There are several factors at play here.

(a) Muscles work most efficiently in mid-range.

In a discussion that Mark Deterline of *Cycling Utah*[3] had with aerodynamics and biomechanics expert John Cobb, and exercise physiologist John McDaniel, PhD, John Cobb stated:

> *"I used to be a big believer in long crank arms, but now I'm going in a different direction. I'm convinced that crank length and pedal rate (i.e., cadence) should be more directly related to one's natural running cadence and stride length than anything else. Every muscle has a natural contraction rate that will yield maximum efficiency. The game is to keep the muscle in its most efficient extension range and at its most efficient rate of rotation [emphasis mine]." Cobb added, "Subsequently, I worked with a rider who is 6'5", bringing his crank length down to 165mm's over three months. He's gained 65 watts of power."*

I agree 100% with Cobb. For most of my clients' post-bike fit, with correct crank lengths, they are averaging 50 more watts of power than prior to the bike fit. I have one client, a local cyclist who teaches kinesiology at a major university in California, who is a Category (Cat) 2 road, criterium, and Individual Time Trial (ITT) racer. He is 6'3" and uses 155mm crank arms on his TT bike and recently won the California State ITT Cat 2 championship.

In the *Cycling Utah*[3] article, John McDaniel explained, *"Every muscle does two things for which an athlete should strive to determine optimal performance parameters: one is the contraction-relaxation rate (the rate at which the muscle will contract, perform work, then relax), and shortening velocity (the speed at which the muscle is working [a muscle shortens as velocity increases]). These two tasks determine maximum power and maximum efficiency. By varying pedal rate and crank length, we can adapt conditions to the muscular system so that it operates closer to its maximum efficiency or power. Our goal is to do both!"*

(b) Too much leverage but not enough cadence.

As said before, the basic power formula is P=F×V, where P=Power in watts, F=Force (how hard you are pushing on the pedals), V=Velocity (how fast you are spinning the pedals, or angular velocity of the cranks).

Most cyclists tend to have a narrow range of cadence in which they are efficient. The longer the crank arm, the larger the pedaling diameter, therefore the distance that the cyclist needs to pedal is farther to make a complete circle and the result is a much slower cadence. The shorter the crank arm, the smaller the pedaling diameter, so there is a shorter distance that the cyclist needs to pedal to make a complete circle. This results in a much faster cadence, helping the cyclist stay within their range of efficiency more easily.

In a study[4] that looked at the effects of crank length on power, a set of cyclists rode a predetermined test set where they sprinted on crank arms that varied in length from 120mm to 220mm. The average power was recorded, and it showed that output power varied by only 1.6%

Continued on page 39

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Continued from page 36

between the crank arms lengths of 145mm and 170mm. Outside of these lengths, power varied by 4%. As McDaniel observed in the discussion with Cobb[3], *"It is interesting to note, however, that the parameters in which max power is produced are often not the same as those that produce max efficiency. This is obvious in cycling where max power is usually produced around 120–130 pedal rpm's (rotations per minute), yet max efficiency is reached at around 60–70 rpms."*

(c) Less leverage, more cadence, less force, and less stress on the knee

Looking at the power formula, P=F×V, shorter crank arms require the cyclist to spin the cranks faster rather than using brute force to turn the cranks. Less force saves wear and tear on the knees and hips. By using the formula above, the bike fitter should shorten the crank arms so that the cyclist has a good balance of force and velocity AND no over-flexion at the top of the pedal stroke.

(d) Knee pain caused by over-flexion at the top of the pedal stroke

Several studies[4-10] looked at the biomechanics and overuse injuries in cycling and concluded that knee injuries were among the most common injuries for both professional and recreational cyclists. Table 2 is a summary of the findings from Clarsen et al.[7] In their conclusion, they wrote:

> *Lower back pain and anterior knee pain are the most prevalent overuse injuries, with knee injuries most likely to cause time loss and lower back pain causing the highest rates of functional impairment and medical attention.*[7]

Shorter crank arm lengths can reduce anterior knee pain by reducing the knee flexion angle at the top (12 o'clock) of the pedal stroke.

(e) Cycling restrictions

Many cyclists suffer from (a) general muscle weaknesses–hips, glutes, core, (b) muscle imbalances–quadriceps, hip flexors, and (c) mobility restrictions, especially the hips and knees. Shorter crank arms can help with hip weaknesses/reduced hip mobility by decreasing the range of motion of the hips during the pedal stroke.

TABLE 2. COMMON INJURIES OF PROFESSIONAL VS RECREATIONAL CYCLISTS.

Professional Cyclists (N=116)	Recreational Cyclists
94 Required Medical Attention Low Back Injury: 45% Knee Injury: 23% Neck Pain: 10%	**Required Medical Attention** Anterior Knee Pain Neck Pain Lower Back Pain Ulnar Nerve Palsy Hand Numbness Upper Extremity Injuries Foot Pain/Numbness
23 Time Loss Injuries Knee Pain: 57% Low Back Pain: 22% Leg/Achilles Tendon Injury: 13%	
Pain Reported Past 12 Months Lower Back: 58% Anterior Knee: 36%	

Used with permission from Clarsen B, Krosshaug T, Bahr R. Overuse Injuries in Professional Road Cyclists. Am J Sports Med. 2010;38(12):2494-2501, copyright ©2010 by American Orthopaedic Society for Sports Medicine. Reprinted by permission of SAGE Publications.

Regarding knee mobility, longer crank arms force the knee to flex more and with reduced mobility. In most cases, the knees will move outward at the top of the pedal stroke. Shorter crank arms reduce knee flexion, allowing the knees to track straight throughout the pedal stroke. Bike fitters continue to use the bicycle's existing (i.e., too long) crank arms and use cleat wedges to force the knees inward. Although the tracking is straightened out, since this is not the natural body position of the cyclist, we hear from our clients that this just displaces pain and potential injury to another part of the body, usually the hips and ankles. With correct (shorter) crank arm length, natural position is achieved as well as a reduction in pain.

One more cause of knee pain in cyclists and runners is the iliotibial band (ITB).[8,9] In Erik Dalton's blog, "Treating Cycling Injuries," he writes, "The actual cause of ITB pain is an extremely important discovery for manual therapists or sports therapists who work with cyclists and runners. ***Iliotibial band syndrome*** is an overuse injury of the connective issues that are located on the outer thigh and knee. If the underlying fat pad is indeed the main cause of our client's lateral knee pain, it is probably not a good idea to apply compressive forces over the ITB tendon, which is already squashing the inflamed fat pad. Traditional techniques, such as cross-fiber frictioning and ITB fascia-mashing [foam roller], would be contraindicated."[10] Shorter crank arms reduce knee flexion, so the ITB is not pulled as tight, thereby reducing compression to the knee.

(f) Iliac artery occlusion is a potentially life-threatening condition in which partial or complete closure, or blockage of the iliac arterial system obstructs blood supply to the pelvis, or via the connecting femoral artery to the leg and even the genital and gluteal regions.

For a cyclist, the top of the pedal stroke is the issue. Crank arms that are too long create unnecessary hip flexion. This can pinch the tissues in the front of the hip if there is an imbalance of length tension in hip soft tissues. This can lead to FAI (femoral acetabular impingement), soft tissue impingement (hip flexors and adductors mainly) and even iliac artery occlusion in rare cases. Short crank arms open the hip joint more (less flexion at 12 o'clock).

(g) Evening out the left-right (power) balance
During pre-bike fit workups, I use a dual-sided power meter and often see cyclists pedaling at a 60%–40% balance. Most cyclists do not ride with dual-sided power meters so they will not know which leg is pushing harder.

Putting all of these factors together, when crank arms are too long, road/gravel/Tri/TT cyclists are forced to 'stab' at the pedals because a smooth high-cadence pedal stroke usually cannot be achieved. Since we usually have a dominant leg, long crank arms coupled with high force on

Continued on page 40

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the pedals and a slow cadence can lead to what we see as single leg pain and injury. Since cyclists tend to push harder with their dominant leg and due to the thousands of pedal strokes per ride, overuse injuries occur on the dominant leg. Others tend to push harder with their non-dominant leg causing overuse injuries on this leg. Shorter crank arms reduce the force applied to the pedals allowing for the realization of a higher cadence, which tends to even out the left-right balance.

Conclusion

The length of the crank arms is one of the most crucial factors in a bike fit and is critical in placing the cyclist into the strongest, safest, and least injury-causing position, however, it is the most overlooked adjustment considered.

The advantages to riding with the correct length of crank arms is far reaching. For example, using shorter crank arms, the knees are not being driven up as high (at the 12 o'clock position) and many cyclists mention that any hip pain subsides with the short crank arms as well.

In our opinion, selecting the correct crank arm length should be the first step before any other adjustments are to be made by a bike fitter. ler

Rick Schultz, MBA, DBA, is a master bike fitter and USA Cycling (USAC) Level 2 Coach and Certified Skills Instructor. He is the owner of Bike Fitness Coaching, San Juan Capistrano, California.

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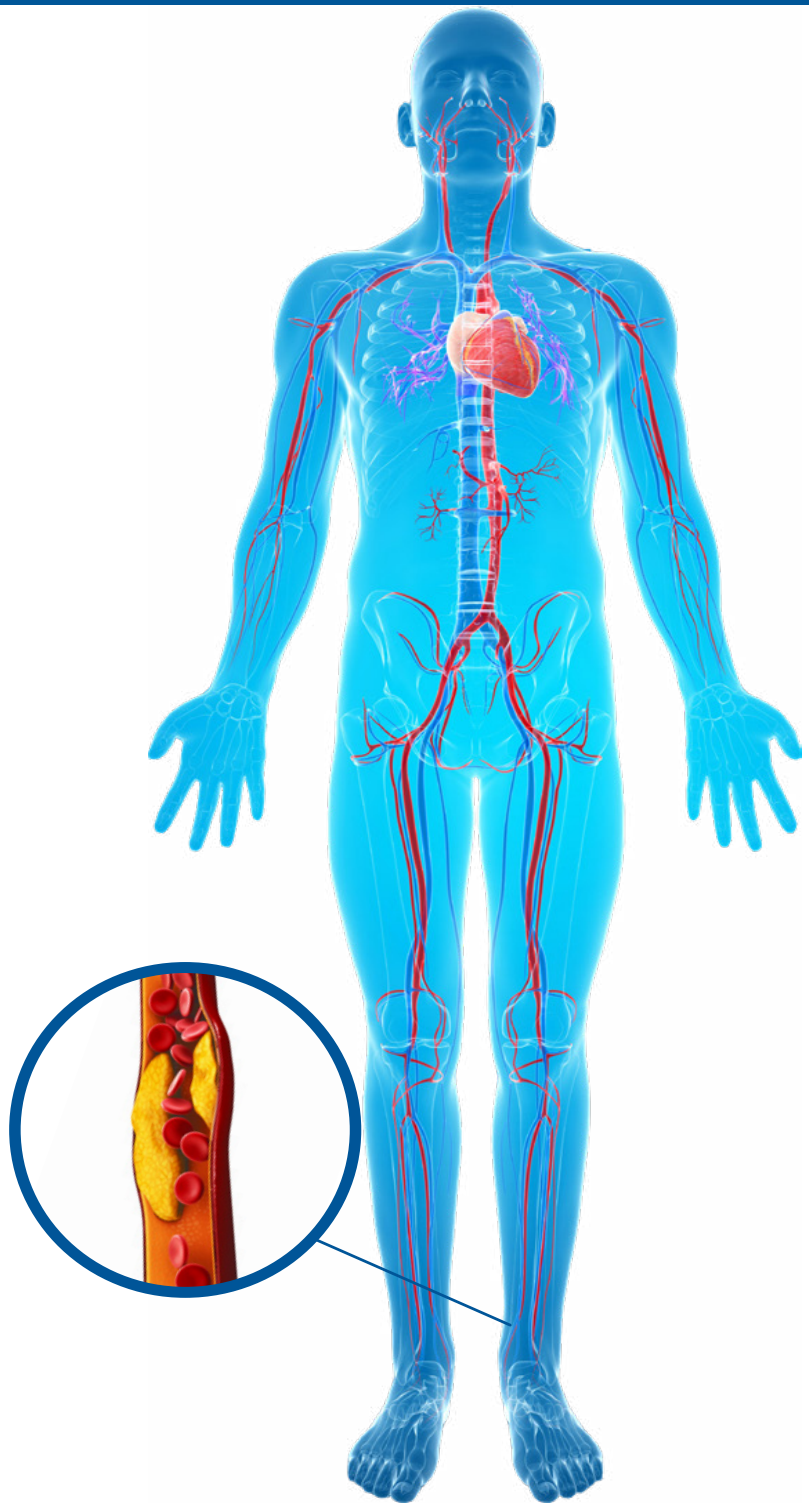

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The Habits of Successful Weight Losers*

By Jason R. Karp, PhD

Obesity is among today's most pressing public health concerns and it's negative impact on the human body—particularly in light of SARS-COV-2 infection, can be devastating. Once gained, losing weight can be difficult, but maintaining weight loss is even more difficult. This author provides evidence-based tips for maintaining lost pounds that you can share with patients and clients.


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In a national television interview with Barbara Walters in 2014, Oprah Winfrey confessed that not being able to maintain her weight loss was her biggest regret. In that interview, Walters asked Winfrey to finish the sentence, "Before I leave this Earth, I will not be satisfied until I…"

"Until I make peace with the whole weight thing," Oprah replied.

Losing weight is hard; keeping it off is even harder. What is unique about those who succeed? The answer is buried deep in the archives at the Weight Control and Diabetes Research Center in Providence, Rhode Island: The National Weight Control Registry (NWCR), the largest database ever assembled on individuals successful at long-term maintenance of weight loss. Founded in 1994, the NWCR includes more than 10,000 individuals who complete annual questionnaires about their current weight, diet and exercise habits, and behavioral strategies for weight loss maintenance.

Habit #1: Live with Intention

Living with intention eliminates the random approach to weight loss maintenance in favor of the systematic and methodical one that leads to results. The NWCR has shown that, when intention is behind weight loss maintenance, 21% of overweight people are successful weight losers.

The longer people keep their weight off, the fewer strategies they need to continue keeping weight off. In other words, weight maintenance gets easier. The longer your clients persist in their intention and behave in accord with that intention, the easier it is for that behavior to "stick" and turn into a habit.

What makes one individual persist at a specific behavior while another individual doesn't? For starters, the persistent individual has a conscientious personality (conscientiousness comprises self-control, industriousness, responsibility, and reliability). In the most recent NWCR study published in 2020, conscientiousness was compared between successful weight losers from the NWCR and non-NWCR weight regainers. The successful weight losers were found to be more conscientious than the weight regainers and scored higher on measures of order, virtue, responsibility, and industriousness. The scientists suggest that being conscientious may help individuals maintain their weight loss by improving adherence to specific behaviors.

In a review of 56 studies that contained 58 health behaviors, researchers at Université Laval in Quebec, Canada and the University of Limburg in The Netherlands found that intention remained the most important predictor of health behavior, explaining 66% of the variance. In half of the reviewed studies, perceived behavioral control (believing that you have control over your behavior) significantly added to the prediction.

Habit #2: Control Yourself

Being a successful weight loser requires a lot of self-control, delaying gratification now (eg,

Continued on page 44

A fully referenced version of this article is available online at lermagazine.com.

Continued from page 43

dessert) for the more desirable reward later (eg, a slimmer waistline, better health, enhanced self-esteem, and happiness).

Compared to typical unsuccessful dieters, successful weight losers are better able to resist temptation, control themselves, and push back against the environment. They restrict certain foods, weigh themselves regularly, and use digital health technology.

One of the key factors of self-control is disinhibition, which literally means not being inhibited. Some inhibition is good, because it prevents people from not giving into temptation and eating whatever and how much they want. High levels of disinhibition are bad, because it leads to risky behavior. Disinhibited eating is a failure to maintain control over eating. The opposite of disinhibited eating is dietary restraint. Several NWCR studies have found that increased disinhibition leads to regaining lost weight. Other studies have found strong relationships between a lack of self-control—impulsivity—and obesity.

Habit #3: Control Calories

Successful weight losers consume fewer daily calories than the general population. Table 1 shows the number of calories the NWCR members consume per day, from the several studies that have reported it, along with the amount of weight they lost at the time they entered the NWCR.

TABLE 1 - CALORIC INTAKE OF SUCCESSFUL WEIGHT LOSERS

	Calories Per Day	Pounds Lost
	1,381 1,297 (women) 1,725 (men)	66 63 (women) 78 (men)
	1,306 (women) 1,685 (men)	63 (women) 77 (men)
	1,390	69
	1,462	124
	1,400	62
	1,399	73
Average Women Men	**1,406 1,302 1,705**	79 63 78

Successful weight losers consume a low-calorie diet of about 1,400 calories per day, with women consuming about 1,300 and men consuming about 1,700 calories per day.

> Hardly anyone in the NWCR is consuming a very low-carbohydrate or ketogenic diet. The word "ketogenic" doesn't even exist in any of the NWCR's published studies.

By comparison, the U.S. adult population consumes an average of 2,120 calories per day (women consume about 1,820 calories per day and men consume about 2,480 calories per day).

Successful weight losers control calories several ways, including limiting how often they eat out at restaurants, rarely eating fast food, and limiting how many calories they drink. They are also more likely than normal-weight individuals to have plans to be extremely strict in maintaining their caloric intake, even during times of the year when it's easy to consume calories, like during holidays.

Habit #4: Eat a Low-Fat, High-Carbohydrate Diet

Successful weight losers eat a low-fat, high-carb diet. Table 2 shows the percentage of carbohydrate, fat, and protein the NWCR members consume, from the several studies that have reported it.

TABLE 2 – MACRONUTRIENT CONSUMPTION OF SUCCESSFUL WEIGHT LOSERS

	% Fat	% Carbohydrate	% Protein
	24 (women) 24 (men)	56 56	20 20
	24	56	19
	23	58	19
	26	55	19
	24	56	19
	29	49	22
Average	**25**	55	20

NWCR members consume an average of 25% of their calories from fat, 55% from carbohydrate, and 20% from protein, with no difference in the macronutrient percentages between women and men.

In the early 2000s, when low-carb diets were becoming all the rage, the fat content of the NWCR members' diet increased and the carbohydrate content of their diet decreased compared to earlier years. The percentage of NWCR members consuming a low-carbohydrate diet (less than 90 grams, which is less than 25% of daily calories) increased from 5.9% in 1995 to 7.6% in 2001 to 17.1% in 2003, although it still remains low for successful weight losers, despite the media's attention on low-carbohydrate diets. Even with the increasing percentage of NWCR members consuming a low-carbohydrate diet, the fat content of the diet still remains far below the national average. Hardly anyone in the NWCR is consuming a very low-carbohydrate or ketogenic diet. The word "ketogenic" doesn't even exist in any of the NWCR's published studies.

Habit #5: Eat Breakfast

Seventy-eight percent of NWCR members eat breakfast every day, while only four percent never eat breakfast. These successful weight losers lost an average of 71.3 pounds and maintained the NWCR-required minimum weight loss of 30 pounds for an average of 6 years. Eating breakfast every day is also common among other successful weight losers: The NWCR's sister registry in Portugal (Portuguese Weight Control Registry) has found that daily breakfast is one of their members' most common strategies.

Skipping breakfast is associated with consuming more total daily calories. Skipping breakfast makes people hungry and therefore more likely to eat more later in the day to compensate. Breakfast skippers also tend to weigh more than breakfast eaters, and obese individuals are more likely to skip breakfast.

Eating breakfast is important for several reasons. When your clients get out of bed in the morning, their blood glucose is on the low side of normal. Their bodies need energy for the day's activities. Since it has been many

Continued on page 47

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Continued from page 44

hours since their last meal, they need to break the fast, literally. The macronutrients they eat at breakfast will be used for their important jobs—carbohydrate will be used to replenish their blood glucose from their overnight fast to provide immediate fuel for their cells and to store muscle glycogen for later use; protein will be used to maintain the structural integrity of their cells and tissues and to transport nutrients in their blood; and fat will be used to provide energy, absorb fat-soluble vitamins, and maintain their bodies' temperature. Because your clients are in a metabolically needy state when they get out of bed, all those calories from carbohydrates, protein, and fat that they eat at breakfast will be used to fulfill their bodies' metabolic demands. Skipping breakfast only serves to deny their bodies the fuel they need.

Habit #6: Exercise (a Lot) Every Day

Successful weight losers exercise a lot every day, burning a lot more calories than the general population. Table 3 shows the number of calories the NWCR members burn per week during physical activity, from the several studies that have reported it, along with the amount of weight they lost at the time they entered the NWCR.

TABLE 3 – CALORIC EXPENDITURE OF SUCCESSFUL WEIGHT LOSERS

	Calories Expended Per Week	Pounds Lost
	2,832	69
	2,829	66
	2,985	124
	2,545 (women) 3,293 (men)	63 (women) 78 (men)
	2,542	71
	2,621	71
	2,521	73
Average **Women** **Men**	**2,722** **2,545** **3,293**	79 63 78

Successful weight losers burn about 2,700 calories per week. Seventy-two percent burn more than 2,000 calories per week and 35% burn more than 3,000 calories per week.

A major finding of the NWCR is that a large part of regaining weight after losing it is due to the inability to maintain exercise habits for the long term.

A consistent, high level of exercise is one of the most important predictors of whether someone will be able to keep the weight off. A major finding of the NWCR is that a large part of regaining weight after losing it is due to the inability to maintain exercise habits for the long term.

While it may be easy or convenient to think that the reason why some people exercise and others don't is because the ones who do have the time and resources, like access to a gym or personal trainer, or because they simply like to exercise, the NWCR has shown that what makes a successful weight loser exercise has little to do with these factors. Whether or not someone exercises comes down to his or her commitment and the creation of and persistence in the habit. See habit #1. Live with intention. ler

Jason Karp, PhD, is founder and CEO of the women's-specialty run coaching company, Kyniska Running. A competitive runner since sixth grade, Karp quickly learned how running molds us into better, more deeply conscious people, just as the miles and interval workouts mold us into faster, more enduring runners. This passion Karp found as a kid placed him on a yellow brick road that he still follows as a coach, exercise physiologist, bestselling author of 12 books and 400+ articles, and speaker. He is the 2011 IDEA Personal Trainer of the Year and two-time recipient of the President's Council on Sports, Fitness & Nutrition Community Leadership award. His REVO$_2$LUTION RUNNING™ certification has been obtained by coaches and fitness professionals in 25 countries. His book, Lose It Forever: The 6 Habits of Successful Weight Losers from the National Weight Control Registry *is available on Amazon. He is a member of MedFit Network, one of* LER's *partners.*

PATIENT GUIDANCE

6 Habits For Successful Weight Loss Maintenance*

Losing weight is hard; keeping it off is even harder. What is unique about those who succeed? Below are 6 habits that have been identified from the archives at the Weight Control and Diabetes Research Center in Providence, Rhode Island: The National Weight Control Registry (NWCR), the largest database ever assembled on individuals who have successfully maintained weight loss.

1. Live with Intention
2. Control yourself
3. Control calories
4. Eat a low-fat, high carbohydrate diet
5. Eat breakfast
6. Exercise (a lot) every day

*Adapted from the book, *Lose It Forever: The 6 Habits of Successful Weight Losers from the National Weight Control Registry*, by Jason R. Karp, which is available on Amazon.

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Foot Orthoses Do Not Change Soft Tissue Morphology, Skin Sensitivity

By Joanna Reeves, Richard Jones, Anmin Liu, Leah Bent, Ana Martinez-Santos, and Christopher Nester

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Some have worried that foot orthoses that shift plantar load may alter the mechanical work of internal structures and change the size of muscle and connective tissues, and actually make them smaller. These authors challenge that notion.

The effect of foot orthoses (FOs) has not been well studied with respect to adaptations to the internal foot structures and skin sensitivity over time. Plantar pressure is altered with FOs, consequently altering the distribution of resultant force through foot tissues. Muscles and tendons can change their activity, size, and structure as a result of a change in loading with training, and intrinsic foot muscles can also change size in response to modified loading of the foot with altered footwear. Therefore, redistributing the external loading of the foot with FOs could alter muscle and connective tissue morphology. It has been suggested that FOs and arch support from footwear leads to smaller and weaker foot muscles. However, intervention studies on the effect of FOs on muscle are limited. Although there is evidence for altered tissue thickness and stiffness of the Achilles tendon and plantar fascia in pathologies such as diabetes, which will influence the distribution of plantar stress, the effect of FOs on these connective tissue also requires investigation.

Foot orthoses can alter the contact area at specific regions of the foot, like increase the contact area in the medial arch, which could influence skin sensitivity. Skin sensitivity is comprised of both peripheral (alterations to the cutaneous mechanoreceptor activation or transmission) and central influences (cortical plastic changes based on input). Changes in contact area could alter, and potentially increase, the capacity for cutaneous mechanoreceptors to detect mechanical stimuli. There are 4 different classes of mechanoreceptors in glabrous skin, like on the foot sole, which respond to stretch, contact forces, vibration, and pressure. Cortical plasticity allows for the potential for increased skin sensitivity through increasing the relevant area in the primary somatosensory cortex, and neurophysiological changes with training has been shown in primates following stroke. Increased pressure in the medial arch could increase sensitivity due to the increases in the relative weighting given to receptors from that region, or skin sensitivity could decrease if the receptors become desensitized. Altered stimulation of mechanoreceptors can modulate afferent feedback to the central nervous system, influencing muscle activity and movement of the lower and upper limbs. Consequently, the skin's contribution to gait and posture could be influenced with use of FOs through long-term stimulation of mechanoreceptors (a response to mechanical load being elicited in mechanoreceptors repetitively over time).

Preliminary work (n=12) has shown using a metatarsal bar to increase pressure can increase skin sensitivity in the forefoot; however, the effect of increases in pressure on

This article has been excerpted from "No change in foot soft tissue morphology and skin sensitivity after three months of using foot orthoses that alter plantar pressure" by the same authors, which was published online August 18, 2021, in the journal *Footwear Science*. https://doi.org/10.1080/19424280.2021.1961880. Editing has occurred, including the renumbering of figures, and references have been removed for brevity. Use is per CC BY 4.0.

Continued on page 50

Continued from page 49

skin sensitivity in other regions of the foot with FOs has not been investigated. Skin sensitivity in the medial arch may adapt differently to pressure changes from the forefoot because the medial arch is not normally loaded, and is the most sensitive region of the foot, despite having potentially fewer mechanoreceptors than other regions. The arch region of the foot is of particular interest as it is frequently loaded in FOs interventions. The arch region also has the lowest perceptual threshold (greatest sensitivity), while the heel has the greatest perceptual threshold.

Prefabricated FOs were used by 93% of responders to a national survey of clinicians prescribing FOs in the UK, and ethylene vinyl acetate (EVA) and rigid plastic were the most commonly used materials for prefabricated FOs. The effect of FOs that affect loading under the heel and medial arch on soft tissue size and structure and foot/ankle skin sensitivity is unknown. The purpose of this study was to enhance our understanding of the mechanisms behind the effect of prefabricated FOs by investigating whether skin sensitivity and soft tissue morphology would be altered when plantar loading was changed with FOs.

Materials and methods

This study investigated the effects of FOs on foot soft tissue morphology and skin sensitivity over 3 months of use. Forty-one healthy partici-

Figure 1. Salfordinsole foot orthosis. The majority of participants (n=18) wore medium density ethylene vinyl acetate (EVA) or thermoplastic (Shore A 70) depicted.

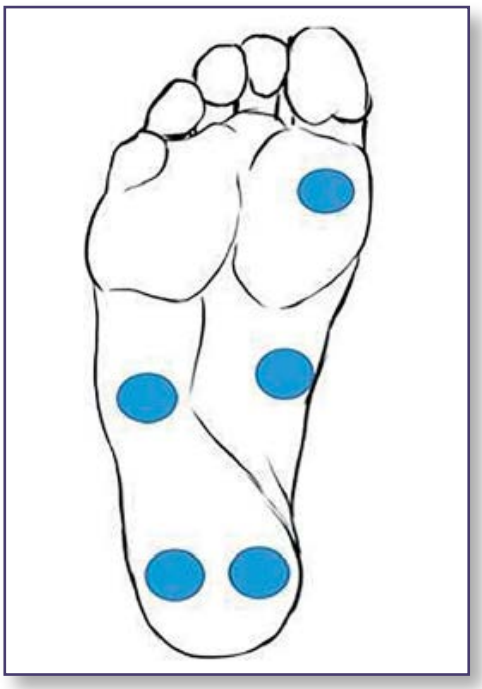

Figure 2. The foot sole with blue dots depicting the approximate locations of skin sensitivity testing. An additional site was on the dorsum at approximately the level of the distal interphalangeal joint between the hallux and second toe.

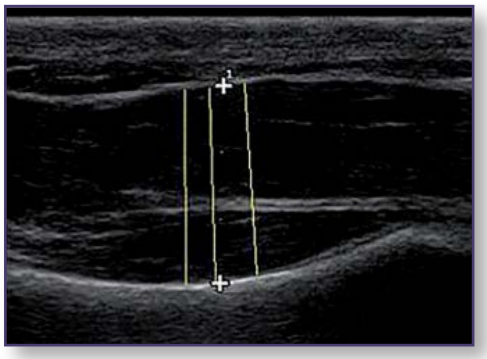

Figure 3. Ultrasound image of the flexor hallucis brevis with 3 thickness measurements (yellow lines).

pants wore prefabricated FOs (n=23) (Figure 1) or no insert (n=18) for 3 months. The FOs were prescribed specific to each participant, using criteria of a change in peak pressure of 8% in the medial arch (pressure increase) and medial heel (pressure decrease). Ultrasound images were recorded pre- and post-FOs use to derive cross-sectional area and thickness of abductor hallucis, flexor hallucis brevis, flexor digitorum brevis, and the Achilles tendon at the insertion and mid-portion (Figure 3). Plantar fascia thickness was measured at the insertion and midfoot. The minimal detectable difference (MDD) was established in piloting (n=7). Skin sensitivity (Figure 2) was measured with monofilaments at the dorsum (between the hallux and second toe), medial and lateral heel, medial and lateral arch, and the 1st metatarsal head.

For specifics, see full article at https://doi.org/10.1080/19424280.2021.1961880.

Results

Participants: Twelve of the 53 participants recruited dropped out, including 4 from the FOs group. One in the FOs group dropped out due to hip pain which they attributed to the FOs. The other 3 participants in the FOs group who dropped out did not report an adverse event, but did not respond to the invitation to return for postintervention assessments. Several included participants experienced some foot soreness using the FOs, but this did not persist beyond week 1 and is typical, and these participants continued with the study.

Foot orthoses

The actual mean (± SD) change in peak pressure due to FOs was significantly larger than the minimum requirement. In the medial heel the mean reduction was 21% (± 14%, p=0.012) and for the lateral heel 17% (± 14%, p=0.004). Mean (± SD) peak pressure at the medial arch was significantly greater at 15% (± 19%, p=0.005), though not significantly greater at the lateral arch 7% (± 17%, p=0.106).

Compliance

Sixteen of the 23 participants in the FOs group completed the postintervention compliance questions and all, bar 1, wore the FOs for more than the minimum of 4 hours per day (mean ± SD: ~8.5 ± 3 h). The 7 participants who did not complete these questions had confirmed via email that they were wearing the FOs more than the minimum of 4 hours per day.

Continued on page 53

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Continued from page 51

Physical activity levels

In the FOs group, 21/23 (91%) were active pre-intervention and 22/23 (96%) were active postintervention. In the control group, 14/18 (78%) were active pre-intervention and all remained so.

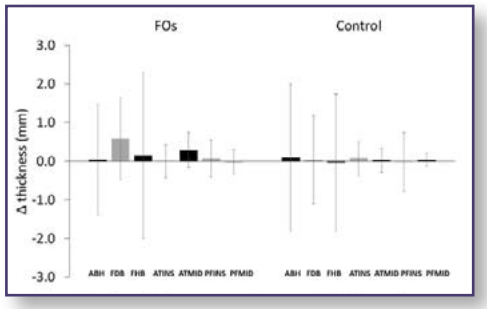

Figure 4. Median difference in ultrasound thickness from pre- to post-three months in the foot orthoses group (FOs) and control group for abductor hallucis (ABH), flexor digitorum brevis (FDB), flexor hallucis brevis (FHB), Achilles tendon at the insertional site on the calcaneus (ATINS) and the mid-portion (ATMID), proximal plantar fascia (PFINS) and mid-portion plantar fascia (PFMID).

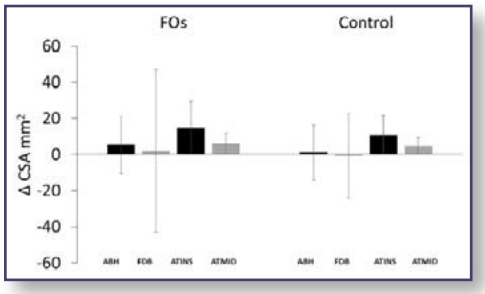

Figure 5. Median difference in ultrasound cross sectional area (CSA) from pre- to post-three months in the foot orthoses group (FOs) and control group for abductor hallucis (ABH), flexor digitorum brevis (FDB), Achilles tendon at the insertional site on the calcaneus (ATINS) and the mid-portion (ATMID).

Ultrasound

Difference in ultrasound measurements pre- and post-intervention are presented in Figures 4 and 5 for thickness and cross-sectional area (CSA) respectively and mean values pre- and post-intervention are presented in Tables 2 and 3. No average difference in ultrasound measurement was greater than the MDD (Tables 2 and 3). There was a trend for an effect of time

Table 2. Mean ultrasound thickness measurements at pre- and post-intervention.

Thickness (mm)		Pre Mean	Pre SD	Post Mean	Post SD	Difference (median)	MDD
ABH	FOs ($n=19$)	10.639	2.268	10.736	1.720	0.037	0.742
	CO (=16)	10.491	1.739	10.568	2.134	0.092	
ATINS	FOs ($n=19$)	4.339	0.680	4.348	0.657	0.001	0.323
	CO ($n=17$)	4.245	0.581	4.259	0.517	0.076	
ATMID	FOs ($n=19$)	3.577	0.781	3.773	0.831	0.289	0.451
	CO ($n=17$)	3.922	0.882	4.009	0.788	0.034	
FDB	FOs ($n=19$)	8.916	1.437	9.304	1.575	0.581	2.138
	CO ($n=17$)	9.892	2.101	9.745	1.542	0.033	
FHB	FOs ($n=16$)	11.989	2.602	11.682	2.608	0.151	1.032
	CO ($n=12$)	12.902	2.840	11.688	3.352	−0.031	
PFINS	FOs ($n=20$)	2.178	0.457	2.286	0.380	0.070	0.495
	CO ($n=17$)	2.204	0.448	2.100	0.407	−0.018	
PFMID	FOs ($n=20$)	1.652	0.193	1.667	0.260	−0.010	0.302
	CO ($n=17$)	1.600	0.151	1.629	0.183	0.036	

FOs: foot orthoses group; CO: control group; MDD: minimal detectable difference; ABH: abductor hallucis; ATINS: Achilles tendon at the insertional site on the calcaneus; ATMID: Achilles tendon at the mid-portion; FDB: flexor digitorum brevis; FHB: flexor hallucis brevis; PFINS: proximal plantar fascia and PFMID: mid-portion plantar fascia.

Table 3. Mean ultrasound cross-sectional area measurements at pre- and post-intervention.

CSA (mm^2)		Pre Mean	Pre SD	Post Mean	Post SD	Difference (median)	MDD
ABH	FOs ($n=17$)	204.332	62.368	203.705	57.624	5.232	7.229
	CO ($n=15$)	198.601	53.211	197.935	48.367	1.062	
ATINS	FOs ($n=17$)	68.460	13.890	69.971	12.591	1.808	11.963
	CO ($n=16$)	66.365	16.741	67.263	14.149	−2.716	
ATMID	FOs ($n=15$)	53.495	13.717	55.527	9.472	1.829	14.169
	CO (n =16)	47.986	7.826	51.044	9.347	2.108	
FDB	FOs ($n=17$)	200.401	44.741	204.332	46.820	2.086	40.360
	CO ($n=14$)	195.531	55.193	199.157	57.221	−0.790	

FOs: foot orthoses group; CO: control group; MDD: minimal detectable difference; ABH: abductor hallucis; ATINS: Achilles tendon at the insertional site on the calcaneus; ATMID: Achilles tendon at the mid-portion and FDB: flexor digitorum brevis.

for ATMID thickness ($p=0.056$, $\eta p2 = 0.103$) and a main effect of group for ATMID CSA ($p=0.049$, $\eta p2$ ¼ 0.127) and other effect sizes were also small (<0.1).

Skin sensitivity: Mean skin temperature was 26.3°C (± 1.6°C) pre- and 29.8°C ± 1.3°C post-intervention, both above the recommended minimum threshold of 20°C. The monofilament results are presented in Table 4 and Figure 6, which are presented in the original article. There was a main effect of time for the 1st metatarsal head. Monofilament threshold increased with time for both control (0.34 ± 0.53 to 0.60 ± 0.55 g) and FOs groups (0.27 ± 0.42 g to 0.55 ± 0.62 g, $p=0.003$, $\eta p2 = 0.211$). There were no significant effects in other locations, with effect sizes <0.1 and large variability in thresholds across regions.

Discussion

This study investigated whether skin sensitivity and selected soft tissue morphology were altered when plantar loading changed due to use of FOs. Despite successfully altering pressure across the foot sole, the FOs did not significantly change soft tissue morphology or skin sensitivity when compared to the control group. There may be a number of reasons why this was the case. The neurophysiological and active and passive systems of the foot are thought to be flexible in coping with changing demands. So the change of demand with altered plantar loading due to FOs may have been accommodated without changing soft tissue morphology or sensory function. However, effects could have occurred in muscles other than those we could reliably assess with ultrasound, or other muscle properties or aspects of skin sensitivity that we did not measure. The daily wear time of FOs and study duration might also have been insufficient to cause changes. However, mean FOs wear time (8.5 hour/day) was arguably close to what could be expected in clinical practice and comparable to previous research and might therefore be considered a pragmatic dose of altered plantar loading. Several participants reported not wearing the FOs some days on weekends when indoors, which also likely reflects clinical practice. In a trial of custom FOs for patients with rheumatoid arthritis, FOs were worn 6 days/week on average. Increases in muscle CSA have been documented after 8–12 weeks, so it is conceivable that a 12-week FO intervention would be long enough to see change in intrinsic foot muscle CSA. Physical activity levels were comparable throughout and so unlikely to confound results.

Soft tissue measures

A lack of change in the FOs group conflicts with previous research investigating FOs, whereby CSA decreased in the FOs group and not the control group and an earlier study that found an increase in CSA of ABH with FOs with and without the addition of short foot exercises. However, the study by Jung et al [2011] is difficult to interpret without a control group. The study by Protopapas and Perry [2020] only evaluated the cross-sectional area of 5 participants in each of a control and intervention group, reporting that FDB reduced 9.6% and ABH reduced 17.4% over 12 weeks. However, the MDDs of measures were not reported and

Continued on page 54

Continued from page 53

the reduction in FDB CSA was smaller than the MDD in this study. Given the small sample size, the reported change might be measurement error and not meaningful. Furthermore, the results from this and earlier reliability work (2014) showed better measurement reliability for thickness rather than CSA. For example, limits of agreement were 13% and 13.5% for ABH and FDB thickness respectively, and 16% and 17% for ABH and FDB CSA. Using prefabricated FOs in this study rather than customized FOs could also explain the different outcomes, if match between FOs and foot shape influences neuromuscular adaptations. However, prefabricated and customized FOs have similar effects on peak plantar pressure and can be equally effective in reducing pain in a clinical population. Without knowledge of the change in plantar pressures or the material of the FOs in the earlier study, we cannot compare the changes in loads achieved. In the current study the mean 21% decrease in peak pressure at the medial heel and 15% increase in peak pressure at the medial arch with prefabricated FOs were similar or greater than a previous study using custom FOs that reflect common clinical practice, in which there was a 13% reduction in the medial heel and 15% increase in the medial midfoot.

Skin sensitivity

As participants were young, healthy, and mostly active, it is possible that they had little capacity to increase skin sensitivity. Baseline monofilament threshold in the medial arch was low, indicating high sensitivity (~0.1 g vs. ~1.0 g at the heel), which reflects the level of sensitivity previously reported in the literature. In this young healthy population, it may be that increased loading in this area would not increase sensitivity because it was already very sensitive. Alternatively, decreased sensitivity in one region could have increased sensitivity in another region that perhaps was not measured. Previous preliminary work has shown increased forefoot sensitivity following the use of a hard metatarsal pad. This differs from our results here. Differences could be attributed to the different methods of measuring skin sensitivity (the previous study used a bespoke loading device), different regions of pressure change (they used the forefoot, which is less sensitive than the medial arch), and/or the density of FOs material.

Mean skin temperature at the time of measurement increased by ~3.5°C from pre- to postintervention assessments, possibly due to seasonal weather variation, but remained within the typical range. This was not felt to mask any underlying change in sensitivity. The increase in monofilament threshold at the 1st metatarsal head with time in both groups could be interpreted simply as noise in the measurement.

It is conceivable that changes in skin sensitivity occurred outside of those mechanisms tested using monofilaments, which target fast adapting type I receptors (FAIs). Perceptually, it is known that FAIs are responsible for the sensation of touch using monofilaments, so it is possible that we missed changes that were experienced by other mechanoreceptors in the glabrous skin. No change in perceptual threshold measured with monofilaments was reported following space flight, despite some changes in vibration sensitivity at frequencies that target other receptors, namely fast adapting type II receptors and slow adapting type I receptors. If monofilaments were insensitive to changes in skin sensation following the large pressure changes that occurred due to microgravity, it seems unlikely monofilaments would be sensitive enough to detect changes in skin sensitivity following ~20% changes in pressure due to FOs at a localized area. So perhaps if minor changes in skin sensitivity occurred, the monofilaments were not able to detect the change. The increased pressure in the medial arch and arch curvature of the FOs may have changed the sensitivity of slow adapting type I (SAI) receptors, which are not tested by monofilaments. Development of a validated measure of spatial acuity would enable testing of these receptors. Participants reported 'getting used to' the FOs after around a week, so anecdotally it appeared some neurological adaptation to the redistribution of plantar pressure occurred that was not captured using monofilaments.

Nil effects could have been due to sample size, characteristics, or group allocation. The sample was pseudo-randomized as participants at one site were randomly allocated into groups (n=39) whereas at the other they were allocated on convenience (n=14), based on the sizes of FOs that were available at that location. There were no statistical differences in participant characteristics between the FOs and control groups for the latter sample, which refutes the idea that a lack of randomization contributed to a nil effect. The nil effects are unlikely due to a lack of power, as effect sizes were typically less than small (≤0.1). Although on visual inspection no differences in responses were observed between foot types, recruitment did not target specific foot types and so most participants had a neutral foot posture. Given the potential importance of sub-groups, perhaps the mixed sample of foot postures masked an effect of FOs for a specific foot type, as foot type and medial arch height in particular will influence the contact area of FOs with the foot and may also influence soft tissue size. Our sample size was insufficient to account for the effect of foot posture on foot soft tissue morphology or skin sensitivity. However, we used plantar pressure measures to ensure all participants experienced minimum changes in pressure independent of foot type. We were also not able to account for any changes in skin thickness, which partially influences skin sensitivity.

Conclusion

This study found no detectable change in foot soft tissue morphology nor skin sensitivity after 3 months of FOs use. Future study on the effects of FOs on the neuromuscular system could consider using alternative measurement techniques and foot posture subgroups. Although this study does not explain the mechanism of FOs benefits, it challenges the notion that FOs reduce muscle size.

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REBOUND ACL BRACE

The REBOUND® ACL brace has been designed to help patients recovering from anterior cruciate ligament (ACL) injury. Designed to dynamically reduce strain on a patient's ACL and provide a comfortable load on their posterior thigh and anterior tibia, the brace provides comfort that has been validated through clinical testing with load-mapping data collected during daily activities. The brace's proprietary Dynamic Tension System (DTS) allows for adjustable settings according to individual anatomy and rehabilitation requirements, whether the patient is undergoing non-surgical conservative treatment approaches or recovering from post-op reconstruction. Constructed of lightweight aluminum, the REBOUND ACL brace features flexion and extension range-of-motion lockouts for enhanced patient safety, a posterior frame design that has been optimized for fit and support, and an open anterior to facilitate donning and doffing. The brace also features Össur's proprietary Blue is You™ system of intuitive patient touch points and ActiveGrip™ liners.

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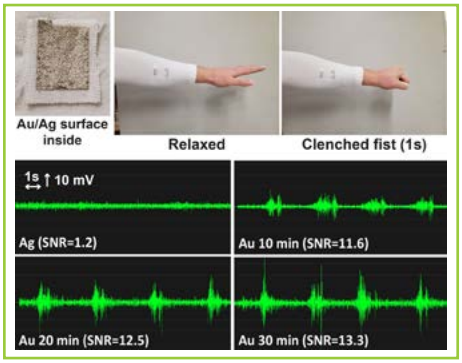
PROCESS TURNS ORDINARY CLOTHING INTO BIOSENSORS

The University of Utah chemical engineering assistant professor Huanan Zhang, PhD, and his team have developed a process that turns ordinary textile made of a cotton/polyester blend into sensors that measure electrical impulses generated from muscle movement. This could become a much better solution for measuring muscle activity for physical rehabilitation or for other medical applications, as compared to bioelectrical sensor technology in which sensors with wires are taped to the skin.

"This new method can enable clinicians to collect a muscle's long-term electrical signals with more precision," said Zhang. "And we can get a better understanding of a patient's progress and therefore their therapeutic outcomes over time."



In this graphic, a compression sleeve is turned into a biosensor that measures electrical impulses generated from muscle movement. Shown is the measurement of electrical activity picked up by the sleeve when a fist is made. Image courtesy of the University of Utah.

When human muscle contracts, it emits electrical signals in the form of ions (as opposed to electrons from an electrically powered device). Zhang's process involves depositing a microscopic layer of silver over a piece of fabric to make the material conductive and therefore receive the electrical signal from the muscle. But since having just a layer of silver can be problematic as the metal can be somewhat toxic when in prolonged contact with the skin, the researchers also deposit a second, microscopic layer of gold, which is non-toxic to the touch. The gold not only protects the skin from the silver, but it also enhances the electrical signal, Zhang said.

The silver layer is applied to the fabric in a process similar to screen printing a graphic onto a T-shirt, and it's applied to just the areas of the clothing that touch the muscle being measured. Then the gold layer is deposited by an electrochemical method. The patches of sensors are then attached to wires and a portable electromyography device that measures muscle contractions. Just as important, the process is also resistant to repeated cycles in a washing machine, Zhang said.

Currently, Zhang and his team have tested the method on a compression sleeve for the forearm. While this technology would mostly be used on compression sleeves or socks since it requires the clothing constantly touch the skin, Zhang imagines it could also be used for other skin-tight clothing such as bicycle pants or athletic tights.

DIABETIC'S SKIN ULCER & SORE OINTMENT

The Terrasil brand Diabetic's Ulcer & Sore Relief Ointment is a non-prescription ointment that was developed and released for distribution by Aidance Scientific. It is a low-cost option that was formulated to provide for early care of emerging foot ulcers and other sores before the ulcers and sores become acute and

require hospital care. This soothing natural antiseptic ointment promotes rapid healing and helps prevent infection of skin ulcers and sores. Key ingredients include premium natural emollients, herbal extracts, essential oils, and the company's patented Activated Minerals® proprietary blend, which includes magnesium oxide and zinc oxide. The ointment is available in 44gm jars featuring an easy-grip contoured lid.

Aidance Scientific
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ULTRASOUND USED TO BETTER CALIBRATE ASSISTIVE EXOSUITS

Researchers from Harvard University's John A. Paulson School of Engineering and Applied Sciences (SEAS) and Harvard's Wyss Institute for Biologically Inspired Engineering have developed a new approach in which robotic exosuit assistance can be calibrated to an individual and adapt to a variety of real-world walking tasks in a matter of seconds. The bio-inspired system uses ultrasound measurements of muscle dynamics to develop a personalized and activity-specific assistance profile for users of the exosuit.

Researchers developed a new approach in which robotic exosuit assistance can be calibrated to an individual and adapt to a variety of real-world walking tasks. Image courtesy of Biodesign Lab, Harvard John A. Paulson School of Engineering and Applied Science at Harvard University

"We used ultrasound to look under the skin and directly measured what the user's muscles were doing during several walking tasks," said Richard Nuckols, PhD, a postdoctoral research associate at SEAS and the Wyss Institute. "Our muscles and tendons have compliance, which means there is not necessarily a direct mapping between the movement of the limbs and that of the underlying muscles driving their motion."

The research team strapped a portable ultrasound system to the calves of participants and imaged their muscles as they performed a series of walking tasks. The new system only needs a few seconds of walking to capture the muscle's profile. For each of the ultrasound-generated profiles, the researchers then measured how much metabolic energy the person used during walking with and without the exosuit. They found that the muscle-based assistance provided by the exosuit significantly reduced the metabolic energy of walking across a range of walking speeds and inclines. The exosuit also applied lower assistance force to achieve the same or improved metabolic energy benefit than previous published studies.

When tested in real-world situations, the exosuit was able to quickly adapt to changes in walking speed and incline. This approach may help support the adoption of wearable robotics in real-world, dynamic situations by enabling comfortable, tailored, and adaptive assistance.

Next, the research team aims to test the system making constant, real-time adjustments.

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The Propel™ and Propel™ + Carbon insoles are designed to supercharge the user's favorite running shoe with the latest advancements in running technology. These insoles allow runners to experience the sensation of propulsion without buying additional racing-specific shoes. The insoles feature lightweight, durable, responsive cushioning and game-changing energy return foam to make runs feel easier and more explosive. The Propel™ features INergy™ Foam technology for a lighter, more durable insole that provides superior energy return versus the standard insole. The Propel™ + Carbon insole was designed by biomechanical experts. This insole features a full-length carbon plate for explosiveness with each foot strike and INergy™ Foam for next-level energy efficiency.

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OSU-CASCADES LAUNCHES DPT PROGRAM

Oregon State University – Cascades (OSU-Cascades) launched the first doctor of physical therapy (DPT) degree program at a state public university this fall, welcoming an initial cohort of 45 students.

Beginning in their first year, DPT students will work with patients in local physical therapy clinics under the supervision of practicing clinicians. Students will engage in 35 weeks of clinical internships during the 3-year program, participating in at least 1 clinical rotation in a rural or underserved community. During the program, teams of students will also embark on capstone projects in the field focusing on areas including oncology, disparity in healthcare access in diverse populations, interventions for neurological conditions, and biomechanics.

The program will be housed in the newly opened Edward J. Ray Hall on the OSU-Cascades campus, which has state-of-the-art classrooms, labs, and research areas in the building, including a classroom with 24 treatment tables and a clinical skills classroom where students train on equipment used in physical therapy settings. The program also is served by a specialized laboratory for cadavers, which support students' understanding of musculoskeletal

anatomy and neuroanatomy.

The program employs 7 full-time faculty, 25 associate faculty who are primarily practicing physical therapists in Central Oregon, as well as other experts from around the state. Faculty represent a variety of specializations including orthopedics, neurology, physiology, sports medicine, biomechanics, and oncology.

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VARIAN RECEIVES FDA BREAKTHROUGH DEVICE DESIGNATION FOR KNEE OA TREATMENT

Varian, a Siemens Healthineers company, announced that the U.S. Food and Drug Administration (FDA) has granted the company Breakthrough Device Designation for its Embozene® microspheres for genicular artery embolization (GAE), a minimally invasive procedure, for symptomatic knee osteoarthritis (OA). Embozene is a medical device that is FDA cleared for the embolization of hypervascular tumors, arteriovenous malformations, uterine fibroids, and benign prostatic hyperplasia.

Embozene microspheres received this designation due to their potential to offer a more effective treatment for appropriate patients with knee OA. GAE is designed to reduce the blood flow to the periarticular tissue of the joints, limiting the inflammatory process.

FRIENDLY FORCE SHOES

Friendly Shoes look and feel like modern comfort sneakers, but patented Easy Shoe Access zippers make them a functional solution for individuals struggling with shoe donning or fitting AFOs/SMOs. Invented by an occupational therapist, users simply fold open, enter, and zip. The Force is a featherweight, versatile zip-on available in wide widths. It features removable memory foam insoles, slip-resistant outsoles, and front Easy Shoe Access that's well suited for individuals who prefer donning shoes from a seated position. The Friendly fit accommodates wider feet. See sizing guide for AFO/SMO compatibility; not recommended for medium-to-large sized AFOs. The shoes are elderly friendly, disabled friendly, diabetic friendly, pregnant friendly, and eco-friendly. They are available in 2 women's styles and a unisex black version.

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SUPER STRETCH COMPRESSION SOCKS

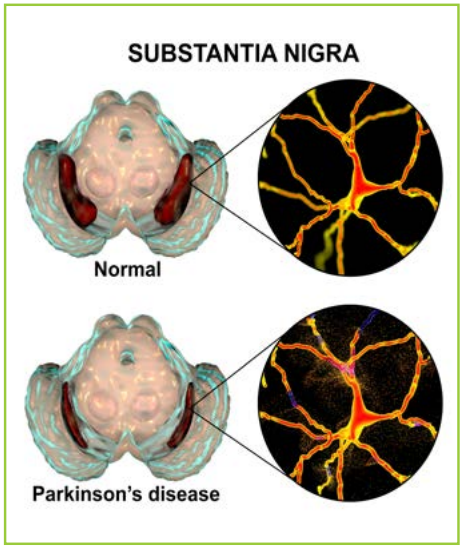
Sugar Free Sox has launched its new product, Super Stretch Compression socks, which have 26-inch stretch while maintaining therapeutic graduated compression. They are designed to help reduce ankle and foot swelling and avoid leg fatigue and aches. In addition to fitting wide calves, the socks are easy to don and doff. These socks feature graduated moderate compression—15-20 mmHg; outstanding elasticity for proper fit; soft, breathable material, a non-binding top; durable reinforced heel and toe; and extended toe for extra comfort. Super Stretch Compression socks are available in 3 sizes: sock size 9–11 (19.5" max. calf), sock size 10–13 (22.5" max. calf); and sock size 13–16 (26" max. calf).

Sugar Free Sox
858/481-7691
sugarfreesox.com

UNCOVERING THE DEGENERATIVE BASIS OF PARKINSON'S DISEASE

Northwestern University investigators have discovered the molecular signature of a subset of dopaminergic neurons with an increased vulnerability to degeneration. The findings shed light on the mechanisms at play within a small subsection of the brain's substantia nigra, called the pars compacta, which contribute to the development of Parkinson's disease and may help identify novel therapeutic targets, according to a study published in the journal *Cell Reports*.

"This provides a better understanding into the neuronal diversity within the substantia nigra and why some cohorts may be more vulnerable than others. In doing so, it might provide a better understanding of the degenerative underpinnings of Parkinson's disease," said senior author Rajeshwar Awatramani, PhD, professor in the Division of Movement Disorders.



A hallmark of Parkinson's disease is degeneration of the brain's substantia nigra, a midbrain structure containing dopaminergic neurons which serves a critical role in reward response and movement. Parkinson's disease is characterized by selective loss of dopaminergic neurons in the substantia nigra's ventral tier, while dopaminergic neurons in its dorsal tier are generally untouched.

For this study, the team performed immunofluorescence staining on post-mortem samples from patients with Parkinson's disease and discovered that ventral dopaminergic neurons express different molecular signatures than dorsal dopaminergic neurons. Specifically, ventral dopaminergic neurons express the transcription factor Sox6 and are enriched in mitochondrial pathways such as mitochondrial biogenesis and electron transport, which may increase vulnerability to degeneration.

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PriMatrix is a unique scaffold for the management of wounds that includes diabetic foot ulcers (DFUs). Derived from fetal bovine dermis, this novel acellular dermal matrix provides an ideal environment to support cellular repopulation and revascularization processes critical in wound healing. PriMatrix is particularly rich in Type III collagen, a collagen found in fetal dermis that is active in developing and healing tissues. Recently published clinical data demonstrates that PriMatrix is an adaptable solution to address the most challenging DFUs in a single application. It also further supports PriMatrix's clinical and economic value to healthcare professionals who are treating patients.

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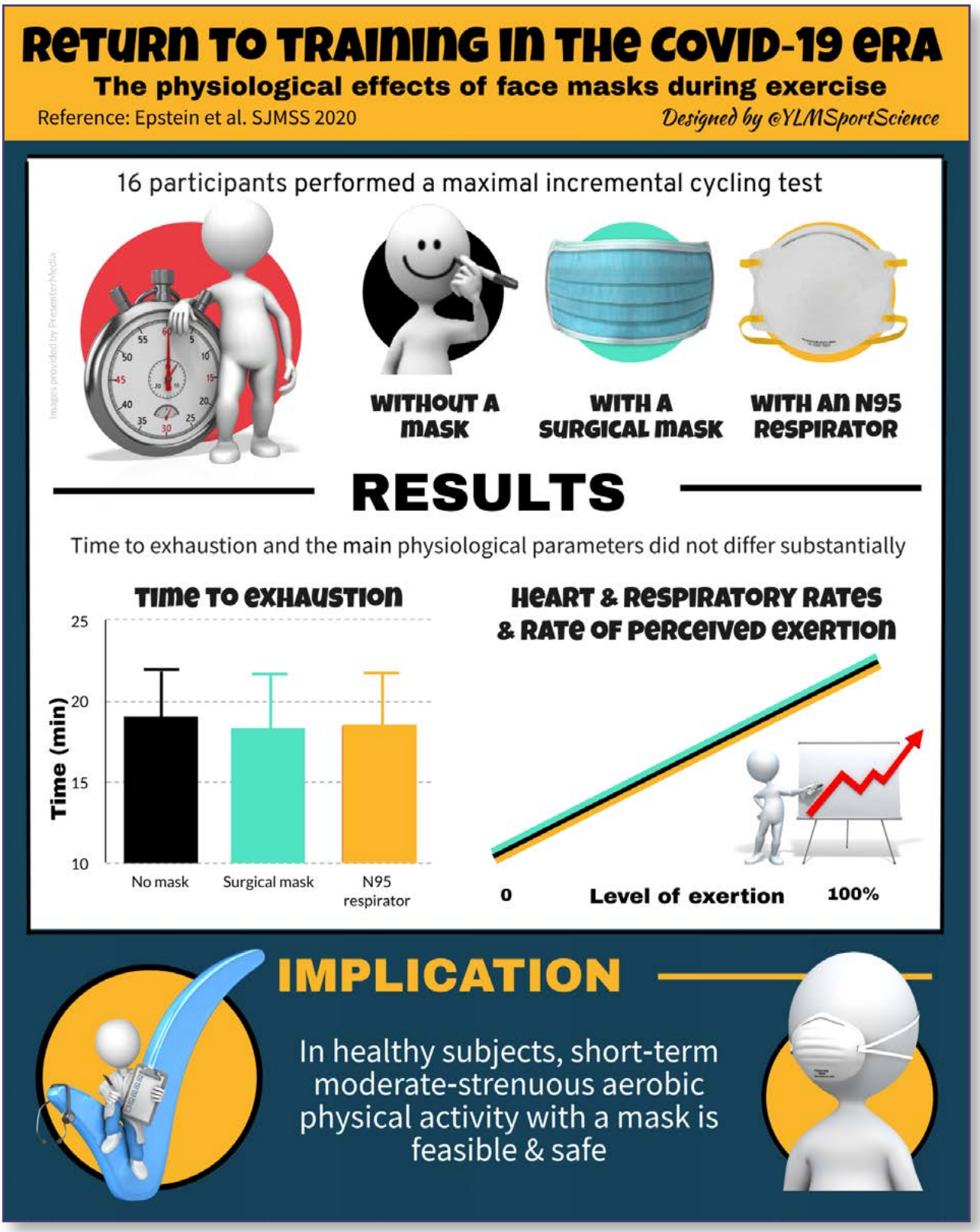
NATIONAL BIOMECHANICS DAY GRANTS: DEADLINE JAN. 31

The Biomechanics Initiative has announced 4 grant programs to support minority sponsored events for National Biomechanics Day, to be held on April 6, 2022. The day-long event is designed to introduce biomechanics to high school students around the globe. The grant program is looking for MS- or PhD-level students to support outreach programs among 4 key communities: Black, Women, LatinX, and Disability; up to 5 $1,000 grants will be awarded in each category. Applications can be retrieved from thebiomechanicsinitiative.org, click Grants & Scholarships. But hurry, application deadline is January 31, 2022!

RETURN TO TRAINING IN THE COVID-19 ERA



Source: https://ylmsportscience.com/2021/03/10/return-to-training-in-the-covid-19-era-the-physiological-effects-of-face-masks-during-exercise/

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