CADCAM Orthotic Prescription and Design

Session 3

Total Contact Orthotic & Shoe Modifications for High Risk Feet

Step Force Training

Presented By
Paul Graham

12/09/2020

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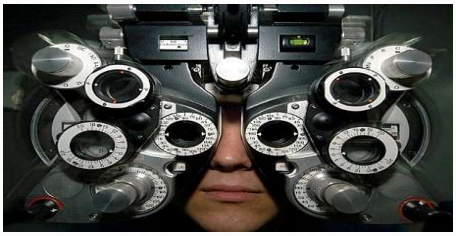
All about perspective



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DIABETICMedicine

DOI: 10.1111/j.1464-5491.2009.02835.x

Original Article: Complications

Plantar pressures in diabetic patients with foot ulcers which have remained healed

T. M. Owings, J. Apelqvist*, A. Stenström†, M. Becker‡, S. A. Bus§, A. Kalpen¶, J. S. Ulbrechts and P. R. Cavanagh**

Department of Biomedical Engineering, Lerner Research Institute, Cleveland Clinic, Cleveland, OH, USA, *Department of Endocrinology, University Hospital of Malmö, Malmö, Sweden, †Department of Orthopaedic Surgery, University of Lund, Lund, Sweden, ‡Department of Biobehavioral Health and Medicine, Pennsylvania State University, University Park, PA, USA, §Department of Rehabilitation, Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands, ¶Ivoxi gmbh, Munich, Germany and **Department of Orthopaedics and Sports Medicine, University of Washington, Seattle, WA, USA

Accepted 8 August 2009

Abstract

Aims The recurrence of foot ulcers is a significant problem in people with diabetic neuropathy. The purpose of this study was to measure in-shoe plantar pressures and other characteristics in a group of neuropathic patients with diabetes who had prior foot ulcers which had remained healed.

Methods This was an epidemiological cohort study of patients from diabetes clinics of two Swedish hospitals. From a database of 2625 eligible patients, 190 surviving patients with prior plantar ulcers of the forefoot (hallux or metatarsal heads) caused by repetitive stress were identified and 49 patients agreed to participate. Barefoot and in-shoe plantar pressures were measured during walking. Data on foot deformity, activity profiles and self-reported behaviour were also collected.

Results Mean barefoot plantar peak pressure at the prior ulcer site (556 kPa) was lower than in other published series, although the range was large (107–1192 kPa). Mean in-shoe peak pressure at this location averaged 207 kPa when measured with an insole sensor. Barefoot peak pressure only predicted ~33% of the variance of in-shoe peak pressure, indicating variation in the efficacy of the individual footwear prescriptions (primarily extra-depth shoes with custom insoles).

Conclusions We propose that the mean value for in-shoe pressures reported in these patients be used as a target in footwear prescription for patients with prior ulcers. Although plantar pressure is only one factor in a multifaceted strategy to prevent ulcer recurrence, the quantitative focus on pressure reduction in footwear is likely to have beneficial effects.

Diabet. Med. 26, 1141–1146 (2009)

Keywords barefoot pressure measurement, in-shoe pressure measurement, neuropathy, threshold

Owings, T. M., et al. (2009). "Plantar pressures in diabetic patients with foot ulcers which have remained healed."

Diabet Med **26(11): 1141-1146.**

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Journal of Foot and Ankle Research

RESEARCH Open Access

Diabetic Foot Australia guideline on footwear for people with diabetes

Jaap J. van Netten[1,2,3*], Peter A. Lazzarini[1,2,3,4,5], David G. Armstrong[6], Sicco A. Bus[7], Robert Fitridge[8,9], Keith Harding[10], Ewan Kinnear[11], Matthew Malone[12], Hylton B. Menz[13], Byron M. Perrin[14,15], Klaas Postema[16], Jenny Prentice[17,18], Karl-Heinz Schott[19] and Paul R. Wraight[2,20]

Abstract

Background: The aim of this paper was to create an updated Australian guideline on footwear for people with diabetes.

Methods: We reviewed new footwear publications, (inter)national guidelines, and consensus expert opinion alongside the 2013 Australian footwear guideline to formulate updated recommendations.

Result: We recommend health professionals managing people with diabetes should: (1) Advise people with diabetes to wear footwear that fits, protects and accommodates the shape of their feet. (2) Advise people with diabetes to always wear socks within their footwear, in order to reduce shear and friction. (3) Educate people with diabetes, their relatives and caregivers on the importance of wearing appropriate footwear to prevent foot ulceration. (4) Instruct people with diabetes at intermediate- or high-risk of foot ulceration to obtain footwear from an appropriately trained professional to ensure it fits, protects and accommodates the shape of their feet. (5) Motivate people with diabetes at intermediate- or high-risk of foot ulceration to wear their footwear at all times, both indoors and outdoors. (6) Motivate people with diabetes at intermediate- or high-risk of foot ulceration (or their relatives and caregivers) to check their footwear, each time before wearing, to ensure that there are no foreign objects in, or penetrating, the footwear, and check their feet, each time their footwear is removed, to ensure there are no signs of abnormal pressure, trauma or ulceration. (7) For people with a foot deformity or pre-ulcerative lesion, consider prescribing medical-grade footwear, which may include custom-made in-shoe orthoses or insoles. (8) For people with a healed plantar foot ulcer, prescribe medical grade footwear with custom-made in-shoe orthoses or insoles with a demonstrated plantar pressure relieving effect at high-risk areas. (9) Review prescribed footwear every three months to ensure it still fits adequately, protects, and supports the foot. (10) For people with a plantar diabetic foot ulcer, footwear is not specifically recommended for treatment; prescribe appropriate offloading devices to heal these ulcers.

Conclusions: This guideline contains 10 key recommendations to guide health professionals in selecting the most appropriate footwear to meet the specific foot risk needs of an individual with diabetes.

Keywords: Foot ulcer, Diabetes mellitus, Footwear, Prevention, Guideline

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van Netten, J. J., et al. (2018). "Diabetic Foot Australia guideline on footwear for people with diabetes." Journal of foot and ankle research **11(1): 2.**

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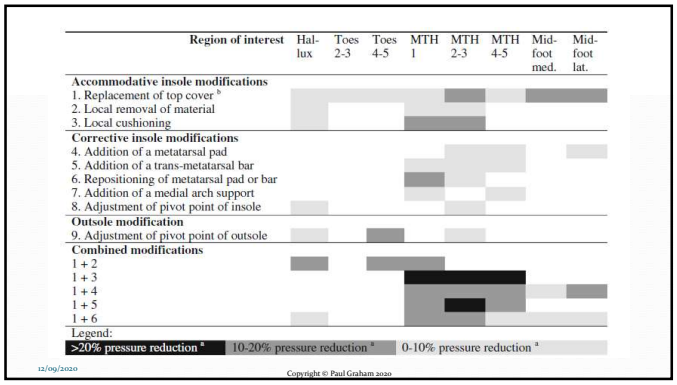

Region of interest	Hal-lux	Toes 2-3	Toes 4-5	MTH 1	MTH 2-3	MTH 4-5	Mid-foot med.	Mid-foot lat.
Accommodative insole modifications								
1. Replacement of top cover [b]								
2. Local removal of material								
3. Local cushioning								
Corrective insole modifications								
4. Addition of a metatarsal pad								
5. Addition of a trans-metatarsal bar								
6. Repositioning of metatarsal pad or bar								
7. Addition of a medial arch support								
8. Adjustment of pivot point of insole								
Outsole modification								
9. Adjustment of pivot point of outsole								
Combined modifications								
1 + 2								
1 + 3								
1 + 4								
1 + 5								
1 + 6								

Legend:

>20% pressure reduction [a] | 10-20% pressure reduction [a] | 0-10% pressure reduction [a]

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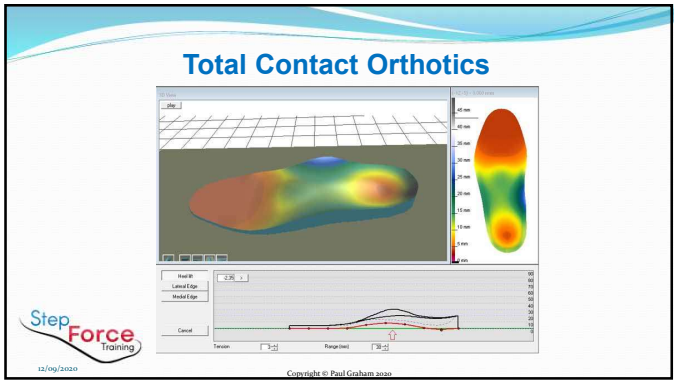

Total Contact Orthotics

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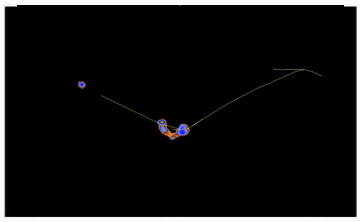
Total Contact Orthotics



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Footwear Modification

Metatarsal Rocker

Midsole Rocker

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Footwear Modification

Special Area Modifications

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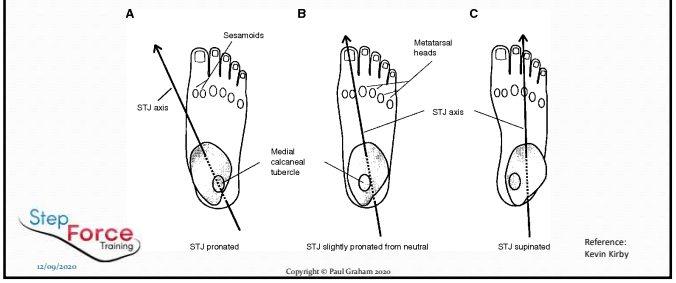
Significant Sub talar joint axis displacement



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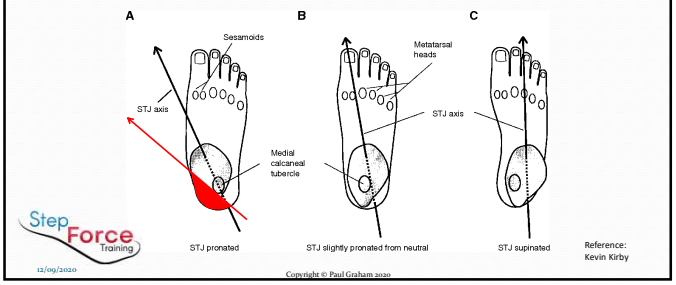
Footwear Modification

Varus Heel and Sole Wedge

11

Significant Sub talar joint axis displacement



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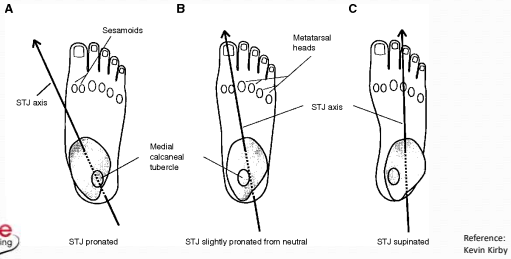
Footwear Modification

Medial Buttress

13

Significant Sub talar joint axis displacement



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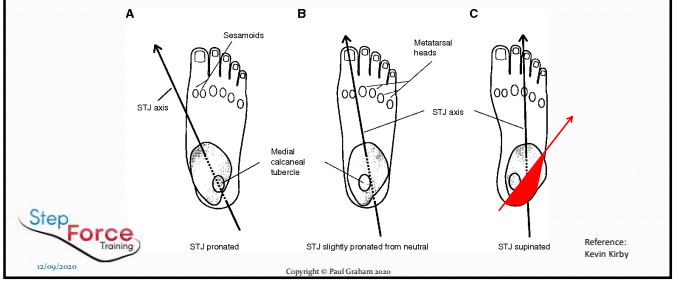
Footwear Modification

Valgus Heel and sole Wedge

15

Significant Sub talar joint axis displacement



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Footwear Modification

Lateral Buttress

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Significant Structural Leg Length Difference

18

Footwear Modification

Graduated Sole Lift

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Footwear Modification

Full Sole Lift

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Footwear Modification

Shoe Re-lasting Options

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Footwear Modification

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Case Study

HISTORY

- 68-year-old women in overall good health
- Spinal Fusion - 2014; L4 & L5 – successful, but has resulted in numbness in the most of the foot up to the ankle. When barefoot she loses balance and struggles to walk. The Left foot has slight numbness through the forefoot.
- Right Foot - 2005. Fusion of the 2nd met and intermediate cuneiform - successful until 2 years ago. CT exam shows significant progression of osteoarthritis

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Case Study

HISTORY

- Metatarsal Fusion, left foot - 2019, 2,3 & 4 at midfoot. Also straightening and pinning L2/ - healing well but she is having repeated stress fractures due to the osteoporosis
- Has been advised that the R/foot will require further surgery but is concerned about having the stress fractures occur in the R/foot also.

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Case Study

2. **EXAMINATION RESULTS**
   - Factors affecting the Force Pathway
     - Moderate High arch structure
     - Short first Metatarsal
   - Compensation Available
     - Stiffness and pain in midfoot and L/hallux dorsiflexion
     - Lower leg Muscle strength shows weakness and imbalance
     - Balance and proprioception decreased ? Due to lumbar fusion
     - Tightness in the leg posterior muscle and soft tissues; L > R

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Case Study

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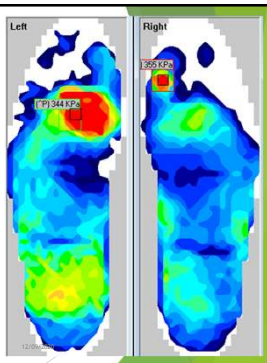
Orthoses don't work alone.

David Sutton CPedCM.AU
Clinical Advisor to Tekscan(Aust.) & Distributor.



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The Why?

DiabeticFoot Australia

Van netten et al. 2018 paper produced for DFA. Guideline on footwear for people with Diabetes.

DFA is the peak national clinical and research body for diabetes-related foot disease in Australia.

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DiabeticFoot Australia

Van netten et al. 2018 paper produced for DFA. Guideline on footwear for people with Diabetes

IWGDF Guidelines

Bus et al. Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF 2019 update). Diab Metab Res Rev. 2020. e3269

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DiabeticFoot Australia

IWGDF Guidelines

"200kPa or reduce peak pressure by 30%..."

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The How?

The sensor between the foot and the orthosis

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The when?

After the wound is healed.
Assess the range of motion both passive and active.

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Modified Jacks Test to assess balance

Poor balance needs to be considered?

Because we spend 2x more time standing

Importance of Time Spent Standing for Those at Risk of Diabetic Foot Ulceration. Bijan Najafi et al.2010

"RESULTS Patients daily spent twice as much time standing (13 ± 5%) as walking (6 ± 3%)…"

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The Shoe

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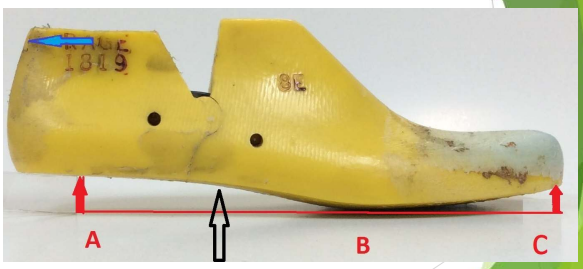
The Last



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Case presentation: Referred Patient, 74yr old male, 112 kg.
Hallux rigidus RF, ulcer IP RF plantar. Rl shorter 12mm, restricted ROM ankle.
Ulcer is reoccurring over a 4 year period.
Has Diabetes.
Has retired from his volunteer job as a result.

MUSCLE STRENGTH TESTING (Oxford scale)

- KNEE FLEXORS: R 5 L 5
- KNEE EXTENSORS R 4 L 5
- DORSIFLEXORS: R 4 L 4
- PLANTARFLEXORS: R 4 L 4
- EVERTERS: R 1 L 3
- INVERTERS: R 1 L 3

0/5 No contraction.
1/5 Visible/palpable contraction, but no movement.
2/5 Movement with no gravity resistance.
3/5 Movement against gravity possible.
4/5 Movement against gravity and some resistance.
5/5 Movement against gravity with full resistance

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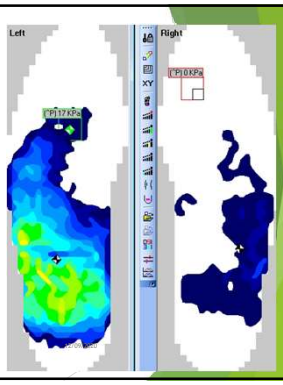
We record 8 steps.

Sensor between the foot and the orthosis.



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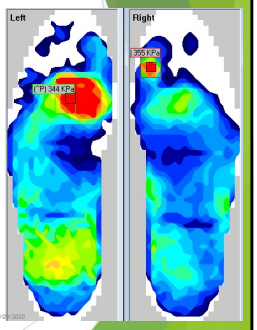
First In-shoe pressure mapping (ISPM) assessment of the client.
Right Foot IP (ulcer site) 355kPa
Left Foot MPJ 344kPa



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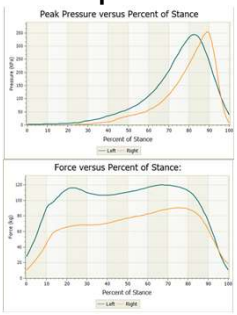
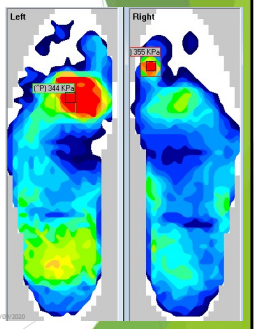
Peak pressure report





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Altered rocker, altered orthosis and altered Toe spring.

40

Altered rocker, altered orthosis and altered Toe spring.

Cling wrap can support weight under tensioning

41

Altered rocker, altered orthosis and altered Toe spring.

Cling wrap can support weight under tensioning

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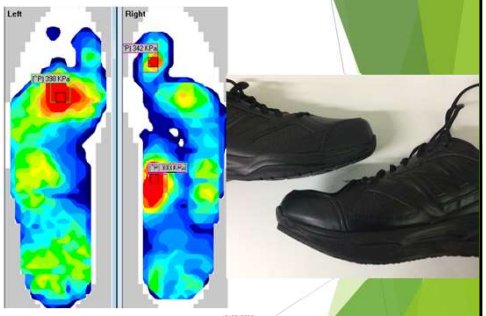
Inversion?

Created LLD

Toe nail lifted



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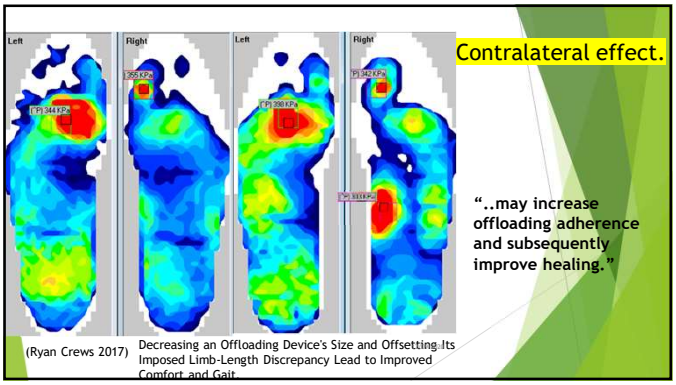

Contralateral effect.

"..may increase offloading adherence and subsequently improve healing."

(Ryan Crews 2017) Decreasing an Offloading Device's Size and Offsetting Its Imposed Limb-Length Discrepancy Lead to Improved Comfort and Gait

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New shoe
Sole modification
New orthoses

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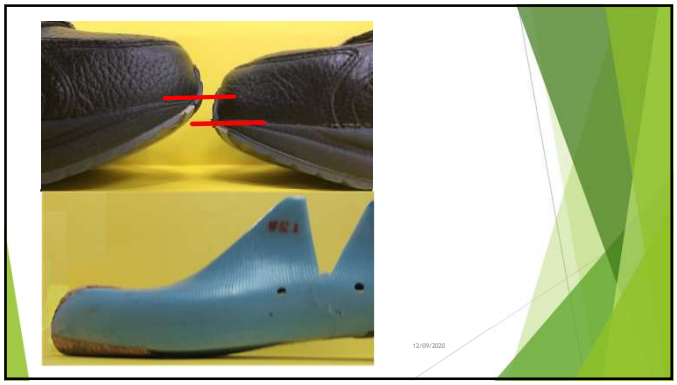

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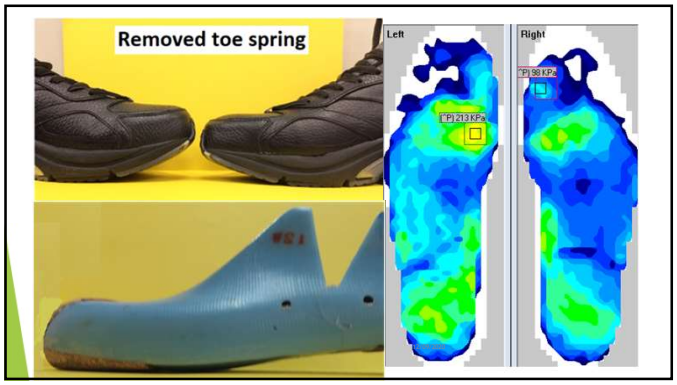
Removed toe spring
Left
Right

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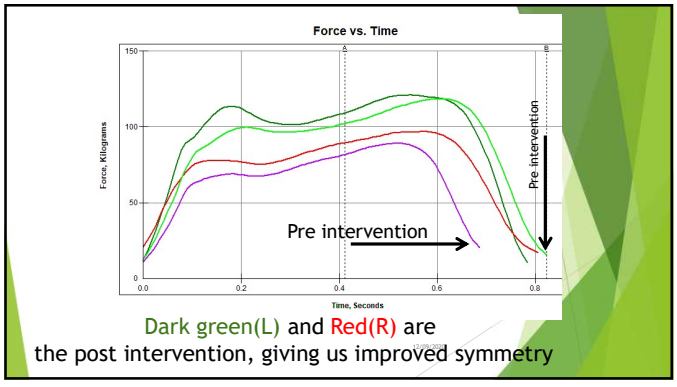
Force vs. Time
Force, Kilograms
Time, Seconds
Pre intervention
Pre intervention
Dark green(L) and Red(R) are
the post intervention, giving us improved symmetry

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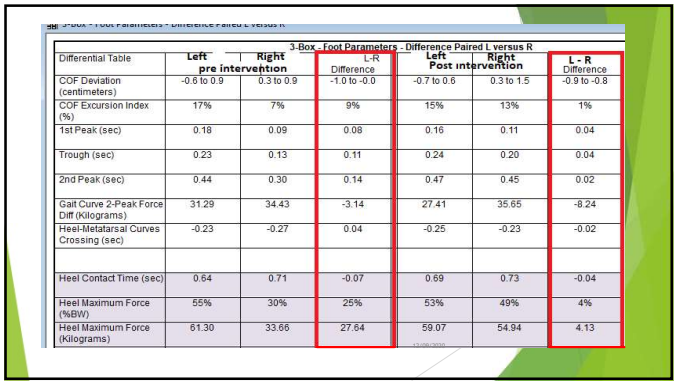

3-Box - Foot Parameters - Difference Paired L versus R

Differential Table	Left pre intervention	Right pre intervention	L-R Difference	Left Post intervention	Right Post intervention	L - R Difference
COF Deviation (centimeters)	-0.6 to 0.9	0.3 to 0.9	-1.0 to -0.0	-0.7 to 0.6	0.3 to 1.5	-0.9 to -0.8
COF Excursion Index (%)	17%	7%	9%	15%	13%	1%
1st Peak (sec)	0.18	0.09	0.08	0.16	0.11	0.04
Trough (sec)	0.23	0.13	0.11	0.24	0.20	0.04
2nd Peak (sec)	0.44	0.30	0.14	0.47	0.45	0.02
Gait Curve 2-Peak Force Diff (Kilograms)	31.29	34.43	-3.14	27.41	35.65	-8.24
Heel-Metatarsal Curves Crossing (sec)	-0.23	-0.27	0.04	-0.25	-0.23	-0.02
Heel Contact Time (sec)	0.64	0.71	-0.07	0.69	0.73	-0.04
Heel Maximum Force (%BW)	55%	30%	25%	53%	49%	4%
Heel Maximum Force (Kilograms)	61.30	33.66	27.64	59.07	54.94	4.13

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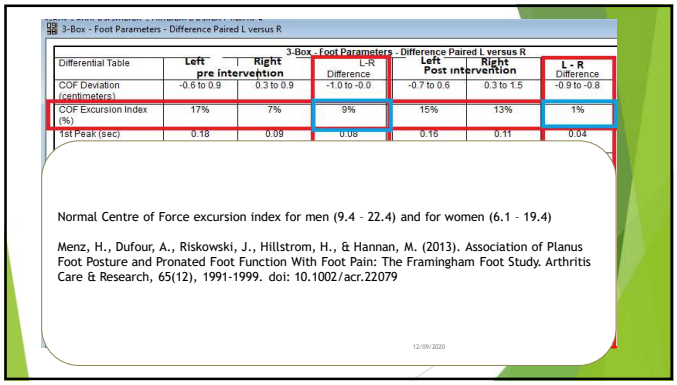

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Normal Centre of Force excursion index for men (9.4 - 22.4) and for women (6.1 - 19.4)

Menz, H., Dufour, A., Riskowski, J., Hillstrom, H., & Hannan, M. (2013). Association of Planus Foot Posture and Pronated Foot Function With Foot Pain: The Framingham Foot Study. Arthritis Care & Research, 65(12), 1991-1999. doi: 10.1002/acr.22079

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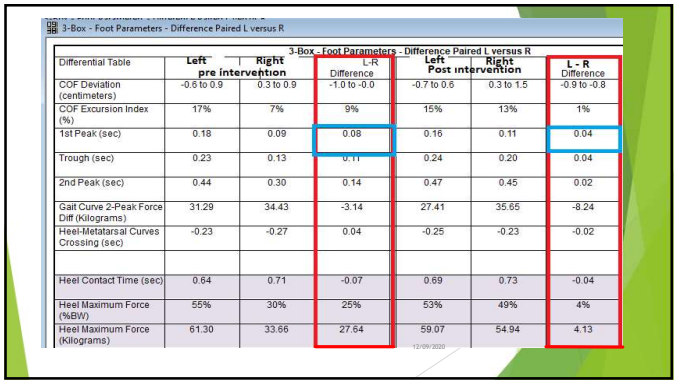

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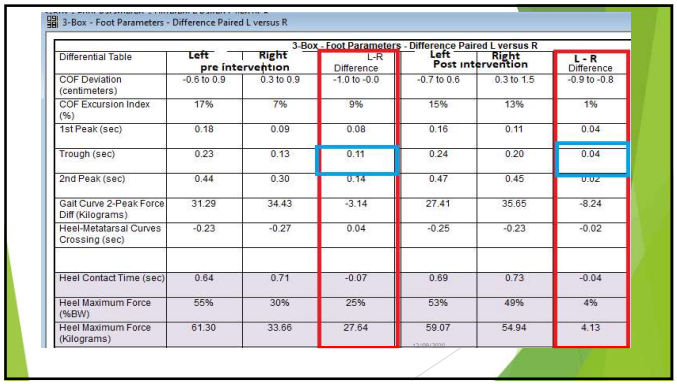

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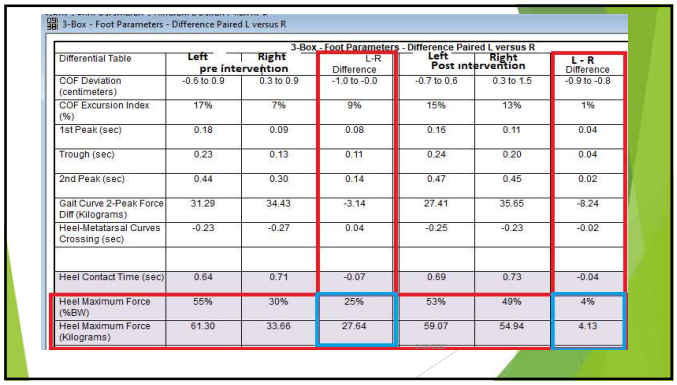

3-Box - Foot Parameters - Difference Paired L versus R

Differential Table	Left pre intervention	Right pre intervention	L-R Difference	Left Post intervention	Right Post intervention	L - R Difference
COF Deviation (centimeters)	-0.6 to 0.9	0.3 to 0.9	-1.0 to -0.0	-0.7 to 0.6	0.3 to 1.5	-0.9 to -0.8
COF Excursion Index (%)	17%	7%	9%	15%	13%	1%
1st Peak (sec)	0.18	0.09	0.08	0.16	0.11	0.04
Trough (sec)	0.23	0.13	0.11	0.24	0.20	0.04
2nd Peak (sec)	0.44	0.30	0.14	0.47	0.45	0.02
Gait Curve 2-Peak Force Diff (Kilograms)	31.29	34.43	-3.14	27.41	35.65	-8.24
Heel-Metatarsal Curves Crossing (sec)	-0.23	-0.27	0.04	-0.25	-0.23	-0.02
Heel Contact Time (sec)	0.64	0.71	-0.07	0.69	0.73	-0.04
Heel Maximum Force (%BW)	55%	30%	25%	53%	49%	4%
Heel Maximum Force (Kilograms)	61.30	33.66	27.64	59.07	54.94	4.13

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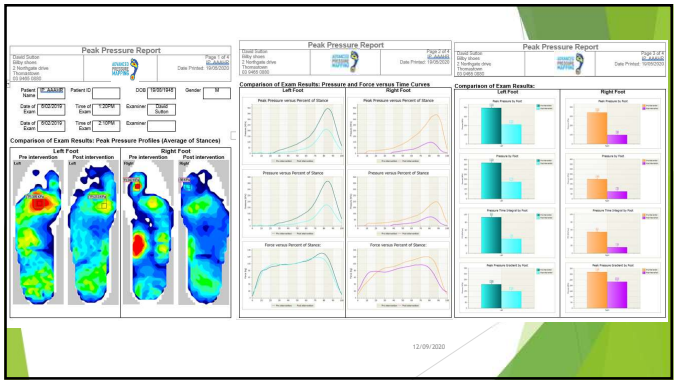

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Before and after with multidisciplinary approach,11 months on.

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Thank you.

ADVANCED PRESSURE MAPPING

All research referenced can be found here
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Q and A Discussion

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