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The Right Fit: Making Sense of Footwear and Orthotic Interventions

Colin Dombroski, PhD, C.Ped(C)

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LIFE IS
BETTER
in running shoes
CANADA


CASUAL DRESS

Historical View: ***Arch Classification*** **based**

Low = BAD / dysfunctional / Abnormal

High = Good or BAD

“**Normal**” = GOOD / Ideal

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Historical Context for CMO use / Rx

- “Correcting” “Abnormal” or “faulty” Biomechanics
- Holding a foot in it’s “Neutral” position will solve all issues
- Hard, uncomfortable plastic devices will place your foot in it’s “Correct” position.
- Industries were created and fortunes made to support this school of thought
- Clinically convenient and simple to apply

"large numbers of symptom free feet exhibit the so-called 'structural deformities,' and that these deformities are not associated with differences in foot kinematics, leads us to believe that the ***"deformities" are <u>normal</u> and <u>irrelevant</u> variations in foot alignment***."

Jarvis *et al. Journal of Foot and Ankle Research* (2017) 10:7
DOI 10.1186/s13047-017-0189-2

Journal of Foot and Ankle Research

RESEARCH Open Access

Challenging the foundations of the clinical model of foot function: further evidence that the root model assessments fail to appropriately classify foot function

Hannah L. Jarvis[1,2*], Christopher J. Nester[1], Peter D. Bowden[1] and Richard K. Jones[1]

Abstract

Background: The Root model of normal and abnormal foot function remains the basis for clinical foot orthotic practice globally. Our aim was to investigate the relationship between foot deformities and kinematic compensations that are the foundations of the model.

Methods: A convenience sample of 140 were screened and 100 symptom free participants aged 18–45 years were invited to participate. The static biomechanical assessment described by the Root model was used to identify five foot deformities. A 6 segment foot model was used to measure foot kinematics during gait. Statistical tests compared foot kinematics between feet with and without foot deformities and correlated the degree of deformity with any compensatory motions.

Results: None of the deformities proposed by the Root model were associated with distinct differences in foot kinematics during gait when compared to those without deformities or each other. Static and dynamic parameters were not correlated.

Conclusions: Taken as part of a wider body of evidence, the results of this study have profound implications for clinical foot health practice. We believe that the assessment protocol advocated by the Root model is no longer a suitable basis for professional practice. We recommend that clinicians stop using sub-talar neutral position during clinical assessments and stop assessing the non-weight bearing range of ankle dorsiflexion, first ray position and forefoot alignments and movement as a means of defining the associated foot deformities. The results question the relevance of the Root assessments in the prescription of foot orthoses.

Keywords: Static, Dynamic, Assessment, Neutral

Background

The first definitive protocol for clinical biomechanical assessment of the foot was developed by Root et al. [1, 2] which is often referred to as the "Root model" of foot function. The core concepts continue to be prominent in popular texts [3–6], debates, conferences [7–10], practice [11–17], undergraduate podiatry syllabus across the United Kingdom [Nester, personal communication, December 2016] and are highly prevalent in grey literature and online resources. These include using static assessment of the foot to infer dynamic foot kinematics [15], defining structural deformities between foot segments and advocating their correction [4, 5], and using foot shape when the sub talar joint is in a 'neutral positon' as a basis for orthotic design[4, 11, 16]. The Root model was based on the premise that in a "normal" foot the bones and joints demonstrate specific biomechanical alignments and ranges of motion and that these can be measured in a static (non-weight bearing or standing) biomechanical assessment. Abnormal alignments or movement range could also be identified through this static assessment of the foot and were classified as 'deformities.' Different deformities

* Correspondence: H.L.Jarvis@salford.ac.uk
[1]School of Health Sciences, University of Salford, Salford, UK
[2]Department of Exercise and Sport Science, Manchester Metropolitan University, Crewe Campus, Crewe, UK

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Half of what you have been taught will, in 10 years, **be proven to be wrong.**

The problem is, none of your professors know which half.

– Dr. Sydney Burwell
Dean of Harvard Medical School

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Soft Tissue Stress Theory

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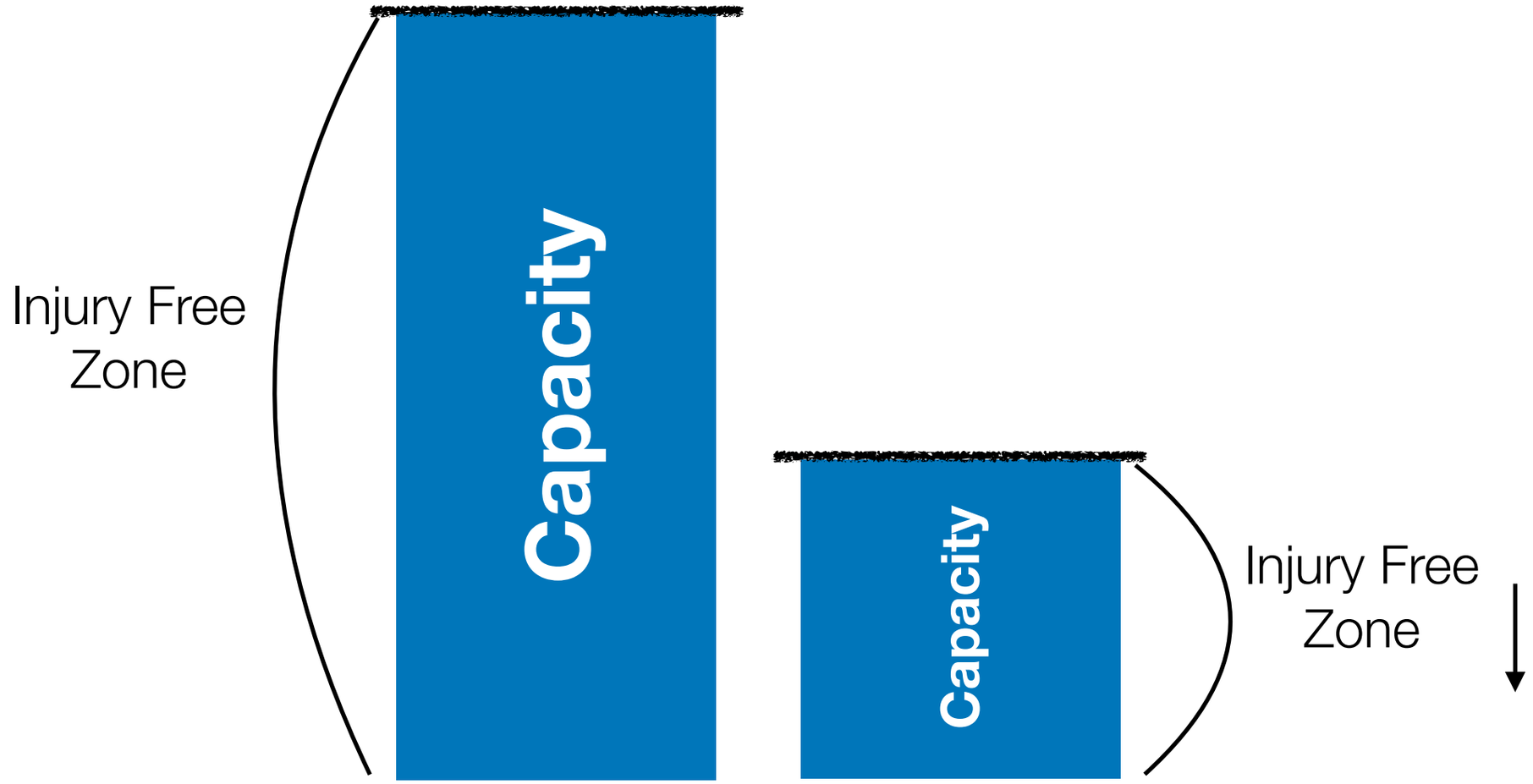
Capacity Ceiling



SELDOM INJURED
(HIGH-CAPACITY)

OFTEN INJURED
(LOW-CAPACITY)

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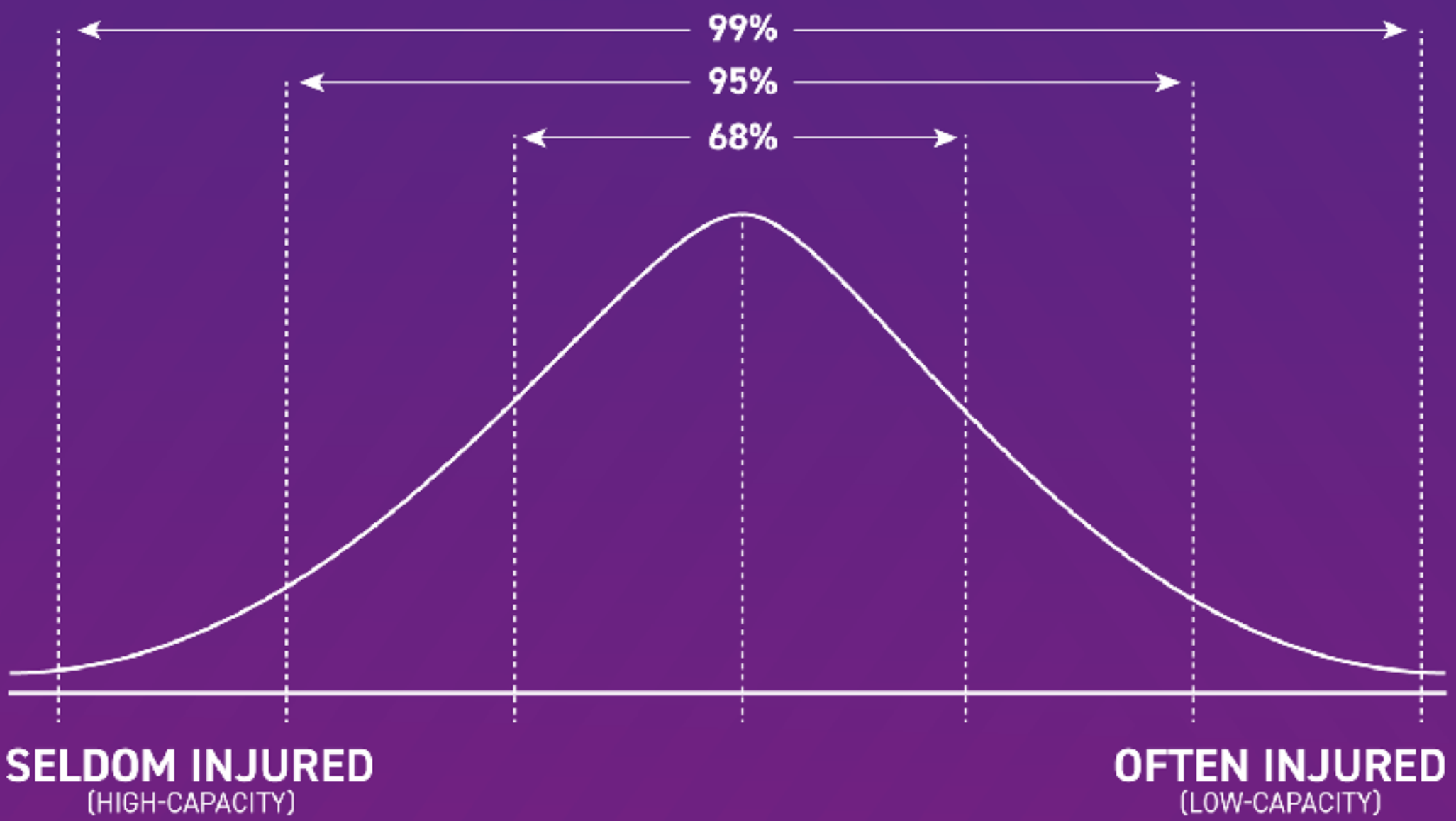

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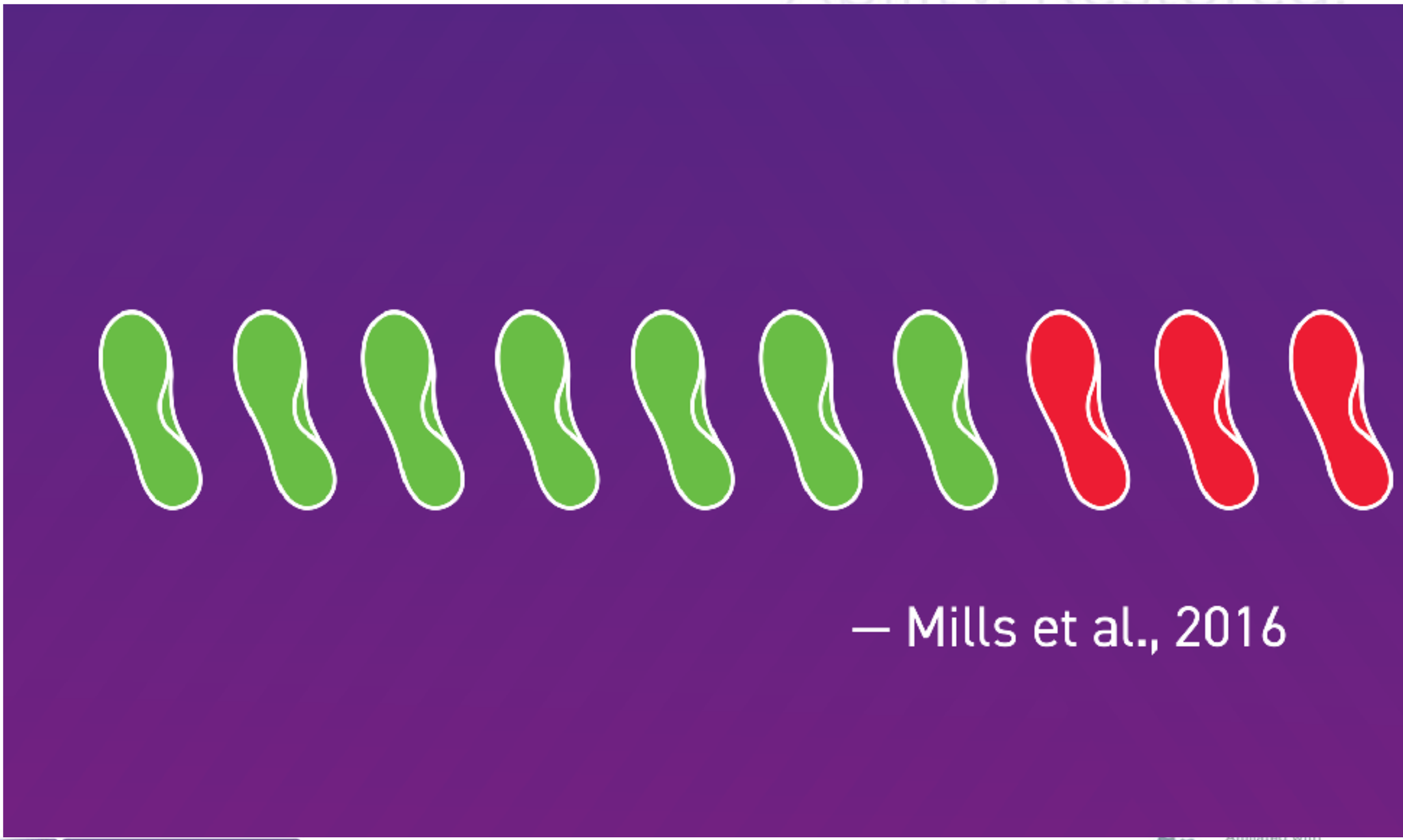
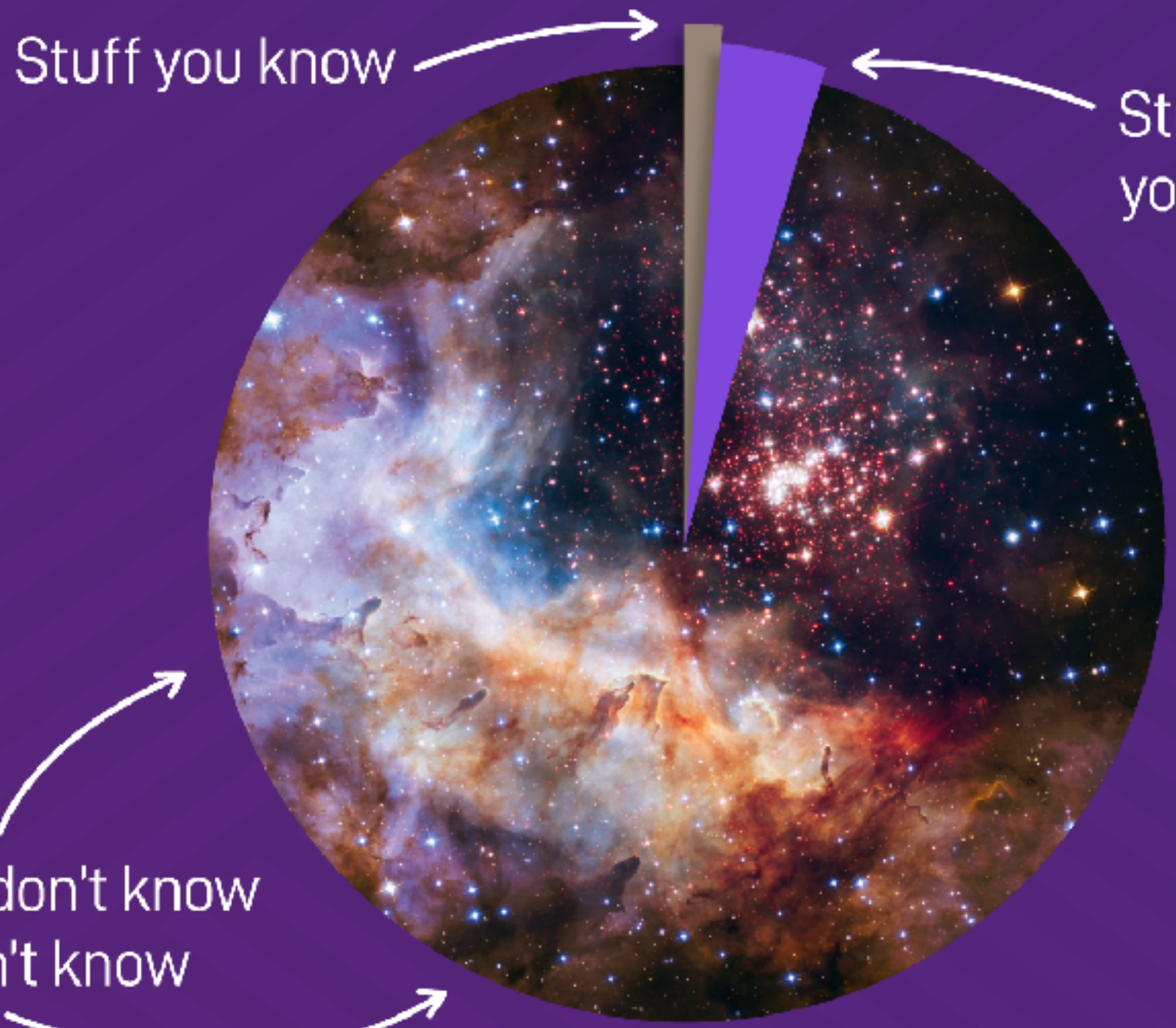
Hard = Corrective

Soft = Accommodative



— Mills et al., 2016



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Hard V Soft

- 17 Subjects recruited (mean age 27.1)

Pes Cavus

Pes Planus

Prosthetics and Orthotics International

ISPO INTERNATIONAL SOCIETY FOR PROSTHETICS AND ORTHOTICS

Original Research Report

Prosthetics and Orthotics International
2019, Vol. 43(3) 331–338

DOI: 10.1177/0309364619825607
journals.sagepub.com/home/poi
SAGE

Hard, soft and off-the-shelf foot orthoses and their effect on the angle of the medial longitudinal arch: A biplane fluoroscopy study

Megan Balsdon[1], Colin Dombroski[2], Kristen Bushey[1] and Thomas R Jenkyn[1]

Abstract

Background: Foot orthoses have proven to be effective for conservative management of various pathologies. Pathologies of the lower limb can be caused by abnormal biomechanics such as irregular foot structure and alignment, leading to inadequate support.

Objectives: To compare biomechanical effects of different foot orthoses on the medial longitudinal arch during dynamic gait using skeletal kinematics.

Study design: This study follows a prospective, cross-sectional study design.

Methods: The medial longitudinal arch angle was measured for 12 participants among three groups: pes planus, pes cavus and normal arch. Five conditions were compared: three orthotic devices (hard custom foot orthosis, soft custom foot orthosis and off-the-shelf Barefoot Science©), barefoot and shod. An innovative method, markerless fluoroscopic radiostereometric analysis, was used to measure the medial longitudinal arch angle.

Results: Mean medial longitudinal arch angles for both custom foot orthosis conditions were significantly different from the barefoot and shod conditions ($p < 0.05$). There was no significant difference between the off-the-shelf device and the barefoot or shod conditions ($p > 0.05$). In addition, the differences between hard and soft custom foot orthoses were not statistically significant. All foot types showed a medial longitudinal arch angle decrease with both the hard and soft custom foot orthoses.

Conclusion: These results suggest that custom foot orthoses can reduce motion of the medial longitudinal arch for a range of foot types during dynamic gait.

Level of evidence: Therapeutic study, Level 2.

Clinical relevance

Custom foot orthoses support and alter the position of the foot during weightbearing. The goal is to eliminate compensation of the foot for a structural deformity or malalignment and redistribute abnormal plantar pressures. By optimizing the position of the foot, the medial longitudinal arch (MLA) will also change and quantifying this change is of interest to clinicians.

Keywords

Foot orthoses, medial longitudinal arch, fluoroscopy, radiostereometric analysis

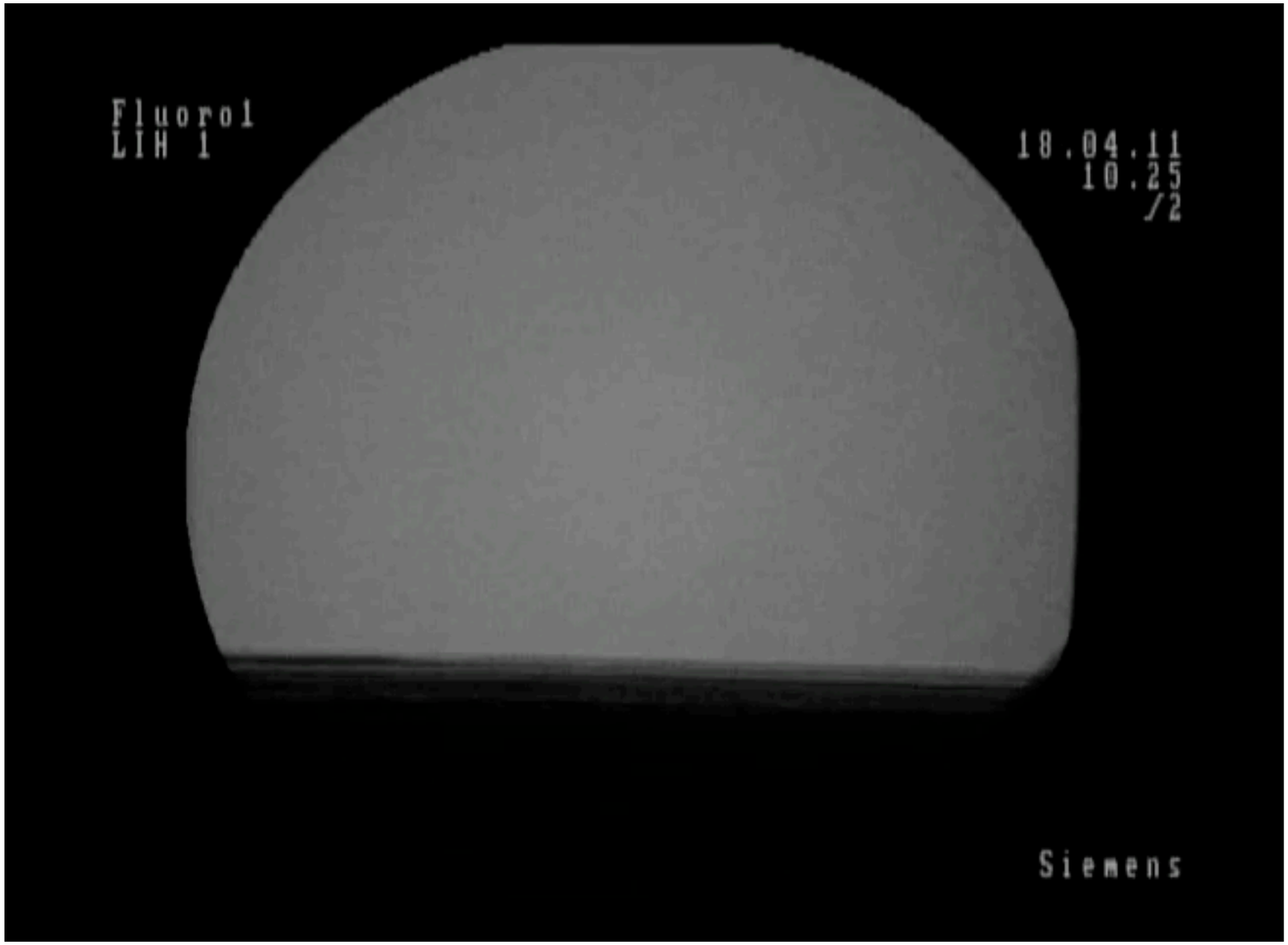
Date received: 15 March 2018; accepted: 30 December 2018

Background

Custom foot orthoses (CFOs) have proven to effectively manage various pathologies of the lower extremities.[1–4] Pathologies associated with the lower back, upper and lower legs, as well as general foot pain can be a result of poor biomechanics, such as in altered foot alignment in pes planus (flat foot/low arch) and pes cavus (high arch).[5,6] A pes cavus foot typically presents with an uneven distribution of weight along the metatarsal heads and lateral border of the foot and tends to have a more rigid medial

[1]Faculty of Engineering, Western University, London, ON, Canada
[2]SoleScience Inc., London, ON, Canada

Corresponding author:
Megan Balsdon, Faculty of Engineering, Western University, London, ON N6A 5B9, Canada.
Email: mbalsdon@uwo.ca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Siemens

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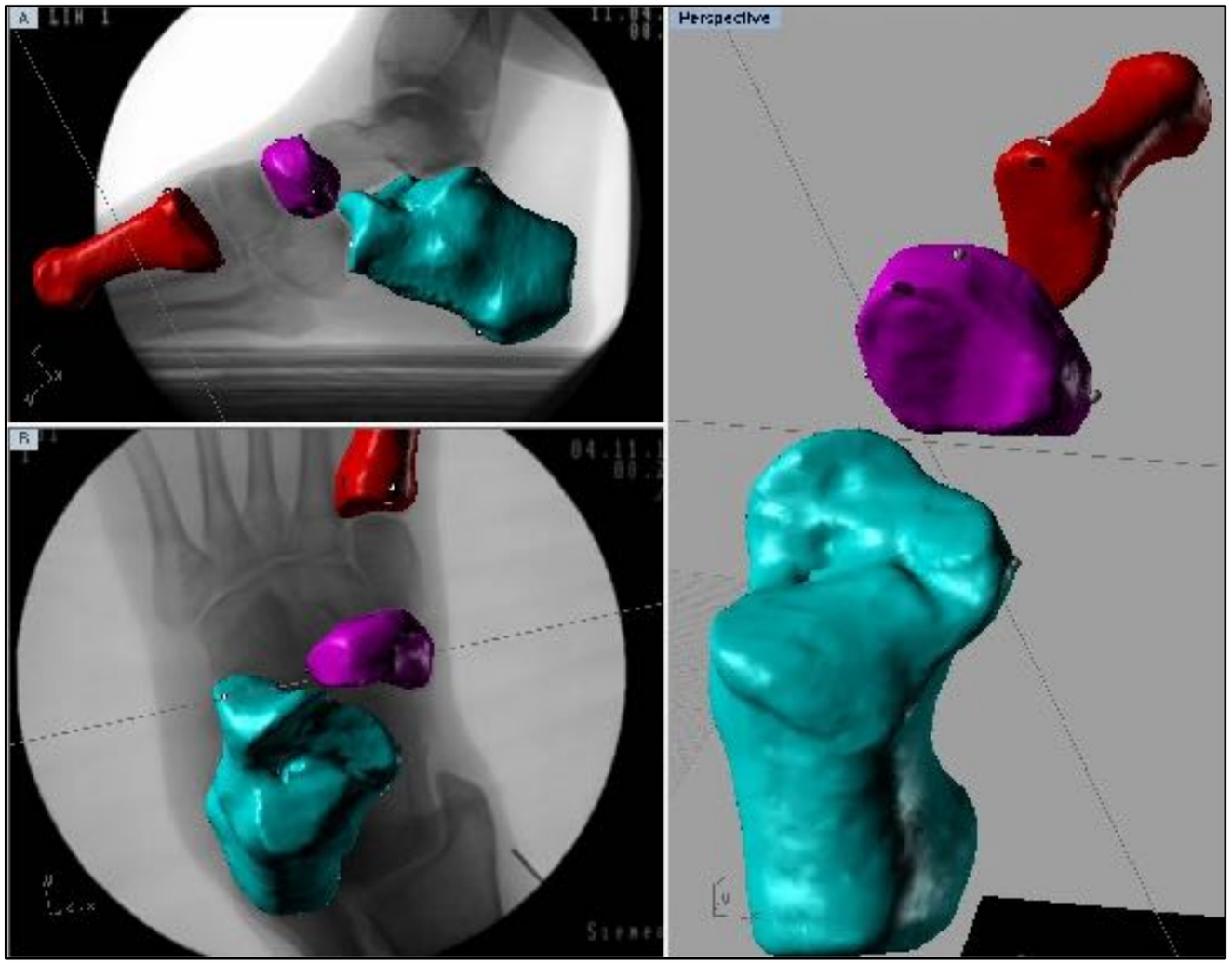
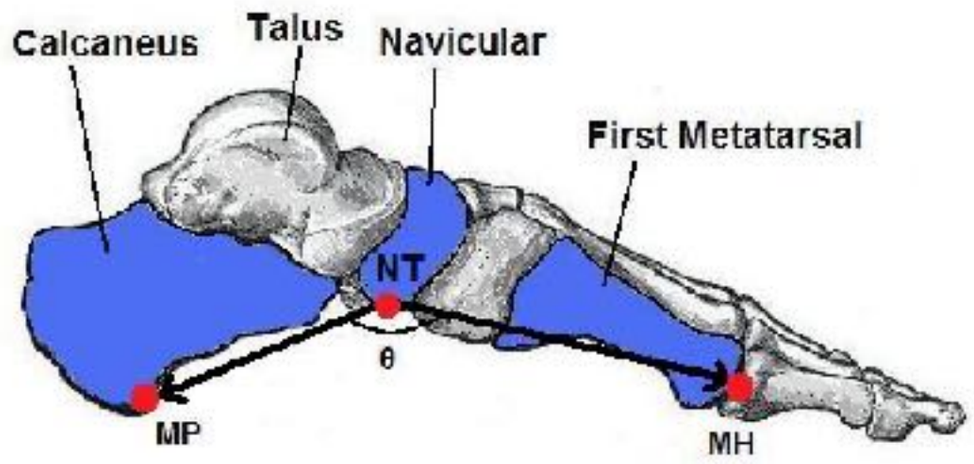
Matching & Analysis





$$\mathrm{MLA}(\theta) = \cos^{-1}\left[\frac{(\overrightarrow{\mathrm{NTMP}} \cdot \overrightarrow{\mathrm{NTMH}})}{(|\mathrm{NTMP}| \cdot |\mathrm{NTMH}|)}\right]$$

Rhinoceros (Robert McNeel & Associates)

Summary (Hard vs. Soft)

- No significant difference between:
  - Hard & Soft orthotics (p=0.834)
- **Significant** difference between:
  - *Hard and Soft orthotics compared to barefoot*
  - *Hard and soft orthotics compared to shoe*
- No significant difference between:
  - Barefoot Science and Barefoot/Shoe conditions (p=0.712)

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it's **feedback**, **compliance**,
and **trust**

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Falls Risk increase:

* Pain
* Hallux Valgus
* Toe deformities

Maturitas 118 (2018) 7–14

Contents lists available at ScienceDirect

Maturitas

journal homepage: www.elsevier.com/locate/maturitas

Foot problems as a risk factor for falls in community-dwelling older people: A systematic review and meta-analysis

Hylton B. Menz[a,*], Maria Auhl[a], Martin J. Spink[b]

[a] School of Allied Health, College of Science, Health and Engineering, La Trobe University, Melbourne, Victoria 3086, Australia
[b] School of Health Sciences, Faculty of Health, University of Newcastle, Ourimbah, New South Wales, 2258, Australia

ARTICLE INFO

Keywords:
Foot problems
Ageing
Accidental falls

ABSTRACT

Background: Foot problems are common in older people. The objective of this systematic review was to determine whether foot problems increase the risk of falling in community-dwelling older people.
Methods: Electronic databases were searched from inception to May 2018. To be eligible for inclusion, papers needed to (i) include community-dwelling older participants, (ii) document falls either retrospectively or prospectively, and (iii) document or assess the presence of foot problems. Screening and data extraction were performed by two independent assessors, with disagreements resolved by consensus.
Results: A total of 146 papers were screened by title and abstract, and nine met the inclusion criteria. An additional six eligible papers were identified by searching the reference lists of included papers, resulting in a total of 15 papers. Quantitative synthesis indicated that older people who fell were more likely to have foot pain, hallux valgus, lesser toe deformity, plantar fasciitis, reduced ankle dorsiflexion range of motion, reduced toe plantarflexion strength, impaired tactile sensitivity and increased plantar pressures when walking. Meta-analysis indicated that fallers were more likely to have foot pain (pooled odds ratio [OR] 1.95, 95% CI 1.38–2.76, $p < 0.001$), hallux valgus (pooled OR 1.89, 95% CI 1.19–3.00, $p = 0.007$) and lesser toe deformity (pooled OR 1.67, 95% CI 1.07–2.59, $p = 0.020$).
Conclusion: Foot problems, particularly foot pain, hallux valgus and lesser toe deformity, are associated with falls in older people. Documentation of foot problems and referral to foot care specialists should therefore be a routine component of falls risk assessment and prevention.

1. Introduction

Falls in older people are a major public health problem and are responsible for substantial morbidity and mortality in this age-group [1]. The aetiology of falls is multifactorial, and over 150 risk factors for falls have been identified. These risk factors include medical conditions (such as Parkinson's disease, stroke and dementia), medications (such as psychotropics and antidepressants) and sensorimotor impairments (such as muscle weakness, slow reaction time and poor balance) [2]. Detailed screening of these factors can assist in identifying older people at elevated risk of falling and inform the selection of interventions targeted at these deficits [3].

Foot problems, which affect between 20 and 45% of older people [4], may also contribute to falls in this population. The foot provides the only direct source of contact with the ground when performing weight-bearing activities, and therefore plays an important role in stabilising the body when negotiating uneven or compliant surfaces [5]. With advancing age, the foot exhibits increased soft tissue stiffness, reduced strength and range of motion, and a more pronated (flat) posture [6], and is more susceptible to the development of structural disorders such as hallux valgus and lesser toe deformity [7]. These changes may impair balance, functional ability and gait patterns, thereby increasing falls risk [8].

To date, there have been no systematic reviews to consolidate and critique the available research literature exploring the association between foot problems and falls. Therefore, the aim of this study was to conduct a systematic review and meta-analysis to determine the extent to which foot problems (including both foot pain and structural foot disorders) are associated with falls in community-dwelling older people.

2. Methods

This review was conducted according to the Preferred Reporting

* Corresponding author.
E-mail address: h.menz@latrobe.edu.au (H.B. Menz).

https://doi.org/10.1016/j.maturitas.2018.10.001
Received 4 September 2018; Received in revised form 1 October 2018; Accepted 1 October 2018

Toe Flexor Strength

Associated with falls.

Matsuno *et al. Journal of Foot and Ankle Research* (2022) 15:42
https://doi.org/10.1186/s13047-022-00548-1

Journal of
Foot and Ankle Research

RESEARCH Open Access

Toe grip force of the dominant foot is associated with fall risk in community-dwelling older adults: a cross-sectional study

Satoshi Matsuno[1,2], Atsushi Yoshimura[1], Takuya Yoshiike[3], Sachiyo Morita[1,4], Yusuke Fujii[5], Motoyasu Honma[6], Yuji Ozeki[1] and Kenichi Kuriyama[1,3*]

Abstract

Background: It is unclear whether the toe grip force (TGF) of the dominant foot (DF) and the lower limb function asymmetry (LLFA) in older adults are associated with fall risk. Therefore, this study aimed to investigate the effect of lower limb properties (such as TGF, muscle strength, and plantar sensation) on the risk of falls in older adults, while considering the foot dominance and asymmetry of lower limb function.

Methods: This study was a cross-sectional study. We determined whether the lower limb function of the DF and non-dominant foot (non-DF) and LLFA had any effect on the fall risk in 54 older adults (mean ± standard deviation: 72.2 ± 6.0, range: 60–87 years). We examined the participants' fall history, Mini-Mental State Examination (MMSE) score, lower limb function, and LLFA. To determine fall risk factors, we performed logistic regression analysis, with presence or absence of falls as the dependent variable.

Results: The independent variables were age, sex, MMSE score, two-point discrimination of the heel (non-DF) as plantar sensation index, and the TGF of both feet. Only the TGF of the DF was identified as a risk factor for falls ($p < 0.05$).

Conclusions: In older adults, clinicians should focus on the TGF of the DF as a risk factor for falls.

Trial registration: This study was retrospectively registered. https://center6.umin.ac.jp/cgi-bin/ctr/ctr_up_rec_f1.cgi.

Keywords: Limb dominance; asymmetry; lower limb, Toe grip force, Dominant foot, Lower limb function asymmetry

Background

More than one-third of older adults aged ≥65 years experience falls in the United States (US) [1], and approximately 6% of older people who fall sustain bone fractures [2]. It has been reported that medical expenses for injuries caused by falls, which contribute to an increase in medical expenses in the US, exceed $31 billion [1]. In addition, the consequent frailty of bones after fracture in older adults imposes critical clinical and economic burdens on the society. Therefore, to maintain the health of older adults and reduce medical expenses, it is crucial to prevent falls among older adults.

Physical deterioration caused by aging-related factors, such as muscle weakness, sensory deficits, and balance dysfunction, is a well-known risk factor for falls [3, 4]. Toe grip force (TGF) affects balance and is a risk factor

* Correspondence: kenichik@ncnp.go.jp
[3]Department of Sleep-Wake Disorders, National Institute of Mental Health, National Center of Neurology and Psychiatry, Tokyo, Japan
Full list of author information is available at the end of the article

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	Durometer		Durometer
Ghost 16	42C	Glycerin 22	40C
Ghost 15	50C	Glycerin 21	42C
Ghost 14	53C	Glycerin 20	42C
Ghost 13	50C	Glycerin 19	50C
Ghost 12	50C	Glycerin 18	53C
Ghost 11	50C	Glycerin 17	53C
Ghost 10	50C	Glycerin 16	53C
Ghost 9	55C	Glycerin 15	55C
Ghost 8	55C		

Critical Stability Features

- Heel to toe drop (less is more) 6-10mm as tolerated
- Midfoot Width
- Midsole Stiffness

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6mm difference

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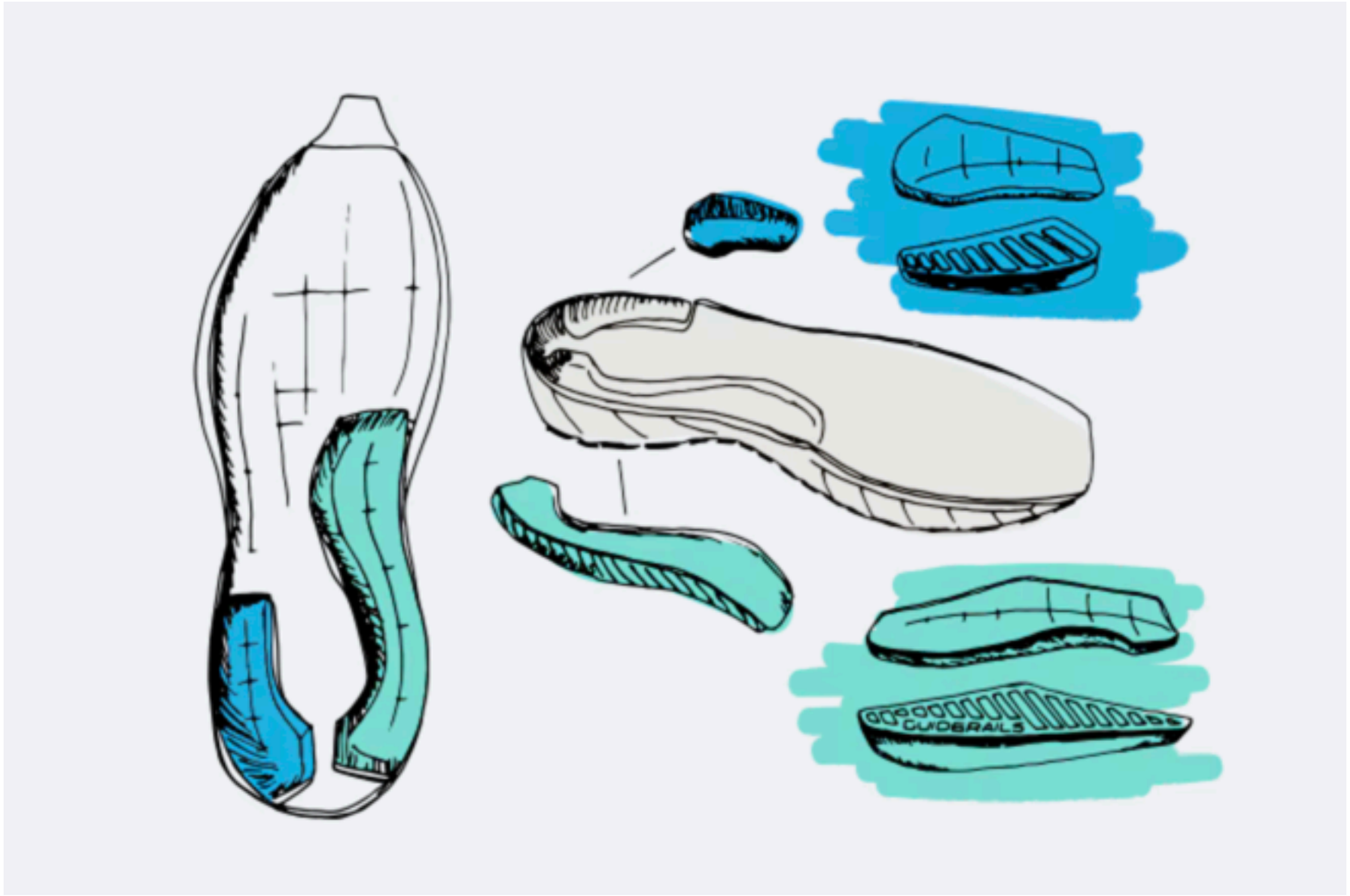
saucony


CUPERAIL 5

Go to Shoes for Adding Stability

- **Brooks**
  - *Ariel / Beast, Adrenaline, Ghost Max 2, Addiction Walker*
- **New Balance**
  - *860, 928, 1540*
- **Asics**
  - *Kayano, Gt-2000, Gt-1000*

Go to Shoes for Adding Cushioning

- **Brooks**
    - Ghost / Ghost Max 2, *Glycerin,*
- **New Balance**
    - *1080, 880*
- **Asics**
    - *Cumulus, Nimbus*

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Footwear & Orthoses are load modifying devices that help people do more with less pain.

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Many thanks to CCAA the symposium committee

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colin@solescience.ca