Session 12b: Posters

4:15PM

Co-Moderators: Irene Davis, PT, PhD (Spaulding Rehab, Harvard University) and Rajshree Hillstrom, PhD, MBA (Anglia Ruskin University)

Poster No. 1: Roberts, Lauren, et al. Ankle Fusion Percutaneous Home Run Screw Fixation: technical aspects and soft tissue structures at risk

Poster No. 2: Roberts, Lauren, et al. Intraoperative Syndesmotic Instability Test: An Alternative Technique

Poster No. 3: Roberts, Lauren, et al. Accuracy of Transarticular Lateral Soft Tissue Release of the 1st Metatarsophalangeal Joint – A Cadaver Study

Poster No. 4: Siegler, Sorin, et al. Validation of a Subject-specific Computational Models of the Ankle Joint Complex

Poster No. 5: Sturnick, Daniel R., et al. The Function Axis of Rotation of the Ankle Joint during Simulated Gait

Poster No. 6: Hatton, Anna L., et al. Textured shoe insoles to improve balance & walking in adults with diabetic peripheral neuropathy: study protocol for a randomised controlled trial

Poster No. 7: Marc, Janin. & Philippe, Dupui. Foot Orthoses reduce repercussions of Ns4 Noxious stimulus

Poster No. 8: Marc, Janin. Foot Function & Sensorimotor Orthoses of Ns4 Noxious stimulus

Poster No. 9: Breard, Thomas. & Janin, Marc. Posturodynamic-6 Perform Sport relate influences performance and competitveness in sports

Poster No. 10: McClymont, Julie. The magnitude and spatial distribution of variability in plantar pressure at a wide range of walking speeds

Poster No. 11: Oakman, Joyann, et al. Reliability of New Forefoot-Rearfoot Measurement

Poster No. 12: Phillips, Robert D., et al. Comparison ofTorsional Stiffness of Orthotics Made from Two Different Materials— A Pilot Study

Poster No. 13: Telfer, Scott. & Bigham, J. The Effect of Age and Disease on Regional Plantar Loading: A Systematic Review and Meta Regression Analysis

Poster No. 14: Turner, Robert. Finding the Kinematic Driver1

Poster No. 15: Lysdal, Filip Gertz, et al. Biomechanics of a Lateral Ankle Sprain – and the Effect of a Minimized Lateral Shoe-Surface Friction

Poster No. 16: Chicoine, Dominic. Customized foot orthoses in the treatment of posterior tibialis tendon dysfunction

Poster No. 17: Tulchin-Francis, Kirsten, et al. Plantar pressures in patients with symptomatic flexible flatfoot: How are they different than adolescents with asymptomatic flatfoot?

Poster No. 18: Giacomozzi, Claudia. Testing Muscle Activation and In-shoe Foot Loading Under Repeatable Conditions: A Stepper-based Approach

Poster No. 19: Franzese, Richard, et al. Velocity and Footwear Effects on Foot-strike Angle during Running

Poster No. 20: Franzese, Richard C., et al. Velocity, footwear, and foot-strike angle effects on lower-leg muscle activity during running

Poster No. 21: Freedman, Happy. & Serotta, B. Intro to bike road fitting

Poster No. 22: Greene, Andrew J. & De Paula, A. Are you experienced yet?

Poster No. 23: Mahaffey, Ryan, et al. Effects of acute fatigue of the lower limb on running mechanics

Poster No. 24: Parker, Winton, et al. Load-limiting Sports Shoe Sole to Reduce Injuries

Poster No. 25: Netto, Cesar de Cesar, et al. Percutaneous Posterior to Anterior Screw Fixation of the Talar Neck: Soft Tissue Structures at Risk

Poster No. 26: Roney, Andrew R., et al. Knee Adduction Moments Associated with Knee Osteoarthritis are Increased by Medial Arch Supports

Poster No. 27: Cha, Seungwoo, et al. Weight bearing with standing position for tibiofibular clear space measurement; using 3D US

Poster No. 28: Naemi, Roozbeh, et al. An explanatory model of risk factors for foot ulcers in patients with diabetes

Ankle Fusion Percutaneous Home Run Screw Fixation: technical aspects and soft tissue structures at risk

Lauren Roberts[1], Cesar de Cesar Netto[1], Scott Ellis[1], Alexandre Godoy-Santos, [2]Ashish Shah[3]
[1]Hospital for Special Surgery, NY [2]University of Sao Paulo, Brazil [3]University of Alabama at Birmingham, AB

Disclosures: No relevant disclosures.

INTRODUCTION:

During internal fixation of ankle fusions, besides the standard crossed screw fixation pattern, the use of a percutaneously placed augmenting screw, directed from the posterolateral tibial metaphysis proximally across the ankle into the talar neck ("ankle fusion home run screw"), is a widely used technique. The placement of this screw is technically demanding and multiple attempts under fluoroscopy guidance are frequently needed to achieve a perfect positioning of the implant. Injuries to local neurovascular and tendinous structures may occur. The objective of this cadaver study was to identify the number of attempts necessary for a perfect positioning of the ankle fusion home run screw and to identify the neurovascular and tendinous structures at risk.

METHODS:

Eleven fresh frozen cadaver limbs were used. Guide wires (3.2mm) from the Stryker (Selzach, Switzerland) 7.0-mm headless cannulated set were percutaneously placed into the distal posterolateral aspect of the leg by a Fellowship Trained Foot and Ankle Surgeon, under fluoroscopic guidance, with the ankle in neutral position. Mal positioned pins were not removed and served as guidance for the following pins. The number of guide wires needed to achieve an acceptable positioning of the implant (pin centered on the axis of the talar neck) was noted. After a layered dissection from the skin to the tibia, we evaluated neurovascular and tendinous injuries, and measured the shortest distance between the closest guide pin and the soft tissue structures, using a precision digital caliper.

RESULTS:

The mean number of guide wires needed to achieve and acceptable positioning of the implant was 2.09 (SD 0.83, range 1 - 4). The mean distances between the closest guide pin and the soft tissue structures of interest were: Achilles tendon 6.90mm (SD 3.74mm); peroneal tendons 9.65mm (SD 3.99mm); sural neurovascular bundle 0.97mm (SD 1.93mm); posteromedial neurovascular bundle 14.26mm (SD 4.56mm). Sural bundle was in contact with the guide pin in 5/11 specimens (45.5%) and transected in 3/11 specimens (27.3%).

CONCLUSIONS:

The placement of percutaneous ankle fusion home run screws is technically demanding and multiple guide pins are needed. Our cadaveric study showed that important tendinous and neurovascular structures are in close proximity with the guide pins and that the sural bundle is injured in approximately 73% of the cases.

SIGNIFICANCE/CLINICAL RELEVANCE:

Neurovascular injury on any scale negatively affects outcomes. Thus, small open incisions should be made to dissect safely down to bone and protect surrounding neurovascular structures while placing screws in ankle fusion.

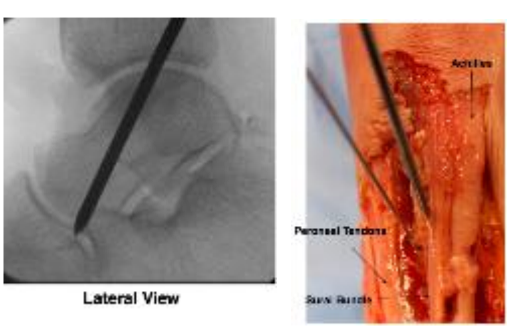


Figure 1:

A) Image on the left shows a radiograph of the trajectory of the home run screw.

B) Image on the right demonstrates the proximity of the guidewire to surrounding posterior lateral structures.

Intraoperative Syndesmotic Instability Test: An Alternative Technique

Lauren Roberts[1], Cesar de Cesar Netto[1], Scott Ellis[1], Ashish Shah[3]
[1]Hospital for Special Surgery, NY [2]University of Sao Paulo, Brazil [3]University of Alabama at Birmingham, AB

Disclosures: No relevant disclosures.

INTRODUCTION:

Precise diagnosis of distal tibiofibular syndesmotic injury is challenging, and a distinction should be made between syndesmotic ligament disruption and real syndesmotic instability. Tibiofibular clear space identified on radiographic imaging is considered the most reliable indicator of the injury as it is not significantly influenced by tibial rotation. A clear space greater than 6 mm at a point 1 cm above the tibial plafond is suggestive of injury. The Cotton test, (or Hook test), is the most widely used intraoperative technique to evaluate the syndesmotic integrity. We advocate an alternative technique using a 3.5mm blunt cortical tap.

METHODS:

Nine fresh-frozen cadaveric specimens were used with mean age of 79 (range, 54-88) years. First, a 2.5mm hole was drilled percutaneously on the lateral aspect of the distal fibula, in position for possible placement of a syndesmotic screw or suture button. A 3.5mm cortical tap was then threaded in the hole. For each specimen, three sequential fluoroscopic mortise images were taken. The first image was with the syndesmotic ligaments intact and no force applied to the tap (intact, non-stressed). In the second, with the ligaments intact, the cortical tap was advanced until its blunt tip was pushing against the lateral tibial surface, thus providing a tibiofibular separation force (intact, stressed). The third one was acquired after the same stress was applied to the tibia through the tap, but all syndesmotic ligaments were released (injured, stressed). Tibiofibular clear space was measured twice, 1 cm above the tibial plafond, by two independent viewers. Non stressed and stressed measurements were compared by Student's t-test. Intra and inter-observer agreements were evaluated by intra-class correlation coefficient (ICC). *P*-values <.05 were considered significant.

RESULTS:

We found excellent intra-observer (ICC 0.97) and inter-observer (0.98) agreement following the imaging assessment. The mean values for the tibiofibular clear space were: 4.21 ± 1.16mm in the intact, non-stressed ankles; 4.49 ± 1.25 mm in the intact, stressed ankles; and 7.10 ± 1.05 mm in the injured, stressed ankles. Significant differences were found in the paired comparison between the groups (p<.05). Our novel syndesmotic instability test has demonstrated a 67%sensitivity, 78% negative predictive value 100% specificity and 100% positive predictive value in diagnosing syndesmotic instability.

CONCLUSIONS:

Our cadaveric study showed that this novel syndesmotic instability test using a 3.5mm blunt cortical tap is a simple and reliable technique. The test was able to demonstrate significant differences in the tibiofibular clear space when comparing normal ankles without stress, normal ankles with stress, and complete injury of the syndesmotic ligaments with stress. It represents a viable, simple, quantitative, and low-cost alternative to the most used Cotton test. Furthermore, the hole that is made for this test can be used in the event that syndesmotic fixation is necessitated, or simply a bi-cortical fibular screw may be placed in this hole if the syndesmosis does not require fixation.

SIGNIFICANCE/CLINICAL RELEVANCE:

Accurately diagnosing syndesmotic instability remains challenging. This novel syndesmotic instability test shows improved sensitivity and reliability to optimize the diagnosis of instability intra operatively thus accurately guiding intraoperative fixation of the syndesmosis to allow for best possible patient outcomes.

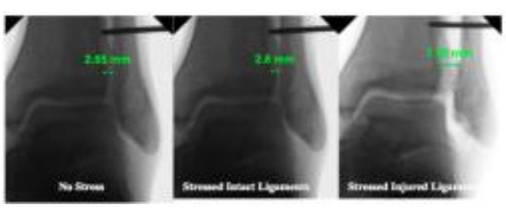


FIGURE 1. Fluoroscopic images of an ankle demonstrating an increase in tibia fibula clear space with the tap test. 3.5mm blunt cortical tap seen in the top right of each of the images entering through the fibula and against the tibia.

Accuracy of Transarticular Lateral Soft Tissue Release of the 1st Metatarsophalangeal Joint – A Cadaver Study

Lauren Roberts[1], Cesar de Cesar Netto[1], Scott Ellis[1], Ashish Shah[2]
[1]Hospital for Special Surgery, NY [2]University of Alabama at Birmingham, AB

Disclosures: No relevant disclosures.

INTRODUCTION:

The release of contracted lateral soft tissue structures of the first metatarsophalangeal joint is frequently part of the surgical treatment of hallux valgus deformity. The 1st intermetatarsal space open dorsal approach and the single medial incision transarticular approach represent possible options. Advantages of the transarticular approach include avoidance of a second incision and a theoretically lower risk of 1st metatarsal head AVN. However, the inherently limited visualization of the structures through this approach might limit its effectiveness. The objective of this study was to evaluate the accuracy of hallux valgus lateral soft tissue release through the transarticular approach.

METHODS:

Ten bellow-knee fresh-frozen cadaveric specimens were used (6 females/4 males, mean age, 73.4 years), including two specimens with moderate hallux valgus deformity. None of the specimens had considerable degenerative changes of the 1st MTP joint. Lateral release was performed by the same Fellowship Trained Foot and Ankle Surgeon through a single medial approach of 2.5cm with a no15 scalpel blade. Surgical aim was to release four 1st MTP joint complex structures: lateral collateral ligament, lateral capsule, adductor hallucis muscle tendon and lateral metatarsosesamoid suspensory ligament. Once completed, a lateral extended dissection of the 1st - space was performed. Accuracy was graded in accordance to the number of structures successfully released: 0% (no structures), 25% (1/4), 50% (2/4), 75% (3/4) and 100% (4/4). Inadvertent injuries to soft tissue structures (flexor hallucis brevis and longus tendons, deep transverse metatarsal ligament and first intermetatarsal neurovascular bundle) and articular cartilage of 1st metatarsal head and proximal phalanx were recorded.

RESULTS:

The surgical accuracy for lateral soft tissue release of the 1st MTP joint through the transarticular medial approach was 100% in 7 cadaveric specimens, and respectively 75%, 50% and 25% in the other 3 specimens. The lateral collateral ligament was successfully released in all cadavers. The lateral joint capsule, adductor hallucis muscle tendon and lateral metatarsosesamoid suspensory ligament were released in 80% of the specimens. Chondral damage of the 1st metatarsal head and unintended release of the lateral head of the flexor hallucis brevis occurred respectively in 40% and 50% of the procedures. No injuries to the flexor hallucis longus tendon, neurovascular bundle, deep transverse metatarsal ligament and chondral damage of the proximal phalanx were recorded.

CONCLUSIONS:

Our cadaveric anatomical study has shown a high accuracy in the release of specific lateral soft tissue structures of the 1st MTP joint through a medial transarticular approach. Inadvertent release of the lateral head of the flexor hallux brevis and iatrogenic chondral damage of the 1st metatarsal head are complications to be considered. Limitations include a small sample size and inherent differences between live and cadaveric tissue.

SIGNIFICANCE/CLINICAL RELEVANCE:

The medial transarticular approach for distal soft tissue release in a bunion correction can accurately release the specific relevant lateral soft tissue structures of the 1st MTP joint. Performing the release in this way limits the number of incisions and removes the potential risks of a 1st web space incision thus potentially decreasing morbidity to the patient.

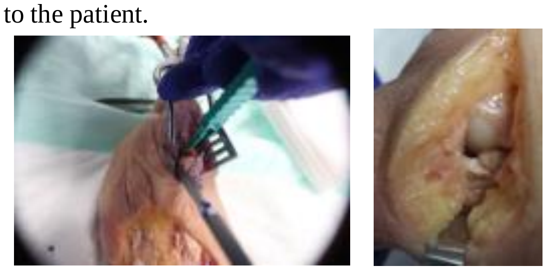


Figure. 1.
A) Image on the left shows lateral release through the medial transarticular approach.
B) On the right shows subsequent assessment of adequacy of lateral release through a secondary 1st web space incision.

Validation of a Subject-specific Computational Models of the Ankle Joint Complex

Sorin Siegler[1], Vishnuvardhan Balakrishnan[1], Claudio Belvedere[2], Paolo Caravaggi[2] , Alberto Leardini[2]
[1]Drexel University, Philadelphia, PA, USA, [2]Movement Analysis Laboratory, Istituto Ortopedico Rizzoli, Bologna, Italy
sieglers@drexel.edu

Disclosures: Sorin Siegler, Vishnuvardhan Balakrishnan, Claudio Belvedere, Paolo Caravaggi , Alberto Leardini (N –all)

INTRODUCTION: Three dimensional (3D) image based, subject specific models of the ankle complex, can be a useful predictive and planning tool in a variety of clinical and biomechanical applications such as diagnosis of ligament injuries and evaluation of surgical reconstructive procedures. However, few computational models can produce the full 3D biomechanical properties of the ankle complex, particularly on a subject-specific basis. Our group introduced one such computational model in 2004 (1). This model was partially validated against experimental data. In the current study, we have improved this model and validated it, on a subject-by-subject basis, using a wide range of 3D biomechanical properties.

METHODS: Five cadaveric lower limb specimens were used in this study. Each specimen was CT-scanned and then tested on a special linkage where they were loaded in three dimensions and the applied loads and associated displacements were recorded (2). Using the imaging data, modified 3D models of the ankle complex used by us in the past (1) were then produced for each specimen. These models included the 3D bone morphology, attachment of the surrounding ligaments, and contact mechanics associated with cartilage mechanical properties. The main improvements in the current models included the specific distribution of cartilage thickness at the ankle rather than a uniform thickness distribution and pre-straining the ligaments to values reported in the literature (3). The evaluation consisted of a subject specific comparison using repeated measure analysis of the following biomechanical parameters: rotational range of motion (ROM) in 3D; three dimensional displacement-load curves and total laxity (ROM/Max torque); surface-to-surface interaction based on distance maps at the ankle and subtalar joints. The straining during 3D motion of the ATFL and CFL obtained through the models were compared against published literature (4).

RESULTS: The results show good agreement in ROM, limited to less than 2 degrees difference between simulation and experiment in dorsiflexion/plantarflexion, 0.3 degrees in inversion/eversion and less than 2.5 degrees in internal/external rotation. Total laxity showed good agreement between simulations and experiments limited to less than 10% while the displacement vs. load curves obtained from the simulations showed similar trends with typical stiffness increase towards the end of ROM and hysteresis (Figure 1). Distance maps produced in neutral and at the extreme of the ROM in all direction showed good agreement between the simulations and the experiments (Figure 2).

DISCUSSION: The data obtained from a subject-specific computational model was compared, on a subject specific basis, to experimental data from cadaver specimens and produced similar results over a wide range of biomechanical parameters, confirming the reliability of this model. Such model improves the state-of-the-art in foot and ankle modeling by enabling reliable simulations of a variety of 3D events.

SIGNIFICANCE AND CLINICAL RELEVANCE: This image-based, subject specific model can be used as a predictive tool to aid in diagnosing and surgical planning for a variety of ankle disorders such as the effect of various ligament injuries and the effect of variations in the surface geometries of total ankle replacements on biomechanical behavior.

REFERENCES: : **1.** Imhauser, C. W., Siegler, S., Udupa, J. K., & Toy, J. R. (2008). *J. Biomech.*, *41*(6), 1341-1349; **2.** Belvedere C, et al. (2017). J Biomech 53, 97-104; **3**.Ozeki, S., Yasuda, K., Kaneda, K., Yamakoshi, K., & Yamanoi, T. (2002). *Foot & Ankle Int.*, *23*(9), 825-832; **4.** Colville, M. R., Marder, R. A., Boyle, J. J., & Zarins, B. (1990). *Am. J. of Sports Med.*, *18*(2), 196-200.

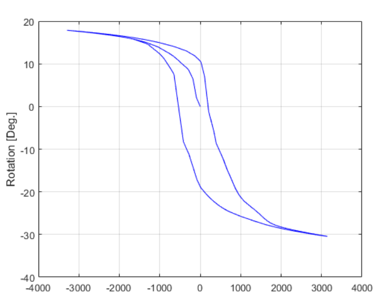


Figure 1 – Displacement vs. load from one typical simulation dorsiflexion/plantarflexion

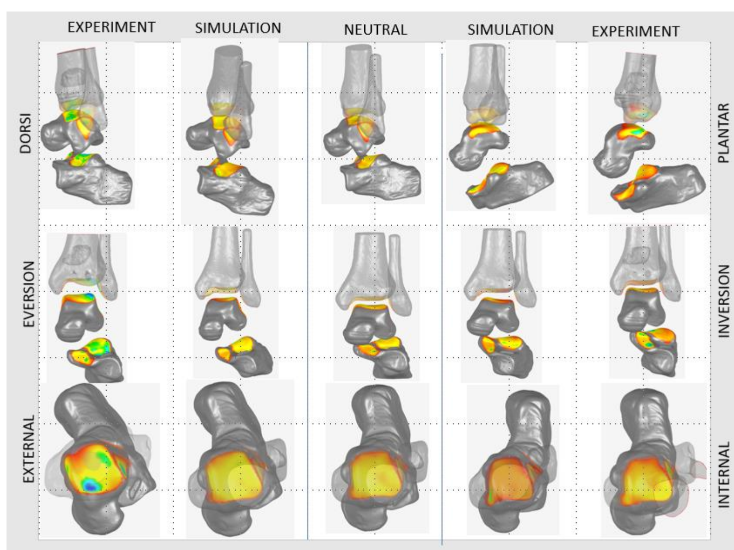


Figure 2 – Distance maps comparison simulation vs. experiment

The Function Axis of Rotation of the Ankle Joint during Simulated Gait

Daniel R. Sturnick MS[1], Guilherme H. Saito MD[2], Jonathan T. Deland MD[2], Scott J. Ellis MD[2], Constantine A. Demetracopoulos MD[2]
[1]Biomechanics Department, [2]Foot and Ankle Service, Hospital for Special Surgery, New York, NY
Email of Presenting Author: sturnickd@hss.edu

Disclosures: Daniel R. Sturnick (N), Guilherme H. Saito (N), Jonathan T. Deland (Zimmer, Arthrex), Scott J. Ellis (Wright Medical), Constantine A. Demetracopoulos (Integra LifeSciences, Wright Medical, Stryker, RTI Surgical)

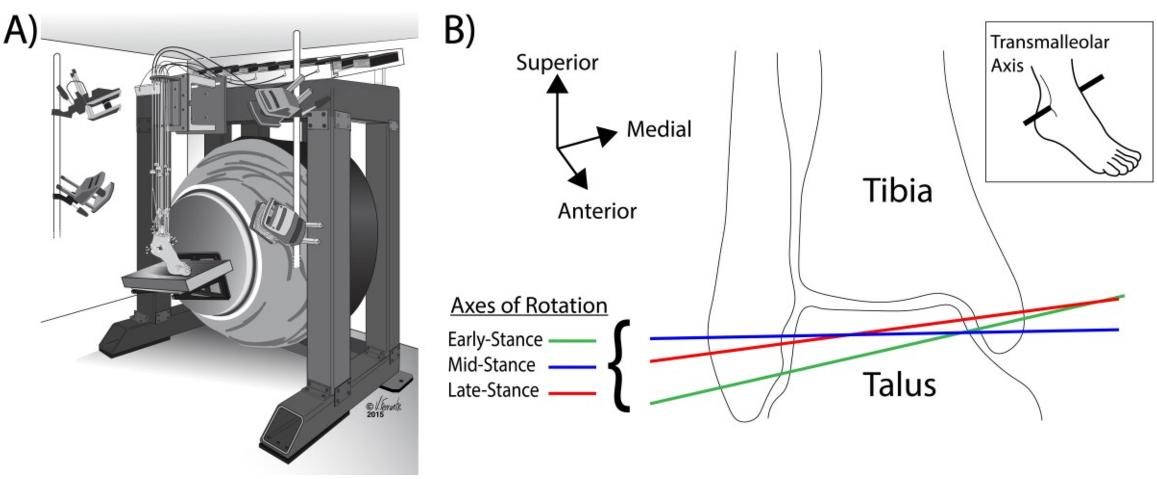
INTRODUCTION: Implant component positioning is considered as an important factor in function and longevity in total ankle arthroplasty (TAA). However, accurate and repeatable positioning remains a limitation with current techniques and instrumentation. In addition, further investigation is needed to objectively define the optimum component positioning. Cadaveric gait simulation is a valuable tool for investigating foot and ankle joint mechanics during functional tasks such as the stance phase of gait. The objective of this study was to investigate the functional axis of rotation of the native ankle joint during simulated gait.

METHODS: The stance phase of healthy gait was simulated with six mid-tibia cadaveric specimens using a previously validated device and methodology. A robotic platform reproduced tibial-ground kinematics by moving a force plate relative to the stationary specimen while physiologic loads were applied to the extrinsic tendons to actuate the foot. (Figure 1A). Ankle kinematics were measured from reflective markers attached to the tibia and talus via surgical pins. The helical axes of rotation of the talus with respect to the tibia was calculated during three portions of stance: initial plantarflexion during earlier-stance after heal strike, dorsiflexion during mid-stance, and final plantarflexion during late-stance. The position and orientation of these kinematic-defined axes of rotation were compared to the transmalleolar axis and reduced to its anteroposterior position (Figure 1B).

RESULTS: Analyses revealed that ankle joint functional axis of rotation varied from the anatomic reference throughout stance. The kinematic center of rotation was located 16.4 ± 5.8 mm, 16.5 ± 6.6 mm, and 15.6 ± 6.5 mm anterior to the transmalleolar axis during early-, mid- and late-portions of stance, respectively.

DISCUSSION: This study revealed that the position of the flexion-extension axis varies greatly between specimens during simulated gait. While previous reports have suggested that the transmalleolar axis is an acceptable approximation for the ankle joint center, these findings suggest that further research in warranted to better describe the complex tibiotalar kinematics.

SIGNIFICANCE/CLINICAL RELEVANCE: This work may provide future insight to guide implant design and advance techniques, to better place articular constraints of a total ankle in the native center of rotation of the joint.



Session 12b-Poster No. 6

Textured shoe insoles to improve balance and walking in adults with diabetic peripheral neuropathy: study protocol for a randomised controlled trial

Anna L Hatton[1], Elise M Gane[1], Jayishni Maharaj[1], Joshua Burns[2], Joanne Paton[3], Graham Kerr[4], Keith Rome[5]
[1]The University of Queensland, Australia, [2]The University of Sydney, Australia, [3]Plymouth University, UK, [4]Queensland University of Technology, Australia, [5]Auckland University of Technology, New Zealand
Email of Presenting Author: a.hatton1@uq.edu.au

Disclosures: This clinical trial is funded by a Diabetes Australia Research Program General Grant (2017-2018).

INTRODUCTION: Peripheral neuropathy is a major risk factor for falls, affecting the lower limbs of up to 86% of fallers with diabetes [1]. Nerve damage can disrupt vital sensory cues about the supporting surface and position of body segments, to help people remain upright. Innovative footwear devices which artificially manipulate the sensory environment at the feet, such as textured insoles, are emerging as an attractive option to help mitigate balance and walking problems in clinical populations [2, 3], by way of a 'sensory training' effect [4]. However, the therapeutic effects of textured insoles for adults with peripheral neuropathy remain unknown. This study will explore whether wearing textured shoe insoles can improve balance, walking, foot sensation, physical activity and reduce the risk of falls, in adults with diabetic peripheral neuropathy.

METHODS: A prospective, single-blinded randomised controlled trial with two parallel groups will be conducted of 70 community-dwelling adults with diabetic peripheral neuropathy, across Brisbane, Australia. Men and women with a diagnosis of peripheral neuropathy (secondary to Type 2 Diabetes), who are aged over 18 years, ambulant over 20m (with or without an assistive device), and meet specific inclusion criteria, will be recruited. Participants will be randomised to a smooth control insole (N=35) or textured insole (N=35) group. The allocated insole will be worn for 4-weeks within participants' own footwear, with self-report wear diaries and falls calendars being completed over this period. Blinded assessors will conduct one baseline assessment and one 4-week post-intervention assessment. Participants will complete surveys addressing their self-perceived foot health (Foot Health Status Questionnaire), fear of falling (Falls Efficacy Scale-International) and will be asked to rate the comfort of wearing their allocated insole (100m visual analogue scale). Habitual activity levels will be assessed using a wireless activity monitor (activPAL), worn for 7 consecutive days (prior to baseline and at Week 3). Lower limb sensory function will be assessed bilaterally, including light-touch pressure (monofilaments), vibration perception (neurothesiometer), and ankle joint proprioception (internet-based goniometer). Static, bilateral standing will be assessed (AMTI force plate) over 30 seconds, under two visual (eyes open, eyes closed) and two surface (firm, foam) conditions (randomly presented). Level-ground gait will be evaluated by completing a 12m walk over an instrumented walkway (GAITRite® CIR Systems Inc.). Balance and gait tasks will be completed barefoot, wearing standardised shoes only, and with two different shoe insoles (smooth, textured). Ethical approval has been obtained from the Human Research Ethics Committee at The University of Queensland. Participants will provide written informed consent prior to enrolment.

RESULTS: The primary outcome measure will be centre of pressure path velocity and excursion in anteroposterior and mediolateral directions. Secondary outcome measures include spatiotemporal gait parameters, physical activity levels, perception of foot sensation and proprioception. To establish any differences between the intervention and control groups for all outcome measures, a repeated measures mixed models approach will be undertaken using data at baseline and 4-weeks. Non-parametric tests will be used where data is not normally distributed. Participant characteristics (e.g. age, gender) will be included as covariates. Multiple regression will be used to determine any relationships between foot sensation and proprioception, balance and gait. Group allocation will be concealed and all analyses conducted on an intention-to-treat basis.

DISCUSSION: There is an urgent need to develop more effective and multi-faceted falls prevention strategies for adults with diabetes, to help reduce escalating health care costs. This study will be the first to explore whether artificially manipulating plantar sensory information, using novel shoe insoles, can address balance and mobility problems in people with diabetic peripheral neuropathy. The findings will be used to inform the development of new, affordable, non-invasive neuropathic treatments, which specifically target diabetic foot sensory complications that can contribute to falls. Importantly, wearing simple shoe insoles have the capacity to promote self-management by the user and enhance independent living.

SIGNIFICANCE/CLINICAL RELEVANCE: This study will determine the efficacy of an innovative footwear device in targeting deficient plantar sensation associated with neuropathic damage, to address falls risk factors in people with diabetes.

REFERENCES:
1. MacGilchrist C, et al. Diabet Med. 2010 Feb; 27(2):162-8. PMID: 20546259
2. Hatton AL, et al. J Foot Ankle Res. 2012 Apr; 5:11. PMID: 22546376
3. Qiu F, et al. PLoS One. 2013 Dec; 8(12):e83309. PMID: 24349486
4. Dixon J, et al. Physiotherapy. 2014 Jun; 100(2):142-9. PMID: 24070573

Session 12b-Poster No. 7

Foot Orthoses reduce repercussions of Ns4 Noxious stimulus.

Janin Marc[1,2], Dupui Philippe[1].

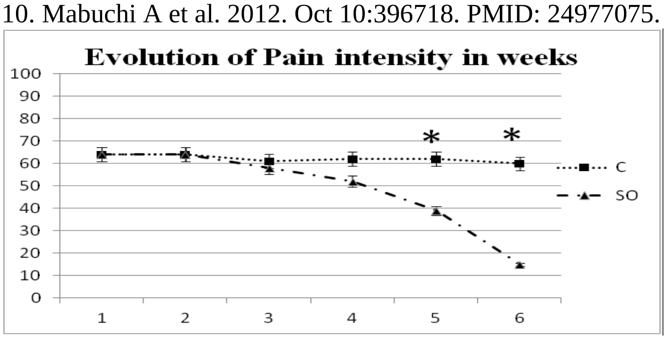
1: Laboratory of Physiology, University of Toulouse, France. 2 : PhD, Podiatrist ; Applied Podiatry College, Poitiers, France.

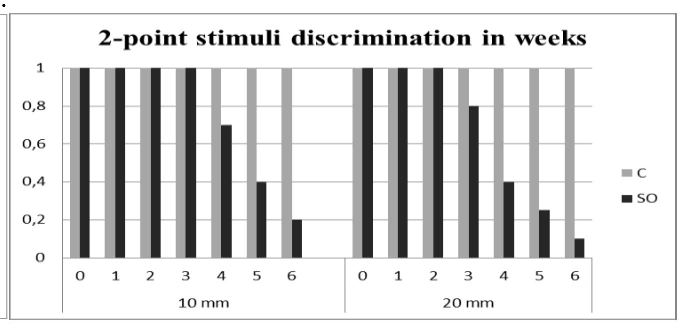
Email of Presenting Author: marcjanin@cegetel.net

INTRODUCTION: Previous studies reported that heterotopically painful stimulation could both depress the nociceptive spinal reflex (1). This effect could represent the neural basis for counter-irritation phenomena, that is, the paradoxical pain relief produced by heterotopic painful stimulation (2, 3). *Noxious stimuli of type 4* (Ns4), condition labelled épine irritative, represents one of several counter-irritation phenomena and designates a nociceptive capacity of plantar irritating stimulus (4, 5). In fact, NS4 is a specific heterotopic nociceptive stimulus produces pain, no expressed by the patient, when all of the four following criteria are met: 1) score variation of clinical PDN-6 into hard and foam ground (6-8); 2) asymmetrical perception of pain on the Ns4 area (5, 8); 3) loss of spatial discrimination (5); and 4) loss of perception of somesthesia (9). We evaluate the efficacy of sensorimotor orthoses/insoles (SO, 9, 10) to reduce the repercussion in patients presenting with Ns4.
METHODS: 20 males and 20 females (29-54 years) with Ns4 (single-point on the first metatarsal head) participated to the study: half of the patients (10 male and 10 female participants) were fitted with SO while the rest was the control group (C). We collected score of pain intensity (v.a.s, 0-100mm), and somesthesia by comparison into Ns4 levels and forehead reference in terms of 2-point stimuli, delivered with two distances (10-20 mm). These measures were taken at baseline and after a period of SO use: 1-2-3-6-12 week's adaptation period. ANOVAs and paired t-tests were used for statistics analyses.
RESULTS: Reduction is observed for pain sensitivity (fig 1) and the number of errors of discrimination of 2-point stimuli (fig 2) was observed. The reduction of sensation of nociceptive signal became perceivable from the 3rd week of use, but proved only significantly beneficial after 4 weeks of use for pain and 20 mm and 4 weeks use from 10 mm.
DISCUSSION: The use of SO induced a new repartition of plantar sensory field information and reduced the heterotopic nociceptive perception of Ns4, mediated by a complex loop involving supraspinal structures. The change in pain intensity diminished the nociceptive withdrawal reflex field size considerably. This effect optimized the fidelity of sensory discrimination by controlling the extent of the neuronal receptor field on decreasing control inhibition/facilitation. When induced by SO, pain stimuli were subject to greater inhibition, therefore improving the 2-point stimuli discrimination. Improvement in integration occurred earlier for 20 mm soles than 10 mm ones, certainly due to the modification of the plantar field in regard to the NS4 localization. Saliency detection is considered to have a pivotal role in sensory integration. The use of SO has the potential to induce a reduction of the Ns4 and to restore foot sole to a functional level. While the perception and the integration of somesthesia improved. Results need further investigations.

SIGNIFICANCE/CLINICAL RELEVANCE: modulation of pain of Ns4, heterotopic nociceptive stimuli, pain perception and somesthesia discrimination by SO influence. SO influence of the repercussion of Ns4 in the sensory integration.

REFERENCES:
1. Roby-Brami A et al. 1987. Dec;110 (Pt 6):1497-508. PMID: 2448000.
2. Le Bars Det al. 1984. In: Stress-Induced Analgesia. pp. 67-101.
3. Le Bars D et al. 1984. In: Spinal Afferent Processing. pp. 467-504.
4. Faganel J, Dimitrijevic MR. 1982. PMID: 7175544.
5. Janin M, Dupui P. 2011. doi.org/10.1016/j.clinbiomech.2011.05.009.
6. Villeneuve P, Parpay S. 1991. PMID: --- and doi.org:---.
7. Janin A et al. 2016. doi.org/10.4236/ijcm.2016.71006.
8. Janin M et al. 2015. doi.org/10.17784/mtprehabjournal.2015.13.298.
9. Janin M. 2016. doi.org/10.1016/j.fas.2016.05.032.
10. Mabuchi A et al. 2012. Oct 10:396718. PMID: 24977075.





Key-words: Foot orthoses, Epine Irritative, Heterotopic Noxious Stimuli, Ns4, podiatry.

Foot Function & Sensorimotor Orthoses of Ns4 Noxious stimulus

Janin Marc,

PhD, Podiatrist; Applied Podiatry College, Poitiers, France; Laboratory of Physiology, University of Toulouse, France.

Email of Presenting Author: marcjanin@cegetel.net

INTRODUCTION: The Foot Function Index (FFI) is one of the five health measurement scales most frequently used in podiatry (1). It was developed to measure the impact of foot pathology on function in terms of pain, disability and activity restriction (2, 3). The FFI was specifically designed to assess the effects of foot orthotics treatments on foot-related problems (e.g *Gross et al.* for patients with plantar fasciitis (4), *Powell et al.* for children with juvenile idiopathic arthritis (5) and *Wrobel et al.* for plantar heel pain (6)). One such foot pathology is an heterotopic nociceptive stimulus entitled Noxious stimuli type 4 (Ns4), *épine irritative*: a nociceptive capacity of plantar irritating stimulus (7,8) characterized by 4 sine qua non criteria: 1) score variation of the clinical PDN-6 into hard and foam ground (8, 9); 2) asymmetrical perception of pain on Ns4 area (7, 9-11); 3) loss of spatial discrimination (7) and 4) loss of feeling of somesthesia (10,11). For podiatrists, the most critical clinical issue is that pain cannot be expressed directly by the patients because it falls under the pain threshold (7, 9, 10). Sensorimotor Orthoses/insoles (SO) already proved potentially effective in reducing the impact of Ns4 and in improving postural performance of patient (10). A systematic literature search found no study using an established quality-of-life instrument to measure the impact of the noxious stimuli Ns4 and the effects of SO on Ns4. This study aims at evaluating the impact and efficacy of SO on patients with Ns4 with regards to pain thresholds, disability, and activity limitation.
METHODS: 30 males and 30 females (aged 29-54 years), all presenting Ns4 (localized as a single-point on the first metatarsal head), participated in the study. Every study participant completed the 3 subscales pain, disability and activity restriction of the FFI at screening, baseline, after 7 and after 21 days (11, French validated translation, 13). Bilateral custom-made SO were given to every patient (4, 10-12). The use of SO was expected to 1) reduce neurogenic cues (14), 2) change the muscular tone distribution (postural mechanical expression of sensory disorders), 3) improve the muscular chain integration of the patient's and 4) limit the mechanical constraints, by stimulating the proprioceptors of the sole (15).
RESULTS: SO induced a reduction of FFI scores at baseline, 7 and 21 days, for: a) pain: 40 28 13 (up to 90), b) distability 31 26 17 (up to 90), c) activity limitation 12 12 8 (up to 50) and d) total maximum score 83 65 38 (up to 230).
DISCUSSION: This study proves that Ns4 negatively impact foot function for the first time. The influence of Ns4 on the FFI score is comparable to the influence of other foot pathologies (previous reports): scores on each subsections were lesser when wearing SO for all subjects. The effect of SO is comparable to the literature: pain and disability readings were better with SO, after 7 days and only after 21 days on activity limitation. There could be two explanations: a) Ns4 cannot be expressed by subjects which makes it more difficult to report; b) SO reduced the noxious expression of Ns4 but 21 days may be too short a time to observe its field impact. Also most patients reported their ability to perform everyday activities with less pain and better foot health with SO. A limitation to this study involves the absence of a control group or alternative treatment group in the design, and the inability to follow the patients for 3 to 6 month to study the lingering benefit of SO on Ns4.

SIGNIFICANCE/CLINICAL RELEVANCE: Ns4, heterotopic nociceptive stimuli, affect foot function. This study supports that sensorimotor orthoses improved foot function of the patients with Ns4. SO also improves patients' quality of life.

REFERENCES:
1 Hasenstein et al. J Foot Ankle Surg. 2017. May/Jun;56(3):519-521 PMID: 28476386. DOI: 10.1053/j.jfas.2017.01.023.
2 Budiman-Maket al. J Foot Ankle Res. 2013. Feb 1;6(1):5. PMID: 3579714 DOI: 10.1186/1757-1146-6-5.
3 Bennett et al. J Am Podiatr Med Assoc. 1998. Sep;88(9):419-28. PMID: 9770933 DOI: 10.7547/87507315-88-9-419.
4 Gross et al. J Orthop Sports Phys Ther. 2002. Apr;32(4):149-57. PMID: 11949663 DOI: 10.2519/jospt.2002.32.4.149.
5 Powell et al. J Rheumatol. 2005 May;32(5):943-50. PMID: 15868634
6 Wrobel et al. J Am Podiatr Med Assoc. 2015. Jul;105(4):281-94. PMID: 25941995 DOI: 10.7547/13-122.1.
7 Janin M, Dupui P. 2011. Doi: 10.1016/j.clinbiomech.2011.05.009.
8 Janin A et al. IJCM. 2016. Jan; 7(1):l. Doi: 10.4236/ijcm.2016.71006.
9 Janin M et al. 2015. Doi: 10.17784/mtprehabjournal.2015.13.298.
10 Janin M. 2015. doi : 10.1016/j.neucli.2015.10.027
11 Janin M. 2016. doi.org: 10.1016/j.fas.2016.05.032.
12 Budiman-Mak et al. 2013. PMID: 23369667 DOI: 10.1186/1757-1146-6-5-6.
13 Pourtier et al. Ann Phys Rehabil Med. 2015 Oct;58(5):276-82. PMID: 26343763 DOI: 10.1016/j.rehab.2015.07.003.
14Bowsher. B.M.B. 1991. doi.org/10.1093/oxfordjournals.bmb.a072498
15 Jahrling L. 1999. OST – Sonderheft Propriozeption, S.52-55.

Key-words: Foot orthoses, épine irritative, Heterotopic Noxious Stimuli, Ns4, podiatry.

Posturodynamic-6 Perform Sport relate influences performance and competitiveness in sports.

Breard Th[1,3], Janin Marc[2,3],

1 Podiatry office, Floirac, France.
2 Podiatry office, Poitiers, France.
3 Applied Podiatry College, Poitiers, France.

Email of Presenting Author: tbreard@hotmail.com

INTRODUCTION: One of the fundamental and primary human principles is to control our environment, to achieve this, you must perform certain functions. Among the most important is the balance function: postural control (seating, standing) and the dynamic control named locomotion (walking, running or jumping; 1). Successful locomotion depends on postural control to establish and maintain appropriate postural orientation of body segments relative to one another and to the environment and to ensure dynamic stability of the moving body, principally sport practice (2). This process critically depends on integration of sensory inputs and must operate within the limits of biomechanical constraints inherent to the individual and the task. The integration of the information and the motor responses are very complex. It require network of neuronal connection between the different structures of the central and peripheral nervous system and also involve other body systems (1, 2). The sport context, the position and the materials (like shoes) influence the balance function (3) by different constraints (i.e: inside outside ground (gymnasium or green and sand); fencing, tennis, golf, kayak for participation of the foot sole and legs information's; running, climbing, football or soccer for different contains applied by shoes). In podiatry practice, we use the Posturodynamic-6 clinical test to evaluate the balance function performance (3), through the postural control (automatic control), the stability with the one legs stance test and the lateral bending movement to assess motor control (4). Each sports induce specifics constraints When athlete practice, the context require an efficient and adapted balance function performed by the central and peripheral nervous system with information's of muscles, joints, and the skeleton, and their actions in the context of movement (5). In fact, posture and movement are not different entities, understanding standing as a posture movement and movement as a quick succession between different positions. Then to evaluate athlete, PDN-6 must be adapt.

AIM: The sport context are different in all sports then we named it PDN-6 Perform Sport s to differentiate it with the clinical practice (PDN-6).

RESULTS: The PDN6 PS is a new tool for evaluating the posture of the athlete. The aim of the PDN6 PS is to help evolve the limitations of performance of the sportsman due to his sport (sports posture, material, wedging, etc...). This test aims to help the athlete and his team to better choose equipment, stalls and athletic ergonomics in order to optimize his performance. The amendment between PDN-6 and PDN-6 Ps will give us the postural limitations present during the sport activity. Like the PDN-6 score, the PDN-6Ps score indicate the performance. Lower is the score, the less stress, postural dysfunction and best coordination and integration of body segment there will be. In the athletic setting, the athlete will gain the lowest score possible, which will increase his athletic performance and reduce the risk of injury.

But this score is not enough, because it does not take into account the specific constraints related to the sport itself. It is therefore necessary to correlate it with the PDN6 Ps, which is the same test but carried out in the sporting conditions. Ours proposition PDN-6 Ps could be used to evaluation tools in regard of sport context: posture and movement of practice, mechanics constraints, integration and material. With the same score of the PDN-6 we could find two principals orientations: 1) scores PDN-6 = PDN-6 Ps. indicating that there are no restrictive limitations on the athlete in his or her sports practice ; 2) scores PDN-6 < PDN-6 Ps indicating the presence of a performance limitation factor due to the constraints of sport. In the latter case, it will be interesting to investigate the various elements that could cause this limitation (i.e: Shoes (football, rugby, racing, sport shod); wedging (kayaking, rowing, etc.); ergonomics (spacing and opening of the feet in shooting sports). The PDN6 Ps is therefore a diagnostic tool for the athlete and his team in order to objectify his postural abilities in his sporting situation, and to help him in the choice of equipment, stallion, and position. It could be used for evaluation of the performance and clinical monitoring.

SIGNIFICANCE/CLINICAL RELEVANCE: This paper provides a framework for considering balance function dynamic postural control and dynamic control, highlighting the importance of coordination, consistency, and challenges to evaluate the control processing in different conditions posed by various sports.

REFERENCES:

1. Ruffieuxet al. Sports Med (2015). DOI 10.1007/s40279-015-0369-9
2. Earhart, Gammon. Physical Therapy Faculty Publications. (2013). http://digitalcommons.wustl.edu/pt_facpubs/33
3. Paillard T. Neuroscience & Biobehavioral Reviews (2016). DOI 10.1016/j.neubiorev.2016.11.015
4. Janin et al. IJCM (2016). Vol.7 No.1. DOI: 10.4236/ijcm.2016.71006
5. Shumway-Cook A, Woollacott MH. Motor control... Philadelphia: Lippincott Williams & Wilkins; 2007.

Title: The magnitude and spatial distribution of variability in plantar pressure at a wide range of walking speeds.

Juliet McClymont[1] ., [1]University of Brighton, U.K,

Introduction: During walking, variability in step parameters allows the body to adapt to changes in substrate or unexpected perturbations that may occur as the feet interface with the environment. Despite a rich literature describing biomechanical variability in step-parameters, there are no studies that explore the habitual spatial distribution or magnitude of variability in plantar pressure in healthy humans.

Method: This experiment used pSPM and two standard measures of variability, the MSE and CV, to assess the magnitude and spatial distribution variability in plantar pressure across a range of controlled walking speeds.

Results: Reduced major axis, and pSPM regression, revealed no consistent linear relationship between MSE and speed or MSE and Froude number. A positive linear relationship however was found between CV and walking speed and CV and Froude number. The spatial distribution of variability was very different when assessed by MSE (Figure 1) and CV (Figure 2): relatively high variability was consistently confined to the medial and lateral forefoot when measured by MSE (Figure 1), but in the forefoot and heel when measured by CV. In absolute terms, variability by CV was universally low (<2.5%).

Discussion: From these results, it was determined that pressure variability assessed by MSE to be independent of changes in walking speeds, and that CV is not an accurate measure of peak pressure for this analysis of spatial variability.

Clinical Relevance: Clinical decisions about normal or otherwise behavior of plantar pressure, requires an understanding of how and why pressure distributions vary with speed, step-to-step. The unique combinations of units of the foot expereicing the highest variability that are confined to the lateral and medial borders of the forefoot, provide insights into the effect of speed on the variability in plantar pressure.

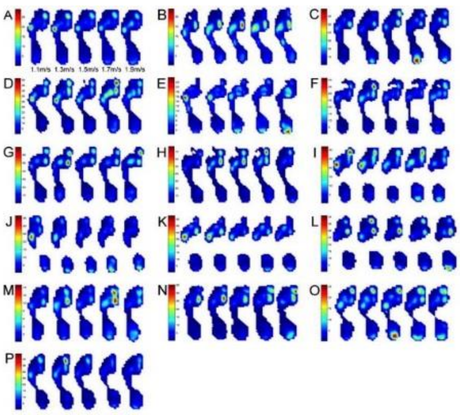


Figure 1: MSE variation maps report the distribution and magnitude of the combined MSE in each pixel from the individual walking speed trial mean p-images in all subjects. Intra- subject spatial variability is highest, and confined almost exclusively to under MTH5 and MTH1, and no consistent increasing or decreasing relationship with walking speed.

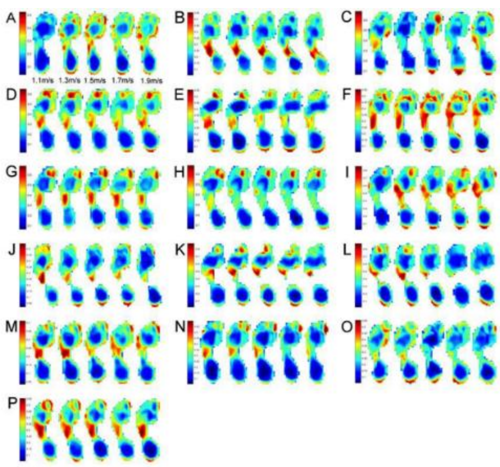


Figure 2: CV variation maps report the distribution and magnitude of the combined CV from each pixel from the individual walking speed trial mean p-images in all subjects. Intra- subject spatial variability is highest and localised under the hallux, medial phalanges, and midfoot. No consistent increasing or decreasing relationship is evident with walking speed.

Reliability of New Forefoot-Rearfoot Measurement

Joyann Oakman, BS[1], Olivia Hammond, BS[1], Judy Tan, BS[1], Clay Shumway, DPM[1], Jinsup Song, DPM[1]
[1]Temple University School of Podiatric Medicine, Philadelphia, PA
Email of Presenting Author: joyann.oakman@temple.edu

INTRODUCTION: Many foot pathologies, such as heel pain and bunions, are theorized to be associated with aberrant foot biomechanics.[1] Forefoot-rearfoot (FFRF) angle is a biomechanical measurement often used to characterize gross foot architecture.[2-4] The FFRF remains a technically challenging measure with a weak inter-rater reliability.[5] The main challenges of this technique include keeping the hind foot and forefoot alignment in position while placing the goniometer appropriately and visualizing the angle. The PI has developed a new weight-bearing FFRF jig, which utilizes a simple platform with a separate forefoot plate that can rotate about the long axis of the foot in stance. A digital goniometer attached to the forefoot plate displays the resulting forefoot angle as the rater places the subtalar joint in neutral position. This device is solely intended to characterize gross foot architecture, and the objective of this pilot study is to test intra- and inter-rater reliability of the new weight-bearing FFRF measurement on 20 healthy subjects by 2 independent raters.

METHODS: Temple University's Institutional Review Board approved the protocol, and all participants gave full verbal consent. Twenty healthy subjects (10 F, 10 M) reported to the Gait Study Center for participation in the study. RCSP (the position of the heel during relaxed stance), arch height index (AHI), malleolar values index (MVI), and barefoot walking plantar pressure were measured to characterize subject population. The two raters made two independent measures of the FFRF angle, both in the traditional open chain setting with the subject prone, and in closed chain using the new weight-bearing jig. The order of raters was randomly selected for each subject, and each rater was blinded to the obtained measurements of the other rater. Intraclass correlation coefficient (ICC) was calculated using an absolute agreement definition for intra-rater, inter-rater, and inter-method reliability.[6]

RESULTS: High intra-rater reliability exists for both the open chain method (Rater 1 ICC=0.904; Rater 2 ICC=0.829) and the new weight-bearing method (Rater 1 ICC=0.890; Rater 2 ICC= 0.905). High inter-rater reliability exists for both the open chain method (ICC=0.751) and the new weight-bearing method (0.788). Inter-method reliability was not as high (ICC= 0.444).

DISCUSSION: The biomechanical measurement of FFRF angle is critical in diagnosing and treating foot pathologies. For example, subjects with flatfoot often demonstrate everted heel and forefoot compensation in standing posture. The FFRF angle traditional measurement is still technically challenging to do, and there is a clinical need for an easier technique that is reproducible. Our study concluded that both the open chain traditional clinical measurement and our new closed chain weight-bearing measurement of FFRF angle are very reliable between multiple measurements by one rater (intra-rater), and between measurements taken by two different raters (inter-rater). In a study looking at intra-rater and inter-rater reliability for various foot and ankle measurements, it was found that extensive examiner training in these measures can improve reliability between testers.[5] Both raters in our study had thorough practice with each method beforehand to limit inconsistency. Our results also determined that there was not as much reliability between measurements obtained between the two methods. This difference may be attributed to more ease in simultaneously recording FFRF angle while keeping the subtalar joint in neutral in stance. More research is needed to determine if the new method is accepted and reproducible among clinicians and also applicable to foot function, considering that true biomechanical function occurs in closed chain.

SIGNIFICANCE/CLINICAL RELEVANCE: The measurement of FFRF angle is critical in diagnosing and treating foot pathologies, and the current standard for measuring it is technically difficult for the examiner, leaving room for human error. The PI's newly developed closed chain method of measuring FFRF angle on a weight-bearing jig has very reliable intra- and inter-rater results, indicating it may be useful and preferred due to the simplicity of the device and technique.

REFERENCES:

1. Golightly YM, et al. Foot Ankle Int. 2014; **35**(11): 1159-65.
2. Mootanah R, et al. Gait Posture. 2013; **37**(3): 452-6.
3. Song J, et al. J Am Podiatr Med Assoc. 1996; **86**(1): 16-23.
4. Hillstrom HJ, et al. Gait Posture. 2013; **37**(3): 445-51.
5. Diamond JE, et al. Phys Ther. 1989; **69**(10): 797-802.
6. Shrout PE & Fleiss JL. Psychol Bull. 1979; **86**(2): 420-8.

Comparison or Torsional Stiffness of Orthotics Made from Two Different Materials— A Pilot Study

Robert D. Phillips, DPM, Scott Anderson, BS, CP, Orlando VA Medical Center, Orlando, FL
Email of Presenting Author: Robert.Phillips9@va.gov

Disclosures: none.

INTRODUCTION: Foot orthotics have been utlized for treating painful feet for over 100 years. The original Whitman plates were made of stainless steel. Other materials that have been utilized over the years include cork, various plastics, and foams.

Steindler (1929) advocated treating flat feet with a varus wedge under the heel of the shoe and a valgus wedge under the forefoot. Root (1971) took this concept inside the shoe by casting the foot with subtalar joint neutral and maximally pronating the forefoot, then using a rigid material to resist the forefoot from inverting against the rearfoot.

A great many of the orthotic efficacy studies have utilized “rigid” or “semi-rigid” to describe the stiffness of the orthotic materials, yet no researcher or orthotic manufacturer has defined what the terms “rigid” or “semi-rigid” mean. The PI has found in clinical practice that changing orthotic stiffness properties can greatly affect the success of the orthotic. The goal of this research proposal, is to investigate torsional stiffness of orthotics made from two common materials, one considered to be a rigid material (acrylic) and one considered a semi-rigid material (polypropylene).

METHODS: Approval for this project given by Orlando VAMC Research Committee. Custom-made orthotics were tested for their torsional stiffness before being dispensed to patients. 12 acrylic and 11 polypropylene orthotics for the right foot were tested, with no knowledge of the identity or pathology of the patient. All orthotics had a noncompressible heel post. The following measurements were taken: “a” the maximum medial arch height, “b” the maximum lateral arch height, “c” the width of the orthotic in the center, “d” the thickness of the orthotic, and “e” the length of the orthotic from the anterior heel post to front clamp.

Testing was performed by two independent testers, 14 independent measures were taken at each torque and averaged. The orthotic was clamped to a solid table with the heel post set flat on the surface of the table, the anterior edge hanging off the edge of the table. A clamp was attached to the front edge of the orthotic, with a 7/16” bolt aligned with the midline of the orthotic. A digital angle finder was taped to the top of the clamp and set to 0º with the orthotic at rest. A clique torque wrench was used to invert the fore part of the orthotic against the rearfoot until the torque wrench cliqued and the distortion angle read (Fig 1) Torques from 5 in-lbs to 75 in-lbs were tested. The tests were then repeated in the eversion direction.

RESULTS: All orthotics had very close to linear torque/displacement slopes. Polar moment of inertia for each orthotic [J] was calculated by $J = cd(c^2+d^2)/12$. The slope of the torque/deflection curve per unit length is plotted against J in Fig 2. It is noted that the acrylic orthotic is much stiffer than the polypropylene orthotics in both direction, however the difference between the two materials greater in the eversion direction than in the inversion direction.

The Torsional Modulus [G] is calculated by $G = (\text{torque/deflection}) \cdot \text{length} / J$. Table 1 shows the comparison for G of the two materials. The G for polypropylene is only slightly less in the inversion direction than the eversion direction. On the other hand, while G for acrylic is greater than polypropylene, it is much stronger in the eversion direction than in the inversion direction.

Because orthotics are complex curves, an analysis of how the arch heights affected the torsional modulus is presented. The asymmetry is the medial arch height minus the lateral arch height. Figure 3 shows G plotted against the asymmetry. For acrylic, as asymmetry increases there is no change in stiffness in the inversion direction and an increase in the eversion direction. On the other hand, for polypropylene, as the asymmetry increases, the stiffness of the orthotic decreases.

SIGNIFICANCE/CLINICAL RELEVANCE: Because all metatarsal heads maintain contact with the ground in stance, orthotics try to resist pronation and supination of the rearfoot by resisting forefoot inversion and eversion of the forefoot. This is the first study that tries to measure how well different materials provide this resistance. It also shows that different foot types may need different materials to provide optimal clinical results. Much more research needs to be done on the torsional properties of materials and how to take advantage of those differences for different foot types.

REFERENCES: Whitman. Boston Med Surg J (1888) 118: 616-620 PMID: 4910899
Steindler. JBJS (1929)11: 272-276
Root, et al. “ Neutral position casting techniques.” Clinical Biomechanics Corporation, 1971.
Smith, et al. “JAPMA (1986) 76: 227-233 PMID: 3701627

Figure 3

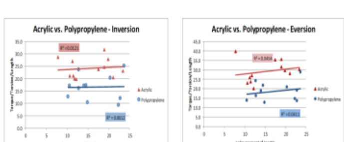


Figure 3

Material	Avg J (cm^4)	G - Inversion (Pascals/deg-)	G - Eversion (Pascals/deg-)
Polypropylene	16.23	16.58	18.66
Acrylic	15.40	24.16	29.23

Table 1

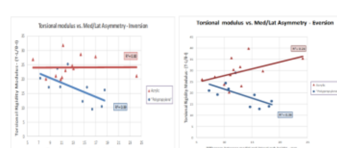


Figure 3

Session 12b-Poster No. 13

The Effect of Age and Disease on Regional Plantar Loading: A Systematic Review and Meta Regression Analysis

Scott Telfer, Joseph Bigham
University of Washington, Seattle, WA
telfers@uw.edu

Disclosures: None

INTRODUCTION: The measurement of plantar pressure distributions during gait can provide a number of insights into foot function in health and disease [1, 2]. A range of tools and protocols are available for the collection of this data, with some conflicting results reported between individual studies. In this systematic review of the literature, we used a meta-regression approach to investigate the effects of age, BMI, disease, and the equipment used on the results reported by studies measuring regional plantar loading.

METHODS: Titles and abstracts containing the search term "plantar pressure" or "pedobarography" along with related Medical Subject Headings were identified from the Pubmed database. Original research studies reporting regional peak pressures during barefoot walking were eligible for inclusion. When a repeated measures analysis was carried out for an intervention, we used the control condition, which was the subject's baseline walk. Abstracts were reviewed by two authors for suitability and data extracted from full texts as required. A mixed-effects modeling approach was used to analyze the data, with moderators including cohort type, age and BMI were included. The effect of different measurement systems was also assessed. Chi-square tests of the moderators were performed to determine significant effects.

RESULTS: From an original 1513 abstracts, 399 subject cohorts were found to meet the inclusion criteria. The measurement system was found to have a significant effect on the results, therefore these were assessed independently. Sufficient complete datasets (88 cohorts) were available to test groups made up of healthy individuals, those with diabetes, and those with diabetes and neuropathy (total n = 2954). Age was found to be significantly associated with increased peak pressures under the 1st metatarsal head (2kPa increase per year, $p < 0.001$, 95% CI [1.00, 3.01]), and BMI was found to be significantly related to peak pressures under the 1st metatarsal head (5.8kPa increase per unit rise in BMI, $p = 0.029$, 95% CI [0.6, 11.1], see Figure 1) and 4th metatarsal head (3.5kPa increase, $p = 0.0002$, 95% CI [1.6, 5.3]). Increased BMI was also associated with elevated peak pressures at the midfoot (4.9kPa rise in peak pressure per unit increase in BMI, $p < 0.001$, 95% CI [2.06, 7.59]). The presence of diabetic neuropathy was associated with elevated pressures under the 1st (119.4kPa, $p = 0.009$, 95% CI [48.7, 190.2]), 4th (29.0, $p = 0.0086$, 95% CI [7.4, 50.7]), and 5th metatarsal heads (58.7kPa, $p = 0.028$, 95% CI [6.1, 111.4]) compared to non-neuropathic subjects. The model was estimated to account for up to 70% of the heterogeneity in the data (1st metatarsal head).

DISCUSSION: We found significant changes in plantar loading associated with age, BMI and diabetic neuropathy. These effects were not universally apparent across all regions of the foot, with, in particular, the relationships between neuropathy and peak pressures limited to forefoot regions. While alternative methods of processing dynamic pressure data have been proposed [2], region loading variables, and primarily peak pressures remain the most commonly reported; therefore, our analysis was based around this measurement. In addition, we note that some ambiguity exists in the terms used to describe variables, with terms like peak pressure, mean peak pressure found to be used inconsistently, leading to some confusion in the reported results.

SIGNIFICANCE/CLINICAL RELEVANCE: We found evidence at the level of the literature that age, BMI, and diabetic neuropathy all significantly influenced regional plantar loading. It should be noted that regional peak pressure results from different collection equipment is not directly comparable.

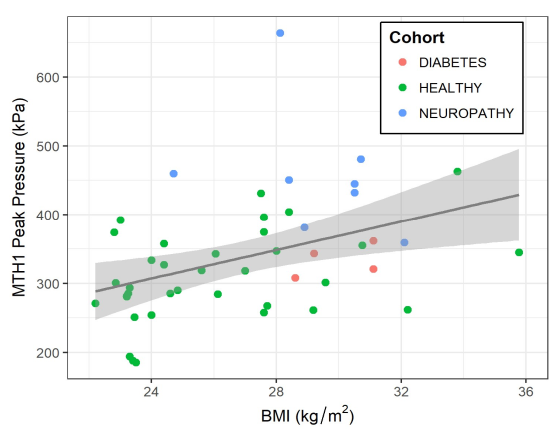


Figure 1- Reported peak pressures below 1st metatarsal for healthy individuals and those with diabetes, with and without neuropathy

REFERENCES:

1. Deschamps K, et al. J Sports Med Phys Fitness. 2015;55:191-204. PMID: 25735228
2. Bus SA. Plast Reconstr Surg. 2016;138:179S-87S. PMID: 27556758.
3. Phethean J, et al. Gait Posture 2014;39:154-60. PMID: 23870488

Finding the Kinematic Driver

Robert R. Turner
Hospital for Special Surgery, NY, NY
Turnerr@hss.edu

Disclosures: None

INTRODUCTION: When treating foot and ankle dysfunctions, it is important to look not only from the perspective of the foot, but also from the kinematics derived from dysfunctions above that may be influencing the foot to compensate sub-optimally. This presentation will discuss the influence a marked scoliosis may have on foot/ankle kinematics as the body weight shifts due to spinal deformity as well as how hip dysplasia may influence what we find below. This presentation will present alternative evaluation techniques to illustrate the importance of finding the major driver of dysfunction which can influence outcomes both pre and post operatively.

METHODS: Case presentations and videos will be used in this discussion to appropriately visualize dysfunctional movement patterns during functional movement tasks and how appropriately directed therapeutic interventions can be used to correct motor patterning and reduce or eliminate sub-optimal patterning. There will be time at the end of the session for discussion with the participants on what they see during the presentation and how they might utilize their expertise in similar cases.

DISCUSSION: It is not uncommon that as we specialize in a body region, that we develop monocular vision and look only at the area of interest. In this case, focusing only on the foot/ankle and not examining how the rest of the body moves over the foot/ankle can lead to poor surgical and rehabilitative outcomes. Successful treatment of the foot/ankle complex is dependent on a broader approach to how the structure and function of the foot/ankle can be appreciated with a more comprehensive physical examination. Conservative efforts to treat these dysfunctions prior to interventional or surgical procedures is critical to optimize procedural success.

SIGNIFICANCE/CLINICAL RELEVANCE: Prior to making orthotics, injecting tissues or performing surgery, it is imperative to put the foot/ankle complex into the context of the rest of the body and use provocative maneuvers to pinpoint areas of dysfunction that may not be within the foot complex itself. This information is useful especially if the practitioner is challenged with a non-progressing or difficult case.

REFERENCES:

1. Sueki et al. A RI model of musculoskeletal dysfunction. J Man Manip Ther 2013 May; 21(2): 90–102.
2. Welsh et al. Rehabilitation of a Female Dancer With Patellofemoral Pain Syndrome: Applying Concepts of Regional Interdependence in Practice. N Am J Sports Phys Ther 2010 Jun; 5(2): 85–97.
3. Wainner et. al. Regional Interdependence: a Musculoskeletal Examination Model Whose Time has Come. J Orthop Sports Phys Ther. 2007 Nov;37(11):658-60.

Biomechanics of a Lateral Ankle Sprain – and the Effect of a Minimized Lateral Shoe-Surface Friction

Filip Gertz Lysdal[1, 2], Thor Buch Grønlykke[2], Uwe Gustav Kersting[1]
[1]Center for Sensory-Motor Interaction, Department of Health Science and Technology, Aalborg University, Denmark
[2]Spraino ApS, Copenhagen, Denmark
Email of Presenting Author: fgly@hst.aau.dk

Disclosures: Filip Gertz Lysdal (Spraino ApS), Thor Buch Grønlykke (Spraino ApS).

INTRODUCTION: Ankle sprains are the most frequent musculoskeletal injury. They account for up to 30% of all sports injuries and make up 1/6 of all time-loss absence due to injury. Up to 90% of all ankle sprains are ligamentous sprains to the lateral ligament complex making it the most frequently injured musculoskeletal structure in the body. Indoor sports are responsible for the highest prevalence of lateral ankle sprains. Spraino® is an adhesive polytetrafluoroethylene (PTFE) patch designed to prevent both primary and secondary acute non-contact ankle sprains in indoor sports (Figure 1). Spraino® attaches to the outside of the shoe thus not affecting ankle joint RoM. The intent is to minimize lateral shoe-surface friction whenever initial contact is made with the foot placed in a supinated position. This allows the foot to slide instead of "catching" the floor. Previous studies have shown no reduction in performance or safety when using Spraino® during typical indoor sports. Thus, the objective of present study was to test the effect in an injury situation.

METHODS: One male athlete (26 years, 1.74 m, 75.5 kg) participated in this preliminary pilot trial. The subject performed 66 lateral cutting movements onto a force platform (AMTI OPT464508HF-1000). In all cases the subject aimed to land with an initial plantar flexion and ankle inversion to force initial contact with the lateral edge of the shoe. Ground reaction forces were collected at a 1000 Hz sample rate and kinematic data were collected at 500 Hz using eight infrared Qualisys Oqus 300+ series cameras (Qualisys AB). Kinematic data were low-pass filtered using a 4th-order Butterworth filter with a cut-off frequency of 14 Hz. Inverse dynamics simulations were conducted using Visual 3D v6 (C-Motion Inc.). Ankle joint kinetics were analyzed between initial contact and impact peak.

RESULTS: The first 65 trials were all performed with Spraino® attached to the outside of the shoes and no lateral ankle sprains were sustained. The subject then removed Spraino from the shoes prior to the subsequent 66th trial. This resulted in an accidental grade 1 lateral ankle sprain. This led to immediate pain and swelling and the injury promoting control trial could not be repeated, thus ending the test session.

DISCUSSION: A complete change in ankle joint kinematics in the frontal plane were evident when comparing the control (injury) trial to a trial with Spraino® with identical pre-contact kinematics (Figure 2). The foot was further supinated after initial contact in the control trial, whereas the foot was realigned into proper position when using Spraino®. In addition, ankle joint kinetics revealed a complete lack of inversion moment at initial contact when using Spraino®. The non-existing horizontal components of the ground reaction force at initial contact and the absent inversion moment highlights the minimized friction. The minimized friction initiates a sliding mechanism in which the normal force acts to realign the foot through an eversion moment. This mechanism appears to be able to prevent acute non-contact lateral ankle sprains.

SIGNIFICANCE/CLINICAL RELEVANCE: The outcomes from this laboratory case-study were of huge clinical relevance prior to the ethical approval and registration of a randomized controlled trial (ClinicalTrials.gov ID: NCT03311490) in which 500 previously injured sub-elite athletes are randomized to use Spraino® for 52 weeks to prevent ankle sprains.

FIGURES AND TABLES:

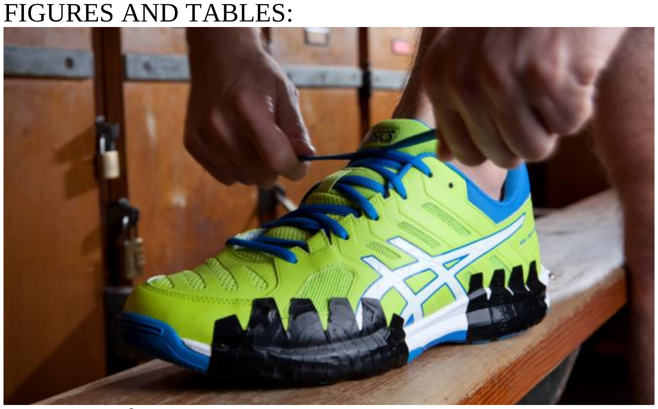


Fig. 1 Spraino®

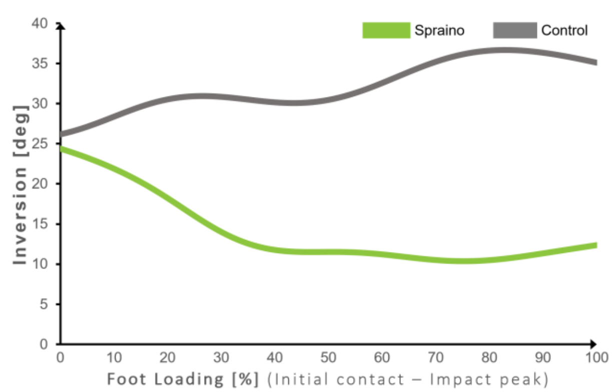


Fig. 2 Ankle joint inversion angle in degrees.

Customized foot orthoses in the treatment of posterior tibialis tendon dysfunction

Dominic Chicoine D.P.M.[1], M.Sc (c)[2]
[1]Degree in Podiatric Medecine at the Université du Québec à Trois-Rivières, Trois-Rivières, Qc, Canada
[2]Master student in kinesiology at the Université Laval, Québec, Qc, Canada
dominic.chicoine.1@ulaval.ca

Introduction:
Posterior tibialis tendon dysfunction (PTTD) is characterized by a loss of function of the posterior tibialis muscle secondary to a tendon deterioration (tendonitis). This pathology shows up by a medial pain to the ankle present at each step. Progression of the pathology is frequently associated by a loss of the medial longitudinal arch, abduction of the forefoot and a valgus rear foot. The aim of this project is to do a narrative review of the literature about foot orthosis treatment for the PTTD.

Methods:
The research of scientific paper has been done by the database CINAHL and Pubmed. The inclusions criteria are to have customized foot orthotics for the experimental condition, the participant had to suffer of a PTTD of grade 1, 2 or 3 according to the classification of « Jonhson and Strom » and the variable had to be the pain. The following terms had been used for the research: adult acquired flatfoot, posterior tibial tendon dysfunction, orthoses, orthosis, insole and conservative treatment.

Results:
Following the reading of the title and the abstract, 18 articles had been kept. After take into account the inclusions and exclusions criteria, four had been kept. When the foot orthoses are used to treat the PTTD, the pain can drop by 62% to 100%. Each study had a higher decrease of pain when the subject wears foot orthoses compare to the subject who hadn’t wearing it.

Discussion:
The conservative treatment for the PTTD are not really count in the scientific literature. This is not surprising to find that they are even less present about the foot orthoses. On the other hand, it is demonstrated in the scientific literature that the customized foot othoses is effective to diminish pain in PTTP of grade 1 and 2. The orthotic treatment is more effective when he’s combined with eccentric and concentric exercises. In fact, the orthotic treatment has never been isolated from other treatment because he’s always combined with strengthening or stretching exercises. Also, study with control group has never be undertaken to be compare with orthotic treatment. But, many authors said that the condition will never improve without treatment. In conclusion, a few studies have demonstrated the customized foot orthoses to be effective in the treatment of PTTD, the big methodological heterogeneity decreases the extern validity of the results. So, it will be important to do a good quality study like a randomized control trial to optimized the orthotic treatment because the PTTD can be very debilitating.

Clinical relevance:
This project will guide clinician in conservative treatment for the light to moderate PTTD by using foot orthoses combine with strengthening exercise instead of other conservative treatment like ankle foot orthoses.

Bibliography

Kulig, K., et al. (2009). Physical therapy 89(1) 26.
Kulig, K., et al. (2009). Foot & ankle international 30(9): 877-885
Alvarez, R. G., et al. (2006). Foot & ankle international 27(1):
Bek, N., et al. (2012. Acta orthopaedica et traumatologica turcica 46(4): 286- 292.
Chao, W., et al. (1996). Foot and Ankle International 17(12): 736-741.

Session 12b-Poster No. 17

Plantar pressures in patients with symptomatic flexible flatfoot: How are they different than adolescents with asymptomatic flatfoot?

Kirsten Tulchin-Francis, Ashley Erdman, Jacob Zide, Anthony Riccio
Texas Scottish Rite Hospital for Children, Dallas, TX
Kirsten.Tulchin-Francis@tsrh.org

Disclosures: Kirsten Tulchin-Francis (N), Ashley Erdman (N), Jacob Zide (N), Anthony Riccio (N)

INTRODUCTION: Flexible flatfoot deformity describes a condition characterized by a collapse of the medial longitudinal arch during weight-bearing which is constituted by unloading of the foot. Several studies have examined the differences in plantar pressures between symptomatic pediatric flexible flatfoot deformity (FF) and healthy age-matched controls [1-3]. The purpose of this study was to assess differences in plantar pressures and patient-reported outcomes in adolescents with symptomatic flexible flatfoot deformities and children with asymptomatic flatfoot.

METHODS: Thirty-two adolescents (57 feet) with painful FF underwent plantar pressure analysis through participation in this Institutional Review Board approved study following informed consent/assent. The foot was subdivided into medial/lateral hindfoot, midfoot, and forefoot regions. Contact area (% of total foot contact, CA%), contact time (% of roll-over process, CT%) and peak pressure (PP) were assessed for each region. Hindfoot to forefoot angle (HFA) was used to quantify forefoot abduction, and displacement of the center of pressure (COP) line relative to the bisection of the plantar angle was assessed. In those with painful FF, patient-reported outcomes were evaluated with the Pain Numeric Scale Rating (PNS), Oxford Ankle Foot questionnaire and Foot and Ankle Outcome Score (FAOS). One hundred and twenty-five age-matched painless feet were used for comparison. Within the control cohort, feet with increased medial midfoot CA% greater than 1 standard deviation from the group mean were identified as the asymptomatic flatfoot [AS] group (13 feet).

RESULTS: Comparing all symptomatic FF patients to the AS flatfeet, there were significant increases in CA% in the lateral hindfoot (p=0.009), medial midfoot (p=0.046) and 1st metatarsal (p=0.042) regions with decreased lateral midfoot area (p=0.001). In the medial midfoot, CT% was significantly increased in FF patients (p=0.040) with increased PP approaching significance (p=0.057). The COP was significantly more medial in FF patients than in AS flatfeet (p=0.023).
Nine symptomatic patients went on to ultimate surgery and 48 were successfully managed nonoperatively. The surgery group had significantly increased PP in the medial hindfoot (p=0.035) and a tendency to have increased CT% and PP in the medial midfoot. The surgery group also reported significantly greater pain on the FAOS pain subscale (p=0.013), increased pain on the PNS (p<0.001) and scored lower on the Oxford School and Play domain (p=0.015).

DISCUSSION: There is a greater medial shift in the pressure variables within symptomatic flatfoot patients when compared to the asymptomatic flatfoot. CA%, CT% and PP were increased in the medial midfoot and CA% was increased in the 1st metatarsal region. COP was shifted even more medially in the flatfoot patients as well. Although small, the surgical cohort displayed a greater medial shift than the nonoperative patients and had significantly greater self-reported pain.

SIGNIFICANCE/CLINICAL RELEVANCE: Differences in plantar pressures are seen in patients with symptomatic flexible flatfeet when compared to those with asymptomatic flatfoot deformities.

REFERENCES: 1. Bok SK, et al. PLOS One. 2016 July; 11(7):e0159831. PMID:27458719. 2. Pauk J, et al. Acta Bioeng Biomech. 2010; 12(1):29-34. PMID: 20653322. 3. Westberry DE, et al. Bone Joint J. 2013 May; 95-B(5):706-13.

ACKNOWLEDGEMENTS: The authors wish to acknowledge support from the TSRHC Research Program Fund.

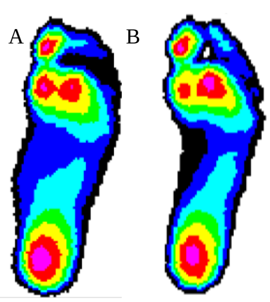


Figure 1: Comparison of average maximal pressure maps for A) Flatfoot patients (N=57 feet) and B) Flatfoot Controls (N=13feet)

TABLE 1. Plantar Pressures Comparing Symptomatic Flatfoot (n=57) and Asymptomatic Flatfoot Controls (n=13)

		Hindfoot		Midfoot		Forefoot		
		Medial	Lateral	Medial	Lateral	1st Met.	2nd Met.	3-5th Mets.
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Peak Pressure (N/cm^2)	FF	433.7 ± 166.8	344.1 ± 102.1	153.3 ± 77.3	145.4 ± 69.5	394.9 ± 248.6	436.1 ± 275.5	278.0 ± 162.2
	AS	399.6 ± 194.6	399.6 ± 194.6	335.4 ± 135.4	127.7 ± 48.3	355.4 ± 225.6	441.5 ± 189.1	295.0 ± 89.4
	P	0.567	0.830	0.057	0.288	0.583	0.933	0.607
Contact Area (% CA)	FF	11.6 ± 1.69	11.7 ± 1.44	13.5 ± 6.21	14.5 ± 2.83	13.3 ± 2.3	9.3 ± 1.1	14.7 ± 2.6
	AS	11.0 ± 0.82	10.9 ± 0.84	11.1 ± 3.04	16.6 ± 1.62	12.4 ± 1.1	8.8 ± 1.2	15.4 ± 1.8
	P	0.119	**0.009***	**0.046***	**0.001***	**0.042***	0.201	0.220
Contact Time (% ROP)	FF	66.0 ± 33.3	84.5 ± 138.9	63.5 ± 19.39	69.4 ± 20.5	77.5 ± 8.7	79.3 ± 8.7	78.9 ± 9.9
	AS	58.2 ± 8.5	57.6 ± 9.49	54.8 ± 11.31	66.4 ± 6.9	77.4 ± 7.0	78.3 ± 6.8	79.4 ± 6.4
	P	0.123	0.152	**0.04***	0.385	0.940	0.651	0.814

Significant differences (P < 0.05 *Flatfoot patients (FF) different from Asymptomic flatfoot controls (AS)

Testing muscle activation and in-shoe foot loading under repeatable conditions: a stepper-based approach

Claudia Giacomozzi[1]
[1]Italian National Institute of Health, Rome, Italy
Email of Presenting Author: claudia.giacomozzi@iss.it

Disclosures: Claudia Giacomozzi (N)

INTRODUCTION: The in-vivo assessment of footwear, a key-point in several scenarios, is often performed through in-shoe pressure measurements during ground walking. However, even under controlled conditions, natural gait variability may mask relevant differences among tested items. Gait may be better controlled on treadmills, though progression against a counter-moving belt may sometimes differ too much from a real scenario ([1-2]). Based on previous experience on cyclic testing [4], this study aims at using a passive stepper to improve repeatability of foot function measurements during a load-bearing indoor motor task, slightly more demanding than natural gait but reasonably considered as part of daily motor activities.

METHODS: A commercial stepper was fixed to the floor lab to validate the testing protocol on a healthy volunteer (F, 49 years, 54kg, 1.58m), after approval of the Institutional ethic committee and signed consent. The protocol consisted of: 5 minutes for warm-up and familiarization; 7 randomly tested sport shoes with different sole flexibility and profile (4 flexible soles, 3 semi-rigid rocker soles); 10s of balance; 60 full steps (to the stroke end of the stepper), at a controlled low cadence (40-50spm); 5 minutes for recovery. In-shoe pressure was measured by the Pedar-X system (Novel$_{Gmbh}$, Germany; 50Hz; wide insoles). Tibialis Anterior and Medial Gastrocnemius (GA) activation of the dominant leg was acquired through a sEMG wireless system (OT Bioelectronics, Italy; 2048Hz), synchronized with Pedar. For the instrumented side (30 step cycles), averaging was applied to the EMG normalized envelopes (5Hz II order Butterworth) and to Pedar parameters of whole foot, hindfoot, midfoot, forefoot and toes ([4], cubic-spline interpolation, force normalization to body weight). ANOVA ($p<0.05$) with post-hoc Bonferroni-Holm correction ($p<0.002$) was applied to all extracted parameters.

RESULTS: High consistency was found between (trials duration: 81.8±0.9s) and within (stance phase: 1.64±0.04s) trials (Figure 1). Despite the residual intrinsic variability, interesting differences emerged: the double rocker flexible shoe significantly changed ($p<0.002$) all foot parameters in all regions, with a much greater midfoot involvement (i.e. force integral: 150.5±16.7Ns) with respect to flexible (74.7±9.9Ns) and to semi-rigid soles (33.8±1.5Ns); GA (relative units, r.u.) modified as well, significantly reducing ($p<0.002$) both peak value (0.34±0.18r.u.; 0.59±0.07r.u.; 0.59±0.04r.u.) and integral (0.18±0.06r.u.*s; 0.23±0.04r.u.*s; 0.23±0.01r.u.*s); semi-rigid rocker soles, when compared with flexible soles, entailed a higher force integral at hindfoot (215.1±10.9Ns; 188.9±4.9Ns) and a lower value at forefoot (187.6±10.8Ns; 202.7±5.5Ns).

DISCUSSION: The use of a passive stepper under controlled conditions seems feasible and effective to improve repeatability during an indoor motor task with full load bearing (max force 98.5±3.4% b.w.). 30 consistent steps per trial seemed adequate to characterize the tested shoes and detect changes at all foot regions without raising any fatigue effect.

SIGNIFICANCE/CLINICAL RELEVANCE: The proposed approach may contribute understanding the impact of shoes and orthoses on muscle activation and foot function. The protocol, reasonably helpful in a clinical scenario, is currently only intended for healthy adults. However, a dedicated re-engineering process may render it safe and suitable for clinical settings.

REFERENCES:

1. Yang F, King GA, J Electromyography and Kinesiology. 2016; 31: 81ï 87.
2. van der Krogt MM et al, J Biomech 2015; 48:3577ï 3583.
3. Vieira T et al, PLoS ONE 12(11): e0187202. https://doi.org/10.1371/journal.pone.0187202
4. Giacomozzi C, Uccioli L, JBSE 2013; 6:45-57

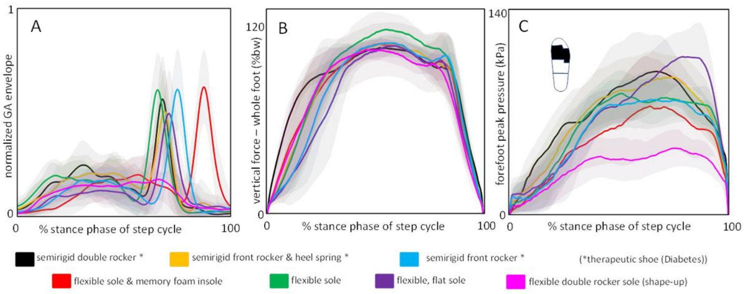


Figure 1. Averaged processes (mean±sd) of A) normalized sEMG envelope from medial gastrocnemius, B) total foot vertical force and C) forefoot peak pressure acquired during 30 step cycles for each of the 7 tested pair of shoes.

Velocity, footwear, and foot-strike angle effects on lower-leg muscle activity during running

Richard C. Franzese[1], Julie Stebbins[2], Amy B. Zavatsky[1]
[1]Dept of Engineering Science, University of Oxford, UK, [2]Oxford Gait Laboratory, Nuffield Orthopaedic Centre, UK
Email of Presenting Author: richard.franzese@gmail.com

INTRODUCTION: Increased plantarflexion during barefoot (BF) running may be caused by higher pre-activation of the *triceps surae* muscles [1] and lower pre-activation of the *tibialis anterior* [2]. This is characteristic of an 'impact reduction' style [3], which lowers or even completely removes the vertical ground reaction force impact peak and reduces the loading rate [4]. Discerning population effects on EMG signals is difficult and signals are typically normalized in some fashion before statistical analysis. Here we use a generalized linear mixed-effects model (GLMM) to avoid such manipulations and retain the original scale of the data, whilst also accounting for between-subject variability and heteroskedasticity. We account for stride-to-stride foot strike angle (FSA) and study the effects of velocity and condition on the root-mean-squared (RMS) EMG signal for *tibialis anterior*, *gastrocnemius medialis*, and *gastrocnemius lateralis.* The applied statistical technique provides less biased results and allows for the measurement and interpretation of between-subject variability. We hypothesize that in general there is more muscle activity during BF running than in SD running, increased muscle activation with increased velocity, and potentially different behaviours of the two heads of the gastrocnemius muscle.

METHODS: Informed consent was obtained from the University of Oxford Research Ethics Committee. Nineteen habitually shod (SD) male distance runners (1500 m personal record: mean (st. dev.) = 3:59.8 (10.0); age: median = 21, min = 19, max = 31) were recruited from a University cross country club. Participants ran BF and then SD on a treadmill (Ultim8 Fitness Ltd, UK) for at least 3 minutes per trial at 12.9 km h^{-1}, 14.3 km h^{-1}, and 16.0 km h^{-1} in a randomized order for BF and SD conditions. All subjects used their personal running shoes. Twelve MX cameras (Vicon, Oxford, UK) captured heel and toe marker data at 200 Hz and muscle activity was measured at 1000 Hz using a wireless surface EMG system with Ag/AgCl electrodes (Cometa Wave Wireless EMG, Milan, Italy). Between 15 and 27 consecutive gait cycles were analyzed for each trial. Foot-strike angle was defined relative the treadmill, and a shoe-specific incline was calculated to ensure FSA in the SD condition still reflected the orientation of the foot relative the treadmill. The time of foot strike was ascertained using kinematic methods [5].

A series of GLMMs were developed to test the effects of velocity, shoes, and FSA on *tibialis anterior*, *gastrocnemius medialis*, and *gastrocnemius lateralis* RMS EMG voltage during five time periods: pre-activation, impact phase, braking phase, stance phase, and the entire stride cycle. A Bonferroni correction was applied for statistical tests to account for multiple testing. Slow BF running was set as the reference condition and the fixed effects were saturated to avoid bias associated with stepwise regression.

RESULTS: The EMG activity reduced for SD versus BF running and EMG activity increased for the highest velocity. The *tibialis anterior* activity increased whilst the *gastrocnemius medialis* and *gastrocnemius lateralis* activities reduced with more foot dorsiflexion at foot strike. Changes in activity for medium versus slow running were statistically significant, but small in magnitude when interaction effects were accounted for.

Random intercepts at the subject level were appropriate for all models, which may be interpreted to mean that each subject had an independent EMG activity for the reference trial. In addition, there was a random effect of condition for *gastrocnemius medialis* pre-activation.

Between-subject variability was typically larger than the largest statistically significant fixed effect, up to a factor of 2.

DISCUSSION: With the use of GLMMs, statistically significant differences may be observed in the function of the *gastrocnemius* heads during steady-state endurance running. From a clinical perspective, understanding the individual is of the utmost importance, evidenced by the between-subject variability explaining most of the change in EMG signal. To understand population behaviour, this variability must be appropriately accounted for in any statistical analysis.

The random effect of condition implies that there is unexplained variability in how *gastrocnemius medialis* activity is affected by footwear. For other muscles a more systematic, population-wide effect, may exist.

SIGNIFICANCE: Between-subject variability is large compared to experimental effects, which underlines the importance of considering EMG activity in the context of an individual. For BF running, the *gastrocnemius medialis* may be more susceptible to fatigue due to the increased activation when compared to the *gastrocnemius lateralis*, possibly because the *gastrocnemius medialis* plays a role in foot stability. In addition, there may be subject-level attributes which affect the response of *gastrocnemius medialis* activity to the use of footwear.

REFERENCES

1. Divert C et al. 2005; Int J Sports Med. 26(59):3-8
2. von Tscharner V et al. 2003 Aug; J Biomech. 36(8):1169-1176
3. Giandolini M et al. 2013; Eur J Appl Physiol. 113(3):599-609
4. Dickinson JA et al. 1985; J Biomech. 18(6):415-422
5. O'Connor CM et al. Gait Posture. 2007; 25:469-74

Intro to Road Bike Fitting

Happy Freedman and Ben Serotta
Bikefit Specialist, Hospital for Special Surgery, New York City,
Bicycle Frame Designer and Fabricator, Saratoga Springs, NY
Freedmanha@HSS.edu

Nothing to Disclose.

INTRODUCTION: Bikefit is the art and science of determining a cyclist's optimal position on a bicycle. It has evolved over the past 40 years to address physical conditions and cyclists' efficiencies for a great diversity of riders, from professional to recreational, young, old, male, female, typical to atypical and everyone in between. Currently, bikefit is approached as a collection of measurements and data points while losing sight of the cyclist's body as a whole. In our current work, we are exploring a return to a holistic approach to bikefit, wherein individual attributes are never considered in isolation, but rather as an integral aspect to be considered while examining the whole cyclist. Our goal is to find the cyclist's optimal fit zone – a position where the cyclist can move around depending on terrain, weather, and type of event, all while being comfortable and efficient. In addition, we address changes that may occur in the cyclist's body over time and the changes in position that may result.

METHODS: At Hospital for Special Surgery (HSS) our bike fitting protocol starts with a detailed patient history, a musculo-skeletal evaluation, measuring the existing bicycle's geometry, followed by an on-bike evaluation observing the cyclist's form, technique, areas of strength and weakness, breathing, cadence, and power output, as well as center of mass. We employ visual and auditory observations, motion capture, 3D imaging, and video, as appropriate.

RESULTS: Anecdotal observations and comments collected from our pool of cyclists at various intervals post bikefit include: reports of reductions of muscular-skeletal pain in neck, shoulders, back, and knees; reduction or elimination of tingling/burning sensations in hands and feet; increased efficiency in breathing; improvements in bike handling, such as balance, cadence, cornering, acceleration, climbing, descending.

DISCUSSION: The standard practice for bike-fit technicians is to begin with the foot, identifying foot type, evaluating stability and reviewing the shoe and pedal selection as well as the shoe cleat placement (the cleat creates a fixed or semi-fixed connection with the pedal). Often, corrections are made to accommodate limb length inequalities, arch collapse, and varus and valgus angles of the feet. Then, the process works up from the foot interface to adjust saddle position and finally back profile and hand position.

At HSS, our approach departs from this standard by starting with an on-bike evaluation (as opposed to the foot first) focusing first on the cyclist's airway, as diaphragmatic breathing is the first landmark to look for in improving performance. We prepare the cyclist to bring the intercostals into play and throughout the process, special attention is given to the cyclist's form and posture for maintaining optimal breathing. Along the way, we focus on core stabilization and the use of gluteus medius and gluteus maximus as counterbalancing muscles for the quadriceps. In addition to stabilizing the quads, we try to bring the rhomboids into play to help keep the chest open so that we can increase the volume of air taken in per breath. In addition, we work on form and technique to find the optimal position for arms so as to maintain optimized breathing. During these processes, the saddle and handlebar placement and as well as other "cockpit (any component that the cyclist is directly or indirectly connected to)" component selection may be altered to enable the cyclist to maintain this most effective posture. Occasionally the client's existing bicycle is beyond the range of required adjustments at which time the fit process is transferred to a more adaptive stationary bicycle fitting device. After adjustments have been completed, the cyclist's position is re-evaluated for comfort as well as sustainability. This process may take several hours for the bikefit, and is followed up with a visual examination or verbal report. Data from the current semi-quantitative/qualitative bike fitting process is being used to design a quantitative study from which objective evidence will be evaluated on an appropriate sample size of riders.

SIGNIFICANCE/CLINICAL RELEVANCE: At HSS, we see injured cyclists, cyclists with joint replacements, as well as recreational and pro athletes, and the adjustments that we make on and off the bike are anchored in a clinical evaluation ahead of the start of the fit. This protocol allows us to alter the cyclist's position through counterbalancing exercise, stretching and other modalities, allowing for changes over time, in the cyclist's body.

REFERENCES:

1. Swift P, Vogel K DPT, https://blog.bikefit.com/how-to-fit-a-road-bicycle/
2. Serotta B, https://benserotta.com/2017/06/24/stepping-into-hss-and-outside-the-box/

Session 12b-Poster No. 22

Are you experienced yet?

Andrew J. Greene [1] and Ana De Paula [1]
[1]University of Roehampton, London, UK
andrew.greene@roehampton.ac.uk

Disclosures: Andrew J Greene (N), Ana de Paula (N)

INTRODUCTION: When assessing the foot and ankle joint, the literature is in agreement that the foot should be modelled as number of segments as opposed to a single, rigid segment as was traditionally used. As such, the use of multi segment foot models have been given significant attention in the literature and their application in gait laboratories has become increasingly widespread. The Oxford Foot Model (OFM) [1] is one such model that has been shown to provide valid and reliable multi segment foot assessment. With a large number of markers being placed upon a relatively small segment, correct marker placement and its repeatability is vital to ensure consistent and comparable measures in both an applied and clinical setting. Recent studies [2] have stressed that experience of marker application is vital for consistent marker placement within gait laboratories and so the training of clinicians and practitioners should be given special attention. As such, the aim of the study was to look at the marker placement repeatability of a novice practitioner before and after a targeted training program, and to compare their findings to that of an experienced marker placement practitioner.

METHODS: One adult (Female, 52, 163cm, 61kg) and one child (Female, 12, 126.5 cm, 26kg) volunteered and provided informed consent for the study which was approved for ethics by the University of Roehampton. Each participant had markers placed by both an experienced (400+ marker placements) and a novice practitioner (MSc Biomechanics student, > 5 marker placements) three times within a 6 week period. Markers were placed according to the OFM documentation [1]. Data was collected for 5 walking trials on each occasion using a 12 camera Vicon Motion Analysis System (Vicon, Oxford, UK) recording at 200Hz. The novice practitioner then undertook a 'training program' during which they palpated and placed markers using the OFM landmarks on 20 adult and 20 child feet in an attempt to improve marker placement and foot structure familiarity (motion data was not collected). Experienced and novice practitioners then placed markers on the original adult and child participants on a further three occasions and collected walking data to assess whether the marker placement repeatability had improved as a result of training. Within Assessor and Between Assessor variability was calculated for both practitioners and results compared with respect to the guidelines outlined in the literature [3].

RESULTS: The mean within-assessor variability of the relative 3D rotations ranged from 0.45–4.83° (mean = 1.98°) and 1.48-5° (mean = 2.47°) for the experienced practitioner for adult and child assessments respectively. Within-assessor variability for the novice practitioner ranged from 2.25-13.04° (mean = 7.07°) pre training and 0.55-1.85° (mean = 1.32°) post training for adult placement, and from 1.81-11.06° (mean = 4.86°) pre training and 0.84-15.6° (mean = 4.35°) post training for the child placement. Between-assessor variability for the adult participant ranged from 2.92-13.49° (mean = 8.03°) pre training and between 3.3-9.78° (mean = 4.94°). Between-assessor variability for the child participant ranged from 3.2-13.56° (mean = 7.25°) pre training and 3-11.6° (mean = 5.09°) post training. For the novice practitioner, during both pre and post testing trials of the child participant, Ankle Inversion / Eversion angle variability was greater than 5°.

DISCUSSION: After a targeted period of training, the novice assessor was able to improve their within-assessor variability to enable all OFM joints two be assessed within the 5° acceptable limit for the adult participant. Subsequently, post training between-assessor variability for the same participant fell below 10° (acceptable limit as stipulated for clinical gait laboratory repeatability standards) for all variables, showing comparable data was collected by both assessors post training. Similar findings were seen for all variables in the child assessment except for Ankle Inversion / Eversion, where variability was greater than 5° in both pre and post training testing for the novice practitioner. This subsequently led to larger ranges of within-assessor and between-assessor variability for this specific variable when examining the child's foot, and therefore a lack of agreement between assessors as to the frontal plane motion at the ankle joint.

SIGNIFICANCE/CLINICAL RELEVANCE: This study shows that a targeted training protocol can enable novice practitioners to develop greater repeatability and comparable marker placement skills to an experienced practitioner for the OFM with adult participants. When placing markers on children's feet, given the greater susceptibility for marker placement error due to the smaller foot structure, novice assessors may need further training and exposure to the developing foot to ensure that repeatable and comparable data is able to be collected.

REFERENCES:
[1] Stebbins, et al. Gait Posture. 2006; 23: 401-410. [2] Deschamps, et al. Gait Posture. 2012; 35: 255-260. [3] McGinley, et al. Gait Posture. 2009; 29: 360-369.

Session 12b-Poster No. 23

Effects of acute fatigue of the lower limb on running mechanics

Rik Mellor[1], Billy Senington[1], Anthony Lockey[1], Megan Le Warne[1], Ryan Mahaffey[1]
[1] St Mary's University, Twickenham, London, UK,
rik.mellor@stmarys.ac.uk

Disclosures: None.

INTRODUCTION

There is a general understanding that running creates a higher incidence of overuse injuries, in particular at or below the knee, which may be related to fatigue of control mechanisms of the lower limb. Research has examined aspects of proximal and distal control of the limb and ground contact, but little has compared distinct muscle groups above or below the knee. This research seeks to identify if acute local muscular fatigue of knee or ankle controlling musculature affects mechanical variables of running gait.

METHODS

Four, injury free male amateur 5/10 km runners (Age 32 ± 17yrs, Height 174.1cm ± 6.7cm, Body Mass 64.0 ± 6.4) consented to participate. Testing was approved by the University Ethics Committee.
A randomized crossover design was employed to test the effects of two local muscular fatigue conditions; (1) of the ankle dorsiflexors and, (2) of the knee extensors, on running mechanics. Pre and post fatigue running mechanics were captured at a controlled pace, on an indoor 15m runway before and after the fatiguing protocols.
A 12-camera system recorded 3D foot segments (shank, calcaneus, midfoot and metatarsals). Medial-lateral Centre of Pressure (MLCoP) excursion and plantar pressures were collected from a pedobarograph. Additionally, electromyography of tibialis anterior, gastrocnemius medialis, vastus medialis, and biceps femoris was collected.
Principle component analysis used employed to reduce the data sets to components of the stance phase with shared variance. The components and peak EMG where entered into a 2-way repeated measure ANOVA. Effect sizes were calculated to compare variables between the groups before 90% confidence intervals and magnitude-based inferences were derived.

RESULTS

There was a significant effect of the type of fatiguing protocol on foot segment angles and MLCoP during the stance phase (Figure 1). Compared to the effects of fatigue of the ankle dorsiflexor, knee extensor fatigue resulted in greater dorsiflexion of the midfoot (effect size 0.55 to 1.3, p = .01), less dorsiflexion of the metatarsals (EF 0.58 to 1.3, p =.008), and greater medial position of the center of pressure (EF 0.59 to 1.3, p = .008).

DISCUSSION

Local muscle fatigue affects running mechanics in a specific manor. Fatigue of the ankle dorsiflexors had a greater effect on metatarsal dorsiflexion and greater lateral movement of the center of pressure possibly due to a reduction in control of foot. These findings are relevant to athletes and coaches looking to avoid fatigue related injuries and to shoe manufactures interested in supporting the foot during long distance running.

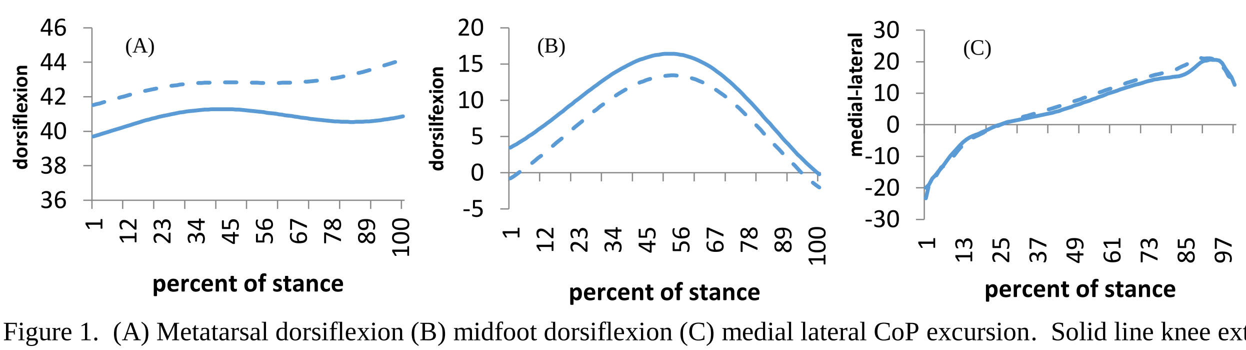


Figure 1. (A) Metatarsal dorsiflexion (B) midfoot dorsiflexion (C) medial lateral CoP excursion. Solid line knee extensor fatigue, dash line ankle dorsiflexor fatgiue

Load-limiting Sports Shoe Sole to Reduce Injuries

Winton Parker[1], Andrew R. Vickery[1], Christopher A. Brown [1, 2]
[1]Worcester Polytechnic Institute, Worcester, MA, [2]Sports Engineering Inc.
Email of Presenting Author: brown@wpi.edu

Disclosures: Christopher A. Brown and Worcester Polytechnic Institute are stockholders in (Sports Engineering Inc.)

INTRODUCTION: The conceptual design and prototype of a load-limiting shoe sole for field, court and floor sports, which is intended to reduce ankle and knee injuries is developed. This design would test the hypothesis that limiting the transmission of loads from the playing surface to the foot can reduce ankle and knee injuries. Ground reaction forces transmitted through the shoe contribute to ankle and knee injuries in floor, court and field sports. Injuries occur during a cutting movement. It is hypothesized that at least some significant part of this injurious load is transmitted through shoe sole and that controlling this transmission and limiting the transmitted loads can reduce injuries. Similar device in ski bindings with adjustable release loads, which thereby limit the load transmissions, practically eliminated tibia factures in alpine skiing during the 1970s. The most widely used strategy for adjusting the release load in ski bindings is based on transmitting the loads just greater than those required for ordinary, and some extraordinary, skiing maneuvers, and then releasing the ski from the boot at higher loads. The approach with designing the response loads for the load-limiting shoe soles is similar in regard to limiting transmitted loads to those required for ordinary play and then responding at higher loads. The sole, however, does not affect some kind of release, like a ski binding, which would require some kind of manual reset. With ski bindings, a release takes a racer out of the competition. The response by release leads to the use of high release adjustment settings by racers in order to avoid inadvertent releases. The shoe sole, instead responds with controlled displacement under loads just above ordinary playing loads, absorbing the energy that could otherwise do work on the ankle or knee and maybe cause injury. After displacement, while the foot is off the playing surface before being planted again, the sole recovers to its normal configuration. The player might not even know that there has been a response, because it occurs at a constant, high and safe, load. An important constraint in the design of the sole is to maintain current performance characteristics of the shoe.

METHODS: An axiom-based, engineering design method, a scientific approach, is used for this technical, computational study (Suh 1990). Suh's axiomatic design postulates that the best design solutions maintain the independence of the functional elements and minimizes the information content. Functional requirements (FRs) are developed for the shoe to reduce injuries. Candidate design parameters (DPs) are studied to find the best physical solutions, according to Suh's two axioms. The design solution includes a collectively exhaustive and mutually exclusive hierarchy of FR-DP pairs, which shows abstractions from high-level concepts to specific detail. At each level, candidate DPs are evaluated with respect to the constraints and the axioms. This is essentially a specialized approach of functional modeling for device designs.

RESULTS: The FR-DP decomposition has been completed at the highest levels with detail sufficient to verify feasibility of the key concepts. The design includes a special system of springs, retaining elements, and sliding interfaces that are carefully integrated into the sole of an otherwise normal sports shoe. This multi-component sole modification allows displacement, under approximately constant load, in three directions. Rotation can take place about any vertical axis, simultaneous with lateral displacement, avoiding the problem with a single vertical axis of rotation in most ski bindings that leads to ACL injuries. During sole displacement, a constant-force spring system absorbs potentially injurious loads when the shoe is in contact with the playing surface. The stored elastic energy in the spring is used for the recovery of the sole to its normal, unloaded configuration. Currently, work is being done on detailed designs of components for a prototype. Final component designs and manufacture are expected in the next two months, with assembly, and some testing, before the conference date.

DISCUSSION: This displacement design provides an important advance over systems that release. Every doubling of the displacement can reduce the peak loads by a similar amount. This system is limited in that is cannot influence loads unless they are transmitted through the sole. The potentially injurious loads must exceed ordinary playing. It cannot protect against loads due to muscular activity, e.g. contraction of the quads, which can apply significant loads across the knee without loading the sole.

SIGNIFICANCE/CLINICAL RELEVANCE: This should keep players out of the clinic and reduce the incidence of ankle and knee injuries in many sports.

REFERENCES:
1. Suh, N.P., 1990. The Principles of Design, Oxford Press, New York.

ACKNOWLEDGEMENTS: The generous support of Sports Engineering Inc. and Ed Cowle are gratefully acknowledged.

Percutaneous Posterior to Anterior Screw Fixation of the Talar Neck: Soft Tissue Structures at Risk

Cesar de Cesar Netto[1]; Lauren Roberts[1]; Guilherme Honda Saito[1]; Scott Ellis[1]; Ashish Shah[2]
[1]Hospital for Special Surgery, NY, [2]University of Alabama at Birmingham

NOTHING TO DISCLOSE

INTRODUCTION:

Fractures of the talar neck and body can be fixed with percutaneously placed screws directed from anterior to posterior or posterior to anterior. The latter has been found to be biomechanically and anatomically superior. Percutaneous pin and screw placement poses anatomic risks for posterolateral and posteromedial neurovascular and tendinous structures. The objective of this study was to enumerate the number of trials for proper placement of two parallel screws and to determine the injury rate to neurovascular and tendinous structures.

METHODS:

Eleven fresh frozen cadaver limbs were used. 2.0mm guide wires from the Stryker (Selzach, Switzerland) 5.0-mm headless cannulated set were percutaneously placed (under fluoroscopic guidance) into the distal posterolateral aspect of the ankle. All surgical procedures were performed by a fellowship-trained foot and ankle surgeon. Malpositioned pins were left intact to allow later assessment of soft tissue injury. The number of guide wires needed to achieve an acceptable positioning of the implant was noted. Acceptable positioning was defined as in line with the talar neck axis in both AP and lateral fluoroscopic views. After a layered dissection from the skin to the tibia, we evaluated neurovascular and tendinous injuries, and measured the shortest distance between the closest guide pin and the soft tissue structures, using a precision digital caliper.

RESULTS:

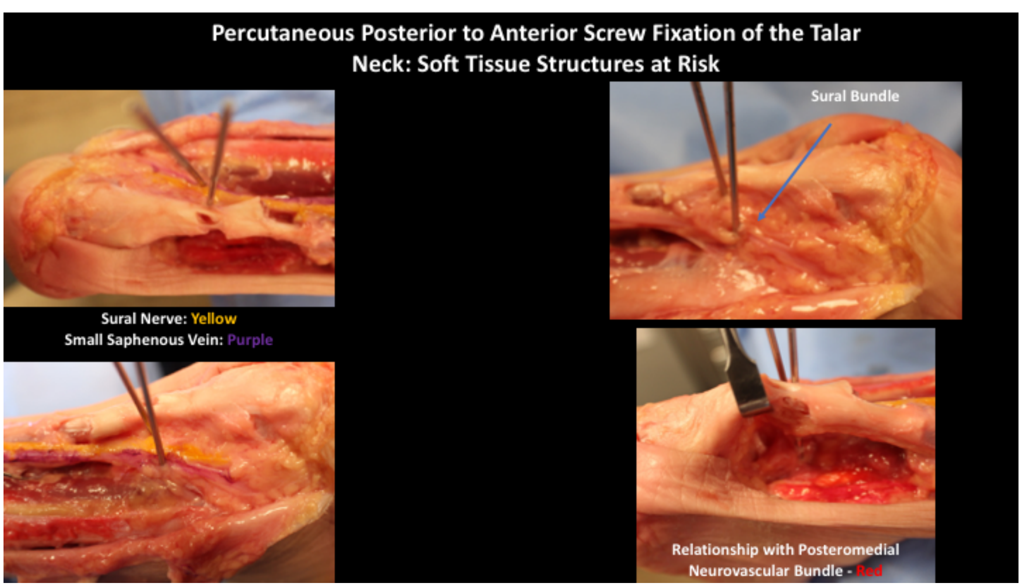
The mean number of guide wires needed to achieve acceptable positioning for 2 parallel screws was 2.91 ± 0.70 (range, 2 - 5). The mean distances between the closest guide pin and the soft tissue structures of interest were: Achilles tendon, 0.53 ± 0.94mm; flexor hallucis longus tendon, 6.62 ± 3.24mm; peroneal tendons, 7.51 ± 2.92mm; and posteromedial neurovascular bundle, 11.73 ± 3.48mm. The sural bundle was injured in all the specimens, with 8/11 (72.7%) in direct contact with the guide pin and 3/11 (17.3%) having been transected. The peroneal tendons were transected in 1/11 (9%) of the specimens. The Achilles tendon was in contact with the guide pin in 6/11 (54.5%) specimens and transected in 2/11 (18.2%) specimens.

CONCLUSION:

The placement of posterior to anterior percutaneous screws for talar neck fixation is technically demanding and multiple guide pins are needed. Our cadaveric study showed that important tendinous and neurovascular structures are in close proximity with the guide pins and that the sural bundle was injured in 100 % of the cases.

CLINICAL RELEVANCE:

We advise performing a formal small posterolateral approach for proper visualization and retraction of structures at risk. Regardless, adequate patient education about the high risk of injury from this procedure is crucial.



Knee Adduction Moments Associated with Knee Osteoarthritis are Increased by Medial Arch Supports

Andrew R. Roney[1], Nicholas Holowka[1], Ian J. Wallace[1], Daniel E. Lieberman[1]
[1]Harvard University, Cambridge, MA
Email of Presenting Author: RoneyA@hss.edu

Disclosures: None

INTRODUCTION: During walking and running an external adduction moment acts on the knee as a result of a medially acting ground reaction force (GRF) vector (Fig. 1). The knee adduction moment (KAM) magnitude is determined by the GRF magnitude and the moment arm of the GRF about the knee. Although KAMs are not a direct measure of site-specific loading in the knee, they are a useful proxy for the dynamic loads sustained by the medial tibiofemoral joint and have been linked to the incidence and progression of knee osteoarthritis (OA). Certain types of footwear have been shown to increase KAMs, but the specific features of shoe design responsible are unknown. One potentially important feature is the medial arch support, which can enhance comfort and limit foot pronation but might increase KAMs by causing a medial shift in the foot's center of pressure (COP). Medially shifting the COP ought to also direct the GRF more medially and thus lengthen the GRF moment arm about the knee (Fig. 1). This study sought to determine if medial arch supports indeed increase KAMs, and if so, whether it is due to medial translation of the COP.

METHODS: Walking and running gaits were analyzed in 18 healthy male participants under three footwear conditions: (1) barefoot, (2) sandals without arch supports ('shod' condition), and (3) sandals with prefabricated medial arch supports ('arch' condition) (Fig. 2). Limb kinematic and kinetic data were measured by tracking reflective body surface markers using a motion capture system while participants walked (0.2 Froude) and ran (1.0 Froude) on a treadmill instrumented with a force plate. Average peak KAMs for each participant were calculated for walking and running using inverse dynamics. The mediolateral position of the foot's COP was measured at the moment of peak the KAM. Effects of footwear condition and COP location on peak KAMs were analyzed using repeated-measures ANOVAs. All methods were approved by the IRB of Harvard University and written informed consent was obtained from each subject.

RESULTS: The peak KAMs generated while walking in the arch condition were, on average, 9% greater than those generated during barefoot walking ($p = 0.013$), but not significantly different than those generated during the shod condition ($p=0.467$). Shod walking generated 6% greater peak KAMs than barefoot ($p=0.176$) (Fig. 3). Average peak KAMs generated during arch running were not significantly greater than those generated when running barefoot ($p=0.214$) or in the shod condition ($p=0.896$), respectively. The peak KAM was 8% greater during shod running compared to barefoot, although this difference only approached significance ($p=0.092$) . Center of pressure position at peak KAM was not different in any of the three footwear conditions for walking or running ($p>0.295$ for all comparisons).

DISCUSSION: The results indicate that neither the medial arch support nor the minimalist sandal directly increases the first peak KAM during walking. However, the sandal-arch combination does increase the first peak KAM compared to barefoot, suggesting that minimalist footwear may be the best option for reducing harmful forces associated with OA. Despite previous research relying on the COP theory, there was no causal relationship found between the COP and the KAM.

SIGNIFICANCE: The findings suggest that footwear with arch supports should be used with some caution as they may increase KAMs that potentially contribute to OA, additionally, the often cited COP link to KAM theory should be reviewed.

FIGURES:

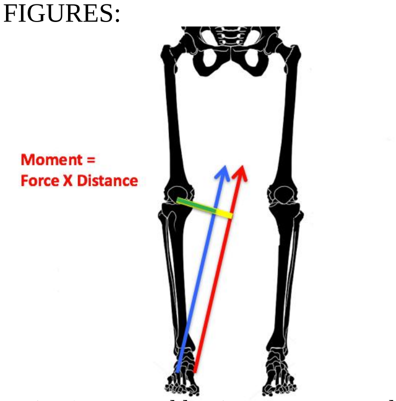


Fig. 1. Knee adduction moment. Red GRF vector has longer moment arm than blue, due to medial shift in COP.

Fig. 2. Three footwear conditions.

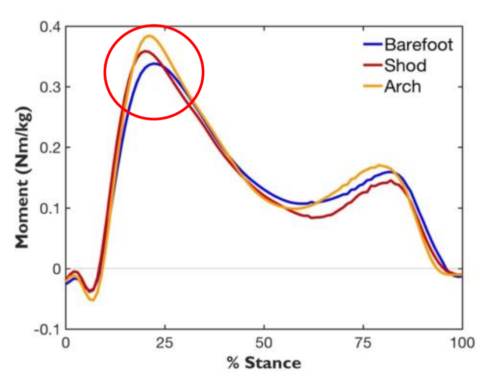


Fig. 3. Average KAMs during walking across all participants. Circled 1st peak, arch significantly greater than barefoot.

Session 12b-Poster No. 27

Weight bearing with standing position for tibiofibular clear space measurement ; using 3D US

Seungwoo Cha[1], Donghyum Kim[1], Jiwon Chai[1], Jina Park[1], Joohee Imh[1]
[1]SMG - SNU Boramae Medical Center
Email of Presenting Author: disupt@nate.com

Disclosures: There are no financial conflicts of interest to disclose.

INTRODUCTION:

The ankle syndesmotic ligamentous complex plays a significant role in the stabilization of the ankle joint [1]. Classically, tibiofibular clear space was measured for syndesmotic ligamentous injuries on radiographs [2, 3]. But the current radiologic parameters in use seems to be inconsistent and of minimal diagnostic value [4].

Recently 3D-ultrasonography has been developed and it can make consistent location for the tibiofibular clear space measurement (figure 1). The objective of this study was to understand the possibility of 3D-ultrasonography for evaluation of tibiofibular clear space. And to clarify the changes of tibiofibular clear space against the weight bearing.

METHODS:

The study was approved by the IRB at Seoul National University. Five consecutive subjects who met the following inclusion criteria were included: (a) without ankle injury or pain and negative findings on routine ankle ultrasonography protocol; (b) who agree to this clinical trial; (c) who can stand up alone.

Neutral images were acquired with the patient sitting on the bed and bending knees about 90 degrees (figure 2A). Weight bearing images were acquired with the patient standing on the bed (figure 2B). After searching the tibiofibular clear space, 3D scan mode was initiated, and volume data were acquired. Then we measured tibiofibular clear space 1cm above the tibial platfond.

RESULTS: Five subjects (age 22.8±1.3, all males) volunteered for the study. Mean values for the syndesmosis clear space on ultrasound examination were determined as 3.44mm in neutral and 4.00mm in standing position.

DISCUSSION: We used weight bearing with standing position as a stress test for the clear space measurement. The result was resemble in the previous study by Mei-Dan et al. who used external rotation as a stress test (Mean ; 4.08mm) [5].

CLINICAL RELEVANCE: Standing position would be the most similar to ankle kinematics. 3D US can make consistent location for the tibiofibular clear space measurement.

REFERENCES:

1. van den Bekerom, M.P., et al., *The anatomy in relation to injury of the lateral collateral ligaments of the ankle: a current concepts review.* Clin Anat, 2008. **21**(7): p. 619-26.
2. Harper, M.C. and T.S. Keller, *A radiographic evaluation of the tibiofibular syndesmosis.* Foot Ankle, 1989. **10**(3): p. 156-60.
3. Beumer, A., et al., *Radiographic measurement of the distal tibiofibular syndesmosis has limited use.* Clin Orthop Relat Res, 2004(423): p. 227-34.
4. Amendola, A., G. Williams, and D. Foster, *Evidence-based approach to treatment of acute traumatic syndesmosis (high ankle) sprains.* Sports Med Arthrosc Rev, 2006. **14**(4): p. 232-6.
5. Mei-Dan, O., et al., *Standardization of the functional syndesmosis widening by dynamic U.S examination.* BMC Sports Sci Med Rehabil, 2013. **5**: p. 9.

FIGURES AND TABLES:

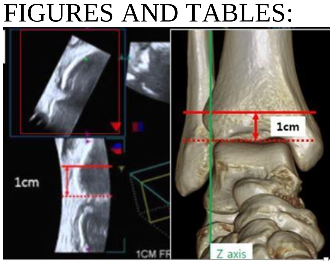


Figure 1. 3D US can make cross sectional images on accurate level we want to evaluate.

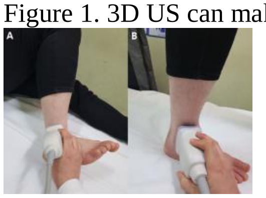


Figure 2A. Neutral images with the patient sitting on the bed and bending knees about 90 degrees.
Figure 2B. Weight bearing images with the patient standing on the bed.

An explanatory model of risk factors for foot ulcers in patients with diabetes

Roozbeh Naemi[1], Nachiappan Chockalingam[1], Janet K. Lutale[2], Zulfiqarali G. Abbas[2,3]
[1]School of Life Sciences and Education, Staffordshire University, Stoke On Trent, United Kingdom,
[2]Muhimbili University of Health and Allied SciencesDar es Salaam, Tanzania,
[3]Abbas Medical Center, Dar es Salaam, Tanzania,
Email of Presenting Author: r.naemi@staffs.ac.uk

Disclosures: Roozbeh Naemi (N), Nachiappan Chockalingam1 (N), Janet K. Lutale (N), Zulfiqarali G. Abbas (N),

INTRODUCTION: The annual incidence rate of Diabetic Foot Ulcers is estimated to be between 15 to 25 % with foot ulceration is the main cause of lower limb amputation in patients with diabetes worldwide. The presence of foot ulcers in a diabetic patient increases the risk of death at 5 years by 2.5 times [Walsh et al, 2016]. Understanding and extending the knowledge of characteristics of patients with diabetic foot ulcer is essential and will be useful in developing clinical management protocols for this group of patients. The aim of this study is to identify the biomechanical, neurological and clinical parameters along with other demographics and life style risk factors for foot ulcers in diabetic patients that can explain the presence of diabetic foot ulcers.

METHODS: A total of 1219 (M/F: 666/553) diabetic patients who attended the diabetic foot clinic in Tanzania between Jan 2011 and Dec 2015 were included in this study. Foot ulcer was defined as a full-thickness wound involving the foot or ankle and was observed in 75 patients, whereas 1144 patients had no foot ulceration. A combination of generic and specific categorical and continuous parameters were collected from the patients during a single visit. The general categorical parameters were: diabetes type, assistive device usage, smoking habit, alcohol habits, physical activity status, previous amputation, and history of ulceration. The general continuous parameters included: age, body mass, height, shoe size, duration of diabetes, and body mass index. The specific continuous parameters included: ankle brachial pressure index, vibration perception threshold, temperature sensation and tolerance thresholds and barefoot plantar pressure during walking. The foot specific categorical parameters included: neuropathy based on impaired skin sensation to monofilament, arterial pulse, foot deformity, Charcot foot, skin status, Mycosis, nail ingrowth, swelling, and presence of callus. The specific categorical parameters for each participant were defined as if these occurred on either (or both) feet for the participant. The specific continuous parameters were averaged between the left and right feet. Multivariate logistic regression was utilised to develop the explanatory model for foot ulceration based on Backward stepwise selection that involves removal of the risk factors on the probability of the Wald statistic ($p>0.1$) and retaining variables with ($p<0.05$).

RESULTS: The proposed model was able to adequately (with 95.3% diagnostic accuracy) justify the presence of foot ulceration based on the common risk factors. While the model's specificity (as the percentage on of participants with no ulceration incidence that are correctly diagnosed) was 99.1 %, the sensitivity (as the percentage of participants with ulceration that are correctly diagnosed) was only 37.3%. Fasting blood sugar level, foot swelling and ankle mobility were among the significant contributors to diagnosing foot ulcers. Also, lower average foot Temperature Tolerance and Temperature Sensation thresholds to cold probe were observed to be significant ($P<0.05$) contributor to diagnosing foot ulceration. The addition of foot specific parameters to the model improved the diagnostic strength. The model as a whole could predict between 17.4 % (Cox and Snell R Square) and 47.1 % (Nagelkerke R Square) of the variation in ulceration status.

DISCUSSION: The model was adequately specific in identifying the factors that protect the patients against ulceration. However, the ability of model in justifying the characteristics of patients with ulcerated foot is currently relatively limited. With just over 1 out of three patients with ulcerated foot showing common characteristics that were investigated in this study.

SIGNIFICANCE/CLINICAL RELEVANCE: This study indicates that specific clinical characteristics of the foot that were investigated in this study can offer further explanation to diabetic foot ulceration. This justifies the need to include further foot-specific parameters like skin perfusion and soft tissue mechanical characteristics in the model that can potentially improve the diagnostic accuracy of the model and can provide further explanation for diabetic foot ulceration.

REFERENCES:

1. Walsh, J. W., et al. "Association of diabetic foot ulcer and death in a population-based cohort from the United Kingdom." Diabetic Medicine 33.11 (2016): 1493-1498.

ACKNOWLEDGEMENTS: Financial support from Higher Education Funding Council of England under quality-related (QR) research funding is acknowledge.