2014 ESM

Proceedings

Expert Scientific Meeting

on Load Distribution Measurement

July 2 - 6, 2014

Cambridge, Massachusetts, USA

The Sheraton Commander Harvard Square

www.esm2014.com

art science

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art.science

Host

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Scientific Chair

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Workshops

Axel Kalpen, Ahmad Dahrouj, Maria Pasquale, Jake Shanesy

Organizing Committee

Vera Novak, Howard J. Hillstrom
Susan Diekrager, Maria Pasquale, Daniela Jírová-Enzmann, Jake Shanesy

Sponsors

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Content

ESM 2014 Program

Welcome

Welcome to Boston

It is my pleasure to welcome you to Cambridge for the 2014 ESM conference.

Boston played a central role in American history, and it remains the political, commercial and educational center of the New England region. The city is the intellectual and educational hub, and the home to the cluster of historic universities and colleges, providing opportunities for education and scientific training to thousands of students. Medicine, biomedical research and biotechnology are the most popular subjects of study.
Our conference center in Cambridge is just minutes away from the Harvard University and Massachusetts Institute of Technology, within the area that is bustling with life and professional events.

The meeting that we have planned for you should be particularly exciting both scientifically and socially. The scientific program will combine 36 oral presentations from over 60 submitted abstracts, poster sessions, a workshop for novel users and four interesting keynote lectures.
In addition to the outstanding scientific program, you will have the opportunity to explore the history and cultural diversity of the city and beyond. You will have opportunity to walk through the Harvard University campus and visit the Harvard Museum of Natural History.

The 4th of July celebrations, on our networking day, will take you on historic tours including the Longfellow House National Historic Site. A Boston harbor cruise will sail up the coast and out into the sunset while whale watching and then return so you can further enjoy the fireworks and other festivities.

On behalf of the ESM organizing committee, it gives me great pleasure to host this event. Enjoy the meeting and your stay in Cambridge and Boston!

Best regards,

Vera Novak, MD PhD
Associate Professor of Neurology
Harvard Medical School
Director Syncope and Falls in the Elderly Laboratory
Beth Israel Deaconess Medical Center

Host

We are very happy that Dr. Vera Novak from the Beth Israel Deaconess Medical Center, a major teaching hospital of Harvard Medical School, will be hosting ESM 2014 in Cambridge, Massachusetts.

Vera Novak, MD, PhD
Associate Professor of Neurology
Harvard Medical School
Beth Israel Deaconess Medical Center
Department of Neurology

Dr. Novak is Director of the Syncope and Falls in the Elderly (SAFE) Laboratory, Associate Professor of Neurology, Stroke Division at Harvard Medical School, and Adjunct Professor of Mathematics at North Carolina State University.
She graduated from Charles University Medical School and obtained her PhD form the Czech Academy of Sciences.
Dr. Novak continued her training at University of Montreal and McGill University, Montreal CA, and Mayo Clinic Rochester MN, U.S. and served as director of Autonomic laboratory at the Ohio State University. In 2001, she founded the SAFE laboratory at the Beth Israel Deaconess Medical Center, Harvard Medical School, Boston U.S.

The SAFE Program utilizes a multidisciplinary approach to understand, model and prevent the problem.

The SAFE Program mission is to determine factors that set the stage for decline in brain function and loss of independence in older adults. SAFE studies the mechanisms by which clinical, environmental, and hereditary factors lead to age-related disorders, abnormalities in systemic regulation and functional decline in older adults.

Dr. Novak's area of interest is to study the effects of life style disorders (obesity, diabetes, hypertension) on well-being of older adults, falls and cognitive decline. She has designed new strategies to promote successful aging.
Implementation of preventive and treatment strategies using novel interventions, modeling and simulations may help to facilitate well-being of people as they age.

Review ESM 2012

The 13th ESM (Expert Scientific Meeting) was hosted by Professor Uwe Kersting and his team at the Department of Health Science and Technology and Center for Sensory-Motor Interaction at Aalborg University, Aalborg, Denmark in 2012. The meeting was an impressive and enjoyable event shared by over 120 scientists who attended from 20 different countries, to make the 13th user meeting a great success.

Written by Uwe Kersting

It is always with great pleasure to remember the hosting of the ESM in Aalborg, North Jutland, in August 2012. The time spent on preparing, conducting and following up on this meeting will always stay in our minds as one of the nicest experiences in relation to scientific and social interactions you can make within your professional life.

On the 1st day, workshops and laboratory tours were delivered at the Department of Health Science and Technology on the University Campus on the eastern rim of Aalborg. Workshops included recent advances in new technology by novel. Current software developments for the evaluation of pedographic data in clinical and scientific settings were presented as well as sessions on applied topics in pressure distribution measurements by advanced users of novel systems. Participants were also given the opportunity of visiting various laboratories at the Center displaying newest technology and research developments in neuroscience, pain research and biomechanics. In the evening we experienced a reception at Kunsten, the Aalborg Museum of Modern Art, hosted by the City Council accompanied by Jazz music and a tour through the art exhibition.

Scientific sessions took place at the Utzon Center with spectacular views onto the fjord in the city centre of Aalborg on day 2 and 4 of the meeting. Forty oral presentations, 30 posters and four keynote talks were presented covering a multidisciplinary picture of science and innovation setting the stage for engaged discussions. For the first time, posters were introduced by a short 'poster power presentation' and the new MPP award was introduced and awarded to Sabata Gervasio, DK. The Best Poster and Best Presentation Awards were received by Roshna Wunderlich, James Madison University, Harrisonburg, VA, USA, and Sicco Bus, Academic Medical Center, Amsterdam, The Netherlands, respectively. The joint winners of the Art in Science Award were Karsten Engel, German Sport University Cologne, Institute of Biomechanics and Orthopaedics, Cologne, Germany and Roelof Waaijman, Academic Medical Center, Amsterdam, The Netherlands.

In the evenings, delegates experienced various Aalborgian highlights always paired with music, arts and good food. Day 1 was concluded by dinner on the boat 'Prinses Juliana' a historical, floating restaurant.

In good ESM tradition, while being somewhat lucky with the weather, the networking day took place on 'Rebild Bakker', in the Rold forest, just a short drive south of the city. Everyone was given the opportunity to clear their head and use up some calories by orienteering tasks, walking or MTB tours exploring the terrain and bushes of an unexpectedly hilly natural reserve. These rather modern ways of recreational pastime were followed by a jaunt into the dark history of Jutland with hands-on experiences in survival activities

required from gangs of brigands foraging these forests only a few centuries ago. Naturally, the event was concluded by a roast on a spit accompanied by some cool beers running down dried out throats. In the evening we gathered in the Nordkraft building at 'Café Azzurra', allowing for a multi-faceted impression of Danish life style, the Danish sense of sharing and community and Danish design. On day 3, the final award evening was arranged at the Obel Auditorium in the Utzon Center, now decorated to embark for an exquisite dinner. The dinner was opened by one of Henriette Gärtner's amazing piano performances, setting the stage for award presentations, enjoying the food, the views and reviewing the meeting by socializing in a relaxed atmosphere.
The team at HST and SMI worked closely together with the team at novel, headed by Daniela, without whom the whole undertaking would have been impossible. Thanks to that, ESM 2012 was perceived by many as one of the most relaxed ESM meetings, living up to the historically high and diverse standards as we had the greatest number of presentations ever. All experienced ESM attendees confirmed that it would be necessary to continue this biannual event while all first-timers were impressed by the diversity and high scientific level of this special event.

novel, go for ESM 2014 wherever it might be – we'll be there!

Scientific and art in science award Committee

Scientific chair

Howard J. Hillstrom, PhD
Leon Root, MD Motion Analysis Laboratory
Hospital for Special Surgery
510 East 73rd Street, Ground floor
New York, NY 10021, USA
e-mail: HillstromH@HSS.EDU

We are very pleased that Dr. Howard Hillstrom, Hospital of Special Surgeries, New York, has accepted to chair the art in science scientific committee for the first time!

Howard J. Hillstrom has directed the Leon Root, M.D. Motion Analysis Laboratory at HSS since 2005. His main research activity is in the biomechanics of posture and locomotion and the underlying neuromuscular physiology of healthy, athletic, and pathological individuals. Exploration of how lower extremity structure and function are related to human movement with special attention to osteoarthritis is a central theme in his research. Dr. Hillstrom has conducted over 75 research studies in predominantly lower extremity pathomechanics and has over 70 peer reviewed publications disseminating his work.

In alphabetical order:

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art in science award

In 1991, the first novel award was presented in recognition of excellence in pressure distribution research. The novel award recipient was determined by an international review committee from the fields of biomechanics and medicine. The novel award for pressure distribution measurement research continued since then to be endowed by novel and the best scientific manuscript in the field of load distribution measurement will receive the 2014 art in science award with a prize of US$ 5,000. The paper must be entirely original, not published at the time of the meeting in any journal nor submitted for publication to any journal or book. The paper must describe a scientific study including pressure distribution measurement. Five abstracts were nominated for the art in science award.
From the year 2010 on, the "novel award" is named the "art in science award". It is intended to award the prize also to scientists presenting papers not only associated with pedography or foot biomechanics.

The nominated authors were requested to send a full length paper and will present the paper at the meeting during a 25 minute talk. The review of the papers will be conducted by the scientific review committee. The art in science award will be presented to the winner at the final reception on Saturday evening, July 5, 2014.

Previous Winners

Aalborg, 2012, Karsten Engel, Germany
Aalborg, 2012, Roelof Waaijman, The Netherlands
Providence, 2010, Josh Slane, USA
Dundee, 2008, Scott Wearing, UK
Spitzingsee, 2006, Wolfgang Potthast, Germany
Leeds, 2004, Joshua Burns, Australia
Leeds, 2004, Mark Thomson, Germany
Kananaskis, 2002, Katrina S. Maluf, USA
Munich, 2000, Matthew Nurse, Canada
Calgary, 1999, Brian Davis, USA
Brisbane, 1998, Margaret Hodge, Australia
Tokyo, 1997, Erez Morag, USA
Pennstate, 1996, Dieter Rosenbaum, Germany
Ulm, 1994, Michael Morlock, Germany
Vienna, 1991, Benno Nigg, Canada

Roelof Waaijman and Karsten Engel, winner of the art in science award 2012
with Michael Morlock, ESM 2012 Scientic Chair

Roshna Wunderlich, the winner of the poster award 2012
with Uwe Kersting, ESM 2012 host and Peter Seitz, CEO novel gmbh

Poster & Presentation Awards
MPP - Most Promising Proposal

Best Presentation Award

Will be presented during the final reception on Saturday evening, July 5, 2014.
The award is based on voting of the scientific committee.
The award winner will receive a prize of US$ 1,000.

Best Poster Award

Will be presented during the final reception on Saturday evening, July 5, 2014.
The award is based on voting of the scientific committee.
The award winner will receive a prize of US$ 1,000.

MPP Award
Most Promising Proposal

Anyone who has not defended his or her PhD prior to the first conference day (July 2, 2014) is eligible for this award. The goal is to present a project proposal which includes the investigation of load distribution on the human or animal body. The topic area can be freely chosen and a document of maximum two pages (excl. reference list) must be submitted to the session chair not earlier than one hour before the award session starts (seven printed copies have to be provided). No prior disclosure of the title, topic area or any details of the proposed study are allowed.

Proposals fitting the requirements will be presented in a separate award session on July 5, 2014.
The main author will have three minutes for a presentation of the study background, concept and plan followed by a three-minute discussion. The presentation should be only verbal, no slides, no poster or PPT are allowed. The award committee will consist of three members of the scientific committee plus three randomly selected ad hoc members.

The winner will be the most innovative, relevant and most convincingly presented proposal.
The winner will be presented at the final conference banquet.
The prize money is US$ 1,000.

Sicco Bus, the winner of the presentation award 2012
with Uwe Kersting, ESM 2012 host

Sabata Gervasio, the winner of the MPP award 2012
with her advisor, Natalie Mrachacz-Kersting and Uwe Kersting, ESM 2012 host

Networking Day
Friday, July 4th, 2014

The 4th of July is one of the most exciting of the US holidays. For those of you who are less familiar with the date, Independence Day commemorates America's signing of the Declaration of Independence on July 4, 1776, declaring independence from the Kingdom of Great Britain. As we will learn through some of the Networking Day's activities, Boston's history is intertwined with the American Revolution and the Independence Day celebrations here are unlike any other in the country!

Morning Event - Cambridge Area Tours

Longfellow House and Gardens

The Longfellow House was built in 1759 by John Vassall, a wealthy royalist. In 1774, he and his family hastily abandoned their estate and fled to British protection in Boston on the eve of the Revolutionary War. Starting in July 1775, George Washington used the house as his headquarters for almost nine months during the siege of Boston. During this time he was visited by Benjamin Franklin, John Adams, John Hancock, and other revolutionary leaders. Henry Wadsworth Longfellow, the famed American poet, moved into the home in 1836 as a boarder, and later in 1843 his father-in-law purchased the home as a wedding gift. He lived in the home until his death in 1882. The Longfellow family was the last family to live in the home establishing the Longfellow Trust in 1913 for preservation of the home, and finally in 1972 donating the home and its furnishings making it part of the National Park Service.

Cambridge Running Tour

Join some of our more active ESM attendees for a guided run throughout Cambridge. We will run past a number of historic and beautiful sites while enjoying some exercise. Runners of all levels are invited to join!

Harvard Yard Walking Tour

Join some of your novel friends for a guided walk with a Harvard Historian and Storyteller around Harvard Yard. We will visit some of the historic and notable buildings and locations on the campus of the oldest University in the United States. We will learn about Harvard's impact on the world of education, and its impact around the globe.

Afternoon Event - Boston Red Sox Game

Baseball is one of the oldest pastimes in the US and is synonymous with the 4th of July! Fenway Park, home of the Boston Red Sox since 1912, is the oldest baseball stadium in use. It is one of the most popular baseball stadiums and has had sold out games consecutively from 2003-2013. We will get to enjoy the festivities before the game on Yawkey Way (food, vendors, street performers, etc) and then sit in the bleachers for an exciting game!

Evening Event - Whale Watching Dinner Cruise with Fireworks from the Boat!

This experience will be truly unique in many ways! On the cruise we will have the opportunity to both see and hear whales in the Boston Harbor. We will head up the coast enjoying spectacular views while searching for whales. As the day nears an end we will head back to Boston Harbor having the opportunity to see fireworks displays as we travel down the coast and finally ending in Winthrop MA for a spectacular fireworks show.

Piano Concert by Henriette Gärtner

Art in Science Concert
Saturday, July 5th, 2014
Cambridge, Massachusetts, USA
The Edward M. Pickman Concert Hall
at the Longy School of Music

Carl NIELSEN (1865-1931)
Six humorous bagatelles op.11 (Humoresken-Bagatellen)
Nr.1: Good morning! (Allegretto)
Nr.2: The spinning top (Presto)
Nr.3: A little slow waltz (Valse lento)
Nr.4: Jumping Jack (Poco Allegretto)
Nr.5: Doll`s march (Allegro moderato)
Nr.6: The musical clock (Allegretto scherzando)

Robert SCHUMANN (1810-1856)
Carnaval op.9
Scènes mignonnes sur quartes notes
Préambule, Pierrot, Arlequin, Valse noble, Eusebius, Florestan, Coquette, Réplique, Papillons, A.S.C.H.- S.C.H.A. (Lettres dansantes), Chiarina, Chopin, Estrella, Reconnaissance, Pantalon et Colombine, Valse allemande, Paganini, Aveu, Promenade, Pause, Marche des „Davidsbündler" contre les Philistins

Henriette Gärtner, piano

Henriette Gärtner grew up in Germany's Black Forest. She started to learn how to play the piano by the age of three and by the age of five had given her first large concert in the capital city of Stuttgart. In 1983, as an eight year old, she garnered international attention and recognition when she performed with the *"Festival Strings Lucerne"* under Rudolf Baumgartner at the International Musical Festival Weeks in Lucerne. In that same year, she also played with the Stuttgart Chamber Orchestra under Karl Münchinger.

Following these large scale performances were numerous master courses and artistic encounters with prominent pianist colleagues as well as honors and awards presented at a variety of piano competitions. She engaged in extensive concert recitals in many European music centers in addition to tours and concerts in the USA, South America, and South Africa. Henriette become involved with CD and DVD recordings, radio productions, and television appearances throughout this time as well.

From 2001 to 2005, the critically acclaimed pianist finished her professional artistic training with a further program of study at the Accademia Pianistica Incontri col Maestro in Imola, Italy. This time was spent under the direction of Leonid Margarius, a student of Regina Horowitz (sister of the legendary pianist Vladimir Horowitz).

"A life without music," says Henriette Gärtner introspectively, *"would be unthinkable"* for her. As Friedrich Nietzsche correctly claimed, *"an error."* She regularly arouses a sense of enthusiasm due to the unconditionality of her playing, which flows from her deeply felt artistic perspective. Always charming, free, and verbally accomplished, she also enters into a musical dialogue by giving impulses and showing her audience a few signposts and cornerstones of the pieces.
"Not only masterful, but brilliant," according to the Pope of Critics Prof. Dr. Joachim Kaiser (who is probably the most influential German-speaking music, literature, and theater critic in the second half of the twentieth century) when asked about Henriette Gärtner's most recent CD, LUNA. In characterizing her rendition of the so-called Moonlight Sonata he called it a *"dramatic fantasy"* that *"made a deep impression"* on him. He thanks the pianist for *"not only masterful, but brilliant direct interpretation."*

There are few artists who beyond their art also make a name for themselves in the natural sciences. Henriette Gärtner also belongs to this select circle. In 2011, she presented her dissertation at the University of Konstanz. The pianist, who also enjoyed training in classical ballet, earned the degree of Dr. rer. Nat. in the area of motion biophysiology/ biomechanics with a dissertation on the topic *"On the Interconnection of Sound, Force, and Kinematics in Piano Playing – Demonstrated using Works from the Piano Literature."* *"The body is my first instrument, the piano my second,"* she explains.

(Text adapted by Jake Shanesy)

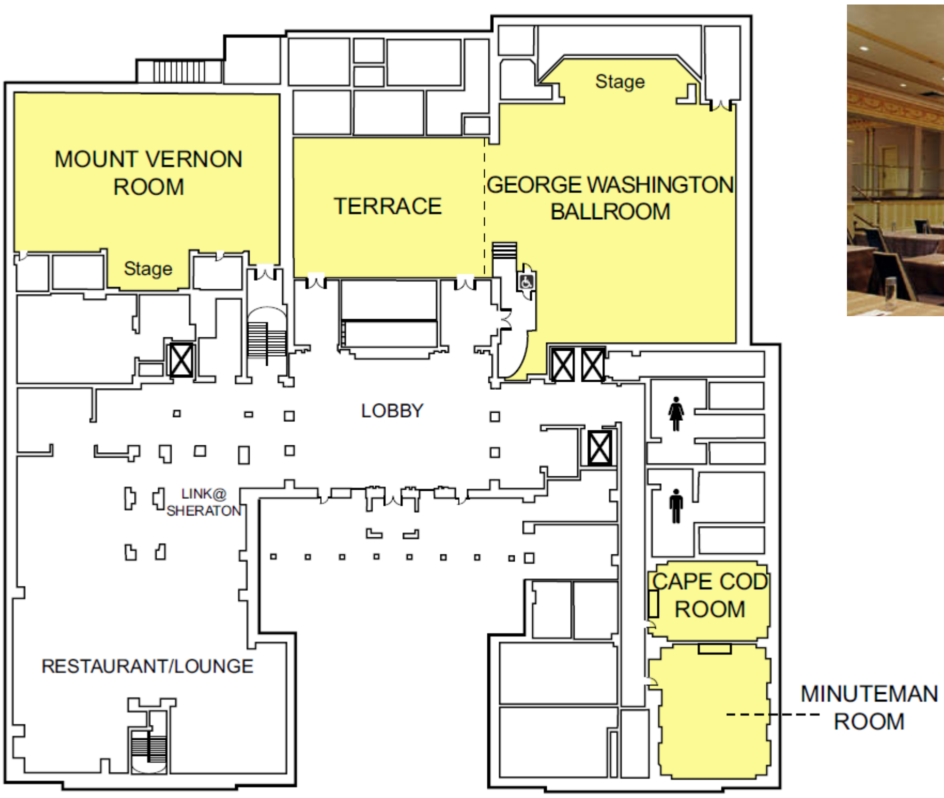
Additional information may be found at:
www.henriette-gaertner.com

Venue – Sheraton Commander Hotel

16 Garden Street
Cambridge, MA 02138, USA
+1 617-547-4800
www.sheratoncommander.com

Sheraton Commander Hotel

- Hotel Lobby – registration
- Nubar Restaurant – opening reception, breakfast, breaks
- George Washington Ballroom – scientific sessions and award dinner
- George Washington Terrace – poster sessions
- Mount Vernon Room – lunch and workshops
- Cape Cod Room – speaker ready room
- Minuteman Room – small group meetings



Podium Session Room

Telephone Numbers and Locations

Telephone Numbers

- The Sheraton Commander: +1 617-547-4800
- novel inc cell (mobile) phone (Maria Pasquale) +1 612-221-0505
- Daniela Jirova-Enzmann cell (mobile) phone: +49 171 650 41 99
- Emergency Service: 911
- Cambridge Police: +1 617-349-3300
- Cambridge Office of Tourism: +1 617-441-2884, www.cambridgeusa.org/
- Metro Cab Taxi Service: +1 617-782-5500
- Boston Logan Airport: +1 800 235-6426
- Massachusetts Bay Transportation Authority: www.mbta.com.

Longy School of Music

Wireless Internet Access

Free wireless internet is available in the Sheraton Commander Lobby and Meeting Rooms. The network name is "Sheraton Meeting Rooms" and the password "ESM2014".

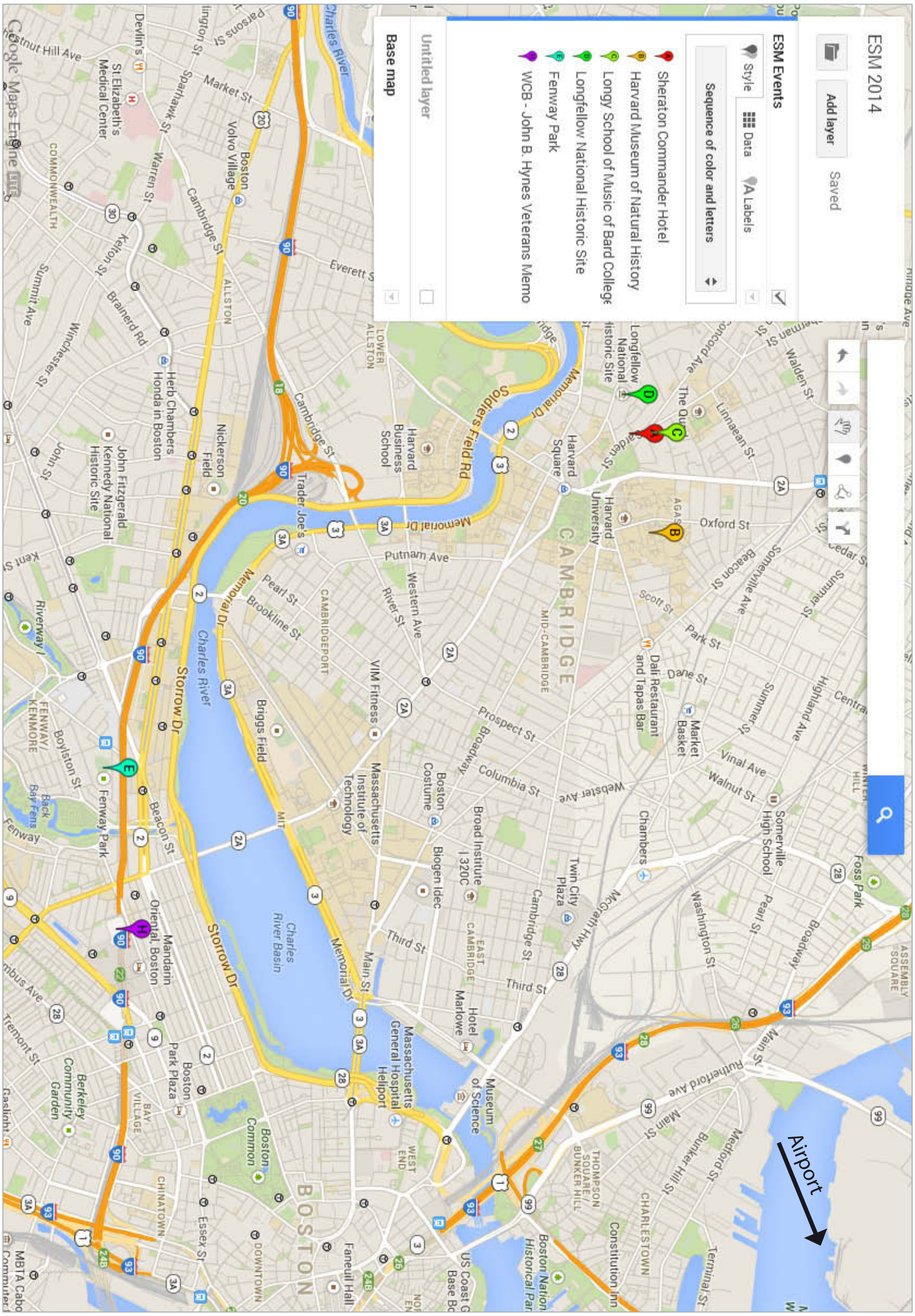
Wireless Internet is also available in the guest rooms. Follow the instructions provided by the hotel to access the Internet.

Memorial Hall (Harvard University)

Harvard Square

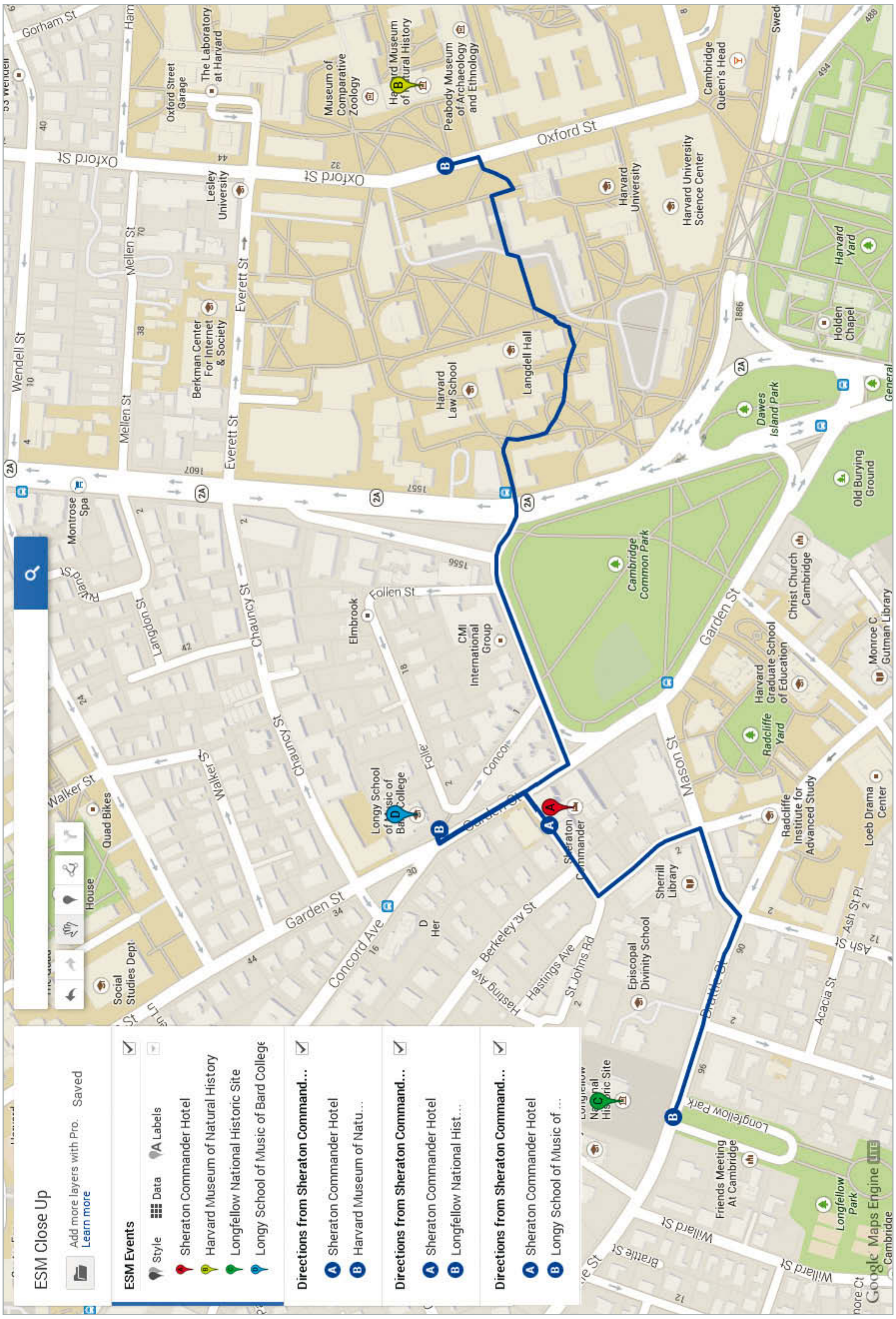
Science Center

Map of Boston and Events



Map data © Google, Sanborn

Map of ESM Events



Map data © 2014 Google

Walking Time from the Sheraton Commander Hotel:

Harvard Museum of National History **9 min.**

Longfellow National Historic Site **5 min.**

Longy School of Music **1 min.**

Meeting Overview

Wednesday July 2nd

Site:
Sheraton Commander Hotel Lobby
- Registration for Attendees *16:30 - 20:30*

Nubar Restaurant (Sheraton Commander)
- Opening Reception *19:00 - 21:00*

Thursday July 3rd

Site:
Sheraton Commander Hotel
- Breakfast in Nubar Restaurant (sit down) *6:30 - 8:30*
- Registration *7:30 - 8:30*
- Scientific Presentations in George Washington Ballroom *8:30*
- Break *10:30 - 11:00*
- Lunch in Mount Vernon Room *12:20*
- Scientific Presentations in George Washington Ballroom *13:20*
- Posters & Coffee Break *15:05 - 16:05*
- Scientific Presentations in George Washington Ballroom *16:05 - 17:25*

Site:
Harvard Museum of Natural History
- Hors d'oeuvres, drinks and light dinner *18:30*
- Tour Museum until *21:30*

Friday July 4th

Site:
Sheraton Commander Hotel
- Breakfast in Nubar Restaurant (sit down) *6:30 - 8:30*

Morning Cambridge Tours
(leaving from the Sheraton Commander Lobby)
- Cambridge Running Tour *8:15 - 9:30*
- Harvard Walking Tour *8:30 - 9:30*
- Longfellow House and Garden Tours (three in total) *8:45 - 10:15*

Sheraton Commander Hotel
- Meet in lobby *10:30*
- Depart on buses *10:45* SHARP

Fenway Park
- Yawkey Way activities upon arrival
- Boston Red Sox vs. Baltimore Orioles *13:35*
- Bus DEPART Fenway *16:30* SHARP

Bay State Cruise
- Board boat at *17:45*
- Whale watching cruise with dinner, drinks and fireworks *18:00 - 22:00*

Sheraton Commander
- Buses return to Sheraton Commander Hotel *22:15*

Saturday July 5th

Site:
Sheraton Commander Hotel
- Breakfast in Nubar Restaurant (sit down) *6:30 - 8:30*
- Registration *8:00 - 8:30*
- Scientific Presentations in George Washington Ballroom *8:30*
- Break *10:25 - 10:50*
- Lunch in Mount Vernon Room *12:10 - 13:10*
- Scientific Presentations in George Washington Ballroom *13:10*
- Posters & Coffee Break *15:25 - 16:25*
- MPP, Most Promising Proposal Award Presentations in George Washington Ballroom *16:25 - 17:00*

Pickman Hall
- art in science Performance by concert pianist Henriette Gärtner *18:30 - 19:30* (Please be seated by *18:20*)

Sheraton Commander Hotel
- Award Presentations & Award Dinner with dancing *19:30 - 23:00*

Sunday July 6th

Site:
Sheraton Commander Hotel
- Breakfast in Nubar Restaurant (sit down) *6:30 - 8:30*
- Workshops in Mount Vernon Room *8:30 - 13:00*

ESM 2014 Program / Presentations

Wednesday, July 2nd 2014

16:30 - 20:30 19:00 - 21:00	**Registration,** Sheraton Commander Hotel, Lobby **Opening Reception, Nubar Restaurant,** Sheraton Commander Hotel

Thursday, July 3rd 2014

6:30 - 8:30	**Breakfast** in Nubar Restaurant (sit down), Sheraton Commander Hotel
7:30 - 8:30 8:30 - 8:45	**Registration** **Welcome** *Vera Novak, Howard J. Hillstrom, Peter Seitz*
8:45 - 9:30	**Keynote Lecture 1** **Design for Extreme Exploration: Self, Sea and Space** *Dava Newman, PhD, MIT, Department of Aeronautics and Astronautics and Engineering Systems, Boston MA, USA* Chair: *Novak, V*
9:30 - 10:30	**Session I: Rehabilitation** Chairs: *Mickle, K and Ford, K*
9:30 - 10:00	**art in science award finalist** **Retraining the Foot Muscles to Restore Toe Flexor Strength in Older People** *Mickle, KJ, Caputi, P, Potter, JM, Steele, JR*
10:00 - 10:10	**The Effect of 6 Weeks Rope Jumping Training on the Plantar Pressure Distribution in Pes Planus, Pes Cavus and Pes Rectus of Secondary Girl Students** *Mimar, R, Khalil, M, Somayeh, H*
10:10 - 10:20	**Pedography as Biofeedback System for Correction of Equinovarus Gait in Individuals with Stroke** *Khallaf, ME*
10:20 - 10:30	**Gait Speed as an Indicator of Endothelial Dysfunction and Chronic Inflammation** *Pimentel, DA, Jor'dan, A, Chung, C, Manor, B, Novak, V*
10:30 - 11:00	**Coffee Break**
11:00 - 11:50	**Session II: Diabetes I** Chairs: *Sinacore, D and Song, J*
11:00 - 11:10	**Reduced Plantar Sensation Leads to Heterogeneous Reactions in Plantar Pressure Distribution During Normal Walking** *Lange, JS, Milani, TL*
11:10 - 11:20	**The Efficacy of Removable Devices to Reduce Pressure and Heal Plantar Foot Ulcers in Diabetes: A Randomized Controlled Trial** *Bus, SA, van Netten, JJ, Manning, E, Bril, A, Spraul, M, and van Baal, S*
11:20 - 11:30	**The Evaluation of Plantar Pressure Distribution in Type 2 Diabetic Patients Native Chinese – A Follow up Study** *Yang, L, Hao, F, Chen, W*

11:30 - 11:40	**A Retrospective Analysis of Peak Plantar Pressure and Shear Locations and their Association with Diabetic Ulcer Sites** *Yavuz, M, Brem, R, Richards, SA, Garfield, K, Gray, ST, Jensen, AE, Rao, N, Delvadia, N, Flyzik, M*
11:40 - 11:50	**Tarsal Bone Density, Alignment & Peak Plantar Stress in Adult-Acquired Neuropathic Mid Foot Deformities** *Sinacore, DR, Gutekunst DJ, Bohnert, KL, Hastings, MK*
11:50 - 12:20	**Session III: Shoes** Chairs: *Pisciotta, J and Woo, H*
11:50 - 12:00	**Method for Measuring Fluid Pressures in the Shoe-Floor Interface for Evaluating the Adequacy of Tread** *Beschorner, KE*
12:00 - 12:10	**The Influence of Boot and Surface Type on In-Sole Pressure and Comfort when Walking on Simulated Coal Mining Surfaces** *Dobson, JA, Riddiford-Harland, DL, and Steele, JR*
12:10 - 12:20	**Biomechanical Evaluation of Two Different Forefoot Relief Shoes** *Lullini, G, Caravaggi, P, Berti, L, Leardini A, Giangrande, A, Giannini, S*
12:20 - 13:20	**Lunch** in Mount Vernon Room, Sheraton Commander Hotel
13:20 - 14:05	**Keynote Lecture 2** **Epidemiology and Foot Pathology: Bridging the Distance between Populations and Foot Sciences** *Marian Hannan, ScD, Harvard Medical School and Institute for Aging Research at Hebrew SeniorLife, Boston MA, USA* Chair: *Hillstrom, HJ*
14:05 - 15:05	**Session IV: Normative Biomechanics** Chairs: *Kersting, U and Hillstrom, HJ*
14:05 - 14:15	**Comparison of Peak Plantar Pressures in the Army Cadet Population: The Impact of a 6 Week Intensive Training Program** *Thaqi, I, Gibbons, MW, Lenhoff, MW, Song, J, Neary, MT, Zifchock, RA, Pasquale, M, Hillstrom, HJ*
14:15 - 14:25	**Plantar Loading Differences Between Genders During an Unanticipated Side-Cut** *Queen, RM, Carpenter AL, Garrett, WE, Butler, RJ*
14:25 - 14:35	**The Effect of Crossed Responses on Dynamic Stability** *Gervasio, S, Kersting, U, Farina, D, Mrachacz-Kersting, N*
14:35 - 14:45	**How Does Step Frequency Influence Plantar Loading During Comfortable Walking?** *Hollanders, L, Melai, T, de Lange TLH*
14:45 - 14:55	**Comparison of Foot Length and Width Measurements: Direct in Stance Versus Calculated From Dynamic Plantar Pressure Footprint** *Song, J, Choe, K, Adams, K, Tango, D, Pettineo, S*
14:55 - 15:05	**Regional Foot Loading During Unweighted Running in a Lower Body Positive Pressure Treadmill** *Ford, KR, Wirfel, LA, Doarnberger, M, Smoliga, JM*

15:05 - 16:05	**Session V: Poster Teaser 1, Posters & Coffee Break** Chair: *Shultz, S*
	Description of Plantar Pressure Parameters in a West Point Cadet Population: Effect of Foot Structure *Gibbons, M, Thaqi, I, Lenhoff, MW, Zifchock, RA, Neary, MT, Brechue, WF, Song, J, Hillstrom, HJ*
	Baropodometric Evaluation of a "Shock Absorbing" Insole in a Group of Italian Special Forces Soldiers Affected by Overload Pathologies *Berti, L, Lullini, G, Ortoloani, M, Caravaggi, P, Leardini, A*
	Perceived Comfort & Plantar Pressure of an Energy Storing and Returning Orthosis in a Prototype Military Boot: A Pilot Study *Goss, DL, Bisagni, FT, Keenan, PG, Call, BP, Harney, NA, Wheelis, IE, Cavanagh, PR, Teyhen, DS, Moore, JH*
	The Correlation Between Static Measurement of Medial Longitudinal Arch and Dynamic Measurement of Arch Index *Shakibi, B, Mimar, R, Shakibi, V*
	Joint Mobilization Forces and Therapist Reliability in Subjects with Knee Osteoarthritis *Tragord, BS, Gill, NW, Silvernail, JL, Teyhen, DS, Allison, SC*
	Using Auditory Feedback to Standardize Pressure for Assessing Tender Points *Degenhardt, BF, Johnson, JC, Webb, SJ, Pamperin, K, Snider, EJ, Snider, KT, Hammond, T*
	Time-Varying Patterns Reveal Foot Loading Changes After Foot-Ankle Exercises for Diabetic Polyneuropathy *Sartor, CD, Sacco, ICN, Vigneron, V*
	Influence of Saddle Pads on the Pressure Distribution of a Well Fitted Equine Saddle: A Pilot Study *Crowell, A, Gavin, A*
	The Influence of an 8-Week Rider Core Fitness Program on Pressure Distribution on the Equine Back *Hampson, AM*
	Evaluation of Interface Load by Angle Variation of Mattress Back Support for Automatic Excretion Handling Systems *Kim, J, Sim, W, Lim, S, Won, B*
	A Comparison Between emed-x and Matscan Plantar Pressure Systems *Hannan, MT, Dufour, AB, Lenhoff, M, Awale, A, Gibbons, MW, Hillstrom, HJ*
16:05 - 17:15	**Session VI: Hands** Chairs: *Mootanah, R and Hillstrom, HJ*
16:05 - 16:35	**art in science award finalist** **Did the Biomechanics of Making and Using Paleolithic Stone Tools Influence the Origin of the Derived Human Thumb?** *Williams, EM, Richmond, BG*

16:35 - 17:05	**art in science award finalist** **Feedback on Force, Sound and Video Sequence of Keystroke During Piano Playing** *Gaertner, H, Pozzo, R*
17:05 - 17:15	**Load Distribution Within the Hand During Cylinder Grip** *Mühldorfer-Fodor, M, Ziegler, S, Harms, C, Neumann, J, Kundt, G, Mittlmeier, T, Prommersberger, KJ*
18:30 - 21:30	**Evening Event** Harvard Museum of Natural History Hors d'oeuvres, drinks and light dinner Tour Museum

Friday, July 4th 2014

	Networking day
6:30 - 8:30	**Breakfast** in Nubar Restaurant (sit down), Sheraton Commander Hotel
	Morning Cambridge Tours (leaving from the Sheraton Commander Hotel Lobby):
	Cambridge Running Tour 8:15 - 9:30
	Harvard Walking Tour 8:30 - 9:30
	Longfellow House and Garden Tours (three in total) 8:45 - 10:15
10:45	Bus Departure from Sheraton Commander Hotel to Fenway Park Yawkey Way activities upon arrival
13:35	Boston Red Sox vs. Baltimore Orioles
16:30	Bus Depart from Fenway Park to By State Cruise
17:45	Boat Boarding for Bay State Cruise
18:00 - 22:00	Whale watching cruise with dinner, drinks and fireworks
22:15	Buses return to Sheraton Commander Hotel

Saturday, July 5th 2014

6:30 - 8:30	**Breakfast** in Nubar Restaurant (sit down), Sheraton Commander Hotel
8:00 - 8:30	**Registration**, Sheraton Commander Lobby
8:30 - 9:15	**Keynote Lecture 3** **Mechano-Biology: Employ Physical Cues to Initiate Tissue Regeneration** *Georg Duda, Julius Wolff Institut at Charité – Universitätsmedizin in Berlin, Germany* Chair: *Brüggemann, G-P*
9:15 - 10:25	**Session VII: Diabetes II** Chairs: *Bus, S and Sacco, I*
9:15 - 9:45	**art in science award finalist** **Clinical Value of Temperature in Assessing Foot Loading in Diabetic Patients with and without Neuropathy** *Yavuz, M , Brem, R, Richards, SA, Garfield, K, Gray, ST, Jensen, AE, Rao, N, Delvadia, N, Flyzik, M*

9:45 - 9:55	**High Plantar Loading and Low Bone Strength Lead to Increased Metatarsal Strain in Individuals with Diabetes and Neuropathy** *Gutekunst, DJ, Bohnert, KL, Hastings, MK, Kaufman, KR, and Sinacore DR*
9:55 - 10:05	**Predictors of Barefoot Plantar Peak Pressure in Patients with Diabetes, Peripheral Neuropathy and a History of Ulceration** *Bus, SA, Barn, R, Waaijman, R, Woodburn, J, and Nollet, F*
10:05 - 10:15	**Biomechanical Sequences of Minor Amputations in Patients With Diabetes Mellitus** *Tsvetkova, TL, Bregovskiy, VB*
10:15 - 10:25	**Clinical and Foot Loading Changes After Foot and Ankle Exercise Intervention for Diabetic Polyneuropathy** *Sartor, CD, Giacomozzi, C, Sacco, ICN*
10:25 - 10:50	**Coffee Break**
10:50 - 12:10	**Session VIII: Pressure Assessment Instrumentation** Chairs: *Steele, J and Yavuz, M*
10:50 - 11:10	**Invited Talk** **Technical Standards for PMDs** *Claudia Giacomozzi, PhD, Istituto Superiore di Sanità, Rome*
11:10 - 11:20	**Identifying Pressure Ulcer Risk of Patient Handling Sling Use with Interface Pressure Mapping** *Peterson, MJ, Gutmann, J, Harrow, J Kerrigan, M, Kahn, J*
11:20 - 11:30	**Feasibility of Wearable Motion Capture System Using Inertial Motion Capture Sensors and In-Shoe Pressure System** *Kim, HK, Khurelbaatar, T, Dorj, A, Kim, K*
11:30 - 11:40	**Ground Reaction Force Computation Tool for OpenSim Using Zero Moment Point Method** *Dijkstra, EJ, Gutierrez-Farewik, EM*
11:40 - 11:50	**A Comparative Study of two Methods for Grip Force Monitoring on the Hand: Manugraphy System Versus Jamar Dynamometer** *Mühldorfer-Fodor, M, Ziegler, S, Harms, C, Neumann, J, Kundt, G, Mittlmeier, T, Prommersberger, KJ*
11:50 - 12:00	**Investigation on the Effects of Billet Placement on a Well Fitted Equine Saddle: A Pilot Study** *Crowell, A, Gavin, A*
12:00 - 12:10	**Testing the Pressure Produced Under Compression Garments: Comparison of Measurement Devices Used in the Clinical Setting** *McLaughlin, P*
12:10 - 13:10	**Lunch** in Mount Vernon Room , Sheraton Commander Hotel
13:10 - 13:55	**Keynote Lecture 4** **Wearable and Home Monitoring Technologies for the Clinical Management of Long-Term Conditions** *Paolo Bonato, PhD, Harvard Medical School and Motion Analysis Lab at Spaulding Rehabilitation Hospital, Boston MA, USA* Chair: *Hillstrom, HJ*

13:55 - 14:25	**Invited Talk** **Navigating NIH** *Mary Rodgers, PhD, NIBIB National Institutes of Health* Chair: *Novak, V*
14:25 - 15:25	**Session IX: Pathology** Chairs: *Queen, R and Mootanah, R*
14:25 - 14:55	**art in science award finalist** **Does Partial or Complete Wrist Fusion Change the Load Distribution of the Hand During Gripping?** *Mühldorfer-Fodor, M, Reger, A, Mittlmeier, T, Prommersberger, KJ*
14:55 - 15:05	**Kinematic and Footprint-Based Parameters for the Classification of Functional Flatfoot** *Giacomozzi, C, Leardini, A, Berti, L, Giannini, S, Caravaggi, P*
15:05 - 15:15	**The Effect of Different Hallux Valgus Angles Upon First Metatarsophalangeal Joint Shear Stress: A Finite Element Study** *Mootanah, R, Morgan, O, Mazzella, J, Reisse, R, Russell, R, Deland, JT, Ellis, SJ, Baxter, J, Hillstrom, HJ*
15:15 - 15:25	**Multifractal Characteristics of Sway: A Comparison of Obese and Non-Obese Children** *Shultz, SP, Fink, PW, D'Hondt, E, Lenoir, M, Hills, AP*
15:25 - 16:25	**Session X: Poster Teasers 2, Posters & Coffee Break** Chair: *Mickle, K*
	Protocol for 1000 Norms Project: Clinical Catalogue of Plantar Pressure and Musculoskeletal Measures Across the Lifespan *Mckay, M, Baldwin, J, Simic, M, Ferreira, P, Hiller, C, Vanicek, N, Nightingale, J, Moloney, N, and Burns, J*
	Influence of Shoe Cushioning and Running Experience on Plantar Pressure Distribution in Recreational Runners *Ribeiro, AP, Dinato, RC, Tessutti, V, João, SMA, Sacco, ICN*
	Research on The Vertical Ground Reaction Force of Midsole Hardness in High Heels *Hao, F, Yang, L, He, Y*
	Functional and Clinical Evaluation of a Biomechanical Shoe with Semi-Rigid Outsole *Berti, L, Lullini, G, Caravaggi, P, Leardini, A, Giangrande, A, Giannini S*
	Foot Loading Under the Heel Bone of Subjects Standing in Unstable Shoes *Jandová, S*
	Evaluation of Balancing Ability in Hemiplegic Patients Using Plantar Pressure Measurement Based on Type of Ankle-Foot Orthosis *Sim, W, Kim, J, Lim, S, Won, B*
	Data-Driven Directions for Effective Footwear Provision in Diabetic Patients with a History of Foot Ulceration *Arts, MLJ, de Haart, M, Waaijman, R, Dahmen, R, Berendsen, H, Nollet, F, and Bus, SA*
	Anthropo-Dynamic Research of Diabetics' Feet in Georgia *Shalamberidze, M, Grdzelidze M, Shalamberidze K*
	Forefoot Plantar Pressures in Mild, Moderate and Severe Hallux Valgus *Hurn, SE, Vicenzino, BT, Smith, MD*

	Pyramidal Tract Neuroaxonal Integrity Predicts Functional Status in Chronic Stroke Patients with Mild Primary Infarction *Dubey, P, Lioutas VA, Manor, B, Bhadelia, R, Novak, P, Selim, M, Novak V*
	The Rule and Its Exceptions for Computing the Center of Pressure Excursion Index (CPEI) *Song, J, Pasquale, MR, Hillstrom, HJ*
	Different Running Shoe Heel Designs Influence Force Distribution at the Heel Upon Impact *Trudeau, MB, Vienneau, J, Nigg, SR, Oda, T, Kaneko, Y, Nigg, BM*
16:25 - 17:00	**MPP, Most Promissing Proposal Award Presentations** Chair: *Kersting U*
17:00	**Closing Remarks** *Vera Novak, Howard J. Hillstrom, Peter Seitz*
18:30 -19:30 (please be seated at 18:20) 19:30 - 23:30	**Evening Event** **Concert by Henriette Gärtner** *The Edward M. Pickman Concert Hall at the Longy School of Music* **Award Presentations & Banquet Dinner with Dancing** *Sheraton Commander Hotel, George Washington Ballroom*

Sunday, July 6th 2014

	novel Workshops in Mount Vernon Room, Sheraton Commander Hotel
6:30 - 8:30	Breakfast in Nubar Restaurant (for full conference attendees), Sheraton Commander Hotel
8:30 - 9:15	**Workshop I: How to measure load distribution correctly** - sensor physics - biomechanical concepts
9:15 - 9:30	Break
9:30 - 10:15	**Workshop II: Practical applications for load distribution measurements in complex environments** - measurements inside joints, "harsh" environments such as Ergonomics, etc. - long term monitoring of total forces in daily life
10:15 - 11:00	Break with snacks & coffee
11:00 - 11:45	**Workshop III: Data evaluation in clinical routine and research** - data acquisition with emed and data evaluation with novel projects, expert rules & reports - Manugraphy for functional hand diagnostics in the clinic
11:45 - 12:00	Break
12:00 - 12:45	**Workshop IV: novel support tools and applications with various hardware systems** - educational videos and web based assistance - calibration of novel systems and synchronization with peripheral systems
13:00 conclusion	Wrap up/catch up

Presentations

Presentations

Presentations

Poster Presentations

Poster Presentation

Abstracts

The following contains the abstracts for each platform and poster presentation throughout the conference.

K1

DESIGN FOR EXTREME EXPLORATION: SELF, SEA AND SPACE

Dava Newman

MIT, Department of Aeronautics and Astronautics and Engineering Systems, Boston MA, USA

Scan-Model-Innovate-Make-Explore!

This talk presents advanced spacesuit concepts for human exploration of Mars as well as how these wearable technologies can be used here on earth to enhance mobility and locomotion. Three suits will be discussed: the Gravity Loading Countermeasure Suit; an Astronaut Injury Prevention suit; and the second skin BioSuit™ for Mars exploration. The gravity loading skin suit strives to alleviate astronaut musculoskeletal loss for intravehicular activity (IVA) and is manifest to fly to the International Space Space in 2015. Current research to prevent astronaut injury and provide protection in traditional gas-pressurized spacesuits has led to a novel wearable pressure sensing garment to quantify human-suit interactions.

Hotspots are identified that correlate with astronaut musculoskeletal shoulder injury. One of the key requirements of human planetary surface exploration is a spacesuit that enables astronaut locomotion. Planetary mobility places new challenges that can only be attained through implementing revolutionary designs that facilitate natural locomotion and minimize energetic expenditures.

The MIT BioSuit™ System leverages patented design concepts and implements active materials technologies to provide a technically feasible 29 KPa mechanical counter pressure spacesuit.

T1

RETRAINING THE FOOT MUSCLES TO RESTORE TOE FLEXOR STRENGTH IN OLDER PEOPLE

Karen J. Mickle (1), Peter Caputi (2), Jan M. Potter (3), Julie R. Steele (1)

1. Biomechanics Research Laboratory, University of Wollongong, Australia
2. School of Pyschology, University of Wollongong, Australia
3. Division of Aged Care, Rehabilitation and Palliative Care, Illawarra Shoalhaven Local Health District, Australia

BACKGROUND

Correct toe function is imperative for performing most activities of daily living. Mechanically, the toes are critical because by applying appropriate amounts of pressure to the ground, they correct for unexpected postural disturbances, help maintain balance and ensure we walk safely. Poor toe function has been strongly associated with atrophy and weakness of the foot muscles. We have previously demonstrated that reductions in toe flexor strength are independent contributors to falls in older people (Mickle, 2009).

Several studies have found that the foot muscles can positively respond to resistance training in younger adults (Goldman, 2013; Unger, 2000). However training studies in older adults are sparse (Kobayashi, 1999; Spink, 2011) and have been limited by the training programs being non-progressive and/or did not target the intrinsic foot muscles. Therefore, the purpose of our study was to investigate whether a progressive resistance training program, focused specifically on the foot muscles, can improve toe flexor strength in older peopleadults.

METHODS

Eighty-five men and women aged 60-90 years volenteered to participate in the study. Toe flexor strength was quantified using an Emed AT4 pressure platform by pushing down on the platform as hard as possible under two conditions: (i) using only their hallux or (ii) using all their toes. Peak force (N) was normalised to body weight (% BW) to represent maximum hallux and lesser toe flexor strength.

After baseline testing, participants were randomised to either a Toe Training group (n = 43; mean age = 69.5 ± 6.0 y) or to an active control group (n = 42; mean age = 69.9 ± 5.6 y). Participants in the Toe Training group attended three 45-minute group exercise classes each week, for 12 weeks. The exercises, which were predominantly designed to strengthen the toe flexor muscles, progressively increased in level of difficulty throughout the intervention. Participants from both groups returned after 12 weeks to have their toe flexor strength reexamined. A 2x2 repeated measures analysis of variance was conducted to test whether the intervention affected toe strength over time.

RESULTS

Compared to baseline, participants in the intervention group significantly increased their hallux and lesser toe strength (up to 36%), whereas there was no significant change in toe strength in the control group (Figure 1).

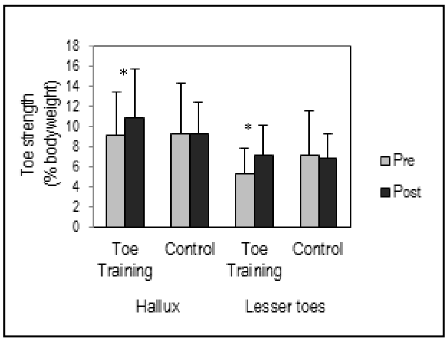


*Figure 1: Change in hallux and lesser toe strength for participants in the toe training and control groups. * indicates a significant difference after the intervention (p<0.05).*

CONCLUSIONS

Our progressive resistance training intervention significantly increased strength of the toe flexor muscles in older adults. The exercise intervention now needs to be trialled in the community to determine whether these improvements in toe flexor strength can be translated into a reduction in the number of falls suffered by older adults.

REFERENCES

Goldman *et al*, J Sports Sci 31:424-433, 2013
Kobayashi *et al*, J Phys Ther Sci 11: 31-34, 1999
Mickle *et al*, Clin Biomech 24:787-791, 2009.
Spink *et al*, BMJ 342:3411
Unger *et al,* J Strength Cond Res 4:373-378, 2000

T2

THE EFFECT OF 6 WEEKS ROPE JUMPING TRAINING ON THE PLANTAR PRESSURE DISTRIBUTION IN PES PLANUS, PES CAVUS AND PES RECTUS OF SECONDARY GIRL STUDENTS

Mimar. Raghad (1), Mousavi. Khalil (2), Hajipour. Somayeh (3)

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2. Phd Students of Sport Biomechanics, Kharazmi university. Tehran, Iran
3. Master Degree of Corrective Exercise, Kharazmi university. Tehran, Iran

Introduction: The anatomical and biomechanical structure of the lower limb especially the foot has an important role in shock observing, supporting function during gait, and weight bearing, which are managed by the medial-longitudinal arch, lateral-longitudinal arch and the transversal arch, respectively (1). Thus, any functional or structural disorder in these areas can violate the foot function. Increase the mobility through exercise and movement activities is a way that not only specialists but also most people spontaneously use to prevent or treat these disorders. Increase the strength (in pes planus) and flexibility (pes cavus) of plantar muscle and fascia is the criteria point in this approach (2). One of the common and inexpensive sports that have these properties is the rope jumping. By considering these items, the aim of this research, was to study the effect of 6-weeks rope jumping training on the plantar peak pressure distribution, contact area and arch index value in pes planus, cavus and rectus of secondary girl students.

Methods: 447 girl students aged 12-14 years were scanned by the emed platform and screened by the arch index for foot type selection (3). And only 27 students (three groups) with a BMI of 19.9±2.2 (rectus), 20.1±1.6 (planus) and 19.1±1.6 (cavus) were randomly chosen. As mentioned, to record the dependent variables in the 10 areas of the foot, the emed platform with an accuracy of ±7 was used and the prc masking procedure was applied. Finally, paired sample t-test and one-way ANOVA was used to compare the result intra and between the groups and the LSD post-hoc ($p \leq 0.o5$) test to check the effects of the training between the groups were applied.

Result: finding in peak pressure and contact area values only showed significant different in rope jumping effect on M03 (sig: 0.034) and M04 (sig: 0.002) that refer to medial mid foot and lateral mid foot respectively. In addition, arch index value showed the significant effect of training in pes planus (sig: 0.01) and normal groups (sig: 0.035).

Conclusion: Switching the pressure focus from the medial forefoot to medial mid foot areas in normal group, increases the pressure value in rare foot area (M01- M04), vise versa the pressure decreases in medial and forefoot area (M05- M10) in pes planus group. finally significant decrease in pressure values in forefoot (M09- M10) in pes cavus group are the considerable effect of rope jumping training in each group which result in significant deference at M03 and M04 areas. additionally, significant decrease and increase of contact area values (M03, MO4) in pes planus and cavus respectively may be the main reason for peak pressure values changes in both groups. significant increase in medial longitudinal arch height in pes planus and reduction of this parameter in pes cavus group (however it was not significant) in this study refer to positive role of rope jumping training in correction of foot deformities in both groups. It may be conclude that the strength and flexibility improvement in plantar muscle, especially those are responsible to maintain the medial longitudinal arch, are the main reason for these changes that was noted.

Reference

1. Hamill Joseph, Knutzen Kathleen M. Biomechanical Basis of Human Movement. 2009. Lippincott Williams and Wilkins.
2. Volpon JB. Footprint analysis during the growth period. J Pediatric Orthopedic 1994, 14: 83- 85.
3. Cavanagh PR, Rodgers MM. The arch index: A useful measure from footprints. Journal Biomechanics 1987: 20, 547-51.

table1) one way ANOVA (peak pressure and contact area value) and Paired sample t- test (arch index) results

Mask Region	**M01** medial heel	**M02** lateral heel	**M03** medial midfoot	**M04** lateral midfoot	**M05** 1st metatarsal head	**M06** 2nd metatarsal head	**M07** Lateral metatarsal heads	**M08** Hallux	**M09** 2nd toe	**M10** 3rd ,4th ,5th toes
Peak pressure value										
mean square	623.14	623.14	1889.81	4100.92	2095.37	6825.92	2142.25	14803.7	2145.3	1114.81
F	13	.15	3.89	8.02	1.03	1.73	.37	.73	.86	1.25
Sig	.872	.861	.034*	.002*	.369	.198	.690	.489	.432	.304
Contact area										
mean square	2.08	1.56	69.33	283.95	18.20	1.00	5.84	.918	1.41	2.07
F	2.23	1.69	9.80	12.40	1.89	.371	.841	.213	1.21	.26
Sig	.129	.205	.001*	.000*	.172	.694	.443	.810	.313	.771

Arch index (Paired sample t- test)

Group	Average		Mean difference	SD	Std error mean	T	Sig
	Pre test	Post test					
normal	24.55	.88	.88	1.09	.35	2.53	.035*
Pes planus	29.00	1.22	1.22	1.09	.36	3.35	.010*
Pes cavus	16.33	-1.44	-1.44	4.41	1.47	-.91	.356

T3

PEDOGRAPHY AS BIOFEEDBACK SYTEM FOR CORRECTION OF EQUINOVARUS GAIT IN INDIVIDUALS WITH STROKE

Mohamed. E. Khallaf

Department of Physical Therapy, Collage of Applied Medical Sciences, University of Hail, KSA

BACKGROUND AND PURPOSE

Spastic foot drop is a common sign of stroke. It is characterized by a patient's inability to dorsiflex the ankle, or raising the foot during walking. Conventionally, Ankle-Foot Orthosis (AFO) is used to correct foot drop during walking. Visual biofeedback is a rehabilitation method that can be used during dynamic gait training, offering the patient visual information about the placement of the foot on the ground durnig walking.

Visual biofeedback stimulates proprioceptive information that may be negatively affected in stroke victims. Novel biofeedback resources are currently being developed. One such device, emed pedograpy, may simulate correct foot contact upon displaying on a screen during gait training. The aim of the present study was to investigate the effect of exercise therapy based on motor relearning with visual biofeedback on correcting equinovarus gait among individuals with hemiparesis following a stroke.

SUBJECTS AND METHODS

Sixteen subjects with first ever ischemic stroke (age 45 ± 7 yrs, BMI 24.6 ± 2.4, and 6-12 months post-stroke) were randomly assigned into two equal groups (G_1 and G_2). All the patients were at grade 4 according to Brunnstrom's grades of recovery for lower limb without any cognitive dysfunction as measured by Mini Mental status examination. Patients were excluded from the study if spasticity of the calves is greater than grade two as measured by the Modified ashwarth's scal or calves contractures or suffering muscle contracture.

Participants in G_1 recieved an exercise therapy and gait trainng based on motor relearning principles. During gait training the patient was instructed to step over an Emed plateform (emed-q100) five times. Data base professional was used for foot placement analysis. The obtained results were used as a teaching material. The results colors and foot roll-over were the key point for the patients to understand the impairment of foot placement. Additionally, as the analysis time is very short, this allow us to repeat the measurement five time or more. A polypropylene posterior splint that keeps the ankle in a neutral position, calf muscles strtching and dorsiflexors strengthening exercises were used for patients represented in G_2. For both groups, the measurements were recorded before randomization and one week after the last session. Both groups recieved 3 sessions a week for 8 weeks.

RESULTS

Significant improvement was observed among patients who have recieved motor relearning exercise therapy with visual feedback in maximum force, and contact time ($p \le 0.05$). on the other hand there were no significant differnces between pre and post measurements of the participants in G2.

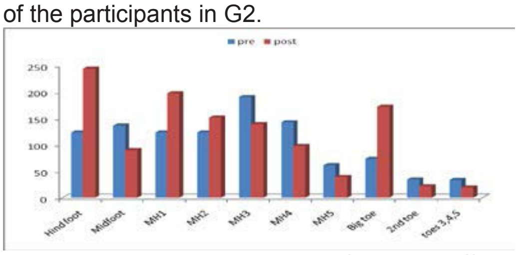

Figure 1: Regional maximum force in different regions of the affected foot.

DISSCUSSION & CONCLUSIONS

The results of this study showed a positive long lasting effect of the motor relearning exercise therapy with visual feedback on equinovarus gait pattern. This can be attributed to the feedback offering positive reinforcement, facilitating improvement in the execution of the tasks. Additionally, this study offered a real functional situation for training which has a positive influence on brain reorganization after stroke as proved by previous studies. Pedography can be used effectively as a biofeedback system for correction of the equinovarus gait among stroke patients.

REFERENCES

Barcala et al. J Phys Ther Sci.2013;25(8):1027-1032.
Palluel-Germain et al. Neurosci Lett. 2011, 498(3):222-226.
Chisholm et al. Gait & Posture. 2011, (33) 238–243.

T4

GAIT SPEED AS AN INDICATOR OF ENDOTHELIAL DYSFUNCTION AND CHRONIC INFLAMMATION

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ABSTRACT

Type 2 diabetes mellitus (DM) is associated with slower gait speed (Volpato, 2010), chronic inflammation and endothelial dysfunction (Novak, 2011) negatively affecting the vascular reserve of the brain and kidney. Slower gait speed, a marker of declining health in older adults, is linked to impaired cerebral vasoreactivity (CVR). CVR is an important regulator of brain perfusion during activity that positively correlates with vascular reserve and brain volume (Last, 2007) (Fig. 1). Albuminuria indicates renal vascular damage and is associated with microvascular disease in the brain (Vuletic, 2011). However, the link between functional outcomes with central and peripheral markers of inflammation-related microvascular disease remains unclear. We aimed to investigate the association between gait speed, serum soluble vascular and intercellular adhesion molecules (s-VCAM and s-ICAM, respectively), CVR and UACR (urine albumin/creatinine ratio) in older adults with DM.

Secondary analyses were performed cross-sectionally: 143 participants, 72 DM, age 65.1±8.4 years, 74 F, DM duration 13.1±10.3 years. Patients completed a walk at preferred speed along a 75m course. Global CVR was calculated as the slope of the regression between perfusion measured at baseline and in response to hyper- and hypocapnia conditions using Continuous Arterial Spin Labeling MRI.

Slower gait speed correlated with increased s-ICAM and s-VCAM levels (r^2_{adj}=0.07, p= 0.006; r^2_{adj}=0.1, p=0.03) independent of age and BMI. In diabetics, but not in controls, slower gait speed was associated with reduced global CVR (r^2_{adj}= 0.09, p=0.04), with higher levels of s-ICAM (r^2_{adj}= 0.05, p=0.01), s-VCAM (r^2_{adj}= 0.03, p=0.04) and UACR (r^2_{adj}= 0.04, p=0.03) independent of BMI, DM duration and HbA1c. Higher s-VCAM levels in the DM group were associated with higher UACR (r^2_{adj}= 0.1, p= 0.04), even at subclinical levels, independent of DM and hypertension duration and HbA1c (fig. 2).

Slower gait speed may indicate chronic inflammation and an impaired ability to increase brain perfusion in response to stressors (i.e. reduced vascular reserve) in older adults with DM. UACR, along with s-VCAM, could reflect the detrimental microvascular changes affecting different vascular beds in the DM population.

FIGURES AND TABLES

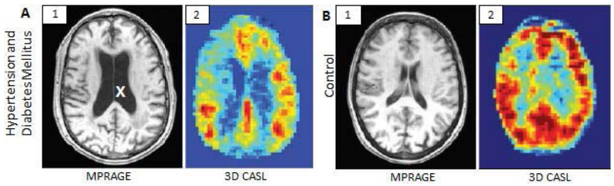

Fig. 1: Ventricular enlargement (x), volume loss (A1) and decreased perfusion (A2, blue) in hypertension and diabetes mellitus. Normal volume (B1) and perfusion (B2). Abbreviations: 3D CASL, three-dimensional continuous arterial spin labeling; MPRAGE, T1-weighted magnetization-prepared rapid acquisition with gradient echography (Novak, 2010).

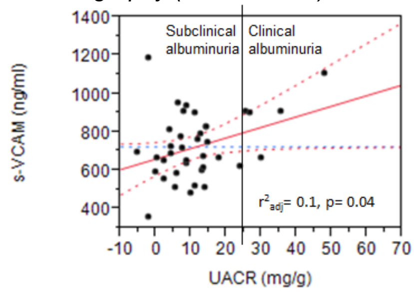

Fig. 2: Higher UACR (kidney vascular damage), even at a subclinical level, correlates with a higher serum s-VCAM (inflammation and vascular integrity marker).

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REDUCED PLANTAR SENSATION LEADS TO HETEROGENEOUS REACTIONS IN PLANTAR PRESSURE DISTRIBUTION DURING NORMAL WALKING

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INTRODUCTION

Many studies have determined the influence of provoking reduced plantar foot sensitivity on plantar pressure distribution patterns during the roll-over process (ROP) (Nurse, 2001; Eils, 2002; Höhne, 2009), but differ considerably in their approaches and results. This raises the question of whether the method of provoking decreased plantar foot sensitivity is responsible for the different results or whether subjects respond so differently that there is no uniform ROP reaction.

Therefore, the aim of this study was to evaluate individual response patterns in the ROP after provoking reduced plantar foot sensitivity and to consider the homogeneity of this reaction pattern within the sample.

METHODS

The plantar foot of 19 subjects was treated with EMLA® cream containing the active ingredients lidocaine and prilocaine (McDonnell, 2000; Wahlgren, 2000) . For each subject, the plantar sensations of vibration and touch at heel, forefoot and hallux were measured before the intervention and at three intervals of 45 minutes (+15 min measuring time). Thereby the active course of the cream was documented. Plantar pressure measurement was performed by a novel emed®-c50 platform. Nine anatomical sub-areas were identified on the peak pressure footprint (Maiwald, 2008). The average ROP of 10 steps was determined at each measurement. Regression analyses were used to estimate the relationships among sensation and ROP variables. Using data from a control group, 'clinical significance' (Jacobson, 1991) was used to evaluate individual subject reactions. A hierarchical cluster analysis was used to form groups with similar behavior within the sample.

RESULTS

Results showed strong interindividual differences in the process of sensation reduction over time. A linear relationship between change in sensory perceptions and plantar pressure variables was not detected. Nevertheless, the ROP results observed for each measurement differed strongly between and within subjects Using cluster analysis, a group with a forefoot load increase was detected. Another group showed less variation in their forefoot pressure variables.

DISCUSSION AND CONCLUSION

The heterogeneity in the responses shows that subjects react differently when plantar foot sensitivity is perturbed by EMLA® cream. Thereby the ROP reaction seems to be not linear dependent from the level of reduction of plantar sensation. Indications for the existence of similar response patterns could be found despite the small sample size. In this study only a small time period of treatment was analyzed. It remains unclear what would happen if plantar sensitivity was reduced for a longer period.

The complex interaction between the body, nervous system and environment may lead to various adaptive behaviors (Chiel, 1997). The idea of plasticity and modular control of locomotor patterns (Ivanenko, 2013) could be useful for further interpretations.

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THE EFFICACY OF REMOVABLE DEVICES TO REDUCE PRESSURE AND HEAL PLANTAR FOOT ULCERS IN DIABETES: A RANDOMIZED CONTROLLED TRIAL

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INTRODUCTION

Adequate pressure relief is required for healing plantar foot ulcers in patients with diabetes mellitus. Guidelines recommend non-removable offloading as primary treatment for these ulcers (Bus et al., 2008). However, in clinical practice removable offloading is more commonly used, mostly for practical reasons.

Compared to non-removable offloading, little is known about the efficacy removable offloading devices to heal plantar foot ulcers, and how healing is associated with plantar pressure reduction (Armstrong et al., 1998).

The aim was to assess the efficacy of three commonly used removable offloading treatment devices on healing of plantar neuropathic foot ulcers in diabetes and to assess the association between peak pressure relief and healing.

METHODS

Sixty patients (48 male, mean age 62.5 years, 87% type 2 diabetes) with a neuropathic non-infected, non-ischemic plantar ulcer in the forefoot were randomized to one of three treatment modalities: a bivalved total contact cast (BTCC), a Mabal cast shoe (MABAL), or a forefoot-offloading shoe (FOS). Patients were stratified according to ulcer size. Patients were followed until healing, or until 12 and 20 weeks, whichever came first. Primary outcome was percentage healing in 12 weeks time. In a subset of 35 patients, dynamic plantar pressure was measured using Pedar-X in both the original shoes of the patient and the offloading device, with peak pressure and peak-pressure-reduction at the ulcer location as outcome parameters.

RESULTS

Foot ulcers were located at the hallux (n = 24), first metatarsal head (n=21), other metatarsal heads (n=13) and toes (n=2). Forty-nine ulcers were small (<2.5 cm^2), 11 large (>2.5 cm^2) and 41 were Texas 1A (i.e. superficial), 19 Texas 2A (i.e. deep). Significantly more 2A ulcers were treated with BTCC than with FOS.

12-week healing rates according to intention to treat were 58% for BTCC, 60% for MABAL, and 70% for FOS (non-significant between conditions, p=0.70). For 20 weeks, healing rates were 63%, 83%, and 80%, respectively (ns, p=0.31). Time to healing was a mean (SD) 6.8 (3.4) weeks for BTCC, 7.0 (5.3) weeks for MABAL and 9.4 (3.7) weeks for FOS (ns)

No association was found between peak pressure or peak-pressure-reduction and healing of the foot ulcer (p-values range 0.47-0.87). Peak pressure and peak-pressure reduction varied significantly between devices. Peak pressure at the ulcer was 82 kPa for BTCC, 113 kPa for FOS, and 147 kPa for MABAL (p=0.016). Peak pressure reduction compared to the original shoes of the patient was 64% for the BTCC, 47% for FOS, and 34% for MABAL; p=0.061).

DISCUSSION AND CONCLUSIONS

Healing rates were not significantly different between the 3 removable devices. The off-the-shelf FOS condition showed more superficial ulcers, higher healing percentage, and longer time to healing than casting.

BTCC healing rates were substantially lower than previously found for non-removable TCC (~90% healing), while healing rates for the other two devices are comparable for those previously found for similar removable offloading devices.

The lack of association found between peak pressure (reduction) and healing is in contrast to that found in non-removable offloading (Armstrong et al., 1998)

Compared to non-removable offloading, lack of forced adherence may explain the lower healing rates and the lack of association with pressure reduction. This stresses the importance of continuous pressure relief in ulcer healing.

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T7

THE EVALUATION OF PLANTAR PRESSURE DISTRIBUTION IN TYPE 2 DIABETIC PATIENTS NATIVE CHINESE—A FOLLOW UP STUDY

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INTRODUCTION

The diabetic foot remains one of the most serious complications of diabetes mellitus. In addition, biomechanical changes in the foot that lead to diabetic foot ulcerations. Hawes (1994) has suggested that the characteristics of foot are typical of ethnic or racial populations. However, seldom research (Veves,1992) has focused on plantar pressures of diabetic patients in different ethnicities.

China is a burdened country by diabetes mellitus, and also the biggest footwear producer in the world, unfortunately, only a few researches have focused on the diabetic foot problems in China and few diabetic footwear was researched and produced.The purpose of this study was to investigate the distribution of plantar pressure in type 2 diabetic patients and compare them to the healthy population, which could supply the basic data for the production of prophylactic shoes for Chinese diabetics

METHODS

A total of 136 (79♀+57♂) type 2 diabetic patients (aged 62±8; BMI 25.4±3.6) from the Sichuan University & West China hospital and 93 (47♀+46♂) health adults without any diabetic history (aged 63±9; BMI 22.5±2.6) in China were also recruited in this study, and informed consent was obtained from all subjects.

Plantar pressures were collected by EMED system (Novel, Germany). All participants were required to walk barefoot at a self-selected speed. The parameters of peak pressure (kPa), pressure-time integral (kPa*s), maximum force (N), contact time (ms) and contact areas (cm2) were collected. During analysis ten plantar regions were identified: hind foot (M01), midfoot (M02), the first (M03), second (M04), third (M05), fourth (M06), fifth (M07) metatarsals, big toe (M08), second toe (M09) and toes 345 (M10). Individual means of all the three repeated trials for right foot were calculated. Only data from the right foot was analyzed, independent samples *t*-tests were used to compare dynamic variables between two groups.

RESULTS AND DISCUSSIONS

No significant difference was found between two groups in the contact area. The contact time of the diabetic group was 1132.7 ± 257.0 ms, which was significantly longer than the control group (1061.9 ± 223.8 ms, $p < 0.05$).

The diabetic group showed the bigger maximum force almost in all regions, the significant differences were found in the M01, M02, M03, M04, M05 and M10 regions ($p < 0.05$). All these parts were important for patients suffered by diabetes, which should be considered in the design of the footwear for diabetics native Chinese.

In this research, the peak pressure for the diabetic group was 475.5 kPa ± 150.41 kPa; the control group was 496.3 kPa ± 140.4 kPa, no significant different was found between them, ($p > 0.05$). This value was lower than the European researches (Lavery,2003), but it was correspond to the Sheng's results (2007), which also proved that the plantar pressure for the Chinese diabetic patients was different to the other nationalities, a lower peak pressure was found in Chinese diabetic patients.

The pressure-time integral was significantly longer than the control group in the M01, M02 and M03 regions.

CONCLUSIONS

The plantar pressure for the Chinese diabetic patients is different to the Caucasian diabetic patients; Chinese diabetics have a lower peak pressure. In this case, no significant difference was found between the diabetics and the control groups, in the future study the enlarged number of samples are recommended.

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T8

A RETROSPECTIVE ANALYSIS OF PEAK PLANTAR PRESSURE AND SHEAR LOCATIONS AND THEIR ASSOCIATION WITH DIABETIC ULCER

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INTRODUCTION

Plantar pressure and shear stresses have been associated with diabetic foot ulceration and related amputations. Studies from the past decade have shown that plantar shear is increased in diabetic patients with neuropathy, compared to non-neuropathic diabetic patients and healthy individuals [3,4]. In addition, peak plantar pressure and shear do not usually occur at the same site in diabetic and healthy subjects [2]. Pollard and Le Quesne (1983) reported that, peak pressure and shear occurred at the same sites, which were also the sites of a previous ulceration in 100% of the patients (N=5) [1]. However, the equipment used by the authors had major drawbacks such as attachment of thick sensors on the plantar surface, need for separate sensors for pressure and shear components. The purpose of this ongoing study was to investigate a site-wise association between healed ulcers and plantar shear loading, using more advanced measurement technology.

METHODS

Three diabetic subjects (2 F, 1 M) with a recently healed plantar forefoot ulcer were recruited after signing an IRB-approved consent form. The ulcers were healed within the past three months of study participation. Subjects walked on a custom-built stress plate that quantified tri-axial plantar stresses. The stress plate was set flush in the middle of a 4-meter walkway. Data were collected implementing the two-step method, and were analyzed after determining averages from three trials. Locations of peak pressure and resultant shear stress were identified based on the averaged data.

RESULTS

In two subjects, peak shear occurred at the healed ulcer site (Figure 1). In one of these subjects, peak pressure and shear location overlapped. In the third subject, peak pressure was seen at the healed ulcer site, but peak shear occurred elsewhere.

CONCLUSIONS

The preliminary results of this ongoing study confirm the clinical significance of plantar shear in diabetic ulceration. Many diabetic ulcers do not develop at peak pressure locations, and this warrants further research to explore whether ulcers develop at peak shear locations. It is thought that diabetic ulcers occur due to a number of biomechanical factors including pressure and shear. Better understanding of these factors will lead to designing more effective preventive footwear and methods.

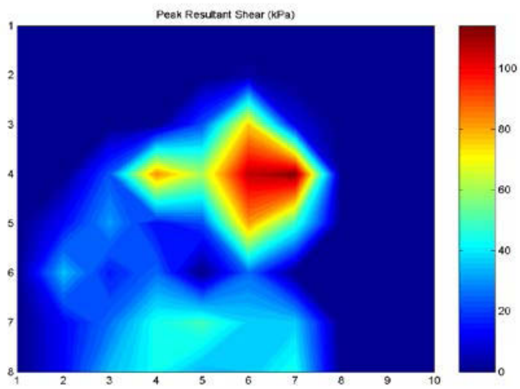

Figure 1: Peak resultant shear profile of a subject who had an ulcer under the left hallux three months prior to the study. Peak pressure also occurred under the hallux in this foot.

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ACKNOWLEDGEMENT

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T9

TARSAL BONE DENSITY, ALIGNMENT & PEAK PLANTAR STRESS IN ADULT-ACQUIRED NEUROPATHIC MID FOOT DEFORMITIES.

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BACKGROUND & PURPOSE

Foot deformity is one of several pathogens leading to high plantar stress, ulceration, infection and ultimately to lower extremity amputation in individuals with diabetes mellitus and peripheral neuropathy (DMPN). Although an incipient cause of excessive plantar stress in DMPN is unknown, our hypothesis is that low tarsal bone mineral density (BMD) coupled with tarsal joint mal-alignment contribute to excessive mid foot stress, ulceration and amputation.

The purposes of this study were to assess BMD in select mid tarsal bones, tarsal alignment and peak plantar stresses in the mid foot in participants with and without DMPN and acquired mid foot deformities.

MATERIALS AND METHODS

We studied 20 participants with DMPN & acquired neuropathic mid foot deformity (DMPN+) (10 men, age=55±9 years, BMI=37±7 kg/m^2); 20 participants without deformity(DMPN-) (9 men, age=58±1 years, BMI=32±8 kg/m^2) and 16 young controls without DMPN or foot deformity (8 men, age=28±6 years, BMI=26±5 kg/m^2).

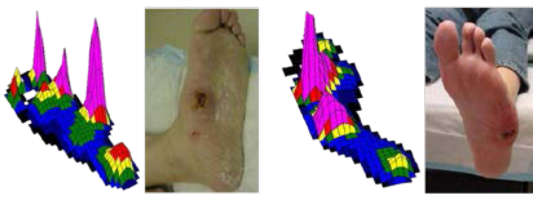

Figure 1: Two feet with DMPN & plantar ulcers. Medial mid foot ulcer due to excessive medial mid foot pressure (left); lateral mid foot ulcer due to excessive lateral mid foot pressure (right).

Whole bone BMD of the talus, navicular and cuboid tarsals were measured using quantitative computed tomography (Commean, 2009). Alignment of talus and cuboid were measured with respect to the weight bearing surface on lateral view foot radiographs (Hastings, 2011). Peak plantar pressure was measured while walking at a self-selected speed over an EMED P2 ST pressure platform embedded in a 7-meter walkway (Sinacore, 2008).

An analysis of variance was used to compare mean values between groups. Pearson correlation was used to assess the inter-relationship among measures between groups.

RESULTS

Talus, navicular and cuboid BMD was lower in DMPN+ (367±55, 407±77, 292+60 mg/cm^3, respectively) compared to YC (462±57, 445±57, 339±48 mg/cm^3, p<0.00). Talar declination angle and cuboid height were greater and lower respectively in DMPN+ participants (33±8 deg, 5±8 mm) compared to YC participants (23±2 deg, 13±4 mm, p<0.01). Peak plantar pressure in the medial and lateral mid foot were greater in DMPN+ compared to DMPN- and YC participants, p<0.00). Peak plantar pressure in medial and lateral mid foot is minimally correlated to tarsal BMD (talus, r=-.151; cuboid, r=.171) and moderately correlated to talar declnation angle and cuboid height (r =.556, r=-.226, respectively).

CONCLUSIONS

Mal-alignment of mid tarsal joints coupled with low tarsal BMD occur in participants with excessive mid foot plantar stress. Our findings support the hypothesis that excessive talar declination angle is associated with medial mid foot pressure, while low cuboid height is associated with excessive lateral mid foot pressures. Excessive mid foot plantar stresses may cause mid foot ulceration (Figure 1) and ultimately result in major lower extremity amputation.

CLINICAL RELEVANCE

Participants with diabetes mellitus and acquired neuropathic foot deformities have low tarsal bone density and mid tarsal joint mal-alignments that combine to result in excessive mid foot stress and may contribute to mid foot ulceration and ultimately to non-traumatic lower extremity amputation.

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METHOD FOR MEASURING FLUID PRESSURES IN THE SHOE-FLOOR INTERFACE FOR EVALUATING THE ADEQUACY OF TREAD

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INTRODUCTION

Same-level falling accidents are the fastest growing source of worker's compensation costs in the US since 1998 (Liberty Mutual, 2012). Shoe tread is important to fall prevention given that 75% of mail delivery workers who were injured in a fall had poor tread (Bentley and Haslam, 2001). Shoe tread provides drainage channels for moving fluid from the shoe-floor interface. Failure to adequately drain fluid causes the fluid to become pressurized, which separates the surfaces and reduces coefficient of friction. The purpose of this abstract is to describe a novel technique for assessing the adequacy of shoe tread by measuring fluid pressures in the shoe-floor interface.

METHOD FOR MEASURING FLUID PRESSURES

Fluid pressures in the shoe-floor interface were measured by embedding pressure sensors in the floor, applying a continuous fluid film across the surface and then sliding the shoe across the fluid. When recording fluid-pressures using slip-testing devices, a single fluid pressure was used and moved to different portions of the shoe in order to determine the variation of fluid pressures across the shoe surface. A slip-testing device was used to quantify how tread design, tread depth, and fluid viscosity influenced the fluid pressures in the interface. The slip-testing device generated forces of 500N, sliding speeds of 0.3 m/s and a shoe-floor angle of 8° to simulate the approximate conditions just after heel contact. Three different tread designs (casual, work and sporting), three different tread depths (full, half and no tread) and two different fluid viscosities (high and low viscosity) were analyzed. The work and athletic shoe had tread channels that were continuous to the exterior of the shoe and thus could drain fluid, while the tread channels of the casual shoe were surrounded by tread and thus could not drain fluid. Human slipping experiments using treaded and untreaded work shoes along with the high viscosity fluid were performed to partially validate the slip-tester methods. A grid of 3x3 sensors was used in order to ensure that the subject stepped on one of the sensors during their slip. The order of shoes was randomized and subjects were not aware that the floor was slippery to ensure the slip was unexpected.

EFFECTS OF TREAD DEPTH, TREAD DESIGN AND FLUID VISCOSITY ON FLUID PRESSURES

For the work and sporting shoe, fluid pressures were negligible when half or all of the tread was present. The no treaded shoes resulted in high fluid pressures (88-230 kPa) when tested against a high viscosity fluid. Thus, shoe tread with drainage was successful at reducing fluid pressures. Peak fluid pressures were observed in the center of the shoe and about 30 mm from the heel of the shoe. The casual shoe had high fluid pressures under full tread conditions suggesting that tread channels need to extend to the shoe perimeter to drain fluid. No fluid pressures were observed for the low viscosity fluid suggesting that tread is most important when stepping on high viscosity fluids.

VALIDATION OF APPROACH WITH HUMAN SUBJECTS

Peak pressures were an average of 124 kPa for the untreaded work shoe and 1.1 kPa for the treaded shoe (Beschorner et al., 2014). Peak pressures were strongly correlated (R^2=0.76) with peak slipping velocity suggesting that fluid pressure is a good predictor of slip severity. Fluid pressures were highest near the center of the shoe. This method confirms the relevance of slip-tester fluid pressure results to slipping.

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T11

THE INFLUENCE OF BOOT AND SURFACE TYPE ON IN-SOLE PRESSURE AND COMFORT WHEN WALKING ON SIMULATED COAL MINING SURFACES

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1. INTRODUCTION

Underground coal mine workers incur a high incidence of work-related lower limb injuries, particularly sprains and strains caused by slips and trips. Anecdotal evidence suggests that uneven surfaces and uncomfortable and poorly fitted boots contribute to these lower limb injuries in coal mining, although this notion has not been systematically investigated. As in-shoe pressure measurements correlate with shoe comfort (Hagen *et al*, 2010; Miller *et al*, 2000), this study aimed to investigate the effects of wearing gumboots and leather lace-up boots on in-shoe pressure and perceived comfort when walking across simulated coal mining surfaces.

2. METHODS

Twenty male participants (age 33.4±12 years) with no lower limb pathology, walked at a self-selected pace around a simulated coal mining circuit. This circuit (≈30 m in length) consisted of level, inclined and declined surfaces, which were composed of rocky gravel and hard dirt. Two boot conditions were included (gumboot, leather lace-up; Fig 1). Plantar pressures and ratings of perceived comfort were recorded using Pedar-X insoles ($\text{Novel}_{\text{gmbh}}$, Germany) and a Visual Analog Scale. Three-way repeated measures ANOVA and *t*-tests were calculated to determine whether outcome variables were significantly ($p \leq 0.05$) different between the two boot types and whether walking surface and/or area of the foot influenced any of these differences.

Figure 1: Two underground mining steel-capped work boots. A: Gumboot (Style 015; Blundstone®, Australia) and B: Leather lace-up boot (Style 65-691; Oliver, Australia).

3. RESULTS

The gumboot was perceived to be significantly easier to walk in and allowed more ankle and knee range of motion than the leather lace-up boot. The leather lace-up boot was perceived to be significantly more stable than the gumboot. Mid-foot peak pressure was significantly increased while wearing the gumboot when walking up the incline (Fig 2). Forefoot pressure-time integrals and forefoot, mid-foot and heel peak pressures also significantly increased when walking down the declined surface while wearing the gumboot compared to the leather lace-up boot (Fig 2).

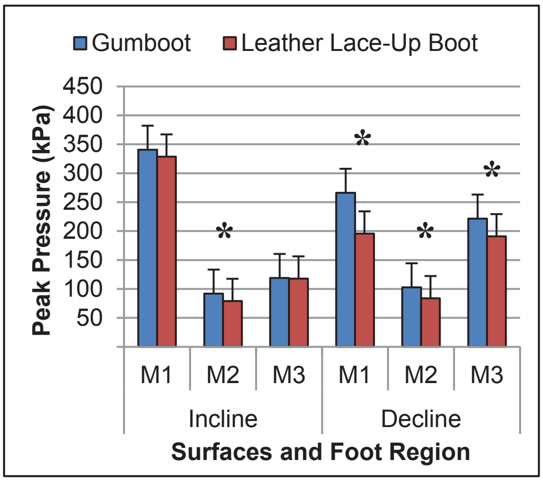

*Figure 2: Mean (+SEM) forefoot (M1), mid-foot (M2) and heel (M3) peak pressure (kPa) while the participants walked up an incline and down a decline in the gumboot and leather lace-up boot (n = 20). *significant difference (p ≤ 0.05).*

4. DISCUSSION

Underground coal mining work boot structure significantly influenced in-shoe pressure and perceptions of comfort when participants walked on sloped surfaces typically encountered by underground coal mine workers. To avoid potential injury, a combination of the preferred features inherent in each boot should be considered for the underground coal mining environment. Further research is warranted, however, to systematically investigate the effects of changes to boot type on underground mining injury rates.

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T12

BIOMECHANICAL EVALUATION OF TWO DIFFERENT FOREFOOT RELIEF SHOES

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INTRODUCTION

After forefoot surgery, patients require forefoot relief, which can be obtained with a variety of shoe designs. Post-operative foot wear can be very different as for the quality and amount of this weight bearing allowed to the forefoot (Hans-Dieter et al, Deleu et al). Another important condition to consider is the gait ability that the shoe can provide to the patient. This is critical, because many of those patients which undergo forefoot surgery belong to the elderly population, therefore with a higher risk of falling. Therefore a most complete gait analysis is sought to quantify the performance.

The purpose of this study was to compare two post-operative forefoot relief shoes based on careful biomechanical measurements. In particular, the comparison was performed mainly in terms of spatial-temporal gait parameters, lower limb kinematics and forefoot plantar pressure.

MATERIALS AND METHODS

Twenty female patients (mean age 64 ± 9.6 years) who underwent first metatarsophalangeal osteotomy for hallux valgus deformity were analyzed, together with a control group of 10 female healthy subjects. Patients evaluation was performed pre-operatively and one month after surgery. Two different post-operative shoe designs were compared: WPS® talus shoe (Podartis, Treviso Italy) with a talus outsole, TD® biomechanical fully rocker rigid outsole shoe (Podartis, Treviso Italy) with a Zero® talus 8° insole. Both models were also compared to a physiological shoe.

Pedobarographic data were obtained using the Pedar® cable system (Novel GmbH, Munich, Germany). Forefoot mean peak forces were analyzed in order to estimate the forefoot relief of each shoe design.

Gait analysis was performed using a stereophotogrammetric system with eight cameras (Vicon 612, Vicon Motion Capture, Oxford, UK) and two dynamometric platforms (Kistler Instrument; Einterthur, Switzerland). Our recently described protocol for kinematic and kinetic analysis of gait (Leardini et al) was used.

ANOVA was used for statistical analysis, and *p* values less than 0.05 were considered significant.

RESULTS

Pedobarographic analysis showed a reduction of the mean forefoot peak force (N) in both post-op shoes (WPS: 81.8 ± 16.8; TD: 170.6 ± 31.3) in comparison to the physiological shoe (523 ± 57.5).

Gait analysis revealed a reduction of gait speed and stride length in both post-op shoes, more evident in WPS than in TD. The former showed also a complete absence of ankle plantarflexion during terminal stance and swing, probably associated to combined alterations of the kinematics patterns observed also at the hip and pelvis in the coronal plane. The TD patients showed a reduction of ankle plantarflexion during terminal stance and swing, and less corresponding alterations at the hip and pelvis.

Figure 1: The WPS® talus shoe (Podartis, Treviso Italy) with a talus outsole equipped for the biomechanical evaluation.

Figure 2: The TD® biomechanical fully rocker rigid outsole shoe (Podartis, Treviso Italy) with a Zero® talus 8° insole.

DISCUSSION

Both forefoot relief shoes demonstrated a reduction of weight bearing on the forefoot in comparison to a physiological footwear design. The 'WPS talus' shoe showed a decreased value of mean forefoot peak force compared to the 'TD biomechanical' shoe. WPS revealed more gait abnormalities than TD.

Both analyzed shoes resulted appropriated in the forefoot relief after surgery. The 'TD biomechanical' shoe ensured less gait alterations, so it could be more advisable for elderly patients.

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K2

EPIDEMIOLOGY AND FOOT PATHOLOGY: BRIDGING THE DISTANCE BETWEEN POPULATIONS AND FOOT SCIENCES

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INTRODUCTION

Advances in ability, accuracy and precision of biomechanical measurements over the past decades have allowed a better understanding for foot structure and function. How humans ambulate and how the possible forms affect function have been the topic of many research presentations. It is well appreciated that many foot disorders and dysfunctions are biomechanically derived. Certainly surgical case series and many laboratory studies have informed treatment of the most severe cases and insights into possible mechanisms. Yet, we know little of the extent of foot problems and prevalence of foot types in the population.

OBJECTIVES

The purpose of this presentation is to provide a population-based perspective of foot type and function in community-dwelling adults; Along with a major dose of "who cares and why!" Objectives are first, to use the foundations of epidemiologic principles to map how populations inform science & medicine; secondly, 'translate' how complex movements and measurements might be obtained from large groups outside the laboratory by identifying key elements and time components; third, discuss major findings of population foot studies and understand how these interpretations help inform the public as well as disseminate clinical and scientific information; Fourth, how to generalize population information currently available from foot studies effectively in evidence-based practice; and finally, to identify aspects of the wonderful world of epidemiology as they relate to your strategies to inform your research, science and communication efforts.

FINDINGS

Population risk factors for hallux valgus, foot & ankle pain, extremes of foot structure, various arch index measures, and specific foot disorders (Dunn, 2004; Menz, 2001) have all informed clinicians and scientists of where specific persons could be placed on a spectrum of experience (Zifchock, 2006). Data from these studies will be presented but more importantly, the inferences from these measures to major populations will also be discussed (Hagedorn, 2013). Insights from studies on foot structure and function with foot disorders and other pathologies in populations will be provided as well as possible genetic influences (Hannan 2013).

This session will discuss what we have learned about interventions for foot disorders and foot pain. Key points will include how populations may differ from laboratory volunteers and also from patients.

How does all of this inform our understanding of foot biomechanics and translation of research? Epidemiology may serve as a bridge between our current knowledge base and how to grow this foundation to the next level of helpful insights and interventions for populations. Kinesiology and bioengineering can merge with population sciences to encourage the integration of our knowledge of biomechanics and movement with "Big Data" collections, taking our field (or even fields) to the next level.

The translation of your work, the insights provided by this society's collection of research abstracts, and the need for population to 'know why' and intervene for betterment is of keen interest. The intersection between epidemiology and foot pathologies will help bridge the distance between population needs and foot sciences.

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T13

COMPARISON OF PEAK PLANTAR PRESSURES IN THE ARMY CADET POPULATION: THE IMPACT OF A 6 WEEK INTENSIVE TRAINING PROGRAM

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INTRODUCTION

Incoming army cadets, although already accomplished athletes, complete additional intensive training immediately upon entering the military academy. This 6 week intensive training program, known as the "beast", consists of a variety of activities to challenge the cadets including high impact and sustained loading activities over extended periods of time. It is unknown if at the completion of the beast, there are changes in foot structure and resultant changes in peak plantar pressures.

The objective of this study was to determine if there were differences in peak pressure (PP) across boot fit day and post beast for the new incoming cadets.

METHODS

225 cadets were enrolled. Dynamic plantar pressures were collected with an emed-x pedobarograph using a 2-step method. Measures were obtained both baseline (during the first week of school [Visit 1]) and 6-weeks post-test training (Visit 2). For every cadet, peak pressures (N/cm²) were averaged for 5 trials for each foot. Masking was done over 12 regions, and peak pressure was calculated in each region.[1] Linear regression was used to compare masked regions of plantar pressure measures across foot structures with GEE to account for correlations between right and left feet of each participant.

RESULTS

Peak pressure remained unchanged in nine regions. Decreases were seen in only three regions: under the hallux, toes 3-5, metatarsal head 2 as well as for the total PP (Table 1, Fig 1).

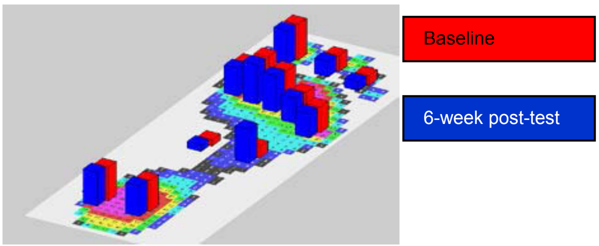

FIGURE 1. PP BY MASKED REGION

DISCUSSION

The overall decrease in total plantar pressure may be related to weight loss following this intensive program although this data is not available at this time. In addition, if the area under a given masked region increased, the peak pressure may be lower. To fully describe the change in plantar pressures following this program, average pressures and area need to be evaluated as well. The next steps are to collect data over a longer period of time to better understand the foot plantar pressure of the cadets.

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Table 1. Result summary for peak pressure (PP) parameter across visit one and visit two

PP (N/cm²)	Visit 1		Visit 2		GEE results	
	Mean	SD	Mean	SD	X²	p-value
Hallux	36.7	16.9	34.4	16.0	7.1	**0.007**
Toe 2	15.2	7.1	14.9	7.3	0.38	0.534
Toes 3-5	9.8	5.2	8.7	4.7	12.0	**0.001**
Metatarsal head 1	29.3	12.7	28.5	11.4	1.4	0.230
Metatarsal head 2	42.6	15.4	41.5	13.5	5.4	**0.020**
Metatarsal head 3	38.5	12.0	38.0	9.8	1.2	0.278
Metatarsal head 4	27.0	8.5	27.6	6.8	2.1	0.151
Metatarsal head 5	27.8	17.1	27.6	15.6	0.03	0.845
Lateral heel	32.0	8.1	31.3	8.6	1.8	0.183
Medial heel	35.0	11.4	34.9	11.3	0.04	0.833
Lateral arch	11.3	5.1	10.9	4.5	2.5	0.113
Medial Arch	6.7	3.3	6.8	3.2	0.34	0.560
Total PP	9.8	5.2	8.7	4.7	12.0	**0.001**

T14

PLANTAR LOADING DIFFERENCES BETWEEN GENDERS DURING AN UNANTICIPATED SIDE-CUT

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INTRODUCTION

Stress fractures account for 10-20% of reported sports injuries (Fredericson 2006, Matheson 1987). Fifth metatarsal stress fractures are more common in men and have a high incidence of delayed union, non-union, and re-fracture (Rammelt, 2004, Nunley 2001).

Overuse injuries could result from the increased loading beneath the foot.(Eils 2004). Men have been shown to have increased loading on the lateral aspect of the foot during various sport specific tasks, which may explain the increased incidence of fifth metatarsal stress fractures in men (Queen 2007, Sims 2008).

Understanding plantar loading is important for the prevention and treatment of metatarsal stress fractures. However, past studies have struggled to replicate the movements and forces that are present during game play. Therefore, the purpose of this study was to use an unanticipated cutting task to better simulate cleated sport game play. We hypothesized men and women would demonstrate significantly different loading in the midfoot and forefoot when completing an unanticipated side cut on FieldTurf.

METHODS

A total of 32 Division I collegiate soccer and lacrosse athletes (16 men, 16 women) were recruited and tested during this study. Subjects were excluded if they had a history of lower extremity injuries within the past 6 months, foot or ankle surgery in the past 3 years, or had a history of a metatarsal stress fracture. Subjects were tested using a standard cleat (Nike Vitoria, Nike, Inc) and the appropriately sized Pedar-X insole, calibrated to 9 bar, to collect bilateral plantar loading data (100 Hz). Testing was completed on an indoor FieldTurf field. Subjects were asked to run straight forward until a light was illuminated which indicated the cutting direction. Subjects were told to cut 45^{o} in the indicated direction for 12 cutting trials, both to the left and to the right.

For analysis, the foot was divided into eight regions using a percentage mask. The focus for this study was the midfoot and forefoot regions. The plant foot alone was used for analysis. The contact area (CA) was normalized to the contact area of the entire insole, while the maximum force (Fmax) was normalized to body weight. Gender differences were assessed using an independent samples t-test (p<0.05). Statistical comparisons were co-varied for course speed.

RESULTS

Males had significant higher contact area in the medial midfoot (MMF) (p= 0.026). Males had statistically significant lower CA in the other five foot regions (p< 0.5). Males had a significantly lower contact time (CT) (p= 0.016) in the MMF. Males had a higher force-time integral (Ns) beneath the total foot (TF) (p< 0.001) and MMF (p< 0.001). Males displayed a greater Fmax in the MMF (p= 0.003) and lower Fmax in the lateral midfoot (LMF) (p< 0.001), middle forefoot (MiddFF) (p< 0.001), and the lateral forefoot (LFF) (p< 0.001). Males had higher peak pressures for the TF (p< 0.001), MMF (p= 0.002), LMF (p= 0.017), MFF (p= 0.04), and MidFF (p= 0.003).

DISCUSSION

During unanticipated cutting, women loaded the lateral column of the foot more than men, which is contrary to the current body of literature. Potentially the unanticipated nature of the task alters the biomechanics and therefore the loading pattern seen during this task. Future work will need to determine the effect of gender specific footwear design on plantar loading. In addition, the effect of different cleat plate configurations need to be assessed in order to optimize foot loading patterns while completing game like tasks such as unanticipated cutting.

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T15

THE EFFECT OF CROSSED RESPONSES ON DYNAMIC STABILITY

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AIM

In recent studies, we have demonstrated that sensory information arising from muscle receptors contributes significantly to the activity of muscles in the opposite limb by eliciting a so-called short-latency crossed response (SLCR) (Gervasio, 2013; Stubbs, 2011). The latency of these responses is too short to traverse to higher centers, suggesting a direct spinal connection between opposing limbs. SLCRs are impaired by central nervous system lesions in patients who do not present a normal walking symmetry (Stubbs, 2012). In this study, we analyze the functional significance of SLCRs by investigating their influence on the center of pressure (CoP) under the contralateral foot, which is a well-established measure used in clinical research.

METHODS

Subjects (n=8, 5 males, age 20-22 years) walked on a treadmill. Electrical stimulation of the ipsilateral tibial nerve was delivered at 80% of the ipsilateral gait cycle as at this time the stimulation elicits a prominent SLCR in the triceps surae (Gervasio, 2013). Surface EMG was recorded from ipsilateral soleus and contralateral gastrocnemius lateralis (cGL). CoP location and pressure distribution under the sole of the contralateral foot were recorded during walking using instrumented insoles (Pedar-x, Novel GmbH) inserted in the subject's shoe. Data were segmented for each gait cycle, time normalized as a percentage of the gait cycle and averaged for each condition (stimulation and control).

RESULTS

Seven out of eight subjects showed a significant short-latency facilitation in the cGL (P = 0.01) (Fig. 1A). A significant medial shift of the CoP location was observed in these subjects from 92% to 100% of the ipsilateral gait cycle (P < 0.03). Likewise, a significant anterior shift of the CoP location was observed from 90% to 98% of the ipsilateral gait cycle (P < 0.048). Moreover, the pressure at the level of the first metatarsal head was significantly higher when applying stimulation compared to the control condition at 95% of the gait cycle (P < 0.05) (Fig. 1B).

CONCLUSION

The SLCR induced an anterior-medial shift of the CoP, increasing the pressure at the level of the first metatarsal head. These results indicate that the SLCR could have the functional meaning of increasing the dynamic stability; with the ipsilateral leg approaching heel strike when the stimulation occurs, the SLCR may accelerate the propulsion phase of the contralateral leg, preparing for a faster step in the event that the stimulated leg is not able to sustain the body weight.

These results provide new insight into the funtionality of SLCRs, introducing the perspective that conditioning these reflexes, as shown successfully for other reflex pathways (Thompson, 2013), would increase dynamic stability in patients with impaired locomotion.

FIGURES

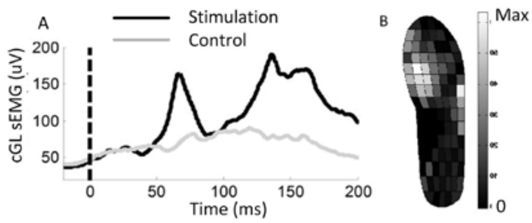

Figure 1: Short-latency facilitation in cGL (A) and absolute difference in pressure values between stimulated and control condition (B) for a representative subject.

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T16

HOW DOES STEP FREQUENCY INFLUENCE PLANTAR LOADING DURING COMFORTABLE WALKING?

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INTRODUCTION

For patients with diabetic polyneuropathy, higher loading of the plantar foot sole, especially the region of the forefoot, has been associated with the development of ulceration [1]. Although the mechanism of the diabetes-related ulceration is not yet fully understood, elevated dynamic plantar peak pressure and pressure-impulse are strong risk factors for future ulceration, in particular in conjunction with the loss of protective sensation [2]. To diagnose and evaluate treatments of high plantar loading correctly, it is important to be aware of what influences plantar pressure measurements. Gait velocity and stride length are considered important confounders. [1, 3] Also step frequency can influence measurement outcome, but the number of studies on this subject are limited and do not control other confounders. [3] Therefore, the aim of the current study is to evaluate the effects of changes in step frequencies on plantar pressures in standardized shoes and at standardized gait velocity.

METHOD

Using the Pedar-X system, in-shoe plantar pressures were measured in 12 young healthy participants (age 22.5 ± 1.5 yrs) walking on a treadmill at 3 step frequency (SF) conditions: own chosen step frequency (SF0), +10% increased step frequency (SF 10) and -10% decreased step frequency (SF -10). Gait velocity was kept constant during all 3 conditions. All participants wore the same canvas shoes with flexible insoles. The primary outcome measures were Peak Pressure (PP) and pressure-time-integral (PTI).

RESULTS

Increasing step frequency did not significantly change PP although some trends can be seen (see Fig 1) such as a decrease of the PP underneath the rear foot, medial part of the forefoot and big toe while the PP underneath the central and lateral forefoot tend to increase.

For PTI, increasing step frequency resulted in a significant decrease for all foot regions (Fig 2).

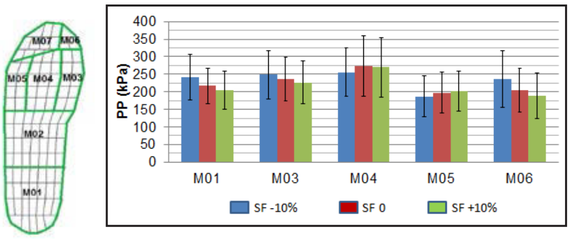

Figure 1 (left): foot mask division. M01=rear foot, M03 = medial forefoot, M04=central forefoot, M05=lateral forefoot, M06=big toe. .
(right): PP in 5 masks for 3 SF conditions.

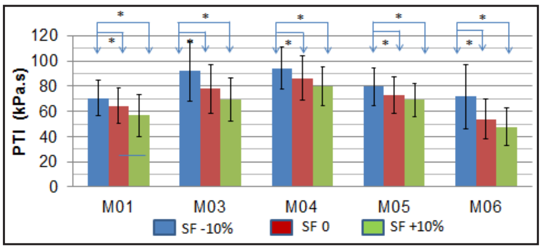

Figure 2: PTI in 5 masks for 3 SF conditions.

CONCLUSIONS

An increase in step frequency results in no significant changes in peak pressures, but does lead to lowering of the pressure impulse per step in all regions. It can be concluded that for studies and clinical evaluations considering only peak pressures, the influence of step frequency is of minor importance. However to measure pressure impulses correctly, step frequencies should be controlled or at least monitored.

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T17

COMPARISON OF FOOT LENGTH AND WIDTH MEASUREMENTS: DIRECT IN STANCE VERSUS CALCULATED FROM DYNAMIC PLANTAR PRESSURE FOOTPRINT

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INTRODUCTION

Foot dimensions can be measured directly in sitting and standing conditions using the modified arch height index measurement system (AHIMS).[1] Foot dimensions may also be calculated from dynamic plantar pressure data. While the AHIMS can measure static foot dimensions reliably[2], it cannot capture dynamic functional foot dimensions that may occur during gait. The purpose of this study was to compare the foot length and width measurements obtained directly in static posture using AHIMS and those calculated from the dynamic plantar pressure.

METHODS

Participants were 33 healthy asymptomatic subjects (66 feet) with a mean ± s.d. age of 31.3 ± 9.5 years, weight of 80.4 ± 18.4 kg, and BMI of 25.7 ± 4.9 kg/m^2. Foot length and width were measured using the AHIMS in sitting and standing conditions. Five left and 5 right barefoot trials were collected with emed-X (novel GmbH, Munich) using a 3-step method while subjects walk at their comfortable speed. A custom-developed program was used to calculate foot length and width, see Figure 1.

A linear correlation was performed (JMP Pro 10) to determine if these two independent measures of foot dimensions agree with each other.

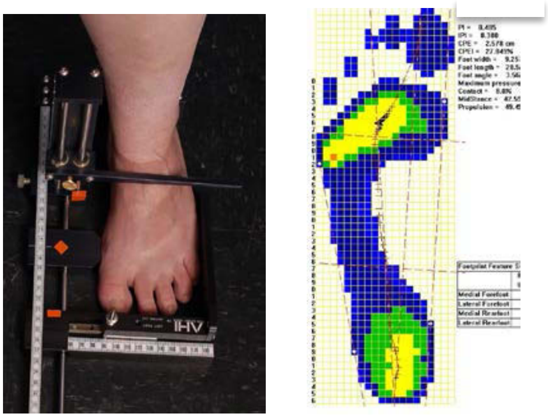

Figure 1: Foot dimensions measured directly using AHIMS in sitting and standing (left) and calculated from the dynamic plantar pressure footprint (right)

RESULTS

Two methods yielded a high linear correlation (range 0.82-1.00), Table 1. Y-intercepts suggest about 1 cm difference (range 0.82-1.27), larger in emed®-based calculation

Table 1: Results – slope and y-intercept (b)

Y	Slope	X	b	P-value
FW_emed	0.82	FW_AHsit	1.26	<.0001
FW_emed	0.85	FW_AHstd	0.82	<.0001
FL_emed	1.00	FL_AHsit	0.97	<.0001
FL_emed	0.98	FL_AHstd	1.27	<.0001

Note: Foot width (FW) and length (FL) measured directly with AHIMS in sitting (AHsit) and standing (AHstd) are compared with those calculated from emed® footprints.

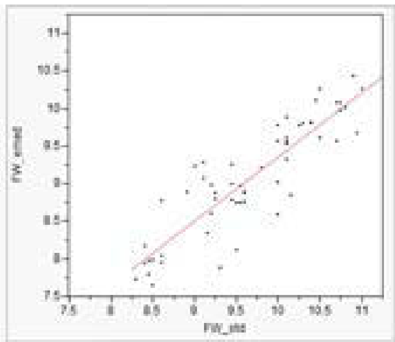

Figure 2: Linear correlation between FW_emed versus FW_AHstd.

DISCUSSION

Both methods yield highly correlated foot length and width. However, emed®-derived measures yield about 1 cm longer dimension than the direct measure obtained from static conditions. Reasons for such discrepancies are not clear. Spatial resolution of emed® (5mm x 5 mm sensors) may have contributed to these differences. Dynamic changes to foot shape in comfortable pace barefoot walking may also have influenced foot dimensions.

This pilot study was limited to healthy subjects without foot pathology. Accurate and reliable measure of foot dimensions could improve shoe fit and minimize foot complications especially in at-risk diabetic subjects with peripheral neuropathy.

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T18

REGIONAL FOOT LOADING DURING UNWEIGHTED RUNNING IN A LOWER BODY POSITIVE PRESSURE TREADMILL

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INTRODUCTION

Reducing load on the body during ambulation has been accomplished through multiple techniques and been shown to be a useful tool in rehabilitation. For example, lower body positive pressure treadmills (LBPPT) successfully reduce loading during gait (Cutuk, 2006). However, there is a paucity of research relating LBPPT with running in an athletic population. Furthermore, certain individuals that may benefit from reduced plantar loading during rehabilitation, such as those returning from a metatarsal stress fracture, may alter running mechanics and not reduce force in explicit plantar areas. The purpose of this project was to determine how different simulated gravity levels alter regional plantar loading patterns while running.

METHODS

Ten experienced runners were fit with pressure distribution measurement insoles (Figure 1, pedar-x, novel). Each subject ran at their self-determined easy training pace after a warm up period of five minutes. All subjects ran on a LBPPT (P200, Alter-G) at 20, 40, 60, 80 and 100% body weight settings in randomized order. Steps from each trial were exported for further analysis. Maximum force (F_{max}) and force time integral (FTI) were computed for the entire foot and nine specific foot regions (M1 medial heel, M2 lateral heel, M3 medial midfoot, M4 lateral midfoot, M5 medial forefoot, M6 central forefoot, M7 lateral forefoot, M8 big toe, M9 lesser toes). Relative load (RL) was determined by dividing each region FTI by the total foot FTI. Data from the right foot were used for analysis. A linear mixed effect model was used to determine how loading parameters varied across body weight percentage settings ($p<0.05$). *Post-hoc* pairwise comparisons were used if a significant main effect of body weight was found.

Figure 1. The initial set- up of the pressure distribution measurement insoles on the PPT.

RESULTS AND CONCLUSIONS

Significant main effects of body weight were found for F_{max} in all 9 foot regions (Figure 2, $p<0.05$). Specifically, differences in F_{max} were not found between 80 and 100% body weight settings in M1-5 and M8-9. F_{max} at the lower body weight settings (20-60%) in the toe region (M8, M9) were not different.

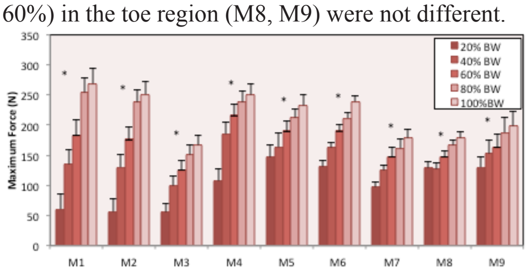

Figure 2. Maximum plantar force for each foot region. (* Main effect of BW $p<0.05$)

Significant main effects of body weight percentage settings were found for percent RL in the heel, midfoot and toes (Figure 3, $p<0.05$). Specifically, differences were found at the lowest body weight setting (20%) compared to the other settings in M1, M3, M8 and M9. Additionally, differences in M3 were found at 40% compared to the higher settings (60-100%). Therefore, similar RL appears to exist at the higher body weight (60-100%).

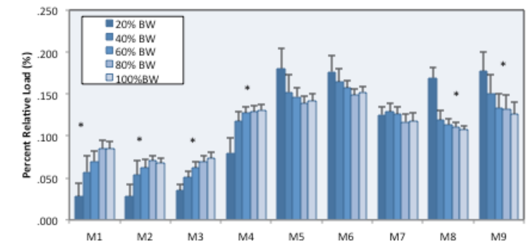

Figure 1. Percent relative load for each foot region. (* Main effect of BW $p<0.05$)

As expected, F_{max} was reduced as body weight support was increased. However, differences were not found in the majority of regions between 80 - 100% of body weight support. Additionally, at 20% body weight, the toes are loaded relatively more (not absolute) than other levels indicating different overall loading patterns exist and should be used cautiously.

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T19

DID THE BIOMECHANICS OF MAKING AND USING PALEOLITHIC STONE TOOLS INFLUENCE THE ORIGIN OF THE DERIVED HUMAN THUMB?

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ABSTRACT

Modern humans are unique in having a long, robust thumb with enhanced musculature compared to living apes. The manufacture and use of anient (Paleolithic) stone tools is commonly cited as a principal selective pressure that acted on the evolution of our thumb anatomy (Susman, 1994, Marzke, 2013) due to the load-bearing role the thumb is thought to play during these behaviors and the significant advantages stone tool behaviors offered our early human ancestors (SchIck and Toth, 1993). Researchers implicitly assume that the actions of making and using tools are biomechanical similar. However, little is known about the manual biomechanical stresses involved in such behaviors.

Here we test the hypothesis that making and using Paleilithic stone tools involve the same manual biomechanical strategies and concentrate high loads on the thumb.

We used a dynamic pressure sensor system to measure pressures and normal forces acting across the hand during stone tool behaviors hypothesized to have been practiced by our ancestors. Amateur and experienced tool-makers (n = 23) produced flakes and “choppers“ (figure 1), and performed the following tool use behaviors: nut cracking with a hammerstone (n = 562), slicing animal tissue with a flake and a “handaxe“ (n = 148, 146), and accessing the marrow cavity of a long bone with a hammerstone and a “chopper“ (n = 98, 96). Flint was used for all tool production and four types of nuts with toughness values similar to those consumed by wild primates were used for nut-cracking. Data were captured at 200 Hz.

Our results show that there is considerable variation in the external loads and internal joint stresses between making and using stone tools. During tool manufacture peak forces and pressures throughout the motion and at strike were concentrated on the 2nd and/or 3rd digits rather than on the 1st digit ($p \leq 0.009$ and ≤ 0.01, respectively). In contrast, during tool use for all behaviors save one (marrow extraction with a chopper), the thumb was subjected to significantly greater forces and pressures compared with the other regions of the hand ($p \leq 0.001$ and ≤ 0.047, respectively, figure 2). The thumb tip (pollical distal phalanx) experienced significantly greater forces during tool use compared with tool making. Due to the uniquely large size of the flexor pollicis longus muscle, activities involving high external forces on the pollical distal phalanx will result in higher pollical joint stresses compared with activities generating lower distal phalanx forces. Together, these results suggest that the evolution of humans’ unique robust thumbs was a selective response to the use rather than the production of stone tools.

FIGURES

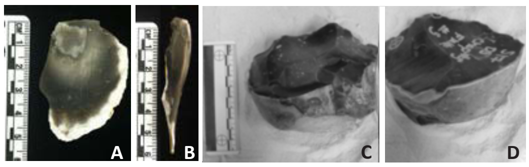

***Figure 1**: (A&B) front and profile of a standard flake. (C&D) front and back of a standard chopper.*

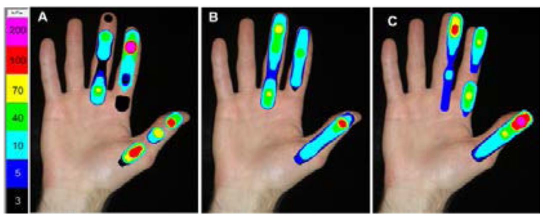

***Figure 2**: pressure distributions during (A) tool production, (B) nut-cracking, and (C) slicing tissue with a flake.*

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T20

FEEDBACK ON FORCE, SOUND AND VIDEO SEQUENCE OF KEYSTROKE DURING PIANO PLAYING

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INTRODUCTION

An understanding of the force and impulse acting on the key by the finger associated to the sound generated is important because it makes the difference between interpretation and pure mechanical played notes.

Using pressure sensors applied on the key surface, it was possible to analysis the relationship between the force-time characteristics and the performance of pianists (Gaertner 2010, Kinoshita 2007).

The aim of this study is to demonstrate a new way to improve the didactics and methods of piano playing using biomechanical methods.

METHODS

A complete set of 2 octaves of pressure sensors (S2125, 20x45 mm^2, <1,2 mm, 10-600 KPa, Pliance-Novel) were developed. They can be attached to the most relevant keys and collected at 300 Hz. Video records are taken via normal CCD at different sample rates (50 to 300 Hz) Sound track are recorded via professional tools.

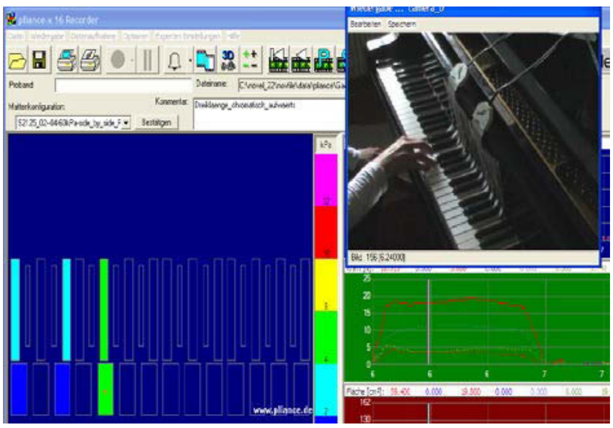

Figure 1: Example of feedback about key stroke force, sensor position and video shot sequences.

A dedicated software allows the calculation of efficiency index according to the force impulse up to the peak force and to the total impulse. This index reveals the capacity of the pianist to produce the desired loudness without exert unnecessary force (Gaertner 2013).

RESULTS

Three piano students with different level of expertise were involved in the experimental procedure. In the classical elements of piano playing (accords, octaves, etc.) subjects could hear the quality of sound and look to the corresponding force-time curves and to the video sequences. Then they were asked to improve the quality of sound at defined passages (key stroke combinations) and to verify the corresponding changes in the force-time curves.

In that case of no substantial changes, the same passages were played and recorded by a very high qualified pianist and compared with the profile reached by the student. Finally, the student had to become confident with the relationship between force-time curves and sound quality in the different situations.

In most cases, after the application of these feedback method, the students were able to directly improve their consciousness about the motor control mechanisms and the quality of sound.

In separate sessions values of the efficiency index and others parameter concerning the kinematics and kinetics of fingers and arm can be discussed with the subject.

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T21

LOAD DISTRIBUTION WITHIN THE HAND DURING CYLINDER GRIP

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PURPOSE

The aim of this study is to identify a high-resolution load distribution pattern of the hand when it is gripping cylindrical objects of two sizes.

METHODS

152 volunteers with a mean age of 34 years (range 18-65 years) performed grip force tests with the novel® manugraphy system. The latter consisted of two cylinders with 15- and 20-cm circumferences, coated with calibrated, capacitive pressure sensor mats. These measured the applied load dynamically with a resolution of 2 sensors per cm².

The subjects performed three times a maximum force grip for 5 s consecutively with both manugraphy cylinders. The tests were repeated at another two days. The mean force over the middle 3 seconds interval was evaluated. The loading pattern within the fingers, thumb, and palm was analyzed and compared for both cylinder sizes, each for the dominant and non-dominant hand, using the Wilcoxon-Test.

RESULTS

For the 15-cm cylinder, the local load was 11% for the thumb, 19% for the index finger (II), 20% for the middle finger (III), 13% for the ring finger (IV), and 7% for the little finger (V), 17% for the thenar, and 13% for the hypothenar. The load distribution was similar for the dominant and non-dominant hand with p= .061-.769 (Fig.1).

For the 20-cm cylinder, the local load was 18% for the thumb, 17% for the index finger (II), 18% for the middle finger (III), 13% for the dominant and 12% for the non-dominant ring finger (IV), and 6% for the little finger (V), 20% (dominant) and 21% (non-dominant) for the thenar (p= .004), and 9% respectively 8% for the hypothenar (p= .006). (Fig.2)

For each of the seven measurement fields, the percent load distribution differed significantly between the 15-cm and 20-cm cylinder with $p < .005$ in all tests.

CONCLUSION

Compared to the 15-cm cylinder, a higher proportion of the load for gripping the 20-cm cylinder is applied by the thumb and thenar but a lower proportion by the hypothenar. and the fingers.

The load distribution pattern of the dominant and non-dominant hand is similar while gripping the 15-cm cylinder. For the 20-cm cylinder, there is a minimal but significant load shift from the thenar to the hypothenar in the dominant hand.

FIGURES

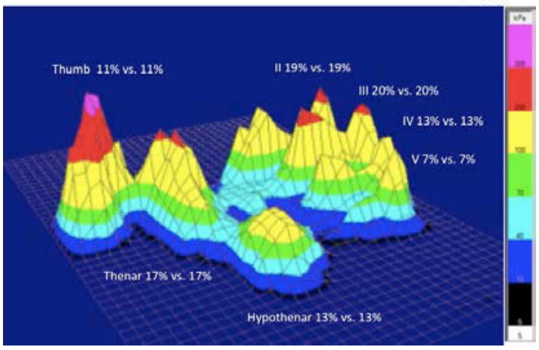

Figure 1: Load distribution of the dominant and non-dominant hand for the 15-cm cylinder

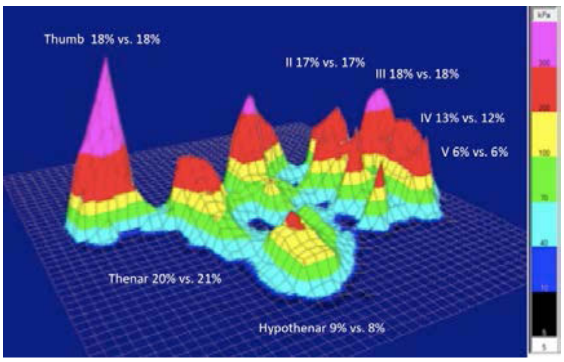

Figure 2: Load distribution of the dominant and non-dominant hand for the 20-cm cylinder

K3

MECHANO-BIOLOGY: EMPLOY PHYSICAL CUES TO INITIATE TISSUE REGENERATION

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Bone is a unique and highly regenerative tissue in vertebrates. Unlike to most injuries that lead to fibrotic scar formation and incomplete restoration of the tissue structure and function, bone healing restores pre-fracture properties under optimal conditions. Thus, a scarless repair of structures such as after fracture is possible leading the path to unravel mechanism of true regeneration. Consequently, the investigation of bone regeneration has significant impact on our understanding of how such processes of regeneration are driven and how it is affected by risk factors such as aging. An understanding of the underlying mechanisms and processes might serve as blue-print to other organ systems where regeneration appears even more challenging.

The formation of callus tissue - as intermediate material to reconstitute the body's own structure and function - proved to be mechano-responsive in both, the type and the amount of tissue formed. Demanding mechanical conditions such as in instable fracture fixations lead to a delay of bone bridging, a prolonged cartilaginous phase of endochondral ossification, a reduced and delayed angiogenesis and a prolonged inflammatory phase. All of the relevant cascades of bone healing and formation are directly influenced by mechanical means. The way tissues are formed, the way they mature and aspects of their re-organization are directly influenced by mechanical constrains. Even though the general nature of mechano-sensitivity are widely known, details of their interplay and specially how the mechano-sensitivity at the various length scales from macroscopic mechanics to sub-cellular signaling are yet not fully understood.

Further, the process of bone healing seems to recapitulate aspects of the embryonic skeletal tissue formation and development. It is yet unclear if the processes of formation and repair are indeed similar. To what degree the key-regulator, the mechano-sensitivity, remains constant with time and across processes such as development, maintenance and regeneration is also relatively unknown. Using mesenchymal stromal (or stem) cells (MSCs) as a key element of regenerative capacity, studies from our and other groups in humans and animals have demonstrated an age dependent regeneration potential that seems to decline with increasing age. The reduced mechano-sensitivity of one of the key-elements of regeneration – mesenchymal stroma cells - combined with a shift in material characteristics and change in tissue straining in aged species compared to their younger counterparts illustrates the importance to characterize mechano-senstivity of biological systems not as static and somehow stable systems but as adaptive systems with changing capacities in all stages of aging.

Mechano-biology seems to be apparently a central aspect of the phases of bone healing and regeneration; it plays a key role in maintenance and seems to be also important in early developmental phases. A further understanding of the underlying mechanism of the link between biology and mechanics and their direct interactions at the various lengths scales and across aging seems to be essential to understand healing cascades, their interaction and limitations in healing in clinically demanding situations. This understanding is mandatory to allow effective stimulation of regenerative cascades even under compromised healing conditions.

T22

Clinical Value of Temperature in Assessing Foot Loading in Diabetic Patients With and Without Neuropathy

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INTRODUCTION

Diabetic foot ulcers lead to an estimated 100,000 amputations every year in the U.S. They are known to have a biomechanical etiology that relates to three dimensional ground reaction forces/stresses. Among these stresses, horizontal shear stress cannot be easily quantified. Brand has suggested that temperature can be used to predict tri-axial loading under the foot [1]. Studies have also revealed that diabetic patients have increased plantar temperatures when compared to control subjects [2]. Diabetic feet may experience elevated stresses that lead to inflammation within foot. High temperatures under the foot may indicate the location of inflammation, hence maximum loads. Unfortunately, this theory has yet to be validated. The purpose of this study was to explore a site-wise association between peak plantar temperature and peak pressure and shear stresses. In addition, a magnitude-wise analysis was performed. If confirmed, thermographs can assist clinicians/researchers in preventing diabetic ulcer related amputations.

METHODS

Two groups, each consisting of 14 diabetic patients with neuropathy (DN) (2 F, 64.8±6.8 years, 32.0±5.1 BMI) or without neuropathy (DC) (9 F, 52.4±12.9 years, 28.9±7.4 BMI), were recruited for the study after informed consent was obtained. Resting foot sole temperatures were recorded using an infrared thermal camera. Subjects walked on a 12 ft. walkway that accommodated a custom-built triaxial stress plate. Stress variables such as peak pressure (PP), peak shear (PS), peak pressure integral time (PTI) and peak shear-time integral (STI) were recorded from five regions of the foot (i.e., hallux, lesser toes, first metatarsal head (1st MTH), central forefoot (2nd and 3rd MTH) and lateral forefoot (4th and 5th MTH)). Global peak values for all variables were determined as well. The stress variables were then correlated with measured plantar temperatures.

RESULTS

Pearson correlation analysis between each stress variable against temperature were statistically significant ($p<0.05$) in both groups. The r values ranged between .405 and .511. Despite significant correlation results, peak temperatures could not successfully identify peak stress locations in Group DN (14-57%). Success rates were higher for the Group DC (50-86%).

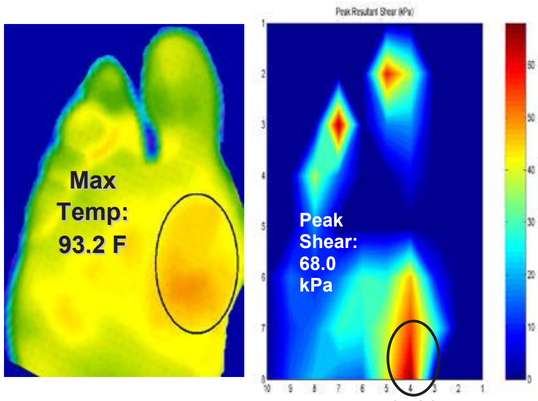

Figure 1: Resting plantar temperature (left) and peak plantar shear (right) profiles of a subject from Group DN. Note the match between the sites of peak temperature and peak shear (MTH1).

CONCLUSIONS

The potential association between plantar stresses and temperature is thought to have a complicated and non-linear relationship. Appropriate modeling schemes can be implemented to explore such relationships. Thus our results warrant further investigation on this topic.

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ACKNOWLEDGEMENT

This study was possible due to research funding from the NIH (R15DK082962).

T23

HIGH PLANTAR LOADING AND LOW BONE STRENGTH LEAD TO INCREASED METATARSAL STRAIN IN INDIVIDUALS WITH DIABETES AND NEUROPATHY

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INTRODUCTION

Individuals with diabetes mellitus (DM) and peripheral neuropathy (PN) have high rates of lower extremity fracture, especially foot bones such as the metatarsals. Low bone mineral density (BMD), poor bone quality, and high biomechanical loading may contribute to DM fractures. Bone stress and strain provide ideal biomechanical indices of fracture risk, as they incorporate bone material strength, geometry, and applied loads.

The purpose of this analysis was to assess *in vivo* metatarsal bending stress ($\boldsymbol{\sigma}_{\text{bend}}$) and strain ($\varepsilon_{\text{bend}}$) during gait in individuals with DM+PN compared to non-DM individuals. We hypothesized that individuals with DM+PN would have higher $\boldsymbol{\sigma}_{\text{bend}}$ and $\varepsilon_{\text{bend}}$ in both a medial column forefoot bone (Metatarsal 2) and a lateral column forefoot bone (Metatarsal 5).

METHODS

Twelve participants, 6 with DM+PN and 6 without DM or PN, gave informed consent to undergo plantar pressure measurement and quantitative computed tomography (QCT) scans of the foot and ankle. Foot bones were segmented in the QCT scans using semi-automated image analysis software (Liu, 2013). ImageJ (imagej.nih.gov), BoneJ (bonej.org), and custom processing algorithms were used to compute volumetric BMD and geometric strength properties from the metatarsal voxel datasets (Gutekunst, 2013).

Participants walked unshod across an EMED pressure platform (Novel USA, St. Paul, MN) at self-selected speed. Two to three trials on each foot were averaged, and the resulting plantar pressure maps were divided into 10 masks using the Novel standard mask template. Maximum force [N] under each metatarsal head served as the kinetic input to compute metatarsal mid-shaft moment (**M**); $\boldsymbol{\sigma}_{\text{bend}}$ was then calculated based on subject-specific bone length, 3D orientation, and cross-sectional periosteal radius (c) and second moment of area (I):

Bone bending stress: $$\boldsymbol{\sigma}_{bend} = \boldsymbol{M} * \frac{c}{I} \quad (1)$$

Elastic modulus (E) was computed from BMD, which allowed bending strain ($\varepsilon_{\text{bend}}$) to be calculated:

Bone bending strain: $$\varepsilon_{bend} = \boldsymbol{\sigma}_{bend}/E \quad (2)$$

Group differences between DM+PN and controls for mid-diaphyseal bone stresses and strains were assessed by t-tests (1-tailed, $\alpha \leq 0.05$).

RESULTS/DISCUSSION

Metatarsal 2: Maximum force, mid-shaft bending moment, and mid-shaft bending stress were not different between the groups (Table 1). There was a trend (p=0.06) toward higher bending strain in DM+PN subjects, indicative of lower elastic modulus and reduced bone material strength in DM+PN.

Metatarsal 5: Individuals with DM+PN had roughly 60% higher maximum force and bending moment than non-DM individuals (p<0.02, Table 1). Bending stresses were 72% higher in DM+PN (p<0.01), due in part to reduced second moment of area. Lower elastic modulus led to an even greater difference in bending strain in DM+PN individuals (158% higher, p<0.001).

CONCLUSIONS

This pilot project suggests individuals with DM+PN experience elevated metatarsal bending stress and strain. Higher bone strains reflect increased plantar loading and reductions in bone geometry and material strength, and may lead to fracture (Milgrom, 2002).

ACKNOWLEDGMENTS

This work was supported by research funding from the National Institutes of Health: R21 DK079457 (Sinacore) and T32 AR056950 (Westendorf).

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Table 1.	Metatarsal 2			Metatarsal 5		
	DM+PN	**Control**	***P***	**DM+PN**	**Control**	***P***
Maximum Force [N]	209 (83)	191 (58)	NS	79 (41)	50 (15)	**0.02**
Mid-shaft bending moment [N*m]	5.95 (2.35)	5.22 (1.70)	NS	2.33 (1.25)	1.44 (0.40)	**0.02**
Bending stress, $\boldsymbol{\sigma}_{bend}$ [MPa]	122 (51)	117 (45)	NS	36.2 (14.8)	21.0 (8.0)	<0.01
Bending strain, ε_{bend} (με)	9990 (4620)	8050 (2850)	0.06	4240 (1440)	1650 (563)	<0.001

T24

PREDICTORS OF BAREFOOT PLANTAR PEAK PRESSURE IN PATIENTS WITH DIABETES, PERIPHERAL NEUROPATHY AND A HISTORY OF ULCERATION.

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INTRODUCTION

The repetitive application of elevated dynamic plantar foot pressures during locomotion causes foot ulcers in persons who have diabetes mellitus and loss of protective foot sensation. Despite preventative treatment, in many patients foot ulcers recur, but the determinants of high plantar foot pressure in these high-risk patients are not well understood (Bus et al., 2013).

The aim was to determine which factors predict barefoot plantar peak pressures in a population of diabetic patients with peripheral neuropathy and a recent history of foot ulceration.

METHODS

Patients with diabetes mellitus, peripheral neuropathy and a history of plantar foot ulceration (i.e. <18 months post-healing) were eligible for inclusion. Demographic data, foot structure and function (e.g. foot deformity, limited joint mobility), and disease-related factors were recorded and used as potential predictor variables in the analyses. Barefoot peak pressures during normal overground walking were measured using EMED-X and calculated for 5 specific foot regions: the heel, midfoot, forefoot, hallux, and lesser toes. Potential predictors were investigated using multivariate linear regression analyses.

RESULTS

167 participants with a mean age of 63 years contributed 329 feet to the analyses. The regression models were able to predict 6% (heel), 40% (midfoot), 30% (forefoot), 13% (hallux), and 19% (lesser toes) of the variation in peak plantar pressures.

The largest contributing factor in the heel model was glycosylated haemoglobin concentration, in the midfoot Charcot deformity, in the forefoot prominent metatarsal heads and claw toe deformity, in the hallux non weight-bearing hallux dorsiflexion angle, and in the lesser toes hammer toe deformity.

Variables with local effects (e.g. foot deformity) were stronger predictors of plantar pressure than global features (e.g. body mass, age, gender or diabetes duration).

DISCUSSION AND CONCLUSIONS

The presence of local deformity was the largest contributing factor to barefoot dynamic plantar pressure in high-risk diabetic patients and should therefore be adequately managed to reduce plantar pressure and ulcer risk. However, a significant amount of variance is unexplained by the models, which advocates the quantitative measurement of barefoot plantar pressures in the clinical risk assessment of diabetic patients who are at high risk of developing plantar foot ulcers.

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BIOMECHANICAL SEQUENCES OF MINOR AMPUTATIONS IN PATIENTS WITH DIABETES MELLITUS

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INTRODUCTION

The reported risk of minor amputations in the patients with Diabetes Mellitus (DM) ranges from 2% to 16% (A Clinical Practice Guideline, 2006). The history of amputations is not limited with one surgery often because of the ulceration caused with the overloading and callus formation. Therefore it is very important to take into consideration the abnormal biomechanics due to the loss of the foot part. The aim of this study was to assess the loading of the foot in different groups of DM patients with minor amputations using the pressure distribution measurement parameters.

METHODS

60 patients (21m/39f), age 60±8 years with DM (type 1/2/2 on insulin-18/9/33) with minor unilateral amputations and without a history of Charcot foot were examined. The patients were divided into the groups based on the amputated toes (T) and metatarsal heads (MTH): Gr.1-T1, Gr.2-T1+MTH1, Gr.3-T2, Gr.4-T2+MTH2, Gr.5-T3, Gr.6-T3+MTH3, Gr.7-T4, Gr.8-T4+MTH4, Gr.9-T5, Gr.10-T5+MTH5, Gr.11-T1+T2, Gr.12-T1+T2+MTH1+MTH2. Two steps analysis was carried out. Step 1: for the first and last examination (at least in 2 years). Step 2: removal of the toe and removal of the toe and MTH. Plantar pressure measurements were performed with emed-AT 25 system (novel, Munich). Five dynamic records of each foot were made with the first step protocol. Peak pressure (PP), Mean pressure (MP), Maximum force (% BW) (MF), Pressure-time integral (PTI), Force-time integral (% BW) (FTI), under the hindfoot (Hf), midfoot (Mf), MTH1-MTH5, T1, T2, and T345 were calculated for each subject and for each group. ANOVA was used for the follow up and intergroup comparison (a significance level <0.05).

RESULTS AND DISCUSSION

Hallux amputation results in increase of the loading of the lateral MTH and toes with time, e.g. PTI, kPa*s: MTH3 (145±38 vs. 186±75), MTH4 (129±66 vs. 176±98), T345 (26±25 vs. 59±40). It is explained with the reduced effectiveness of the first ray due to the movement of the medial column distally (Schoenhaus et al., 1991). The second digit removing causes the rapid development of the hallux valgus, decreasing loading of the hallux and increasing loading of the MTH3 in time, e.g. PTI, kPa*s: MTH3 (192±132 vs. 314±170), T1 (140±83 vs. 82±71). Lesser toes amputations result in insignificant alterations in the weight bearing in time. Removal of the hallux and the MTH1 leads to the increased loading of MTH2 and MTH3 in time, e.g. PTI, kPa*s: MTH2 (74±28 vs. 165±146), MTH3 (204±113 vs. 432±243). Removal of second toe and MTH2 results in significant increase of hallux, MTH1 and lesser toes loading with decreasing loading of MTH4, e.g. PTI, kPa*s: MTH1 (249±79 vs. 447±98), MTH4 (121±30 vs. 79±25), T1 (41±8 vs. 129±38), and T345 (39±30 vs. 100±46).

The removal of both toe and MTH leads to more pronounced changes compared with the toe removal only. The significant results are given in table 1.

Table 1. Comparison of groups

	Gr.2 vs. Gr.1	Gr.4 vs. Gr.3	Gr.6 vs. Gr.5	Gr.8 vs. Gr.7	Gr.10 vs. Gr.9	Gr.12 vs. Gr.11
MTH2	**Decr.**	abs	**Incr.**	**Incr.**	Ns	abs
MTH3	**Incr.**	Ns	abs	Ns	Ns	Ns
MTH4	**Incr.**	**Incr**.	Ns	abs	**Decr.**	**Incr.**
MTH5	**Incr.**	Ns	**Incr**.	**Incr.**	abs	**Incr**.
T1	abs	**Incr.**	Ns	**Incr.**	Ns	abs
T2	**Decr**.	abs	**Decr.**	Ns	Ns	abs
T345	Ns	Ns	**Decr.**	Ns	NS	**Decr**.

abs – amputated area; Ns - nonsignificant

It is known that when T1 is removed, T2 takes its function. The hammer toe deformity of the T2 is typically developed and produces the increased loading of the T2 and MTH2. The removal of both T1 and MTH1 prevents this overloading but increases pressure under MTH3-MTH5 compared with T1 amputation only. The loading of the MTH3 did not influenced by other types of amputations. Amputation of the fifth toe and MTH5 makes the fourth metatarsal bone the most lateral segment of the forefoot. Although the loading of this area is decreased, the development of the varus position of the forefoot is probable. Any type of amputation of MTH+T leads to lower decrease of the loading of the lesser toes compared with toe amputation probably due to their clawing. Amputation of MTH+T leads to more high increase of the loading of MTH5 in most cases. At the same time any amputation of the MTH+T leads to more pronounced loading of the remained MTH in comparison with the consequences of the pure T amputation.

CONCLUSION

The clinical indications in concert with the pressure distribution measurements allow performing the proper assessment the required volume of the surgical intervention and the biomechanical sequences of the minor amputations.

T26

CLINICAL AND FOOT LOADING CHANGES AFTER FOOT AND ANKLE EXERCISE INTERVENTION FOR DIABETIC POLYNEUROPATHY

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INTRODUCTION

RCTs are high-quality clinical studies and the gold standard to assess the efficacy of a treatment under “routine” clinical conditions. Our previous RCT (Sartor et al, 2012) gave evidence that foot and ankle exercises for patients with diabetic polineuropathy (DPN) have the potential to mitigate muscle weakness and joint constraints, thus improving foot function. Briefly, patients showed softening of heel strike, better eccentric control of forefoot contact, earlier contact of lateral rather than medial forefoot, increased participation of toes. However, statistical differences in the clinical results were not evident in the RCT. For a deeper investigation of specific effects of the proposed intervention, some further hypotheses have been raised, starting from the consideration that the improved outcomes of the validated clinical and functional scales (CFSs) balance ABC score, MNSI questionnaire and foot physical assessment do prove improvement of a treated patient in terms of clinical condition and function. Therefore the aim of this study was to differently analyze the foot loading and the foot muscles strength changes after the intervention by grouping patients according to their CFSs outcomes.

METHODS

55 adult DPN patients were randomly assigned to two groups: (IG) 26 patients in the intervention group received exercises for foot-ankle and gait training twice/week, for 12 weeks, and (CG) 29 patients in the control group received traditional care (Sartor et al, 2012). Both groups were assessed before and after 12 weeks. Besides CFSs scores, the outcomes were i) foot loading quantities in 6 plantar areas (peak pressure (PP), time to peak pressure (TPP) and pressure-time integral (PTI)) and ii) intrinsic and extrinsic muscle strength. In both groups, patients were further separated in three subgroups which respectively showed: improvement in all three CFSs (I=improved); improvement in one or two CFSs (PI=partially improved); no improvement (NI=not improved). Final subgroups were IG–I (n=5, 20.0%), CG–I (n=5, 17.2%), IG–PI (n=15, 60.0%), CG–PI (n=18, 62.1%), IG–NI (n=5, 20.0%) and CG–NI (n=6, 20.7%). Parametric statistics was conducted using t-tests or ANOVAs with Bonferroni, according to the analysis performed (α=5%).

RESULTS AND DISCUSSION

The analysis on the CFSs outcomes showed that: (i) improvement in IG was significantly higher than in CG, proving that the intervention treatment was clinically more effective than traditional care; (ii) partial improvement in IG was higher than in CG; (iii) worsening in IG was much smaller than worsening in CG (i.e. the intervention treatment entailed a slower functional worsening). As for the increasing in muscle strength, the treatment was indeed effective with respect to toes flexors, lumbricals, interosseus, tibialis anterior and triceps surae ($p<0.05$). Worth to note, it was more effective on patients with greater muscle weakness. Higher variability was found with respect to foot loading quantities. However, it was observed that: i) significant TPP changes were found at heel (mean delay 24%), medial forefoot and hallux (mean anticipation 3% for both) when comparing IG-I before and after treatment; ii) mean PTI and PP were statistically higher in IG-I after treatment (p=0.055 for PP, reasonably due to low number of patients and high variability in this particular analysis). The above changes altogether may be read as a more physiological change in the global foot-floor management. Interestingly, no relevant changes were found in corresponding quantities of CG-I, thus proving that the effect of the intervention is different from that of traditional care. Table 1 shows main results of the analysis.

Table 1-
IG and CG subgroups: mean(SD) of changes after treatment.

		IG	CG	p
CFSs (%)	I	64.7(36.0)	34.4(6.4)	0.102
	PI	**12.4(21.2)**	**-0.9(13.7)**	**0.037**
	NI	-16.7(7.0)	-36.4(21.1)	0.078
Muscle strength	I	**8.90(5.80)**	**2.80(4.42)**	**0.007**
	PI	-0.70(3.29)	-1.42(3.74)	0.416
	NI	-0.60(4.27)	-1.83(4.20)	0.504
Mean PP (kPa)	I	**36.95(37.51)**	**2.64(36.95)**	**0.055**
Mean PTI (kPa*s)	I	**13.23(13.46)**	**-3.85(9.22)**	**0.004**

CONCLUSIONS

CFSs outcomes have proved the effectiveness of the intervention treatment not only in terms of a true improvement in foot loading - i.e. a more physiological foot rollover - and foot muscle strength (in group IG-I) but also in preventing a worsening of patients’ conditions. Especially important, clinical outcomes also showed that the intervention was more effective on more clinically compromised patients.

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T27

IDENTIFYING PRESSURE ULCER RISK OF PATIENT HANDLING SLING USE WITH INTERFACE PRESSURE MAPPING

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BACKGROUND

Ceiling lifts and patient handling slings have been shown to reduce the risk of musculoskeletal injuries for healthcare providers. However, there is no evidence of their safety with respect to the patient and pressure ulceration. This research is offered in response to concerns regarding the possible contribution that patient handling slings may play in pressure ulcer development in vulnerable populations, specifically persons with spinal cord injury (SCI).

AIM

Using high-resolution interface pressure mapping techniques, the main goal of this study was to describe and quantify risks associated with pressure ulceration due to normal forces and to identify the at-risk anatomical locations that are generated at the sling-participant interface while sitting or lying on a sling and during typical patient transfers.

METHODS

A descriptive, observational study was conducted at a VA research institution. Twenty-three patient handling slings (18 seated, 5 supine) from three international manufacturers (ArjoHuntleigh, Guldmann, Liko) were examined to represent a wide variety of sling styles. High-resolution sling-patient interface pressure measurements were recorded at 5Hz using a high-resolution interface pressure-mapping system (XSENSOR).

A convenience sample of healthy volunteers and persons with SCI provided informed consent (n=12). Interface pressure data was collected from the sling-participant interface while participants sat or lay on the sling, in a wheelchair or modern hospital bed, respectively, and during typical patient transfers in both static and dynamic conditions. Transfers monitored with the seated slings were from the bed to a wheelchair and from the wheelchair back to the bed. Transfers monitored with the supine slings were from bed to bed.

RESULTS

Sling-participant interface pressures were greatest while suspended in the sling compared to seated in the wheelchair or lying on the bed. Interface pressure magnitudes exceeded 200 mmHg for all participants, for all slings, while suspended in seated slings. Sling-participant interface pressures, regardless of position or type of sling, were greatest along the sling seams. The back of the upper and lower thighs, towards the groin and knee respectively, were common areas of high pressure.

CONCLUSION

Transferring individuals with patient handling slings do expose them to high interface pressures; therefore, prolonged suspension in a sling should be limited and/or monitored. Interface pressures are prominent and elevated along the sling seams, independent of sling manufacturer or style. Care should be taken so that while an individual is seated or lying on a sling (not suspended) that the seams are not beneath the patient or have been smoothed to minimize high interface pressures; when lifting an individual, ensure that the seams do not fold over themselves to avoid unnecessarily high interface pressures while suspended.

FEASIBILITY OF WEARABLE MOTION CAPTURE SYSTEM USING INERTIAL MOTION CAPTURE SENSORS AND IN-SHOE PRESSURE SYSTEM

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INTRODUCTION

The marker based motion capture system with force plates has been conventionally used in motion analysis due to its accuracy. However, this conventional system has quite restrictive in capturing area and mobility, while the force plate has limited foot placements. A wearable inertial sensor based motion capture system using the in-shoe pressure measuring system can be a good alternative (Paulis, 2010). The objective of this study is to evaluate feasibility of the wearable motion capture system using Pedar-X® (Novel gmbh, Munich, Germany).

MATERIALS AND METHODS

Five healthy men (age, 27±1 yrs; height, 171.4±3.9 cm; weight, 73.3±12.1 kg) were participated in this study. Two types of motion capture systems were simultaneously used to measure motion data and ground reaction forces (GRFs) during walking: 1) Hawk® digital system (Motion Analysis, USA) and MP4060® force plates (Bertec Corporation, USA); 2) MVN® inertial sensor based motion capture system (Xsens Technologies, Nederlands) and Pedar-X®. In Pedar-X®, the 3D GRF was assumed to be directed to the center of gravity of whole body based on the force plate data. Inverse dynamic analyses were conducted using Matlab® with a dynamics model of the human whole body, which consisted of 16 segments (head, upper thoracic, lower thoracic, pelvis, upper arms, forearms, hands, thighs, shanks, and feet).

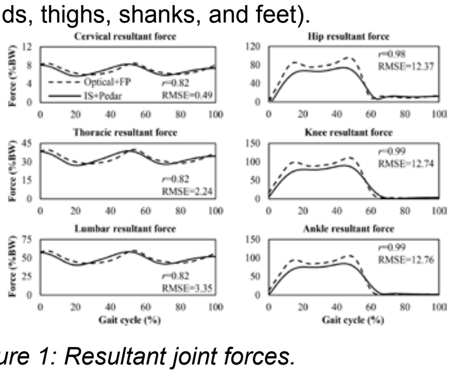

Figure 1: Resultant joint forces.

RESULTS

Comparisons between two systems for joint kinetics were summarized in Figure 1 and Table 1. The resultant joint forces (RJFs) showed good agreement with strong correlations (correlation coefficient r=0.73-0.99). The resultant joint moments (RJMs) showed strong correlations (r=0.71-0.98) except in shoulder joint (r = 0.51).

Joints	RJF	RJM
Cervical	0.82	0.81
Thoracic	0.82	0.93
Lumbar	0.82	0.87
Shoulder	0.81	0.51
Elbow	0.77	0.71
Wrist	0.73	0.74
Hip	0.98	0.97
Knee	0.99	0.92
Ankle	0.99	0.98

Table 1: Correlation coefficients between two systems

DISCUSSIONS

Although marker based motion capture systems with force plates have been extensively used, their limited measurement volume and restricted foot placement lead to the necessity of portable and wearable system (Forner-Cordero, 2006; Picerno, 2008). The results indicated that the portable system revealed reliable joint force and moment in comparison to the conventional system, especially in lower extremities. This study could provide the feasibility of a wearable system as an alternative of conventional system. Because the wearable system is portable without the foot placement limitation, this system can be wildly applicable to various areas such as clinical and sports biomechanics.

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GROUND REACTION FORCE COMPUTATION TOOL FOR OPENSIM USING ZERO MOMENT POINT METHOD

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INTRODUCTION

Obtaining proper kinetic data in motion analysis studies can be challenging; e.g. at least three force plates are required to capture a full gait cycle where foot placement is restricted.

Therefore modelling techniques can be used to estimate the ground reaction loads from known kinematics of the body. Several methods are developed and used to predict ground reaction forces (GRFs). One method is to use detailed contact models. However such models are difficult to tune and tend to be computationally expensive (Anderson and Pandy, 2001). Another method uses optimization to estimate the GRFs. Here the external loads are treated as unknowns and computed in one optimization problem together with the joint torques or muscle forces (Robert et al, 2013). An alternative is the Zero Moment Point (ZMP) method (Vukobratovic and Borovac, 2004) that uses inverse dynamics and a distribution function to solve the underdetermined double stance loads (Xiang et al, 2009).

To the knowledge of the authors, none of these methods have been applied in gait analysis software as a standard method. Therefore an OpenSim plugin was written to compute ground reaction forces for given kinematics.

METHODS

Experimental data was collected on ten subjects but only one is shown in this abstract. The subject (sex: male, age: 24, heigth: 175 cm, weight: 83.8 kg) was asked to do several motions along with normal walking.

A modified Inverse Dynamics Tool is written as a plugin for OpenSim (Delp et al, 2007). The ZMP method as used by Xiang et al, (2009) is implemented to compute the ground reaction forces. Single and double stance were detected by probing the positions and velocities of the heel and ball of the feet. In single stance the computed ground reaction forces can directly be applied to the stance leg. A linear function as in (Xiang, 2009) was applied to obtain the load distribution in double stance.

RESULTS

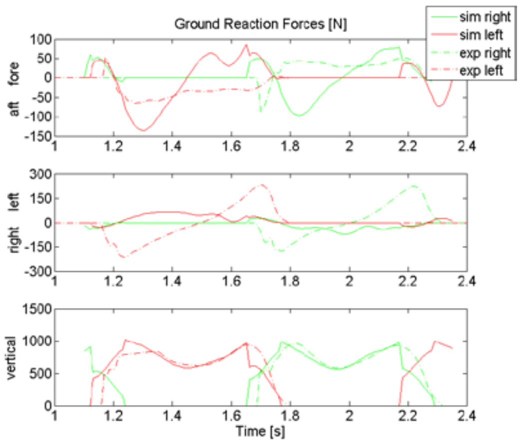

Figure 1: Simulated and experimental ground reaction forces in gait

DISCUSSION

The vertical component of the GRF showed good agreement with the experimental data. Horizontal components' agreement varied between subjects. Unlike assumed by Xiang et al, (2009), the ZMP did not always stay within the base of support, indicating that the human body would not be in dynamic equilibrium.

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T30

A COMPARATIVE STUDY OF TWO METHODS FOR GRIP FORCE MONITORING ON THE HAND: MANUGRAPHY SYSTEM VERSUS JAMAR DYNAMOMETER

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BACKGROUND

Sensor mat systems are devices that measure total grip force as well as identify load distribution patterns of the hand while gripping objects. For clinical use, such a device needs to be validated by means of an assessed and accepted gold standard. The aim of this study was to validate a grip force measurement setting and testing sequence of the Manugraphy system for clinical use. Further, the relationship and difference between grip force measurement with an electronic matrix sensor mat system and the Jamar dynamometer were investigated.

METHODS

At two study centers, 152 healthy volunteers performed grip force tests with a digital Jamar dynamometer (handle positions 3 and 4) and the novel® Manugraphy system. The latter consisted of 2 cylinders with circumferences of 150 and 200 mm wrapped with calibrated capacitive matrix sensor mats. The subjects performed grip force testing with both devices on three different days The maximum and 3-seconds mean forces were recorded. The intra- and inter-day variability for both methods was evaluated. To compare the values of both systems, the Spearman correlation coefficient was calculated.

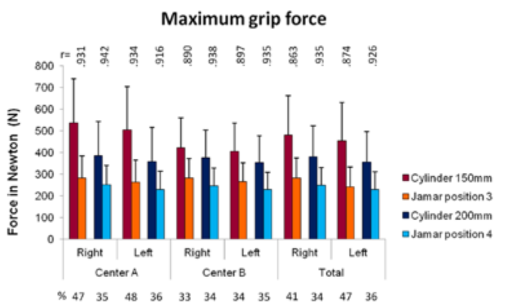
RESULTS

Analyses showed significant positive correlations between values obtained by the two measurement methods with correlation coefficients ranging from r = .863 ($p < .001$) to r = .939 ($p < .001$). The force values, as measured by the sensor matrix, were higher than those of the Jamar dynamometer (Fig.1). There was no significant inter-day variation for the 200 mm cylinder of the Manugraphy system. For the 150 mm cylinder, a low but significant variation was observed at center B, but not at A. Nevertheless, the fluctuation of the grip force values obtained with the Manugraphy system was equal or better than those obtained with the Jamar dynamometer.

CONCLUSION

The force values, obtained using the two systems, have a high correlation but are not directly comparable. Both systems allow valid and constant grip force measurement. As the sensor mat detects all forces applied perpendicularly to the cylinder surface, it characterizes grip force better than the Jamar dynamometer. In addition, information about load distribution of the hand is gained. The Manugraphy system is a useful alternative and complement to the Jamar dynamometer, especially for patients with pathologies of the fingers, tendon injuries, or neurological problems

FIGURES



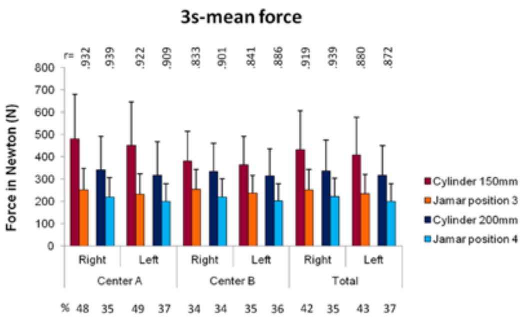


Figure 1: Grip force values assessed by the Manugraphy system and the Jamar dynamometer

T31

INVESTIGATION ON THE EFFECTS OF BILLET PLACEMENT ON A WELL FITTED EQUINE SADDLE: A PILOT STUDY

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INTRODUCTION

Equine saddles are held in place by long straps called billets that are attached to the saddle tree. The saddle tree (figure 1) is the fixed frame that the saddle is built on. Modern English saddlery tends to place billets in one of two positions: 1) center locale near the narrowest area of the tree (twist), or 2) point and (Y) configuration. The point and (Y) configuration has one billet attached to the tree point and the other attached to the rear of the twist. The purpose of this investigation was to determine if billet position has any effect on the pressure distribution produced by the saddle at the halt, walk, trot, and canter.

METHODS

A new high quality UK manufactured saddle was used for the test. The saddle had 4 billets either side located on the points, the center, and rear (Y) positions. The saddle was tested with the horse standing at the halt (unmounted), and at the walk, trot and canter. The girth was attached in the following positions: 1) center billets and 2) point and (Y). Pressure testing was performed using the Pliance saddle test system (Novel, Inc. MN). The rider was a 30 year old female of advanced riding ability, and a weight of 59 kg. The rider's ability to maintain a stable core and load the saddle evenly was assessed as excellent.

RESULTS

In all but one of the trials, the point and (Y) configuration produced higher average peak pressures then the center billeting did (table 1). Only at the walk did the center billeting produce a slightly higher avg. peak pressure (+3.7%). At the faster gaits, the peak pressure differences were greater. At the trot, the point and (Y) billeting avg. peak pressure was 25.4% higher than the center billeting. At the canter, the point and (Y) billeting produced an avg. peak pressure that was 30.9% higher than the center billeting. Analysis of the pressure scans show that the maximum peak avg. pressures at the trot and canter were spatially located near the points of the saddle.

An analysis of a typical laminated wood spring saddle tree shows that the point and (Y) billeting creates an unbalanced net moment about the twist of the tree. The narrowest part of the twist tends to cause the saddle tree to pivot slightly on the horse's back. In the center billeting configuration the billets are located almost equidistant around the pivot, thus creating equal and opposing moments about the pivot.

CALCULATIONS

Let F be the force produced by each billet strap. Let τ_{net} be the net torque produced by the billets and assume CCW rotations are (+). Center billeting: moment arm for each billet was approximately .030m. τ_{net}=.03F-.03F=0. Point and (Y) billeting, the moment arms for the point and (Y) billets were .159m and .052 m respectively. The net torque on the saddle tree is: τ_{net}=.159F-.052F=.107F N*m (CCW). Due to its longer moment arm, the point strap causes a net torque on the tree. This is consistent with the higher pressures measured under the tree points.

FIGURES

Figure 1: Modern wood spring saddle tree showing location of billets for the point and (Y) configuration (left), and center billeting (right). Short blue mark shows pivot location. Blue lines show the billet locations for the two configurations. Tree points are to the left in both pictures.

Peak avg p, center billets (kPa)	Peak avg. p point,Y (kPa)	%diff point,Y vs. center	Gait
6.250	7.500	16.7%	standing
13.500	13.000	-3.7%	walk
11.00	14.750	25.4%	trot
11.750	17.000	30.9%	canter

Table 1: Maximum average peak pressures at the various gaits for center and point and (Y) billeting.

CONCLUSION

Point and (Y) billeting produces higher peak pressures, and increased loading at the front of the saddle, under the points at the higher paces.

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T32

TESTING THE PRESSURE PRODUCED UNDER COMPRESSION GARMENTS: COMPARISON OF MEASUREMENT DEVICES USED IN THE CLINICAL SETTING

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INTRODUCTION

Medical grade compression garments are used in the hospital setting and worldwide, medical standards dictate that the garment must be able to produce graduated compression from distal to proximal, and meet certain compression values (mmHg).

In response to these standards, there are various devices available to assess the compression produced by garments in situ. Two of the most commonly used devices are the PicoPress (MicroLab Elettronica, Italy) and the Kikuhime (TT Meditrade, Denmark).

Both devices are considered easy to operate, relatively cheap (<AUD$2500) and reliable. Previous research has also shown the devices to be highly accurate in isolation of each other and/or in the lab (Partsch & Mosti, 2010).

The aim of this study was to compare the output of these devices from simultaneous measurements of compression garments.

METHODS AND MATERIALS

Testing was conducted using a prosthetic lower limb made from semi-rigid EVA and a hollow core to medium sized specifications (Fig 1) (Circumference at ankle = 21.5cm, calf = 33 cm. Medium size specifications in British Standard BS7672).

Figure 1: a.The prosthetic limb next to human leg of similar size; b.Prosthetic limb in the testing rig with a compression garment and testing device.

The compression garments were 10 medium sized below knee compression stockings with a compression rating at the ankle of 18mmHg and at the calf 14mmHg. Each stocking (n=10) was tested three times (n=3) with each device (n=2) under four conditions (n=4) – a total of 240 measurements.

As a control method, stockings were also tested on the industry standard device (BS7672; HATRA, England). This device was supplied by the manufacturer of the stockings.

RESULTS AND DISCUSSION

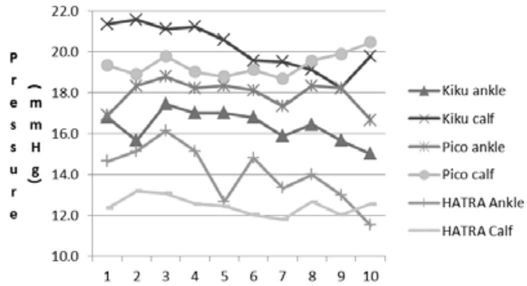

Figure 2: Pressure values per stocking by device and site.

Ideally, the data in Figure 2 would indicate two sets of overlapping lines for the ankle and calf. However, analysis of averaged results suggests that the Kikuhime and PicoPress devices produce significantly different results at the calf ($p<0.001$) and ankle ($p=0.005$), and both are significantly different to the industry standard device at both sites ($p<0.001$). These data indicate a high level of disparity between devices and questions the ability of the devices to provide accurate data.

As clinicians use these devices to prescribe appropriate compression garments to patients, it is clear that an accurate testing device is required. Whilst Partsch et al. (2006) have made recommendations about suitable measurement techniques much work needs to be done on the accuracy of these systems and their ability to measure the relatively low pressures that exist between the patient and their compression garment.

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K4

WEARABLE AND HOME MONITORING TECHNOLOGIES FOR THE CLINICAL MANAGEMENT OF LONG-TERM CONDITIONS

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The staggering costs of acute care are pushing the healthcare system to a tipping point. More than ever before, we are coming to realize that we cannot afford to provide everybody with access to unlimited healthcare services (Wanderer and Ehrenfeld, 2014). The situation in the US exemplifies the mechanisms that underlie the crisis of the healthcare systems around the world. Over the past twenty years, we have witnessed a process of consolidation of hospitals in large healthcare networks (Jiang et al, 2013). Hospitals have come together into networks for the purpose of improving their bargaining power when negotiating reimbursement rates with insurance companies. Consequently, reimbursement rates have been rapidly increasing (Cuellar and Gertler, 2005). Insurance companies have "passed" the costs to their clients. Thus, premiums have skyrocketed to levels that are no longer sustainable. Meanwhile, the increase in life expectancy and the high prevalence of long-term medical conditions in older adults have raised concerns that healthcare costs might get out of control. As we live longer, more and more individuals among us have to deal with long-term conditions such as congestive heart failure, chronic obstructive pulmonary disease, Parkinson's disease, and the consequences of a stroke. The costs associated with the clinical management of these conditions are very substantial. The anticipation that this "perfect storm" of healthcare costs would bring the system to its knees has motivated large healthcare networks to seek alternatives to the fee-for-service business model that they have utilized so far. An emerging, alternative model is focused on "keeping people healthy", namely on primary and secondary prevention. This business model can only work if healthcare networks manage to capitalize on the decrease in acute care services that is expected as a result of aggressive primary and secondary prevention programs. To achieve this goal, healthcare networks have to merge with health insurance companies into single-payer systems. This ongoing revolution in the healthcare system is demanding the rapid development of enabling technologies to "keep people outside of the hospital". Hence, we have witnessed a fast-growing interest for mobile health technologies (Jovanov and Milenkovic, 2011). This talk will discuss current R&D efforts and future potential developments in the field of mobile technology that aim to address the growing demand in the healthcare sector for systems designed to achieve health monitoring of individuals in the home and community settings. Case scenarios based on ongoing studies on patients with chronic obstructive pulmonary disease (Bellos et al, 2014) and patients with Parkinson's disease (Chen et al, 2011) will be presented. The discussion of the case scenarios will emphasize the technical challenges associated with the development of mobile health systems, the potential roadblocks in the path toward adoption of these technologies in the clinic, and the potential economic and societal impact of mobile health systems.

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T33

DOES PARTIAL OR COMPLETE WRIST FUSION CHANGE THE LOAD DISTRIBUTION OF THE HAND DURING GRIPPING?

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BACKGROUND

Many studies attested permanently reduced grip force after partial or complete wrist fusion. The loss of carpal height and a suboptimal wrist position might be the most important reasons for limited flexor muscle force. Measuring cylinder grip forces is proven to represent better all muscle efforts during gripping than the Jamar dynamometer. Using electronic pressure sensor mats, additionally load distribution of all areas with contact to the cylinder can be assessed. Aim of this study was to analyze the influence of wrist fusion on the total grip force and the load distribution of the hand. Further, this study investigates if there is a difference between midcarpal arthrodesis and complete wrist fusion.

METHODS

Twelve patient after complete wrist fusion (CWF) and 12 patients after partial wrist fusion (midcarpal arthrodesis, MCA) were followed 64 months postoperatively (range, 19-100 months). In both groups 10/12 patients had the dominant hand fused. Radiographs confirmed wrist fusion healed and ruled out further pathologies.

Total grip force as well as load distribution of 7 areas of the hand (thumb, four fingers, thenar, hypothenar) were assessed using the manugraphy system. For this, three cylinders with 100 mm, 150 mm, and 200 mm circumference, wrapped with pressure sensor mats (spatial resolution of 2 sensors per cm^2), were used. Results after wrist fusion were compared to the uninjured opposite hand using the Wilcoxon-test. Complete and partial wrist fusion were compared to each other using the Mann-Whitney-test.

RESULTS

For the 100 mm and 150 mm cylinder, the uninjured hand showed a significantly higher grip force than the injured hand after both kinds of fusion ($p< .015$). For the 200mm cylinder, there was no difference between both hands after complete wrist fusion ($p= .182$), but a significant difference after midcarpal arthrodesis ($p= .003$).

For the affected hand, grip force was higher after midcarpal arthrodesis than after complete wrist fusion with 435 N vs. 330 N for the 100 mm cylinder, 397 N vs. 364 N for the 150 mm cylinder, and 354 N vs. 317 N for the 200 mm cylinder. The force of the uninjured opposite hand was also higher in the MCA group than in the TWF group (583/523N, 531/480N, 450/400N). The differences between the complete wrist fusion and midcarpal arthrodesis were without statistical significance.

With regard to the load distribution of the hand, no difference between the healthy and the affected side was found both for the MCA and CWF (Fig. 1). Neither was there a difference between the two types of wrist fusions.

CONCLUSION

Midcarpal arthrodesis and complete wrist fusion result in reduced grip force, which was found to be slightly higher after midcarpal arthrodesis. Both procedures do not influence the load distribution of the hand during cylinder grip.

FIGURES

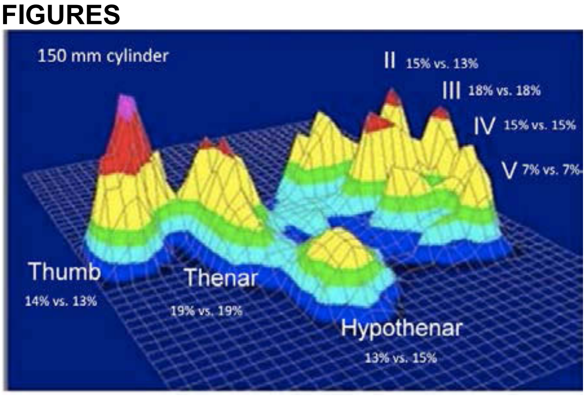

Figure 1: Load distribution of the hand after complete wrist fusion versus the unaffected hand gripping the 15-cm cylinder is depicted

T34

KINEMATIC AND FOOTPRINT-BASED PARAMETERS FOR THE CLASSIFICATION OF FUNCTIONAL FLATFOOT

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BACKGROUND

Static radiographic angles are commonly used to diagnose and classify foot abnormalities such as flatfeet. Angles obtained from footprint shape and parameters like the arch index are also used in both clinical and research settings for foot-type classification. Preliminary investigations on the correlation between radiographic and dynamic footprint angles of flatfeet in young subjects have already been performed. We hypothesized that footprint and kinematic measurements during walking better account for structural and functional changes in the flatfoot. Thus, this study aimed at identifying the most appropriate angles and parameters obtained from both dynamic pressure footprints and multi-segment foot kinematics during gait.

MATERIALS AND METHODS

Sixty healthy volunteers and patients were clinically screened and enrolled in the study. Foot segments kinematic and footprint measurements were acquired during three consistent trials of level barefoot walking for each foot. A validated baropodometric-kinematic integrated technique based on a VICON motion system, an EMED baropodometer, and the IORfoot model (Giacomozzi, 2013) was used for data analysis. 45 feet from different volunteers were clinically classified as Control (C, 15 feet), level-1 flatfoot (F1, 15 feet), or level-2 flatfoot (F2, more compromised than F1, 15 feet). Dynamic footprint measures included (Fig. 1): Subarch Angle (SA) and Arch Index (AI) as in the Novel software; Modified Subarch Angle (SAM) originated at point M; midfoot width *w*; Midfoot/Forefoot Ratio (RMFW) between w and A'B'. Corresponding ROM of sagittal-plane angles at joints J3, J5, J6, of medial longitudinal arch (MLA), of frontal-plane angles at J3 and J6 were also included in the study, in addition to the MLA angle at midstance.

RESULTS

The three groups were homogeneous as for BMI, age and stance duration. SAM (C:107±6°; F1:126±6°; F2:158±19°) and RMFW (C:0.19±0.10; F1:0.41±0.04; F2:0.61±0.13) best identified the three groups, which resulted statistically different ($p<0.05$, ANOVA with Bonferroni correction) for SAM, RMFW, AI and *w*. C was not different from F1 for SA, MLA and MLA at midstance. J3, J5 and J6 did not statistically discriminate the groups. Sensitivity and specificity calculated with respect to C, F1 and F2 separately showed that: sensitivity ranged 73-100% for SAM and RMFW (mean 89%), 73-87% for AI (mean 80%), 60-71% for SA (mean 64%), 53-67% for MLA at midstance (mean 60%), and 20-80% for MLA (mean 53%). Specificity ranged 83-100% for SAM and RMFW, 77-100% for AI, 69-97% for SA, 70-90% for MLA at midstance, and 70-80% for MLA.

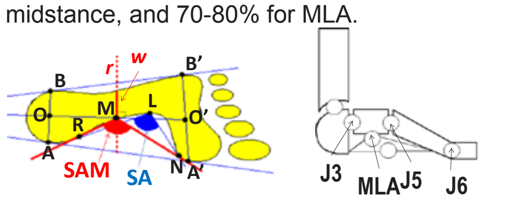

Figure 1. a: Novel software footprint measurements, plus SAM and w. b: joints of the IOR foot model, and MLA angle.

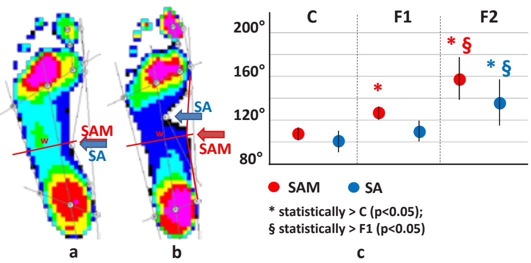

Figure 2. a-b: comparison of SAM and SA on two flatfoot footprints. c: SAM and SA (mean±sd) calculated over 15 feet per group.

CONCLUSIONS

SAM and RMFW showed to be the most appropriate dynamic-footprint indexes for classifying flatfeet. SAM does represent an improvement from the original SA, the latter being less robust in relation to footprint alterations (Fig. 2) and in case of discontinuity between rearfoot and forefoot. MLA seems to be sensitive to F2 only, accounting for significant structural changes with respect to C and F1, and may help to distinguish, within the same group, between flexible and rigid flatfoot.

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T35

THE EFFECT OF DIFFERENT HALLUX VALGUS ANGLES UPON FIRST METATARSOPHALANGEAL JOINT SHEAR STRESS: A FINITE ELEMENT STUDY

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ABSTRACT

Osteoarthritis (OA) of the first metatarsophalangeal (MTP) joint is the most common form of degenerative joint disease in the foot, affecting 35-60% of adults over 65 years (Wilder et al., 2005). Hallux valgus (HV), one of the most common deformities of the foot, results in increased joint stress, which is a primary cause for OA progression (Martinez-Nova et al., 2010). HV correction is a surgical procedure to correct first MTP joint malalignment. However, the role of malalignment on stress in this joint is not well understood. Therefore, the aim of this study is to determine the relationship between HV angle and peak MTP joint shear stress using finite element analysis. We hypothesize that an increase in HV angle will increase peak stress in the first MTP joint.

High resolution 7 Tesla magnetic resonance images of an asymptomatic 55 year-old male were acquired and segmented in Mimics imaging software (Materialise, Belgium) and CATIA computer aided design software (Dassault Systèmes, France) to create accurate three-dimensional (3D) representations of the hallux. The 3D hallux model was then exported to ABAQUS V6.11-2 finite element software (HKS, USA) where the boundary conditions (forces and constraints) were applied for stress analyses in the first MTP joint. Vertical forces of 110 N and 150 N were applied to the distal phalange and the sesamoid bones, respectively, to simulate propulsion (Hillstrom et al., 2013). The model was then modified with virtual HV angles (0° to 30°) and peak shear stress measurements in the 1st MTP joint were computed.

The model, simulating a well-aligned toe, had a peak shear stress value of 4.5 MPa in the proximal phalange cartilage and 3.5 MPa in the first metatarsal cartilage. The peak shear stress in both cartilage increased linearly with an increase in HV angle. Compared to the well-aligned toe, HV angles of 10°, 20°, and 30° resulted in increased peak shear stress by 8.9%, 19.5% and 38.4%, respectively, in the proximal phalange base cartilage, and 5.7%, 13.7% and 25.4%, respectively, in the first metatarsal head cartilage (Figure 1).

This study confirms the hypothesis that an increased HV angle results in increased peak shear stress in the first MTP joint. The ability of a subject-specific model to predict changes in the magnitude and location of peak shear stress within the first MTP joint as a function of HV angle is demonstrated. This is a first step towards understanding the role of transverse plane malalignment on shear stress in the first MTP joint.

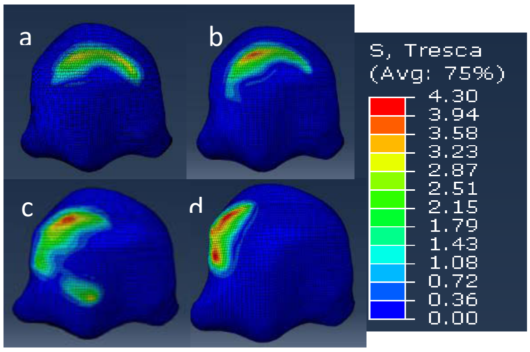

Figure 1: Shear stress in the 1st metartarsal cartilage for a) well-aligned toe, b) 10°, c) 20°, d) 30°

ACKNOWLEDGMENT

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T36

MULTIFRACTAL CHARACTERISTICS OF SWAY: A COMPARISON OF OBESE AND NON-OBESE CHILDREN

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Non-linear analyses of balance using fractal techniques have become common in recent years (for a review, see Capodaglio et al., 2012). These analyses have shown deficits in balance related to many conditions, including obesity (Menegoni et al., 2009). Other studies, however, have shown that motion of the center of pressure is multifractal, rather than monofractal (e.g. Collins & DeLuca, 1993; Laughton et al., 2003), which provides more information about the cause of the balance deficits. As obese children perform consistently worse on both static and dynamic balance field tests, the purpose of the current study is to use a multifractal analysis to further examine if the balance deficits are apparent in obese children and what the source of those deficits may be.

Twenty-two children, ranging from 8 to 15 year in age (11 obese, 11 non-obese) performed 30 second trials of bilateral static balance on a plantar pressure distribution measuring device (EMED-SF, Novel GmbH, Germany) with eyes open and eyes closed. Center of pressure was recorded at 5 Hz, and displacement of the center of pressure was analyzed using a multifractal detrended fluctuation analysis (MFDFA). The MFDFA quantified the tendency towards persistence (i.e. drift) and anti-persistence (i.e. error correction). This was done by breaking the data into segments of different lengths and calculating the slope (Hq) of the root mean square vs segment length curve. Multifractality was determined by weighting the fluctuations, or perturbations, of the center of pressure displacement by a factor q: low or negative values of q weight smaller fluctuations more strongly, while large values of q give greater weight to large fluctuations. The signal is fractal if Hq values either over .5 (indicating persistence), or under .5 (indicating anti-persistence) are seen. If Hq changes with different values of q, the signal is multifractal, with different responses to small and large fluctuations of center of pressure.

Both groups, obese and non-obese, showed a similar pattern of persistence (i.e. Hq larger than .5) with small fluctuations (i.e. negative values of q) and a decrease in persistence for larger fluctuations (i.e. increasing q), shown in Figure 1. A significant interaction of group x eyes open or closed x q was found, p=.0004. With the eyes open, no differences were seen between groups. With the eyes closed, the center of pressure was more persistent for small fluctuations, but no difference was seen for large fluctuations. These results show that obese children are more dependent on vision to detect and respond to small shifts in the center of pressure. This is most likely the result of decreased sensitivity of the pressure sensors (i.e. Meissner's Corpuscles and Pacinian Corpuscles) in the feet. The decreased sensitivity to small fluctuations results in a greater drift in the center of pressure, which increases the risk of falls. A similar trend is seen in the elderly with a history of falling (Laughton et al., 2003), also attributed to the loss of pressure sensors in the feet, which suggests that obese children, in the absence of any intervention, will be at greater risk of falls as they age.

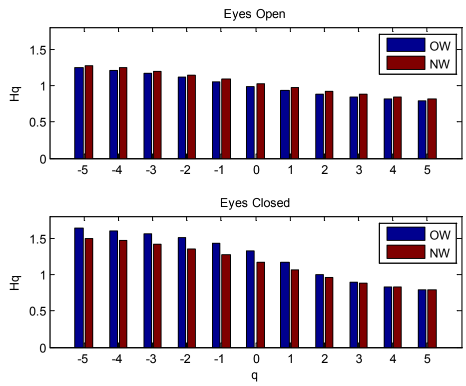

Figure 1: Hq vs q for eyes open (top) and eyes closed (bottom). Both obese (blue) and non-obese (red) are multifractal. The obese group displays significantly more persistence (drift) in the center of pressure.

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P1

DESCRIPTION OF PLANTAR PRESSURE PARAMETERS IN A WEST POINT CADET POPULATION: EFFECT OF FOOT STRUCTURE

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INTRODUCTION

The majority of military injuries occur in the lower extremity.[1] Foot structure and function have been identified as risk factors for lower extremity overuse injuries.[2] While structural and functional parameters of asymptomatic feet have been described in the literature[3], these parameters have not been fully described in such a large group of young, healthy adults.

The purpose of this study was to evaluate the differences in plantar pressure parameters across different foot structures in a healthy West Point cadet population.

METHODS

Arch Height Index (AHI) was calculated for 1,052 incoming cadets who completed arch height measurements in a standing position. Arch Height Index measures were used to define foot structure as planus, rectus, or cavus based on previously described criterion values.[3]

974 of the cadets also walked across an emed-x (Novel, Munich, Germany) plantar pressure measuring device until five left and five right foot trials were collected using a 2-step method. A 12-segment mask was applied to each pressure trial; peak pressure and max force was calculated in each anatomical plantar region.

Linear regression was used to compare plantar pressure measures across foot structures with generalized estimation equation (GEE) to account for correlations between right and left feet of each participant.

RESULTS

A total of 1896 feet were evaluated. Based on the standing AHI criterion values 1547 (81.6%) were planus, 285 (15.0%) were rectus, and 64 (3.4%) were cavus.

Planus feet had significantly higher peak pressure and max force values in the hallux, toe, and metatarsal head 2 regions compared to rectus and cavus. Cavus feet had higher peak pressure and max force values under metatarsal heads 4 and 5. Max force values were also significantly greater in both arch regions in planus feet (Table 1).

DISCUSSION

Plantar pressure parameters were found to be different across foot structures as defined by AHI. Plantar pressure parameters were higher medially in planus feet and laterally in cavus feet.

Although, few differences were found between rectus and cavus feet this could have been because the cohort was a healthy cadet population, which may have naturally excluded pathologic cavus feet.

Knowledge of variations in dynamic plantar pressure parameters in across foot structures in this population could provide information to guide lower extremity injury prevention measures.

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Table 1. Results summary for peak pressure and max force values including GEE and post hoc analysis.

	Planus		Rectus		Cavus		GEE Results		Post Hoc Analysis		
	Mean	SD	Mean	SD	Mean	SD	X^2	*p*-value	P vs C	P vs R	R vs C
PP (N/cm^2)											
Hallux	38.1	17.2	33.5	15.4	26.5	13.3	36.1	**.000**	**.000**	**.000**	**.000**
Toe 2	14.6	7.1	12.5	6.7	10.7	5.7	37.3	**.000**	**.000**	**.000**	**.016**
Toes 3-5	10.8	8.7	8.9	6.1	8.7	7.5	19.7	**.000**	**.037**	**.000**	.804
MH2	41.5	15.5	37.8	12.0	37.0	12.5	9.3	**.009**	**.002**	.150	**.017**
MH4	27.3	10.0	29.0	10.0	29.8	9.7	14.0	**.001**	.056	**.000**	.997
MH5	27.1	17.8	31.1	19.5	33.2	18.4	17.3	**.000**	**.011**	**.000**	.416
MF (N)											
Hallux	109.9	44.4	96.9	40.4	84.0	35.1	40.2	**.000**	**.000**	**.000**	**.036**
Toe 2	20.6	14.3	18.1	11.9	14.5	8.0	23.5	**.000**	**.000**	**.003**	**.001**
Toes 3-5	25.6	34.6	21.3	28.9	18.7	29.2	8.4	**.015**	**.041**	**.023**	.451
MH4	104.4	33.6	113.8	33.4	116.4	29.9	26.5	**.000**	**.025**	**.000**	.873
MH5	67.2	46.7	73.8	41.9	82.1	41.0	8.8	**.012**	**.019**	**.023**	.272
Lat Arch	99.2	67.6	73.2	56.8	70.0	59.2	15.9	**.000**	**.005**	**.000**	.196
Med Arch	14.3	22.5	9.1	7.7	9.3	7.0	34.4	**.000**	**.000**	**.000**	**.004**

P2

BAROPODOMETRIC EVALUATION OF A "SHOCK ABSORBING" INSOLE IN A GROUP OF ITALIAN SPECIAL FORCES SOLDIERS AFFECTED BY OVERLOAD PATHOLOGIES

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INTRODUCTION

Lower limb overuse injuries are common in athletic and military populations (Sharma2011; Beck 1998).
Soldiers are subjected to intense and prolonged training and several studies showed a high incidence of stress diseases caused by overload due to high plantar pressure; this however can be reduced by insoles (House 2002, Franklyn-Miller 2011).
In our knowledge there are no studies conducted on the Italian army. Moreover, existing studies focused on plantar pressure analysis during race and march (Richteret 2011, Hinz 2008), not a single during other more demanding motion tasks, those typical of military training such as climbing and jumping. The purpose of this study was to evaluate the effects of a shock absorbing insoles on plantar pressure during the execution of a simulation of a war path.

MATERIALS AND METHODS

20 soldiers of Italian Special Forces volunteered for the study (mean age 36 ± 6), with an average of 17 ± 7 years of service and a BMI of 25.5 ± 2.8. A clinical evaluation, including comfort investigation, and baropodometric analysis were assessed. Plantar pressure of each soldier was recorded while wearing standard Italian army shoes with and without shock absorbing insoles during a simulation of a war path. This included walking, running and jumping (fig 2). The plantar pressures were recorded by using the Pedar insole system (fig1) (Novel GmbH, Munich, Germany).

RESULTS

Clinical evaluation revealed a high incidence of lower limb diseases related to chronic overloading: 70% lower limb pain, 26% plantar fasciitis, 22% anterior knee pain, 13% had Achilles tendinopathy. 80% of soldiers reported vertebral column pain, 50% lumbar, 20% cervical. Mean comfort evaluation score was 4.3 when wearing insoles, 3.5 without insoles.
Baropodometric analysis during walking showed peak plantar pressure at forefoot of 442 ± 56 KPa without insoles and 421 ± 37 KPa while wearing insoles; in the rearfoot peak plantar pressure was 323 ± 35 KPa without insoles and 302 ± 26 KPa with insoles ($p<0.05$). Mean contact area during walking was 49.8±3 cm² without insoles and 53.2 ± 1.7 cm² with insoles ($p<0.05$); mean contact area during running was 45.1 ±1.6 cm² without insoles and 56 ±0.7 cm² with insoles ($p<0.05$). Pressure/time integral during walking was 80 ± 5.3 KPa/sec without insoles and 68 ± 3.7 KPa/sec with insoles at forefoot; at the rearfoot it was 30 ± 8.2 KPa/sec without insoles and 28 ± 5.4 KPa/sec with insoles.

DISCUSSION

Shock absorbing insoles reduced peak plantar pressures both at rearfoot and at forefoot. Moreover the insoles increased foot contact area during running and walking allowing a better foot balance and stability; these insoles also permit a decrease of overloads during the entire gait cycle. The use of shock absorbing insoles is therefore a correct strategy in order to reduce overuse foot and lower limb diseases in army soldiers.

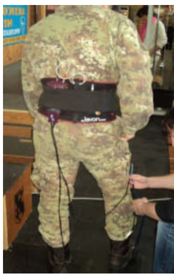

Fig 1: Soldier of the Italian Special Forces wearing the Pedar Insole System

Fig 2: Baropodometric assessment during the simulation of a war path

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PERCEIVED COMFORT & PLANTAR PRESSURE OF AN ENERGY STORING AND RETURNING ORTHOSIS IN A PROTOTYPE MILITARY BOOT: A PILOT STUDY

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INTRODUCTION

Due to the increased demands of military training, soldiers are susceptible to lower extremity injuries (Kaufman et al., 2000). Research suggests that lower extremity injuries comprise the majority of musculoskeletal conditions among soldiers (Hauret et al., 2010).

The second metatarsal head (MTH 2) is commonly susceptible to overuse injury. Studies suggest that MTH 2 experiences increases in peak and mean force following running to fatigue (Willems et al., 2012). Decreasing plantar pressure at this area may lead to decreased injury rates during such military-type activities.

The objective of this pilot study was to test the perceived comfort and plantar measures of a new energy storage and return orthosis (ESRO) in prototype military boots.

METHODS

Five active duty military personnel, 4 male and 1 female, volunteered for this study (age = 33 ± 5.83 yrs; height = 1.72 ± 0.04 m; mass = 72.4 ± 8.31 kg). All participants wore a men's size 9 boot and were healthy with no history of lower extremity injury within the past 3 months. Each participant performed walking and running trials on a treadmill in standard issue and prototype ESRO boots with a standard and off-the-shelf (Superfeet) insole. Boot type and insole conditions were randomly assigned, with walking trials performed before running. Conditions were coded as follows for boot: 1=standard, 2=ESRO; for insole: A=stock insole, B=Superfeet; for activity: W=walk, R=run. Each trial lasted 4 minutes, with data collected in the last minute. A 3 minute rest period was used between trials.

Peak pressures (kPa) were measured in 8 regions of the foot: heel; medial midfoot; lateral midfoot; metatarsal head (MTH) 1; MTH 2-4; MTH 5; hallux; lesser toes. All pressure measurements were performed using Novel Pedar-X Expert Version 20.3.36 software. Participants then rated perceived comfort (0-10, with 10 being "great") within each region for each condition using a Visual Analog Scale (VAS). These values were then averaged across subjects for all conditions.

RESULTS

Mean peak pressures were greatest in the hallux for 4 conditions (2AW = 214.9 kPa; 1BW = 207.6 kPa; 2BW = 229.8 kPa; 2BR = 251.3 kPa); in MTH 2-4 for three conditions (1AR = 230.9 kPa; 2AR = 225.0 kPa; 1BR = 250.3 kPa); and the heel for one condition (1AW = 202.3 kPa). The average mean peak pressures for all of the ESRO and standard boot conditions were 230.3 kPa and 222.8 kPa, respectively. Superfeet insole conditions registered greater mean peak pressures compared to their standard insole counterparts (i.e. 1AW vs. 1BW) across all boot and walk/run trials.

Conditions were ranked (greatest to least comfort) as follows: 2AW > 2AR > 1BR > 1AW > 2BR > 1AR > 1BW > 2BW. Overall, the ESRO boot was perceived as slightly more comfortable than the standard issue boot (ESRO = 5.9, standard issue = 5.7). For walking trials, the ESRO boot with standard insole was perceived as more comfortable than the standard boot regardless of insole (VAS = 6.6 vs. 5.8 [standard] and 5.4 [Superfeet]). In running trials, the ESRO boot with standard insole was perceived to be as comfortable as the standard boot with Superfeet insole (VAS = 6.2 to 6.1, respectively).

CONCLUSION

Peak plantar pressures from least to greatest coincided with overall VAS comfort scores from greatest to least in all four of the conditions with ESRO boot. Overall, the two conditions using the Superfeet insoles resulted in the two least perceived comfort measurements (VAS [1BW, 2BW] = 5.4, 5.1), and the two conditions using the standard insole resulted in the two greatest perceived comforts (VAS [2AW, 2AR] = 6.6, 6.2). There was no clear relationship in peak plantar pressure and comfort in the standard boot.

Insoles that reduce plantar pressure in combination with the ESRO boot may be expected to increase overall perceived comfort. Based on these preliminary data and subject feedback, we plan to modify the boot and repeat the study in a larger sample using custom insoles.

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THE CORRELATION BETWEEN STATIC MEASUREMENT OF MEDIAL LONGITUDINAL ARCH AND DYNAMIC MEASUREMENT OF ARCH INDEX

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INTRODUCTION

One of the structures, which plays an important role in both shock absorption and energy transfer during activity, is the medial longitudinal arch (MLA) of the foot (Ogon, 1999). There are few studies in this context, which have assessed MLA in dynamic and static situations and found an association between them (Chen, 2006; Teyhen, 2009). Although, there are several methods for evaluation of MLA, dynamic measurement for determination of foot type is less considered. Thus, as the function of the foot during dynamic activities depends on its type (Razeghi, 2001), the purpose of this study was assessing the correlation between static measurement of MLA and dynamic measurement of arch index (AI).

METHODS

60 healthy females (mean mass 53.77±8.31 kg, mean height 159.24±4.50 cm, mean age 23.10±3.18 yr), with no history of injuries were included in this study. Static height of MLA was measured using navicular drop test. Dynamic arch index was measured by geometry software using emed-at2 platform. Analysis was carried using Pearson correlation coefficient (95% CI).

RESULTS

As shown in table 1, 45% of subjects were pes rectus, 25% were pes planus and 30% were pes cavus in static situation. While, 66.7% of subjects were pes rectus, 10% were pes planus and 23.3% were pes cavus in dynamic situation.

	Arch Index							
	Rectus		Planus		Cavus		Total	
	n	%	n	%	n	%	n	%
Navicular drop								
Rectus	22	81.5	2	7.4	3	11.1	27	45
Planus	10	66.7	4	26.7	1	6.7	15	25
Cavus	8	44.4	-	-	10	55.6	18	30
Total	40	66.7	6	10	14	23.3	60	100

Table 1: Dividing the foot into three types: rectus, planus and cavus, by navicular drop test and dynamic AI.

The correlation between navidular drop and dynamic AI was significant (r=0.62, P<0.05).

DISCUSSION AND CONCLUSION

The findings demonstrated a significant association between static height of MLA and dynamic AI. But, as shown in table 1, the number of feet which in static situation had the same type as in dynamic situation for pes rectus, pes planus and pes cavus were 22 (81.5%), 4 (26.7%) and 10 (55.6%), respectively. While, the number of feet which in static situation had different types from in dynamic situation for pes rectus, pes planus and pes cavus were 5 (18.5%), 11 (73.3%) and 8 (44.4%), respectively.

In a study, a significant correlation was found between subarch angle and arch height, which were obtained from a radiograph. However, no correlation was found between midfoot arch index and arch height. So, it was concluded that due to variability in soft tissue and bone structure, midfoot arch index is less valid and reliable parameter for assessing MLA structure (Chen, 2006). In another study, a significant correlation was found between dynamic and static arch height indexes. Thus, it was concluded that 60% of variability in static arch height can be predicted by a multivariate model generated by plantar parameters during gait (Teyhen, 2009). The findings of the presented study were consistent with Teyhen et al. (2009) study and confirmed its findings. Maybe, the reason of contradiction with Chen et al. (2006) study is the difference in either measurement methods or the number and age range of the participants.

Although, a significant correlation was found between static and dynamic measurement methods in the present study, the numerous numbers of differences between static and dynamic measurements were related to abnormal feet. So, as the foot sustains pressures generated by dynamic activities, determination of dynamic foot type is more important.

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P5

JOINT MOBILIZATION FORCES AND THERAPIST RELIABILITY IN SUBJECTS WITH KNEE OSTEOARTHRITIS

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BACKGROUND AND OBJECTIVES

Osteoarthritis (OA) is the most commonly reported joint disease and a major cause of disability in the United States[1]. Joint mobilization as part of the manual physical therapist treatment approach, reduces symptoms, improves function and reduces the need for medications, injections and total knee replacement[2,3,4]. This study determined the biomechanical force parameters and reliability among clinicians performing knee joint mobilizations.

METHODS

Sixteen subjects with knee OA and six therapists participated in the study. Forces were recorded using a capacitive-based pressure mat (Pliance-x® Novel Electronics Inc., St Paul, MN, USA) for three techniques at two grades (grade III/ large and grade IV/small movements) of mobilization, each with two trials of 15 seconds (Figure 1). Dosage (force–time integral), amplitude, and frequency were also calculated. Analysis of variance was used to analyze grade differences, intraclass correlation coefficients determined reliability, and correlations assessed force associations with subject and rater variables.

Figure 1: Pliance system set up. The therapist's mobilization force is directed posterior creating a physiological extension movement.

RESULTS

Grade IV mobilizations produced higher mean forces ($P<0.001$) and higher dosage ($P<0.001$), while grade III produced higher maximum forces ($P=0.001$). Grade III forces (Newtons) by technique (mean, maximum) were: extension 48, 81; flexion 41, 68; and medial glide 21, 34. Grade IV forces (Newtons) by technique (mean, maximum) were: extension 58, 78; flexion 44, 60; and medial glide 22, 30. Frequency (Hertz) ranged between 0.9–1.1 (grade III) and 1.4–1.6 (grade IV). Intra-clinician reliability was excellent (>0.90). Inter-clinician reliability was moderate for force and dosage, and poor for amplitude and frequency.

DISCUSSION

Grade III and grade IV mobilizations can be distinguished from each other with differences for force and frequency being small, and dosage and amplitude being large (Figure 2). Intra-clinician reliability was excellent for all biomechanical parameters and inter-clinician reliability for dosage, the main variable of clinical interest, was moderate. This study quantified the applied forces among multiple clinicians, which may help determine optimal dosage and standardize care.

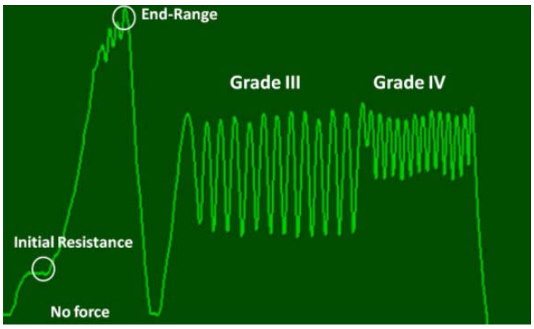

Figure 2: A screen capture of the Pliance system output of force over time outlining knee extension assessment, Grade III and Grade IV mobilizations.

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P6

USING AUDITORY FEEDBACK TO STANDARDIZE PRESSURE FOR ASSESSING TENDER POINTS

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AIM OF INVESTIGATION

While palpation has been used for centuries for diagnostic purposes, current evidence often indicates that diagnostic palpation has poor reliability (Seffinger, 2004), making the scientific assessment of its clinical value difficult. Palpation can be broken down into several physical components which, if standardized, may improve test reliability and provide a foundation for scientific assessment of palpation. One physical component is pressure. In this study, the Novel pliance-X pressure distribution measurement system was used to measure pressure and, with auditory feedback, improve standardization of the rate and accuracy with which pressure was applied during palpation for tender points.

METHODS

Three physicians used palpation and a 4th examiner used algometry to test the supraspinatus muscles of 20 male and 7 female adults (mean [SD] age, 26.7 [6.0] years; mean [SD] body mass index, 23.1 [2.4]) for tender points (n=323), testing each point 1-3 times. Each examiner applied pressure with their thumbs/algometer through a 16-sensor, 4 cm^2 flexible pad until pain was induced or 500 kPa was reached. To assist examiners in pushing at the target rate of 50 kPa/s, audio signals were generated by the Novel pliance-X every 50 kPa and a metronome was used to generate 1 beat/s. The goal of the examiner was to synchronize the beat of the metronome with the tone generated by pliance-X, resulting in a target pressure rate of 50 kPa/s. The average pressure rates for the maximum pressure (MaxPr) and mean pressure (MeanPr) generated by the examiners during testing were estimated using linear regression and were compared to the target rate to assess the ability of the examiners to meet the pressure rate goal. Variation from the steady application of MaxPr and MeanPr was quantified using the root mean square error (RMSE) from the linear regression. Linear mixed models were used to test for differences between examiners on MaxPr and MeanPr rates and RMSE.

RESULTS

The rate at which MaxPr was applied during testing was significantly different from, and primarily less than, the target rate ($P \leq .001$) for all 4 examiners in over 90% of the tests they performed. The mean (SD) MaxPr rate was applied was significantly lower ($P < .001$) for algometry (37.3 [7.9] kPa/s) than the 3 palpating physicians (44.1 [9.8], 44.9 [6.5], and 47.1 [10.5] kPa/s). Results were similar for the rate at which the MeanPr was applied. The RMSE for MaxPr and MeanPr were significantly different between the examiners ($P < .001$). The RMSE for MaxPr was highest for one palpating physician (14.8 [7.1] kPa), followed by algometry (13.2 [6.9] kPa), and was lowest for the other 2 physicians (9.8 [3.7] and 11.1 [5.8] kPa). The RMSE for MeanPr was lower for algometry (3.9 [2.2] kPa) and higher for one palpating physician (7.5 [3.7] kPa) than the other 2 physicians (5.4 [2.2] and 5.9 [3.0] kPa).

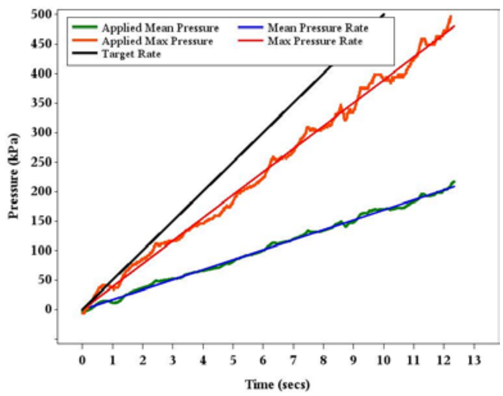

Figure 1: Example of variation of the maximum and mean pressure rates compared to the target rate and the pattern of the applied pressure compared to the steady application of pressure.

CONCLUSIONS

Auditory feedback promoted the steady application of pressure, although variance from the target rate and between examiners was too large. Using the average mean pressure as the basis for the auditory feedback should be considered as well as using the methodology as a training tool to improve the reliability of producing standardized pressures.

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ACKNOWLEDGMENT

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P7

TIME-VARYING PATTERNS REVEAL FOOT LOADING CHANGES AFTER FOOT-ANKLE EXERCISES FOR DIABETIC POLYNEUROPATHY

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INTRODUCTION

The increased risk of plantar ulceration in patients with diabetic polyneuropathy (DPN) is often associated with a heterogeneous plantar pressure distribution characterized by overloading the anterior regions, unloading the toes and hallux, and a reduced role of lateral forefoot and toes in the stance phase of gait. This loading pattern is a result of alterations in the foot rollover process, following an overall worsening of foot-ankle neuro-muscular and joint structures, which restricts the proper load absorption and management during gait. The most studied loading variables in this population are peak pressure and pressure-time integral, that reduces the complex and interdependent foot segments dynamics to a simple average value of many steps. Therefore, they are not optimal variables for describing time changes during the whole process of foot-floor interaction. The aim of the study is to propose a method for identifying plantar areas (referred as pixels) that most discriminate the overall changes through time in the plantar pressure distribution during gait after an exercise intervention protocol for DPN patients[1].

METHODS

We analyzed pressure data from our previous randomized controlled trial[1]. 55 patients with DPN were randomly assigned to 2 groups: (IG) 26 patients in the intervention group received exercises for foot-ankle and gait training twice/week, for 12 weeks, and (CG) 29 patients in the control group received traditional care. We used quantification of the feature importance (FI)[2], that is a key issue not only for ranking the features (from most to least important) before a stepwise estimation model but also to interpret data and understand the underlying phenomenon. We use pixel-wise statistics in the spirit of analysis of variance[2] to identify the set of pixels whose patterns clearly separate classes and sub-classes of pixels, according to the patients group (before and after intervention). We first map the foot during gait on a grid of 99 pixels, corresponding to the sensors of Pedar-X insoles (Novel). For each subject, the footsteps were normalized on the same duration and then comparable pixel by pixel between groups. According to the equation (1), μ_{IG}^{m}, μ_{CG}^{m}, $\sigma^{2}{}_{IG}^{m}$ and $\sigma^{2}{}_{IG}^{m}$ are the estimated mean and variance of the m[th] pixel for both studied groups after intervention. The class separation distance between the IG and CG for the m[th] pixel is defined as (1) and, therefore, points zones of potential interest for image analysis. The potential for discrimination capabilities of each pixel m increases with D_m. The features with larger D_m correspond to the large inertia. The remaining pixels led to poorer discriminative performance. This experiment can be interpreted as a region of interest (ROI) selection experiment.

(1)

RESULTS

According to Fig.1, we show a good congruence between the loading pattern of DPN patients and the pixels ranked by the inter-class separation D_m, represented by the higher amplitude in red. Although regions may be composed of several structures of different scales, it is important to identify the optimal analyzing scales for discrimination purposes.

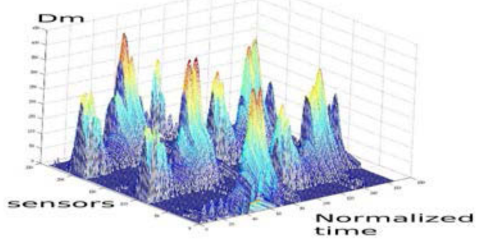

Figure 1- Time varying patterns of plantar pressure.

DISCUSSION AND CONCLUSION

The proposed analysis was efficient in discriminating the changes in specific foot areas after the intervention and could separate classes and sub-classes according to the group of patients. It can be a valuable tool to analyse plantar pressure dynamics through time since it provides further clinical information besides traditional peak pressures and pressure-time integral.

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P8

INFLUENCE OF SADDLE PADS ON THE PRESSURE DISTRIBUTION OF A WELL FITTED EQUINE SADDLE: A PILOT STUDY

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The importance of saddle fit is a topic that has gained gained a great deal of promenance in the last two decades. There is a high correlation between poor saddle fit and poor equine performance (Harman, 2004). The modern English style saddle is technically designed to be used without any additional padding. In practice, though, the vast majority of riders and trainers note that horses usually perform better when some type of saddle pad is placed between the horse's back and the saddle. The purpose of this study was to investigate the influence of saddle pads on the pressure distribution of a well fitted saddle.

METHODS

A modern U.K. manufactured jumping saddle was fit to a 6 year old Thoroughbred cross mare. The saddle was manufactured on a preformed flexible saddle tree. The saddle fit was assessed as excellent by a U.K. Society of Master Saddlers, Qualified Saddle Fitter. The saddle was then pressure tested with no pad so a baseline assessment could be made. Next, pressure testing was done with the addition of various saddle pads to see if any changes in the pressure distribution occurred. Pressure testing was performed using the Pliance saddle test system (Novel, Inc. MN). All measurements were made with the horse at the walk.The rider was a 30 year old female of advanced riding ability, and a weight of 59 kg. The rider's ability to maintain a stable core and load the saddle evenly was assessed as excellent.

RESULTS

In all, a total of 12 different commercially available saddle pads were tested. In every case but one, the saddle pads cause a reduction in the average peak pressure (table 1). The dyed soft pile sheepskin pad produced the best overall reduction in the avg. peak pressure (% diff= -40.0). The only pad that failed to reduce the avg. peak pressure was a pad that had 4 raised gel additions attached to a foam base. This pad raised the average peak pressure by 10.0%. Visual inspection of the pressure map produced by this pad shows a spatial correlation between the location of the gel additions and areas of higher pressure (figure 2). Also, this pad reduced the contact area between the horse's back and the saddle from 1556.250 cm^2 to 1415.625cm^2. It was the only pad tested that reduced the contact area.

FIGURES

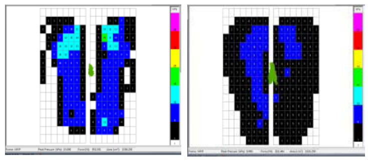

Figure 1:Baseline scan is shown on the left: saddle at the walk with no pad. Scan on the right shows the saddle tested at the walk with a dyed soft pile sheepskin pad. The pad reduced the avg. peak pressure by 40.0%. Contact area increased from 1556.250 $cm^2$to 1931.250 cm^2.

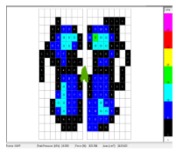

Figure 2: Avg pressure map of pad with raised gel points. High pressure areas are located along the gel points.

Pad Type	Peak avg pressure (kPa)	% Diff
None	15.00	0
Sheepskin, dyed	9.00	-40.0
Sheepskin, undyed	9.50	-36.7
Memory foam	9.50	-36.7
Gel pad, high shear	9.75	-35.0
CC foam, thick *	10.00	-33.3
Quilted cotton	10.25	-31.7
HW quilted cotton**	11.25	-25.0
Nonslip CC foam*	11.50	-23.3
OC Foam***	12.00	-20.0
CC foam, thin	12.25	-18.3
CC foam, w/1shim	13.25	-11.7
Foam with gel points	16.50	+10.0

*Table 1: Lists pad type tested, maximum average peak pressure, and the % diffence in peak pressures compare with the baseline. *CC=closed cell, ** HW=high withered, ***OC=open cell.*

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P9

THE INFLUENCE OF AN 8-WEEK RIDER CORE FITNESS PROGRAM ON PRESSURE DISTRIBUTION ON THE EQUINE BACK

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ABSTRACT

Horseback riding is a unique sport, because it couples two interdependent athletes of different species with varied anatomical and physiological profiles and skill sets. Congruency requires both horse and rider to be fit and balanced. The physical influence of the rider is increasingly being recognized as an important contributor to equine back pain and poor performance (Jeffcott and Haussler, 2004). Asymmetrical loading, in particular, can be damaging to the horse (Greve and Dyson, 2013; deCocq et al., 2009).Evidence-based studies of the human-horse interface, and how forces are influenced by the rider, are gradually gaining momentum, thanks to the emergence of equitation science and validated pressure-mapping technology. The primary aim of this study was to investigate the effects of an unmounted rider core fitness program on the left-right differences in mean pressure distribution on the equine back.

Ten healthy dressage horse and rider pairs (horse age 12.30 ±4.64 years, rider age 41.5 ±14.83 years) performed two ridden tests at sitting trot, before and after participating in an 8-week program. The regime was a sport-specific, 22-minute core fitness program, performed three times weekly.

A Novel Pliance™ electronic saddle mat (60Hz sampling rate) was placed under the saddle and analysis was conducted with Pliance-x 16 Recorder software, using a left-right mask. A single 2D Casio™ high speed camera (240 frames per second) was also used to record all trials, for subsequent calculation of equine stride length with Quintic™ biomechanical software.

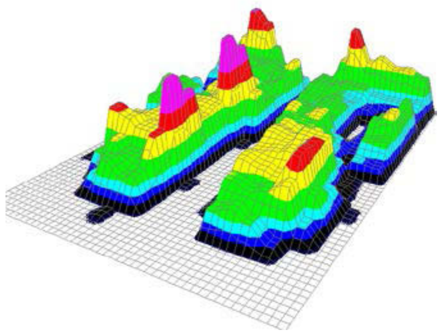

Figure 1. A 3D pressure map from a subject's baseline trial shows asymmetrical loading under the saddle with high peak pressures from the left stirrup bar and left ischial tuberosity of the rider.

All riders (n=10) showed a significant improvement in their mounted symmetry after the program, with a decrease in left-right mean pressure differential of 0.368 ± 0.361kPa. Maximum total force increased by 2.36 ±3.36N/kg. Mean equine stride length (m) increased by 8.4% and equine gait symmetry was improved. This study demonstrates that unmounted physical preparation can have a significant effect on rider symmetry and stability. An appropriate preventative or rehabilitative exercise regime can limit further predisposition to injury and enhance performance (Clayton, 2012).Balanced load distribution may improve equine back kinematics, gait symmetry, range-of-motion and overall athletic sustainability.

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P10

EVALUATION OF INTERFACE LOAD BY ANGLE VARIATION OF MATTRESS BACK SUPPORT FOR AUTOMATIC EXCRETION HANDLING SYSTEMS

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INTRODUCTION

Handling the excreta of bed-ridden patients is difficult work for the caregiver, which involves patient privacy issues and the prevention of secondary infection. Automatic excretion handling systems need a slotted mattress in order to use the diaper cup. However, patients would fall into the mattress slot upon elevating the back support of the electric bed.

The aim of this study was to evaluate the interface load on the slotted mattress as the back support is elevated.

METHOD

Subjects: Five healthy males and five healthy females were selected to participate in this study. The following is a summary of their vital data: 29.9 ± 2.28 years, 165.8 ± 8.26 cm, 64.2 ± 11.7 kg, with a BMI of 23.2 ± 3.04 kg/m^2.

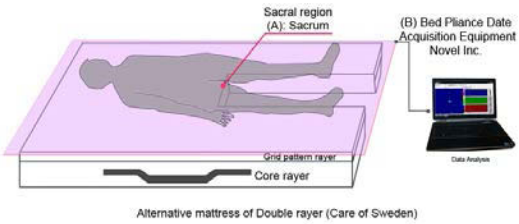

Figure 1: A schematic of the slotted mattress and experimental equipment: (A) Reference position, and (B) bed pliance data acquisition system, Novel Inc.

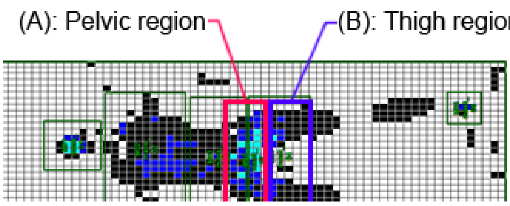

Figure 2: Data masking method: (A) Pelvic region, and (B) thigh region

Measurements and data analysis: The subjects were placed in the reference position considering the typical usage configuration, as shown in Figure 1. The interface pressure was measured sequentially at nine angles of back support: 0°, 10°, 15°, 20°, 30°, 45°, 60°, 80° (elevation), and 0° (descent). The main load areas were expected in the pelvic and thigh regions, shown in Figure 2 as regions A and B, respectively. The measured peak pressures and resulting mean force in these areas are presented in Table 1.

RESULTS

Table 1: The results of interface load.

Angle [°]	Peak pressure [mmHg]		Mean force [N]	
	Pelvis	Thigh	Pelvis	Thigh
0	40.1 ±10.3	37.3 ±6.8	143.8 ±32.8	85.9 ±43.4
10	38.8 ±9.6	38.6 ±7.4	136.6 ±39.3	91.9 ±24.6
15	37.9 ±9.3	42.4 ±7.1	127.8 ±40.7	106.2 ±26.6
20	38.1 ±9.7	43.9 ±7.2	120.8 ±40.0	116.9 ±23.8
30	38.8 ±10.6	52.0 ±12.3	103.8 ±34.6	153.3 ±28.9
45	48.0 ±10.6	51.8 ±7.4	104.9 ±39.3	201.0 ±44.9
60	46.9 ±19.5	64.9 ±12.4	99.1 ±55.8	262.2 ±65.9
80	49.0 ±20.6	84.6 ±10.2	84.5 ±66.1	319.9 ±57.5
0	38.1 ±11.0	37.7 ±6.5	65.3 ±33.0	128.3 ±31.3

DISCUSSION & CONCLUSION

When the back support was raised, the interface load of the pelvic region showed no significant variation. In contrast, the interface load increased for the thigh region. The patient fell into the mattress slot at back support angles of 30° ~ 45° because the interface load moved from the pelvic region to the thigh region in that range.

This study confirmed that the slotted mattress used in conjunction with the automatic excretion handling system needs a new back elevation system.

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P11

A COMPARISON BETWEEN EMED-X AND MATSCAN PLANTAR PRESSURE SYSTEMS.

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INTRODUCTION

Plantar pressure measurement devices are used in many research protocols. It has allowed researchers and clinicians to objectively measure foot function, as plantar pressure measurements provide a direct assessment of how an individual's foot loads during functional activities.

Plantar pressure measurements of an individual, however, may vary between platforms of different manufacturers. Platform technology is manufacturer-specific, leading to a difference in resolutions, sensor types, sampling rates, and ranges of detectable pressure[1]. For researchers and clinicians wishing to compare data collected on different platforms, difference in measurements prove to be a hindrance.

The purpose of the study was to compare the plantar pressure measurements derived from two different systems.

METHODS

Using the plantar pressure data from members of the population-based Johnston County Osteoarthritis Study[2], simple linear regression models were used to assess the relationships between the emed-x (Novel, Munich, Germany; average of 5 trials) and Tekscan MatScan (Tekscan Inc., Boston, MA; average of 2 trials) systems. We assessed the relationship between CPEI, total peak pressure, total maximum force, total pressure time integral, total force time integral and total area under each foot. Slopes (unstandardized beta), y-intercept, and R^2 values were calculated (Table). Extreme outliers were excluded (n=3 people).

RESULTS

330 participants (657 feet) were included. Mean age was 64 yrs (SD 8.1, range 51-86), mean BMI was 31 kg/m^2 (SD 6.56), 67% were female and 68% were white. Table 1 shows slopes, interercepts and R^2 from the linear regression analysis. We found high agreement (R^2>0.74) between emed-x and MatScan for Total Area and Total Max Force. Other measures showed moderate agreement (R^2: 0.26-0.57).

DISCUSSION

This is the first population based study comparing 2 plantar pressure systems that shows reasonable agreement of the data. Currently, the measures considered encompass the entire masking of the foot. Future work should examine specific masked regions which are likely to have less agreement. Also, subsets of interest should be examined, such as sex, BMI groups and racial/ethnic groups.

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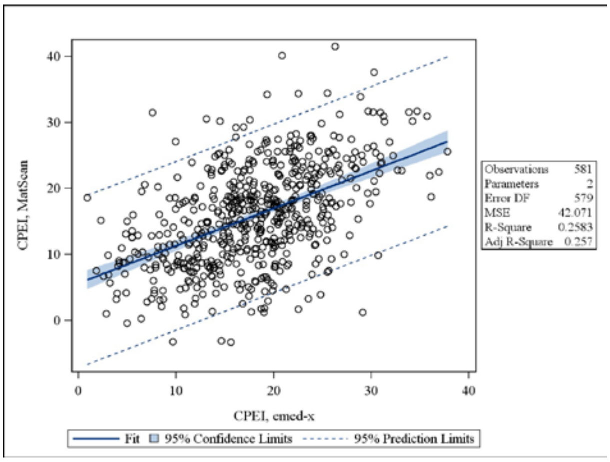

Figure 1:Fit plot for emed-x vs MatScan CPEI Linear Regression.

	Slope	y-Intercept	R^2
CPEI	0.5672	5.634	0.2583
Total area	0.9227	12.559	0.7412
Total force time integral	0.7495	122.912	0.5701
Total max force	0.8556	23.296	0.8419
Total peak pressure	0.2887	23.358	0.4286
total pressure time integral	0.4047	13.324	0.4548

Table 1: Linear regression between emed-x and MatScan pressure measurements

P12

PROTOCOL FOR 1000 NORMS PROJECT: CLINICAL CATALOGUE OF PLANTAR PRESSURE AND MUSCULOSKELETAL MEASURES ACROSS THE LIFESPAN

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INTRODUCTION

In healthcare, understanding normal variation is essential, as decisions regarding diagnosis and management are frequently based on comparison with healthy or normal values (Solomon, 2007). To make these decisions, researchers, clinicians and healthcare policy makers need access to scientifically robust patient-centred outcome measures and knowledge of appropriate reference values. The 1000 Norms Project is currently recruiting a volunteer sample of 1000 healthy individuals between the ages of 3 and 100 years to provide a freely accessible database of normative reference values for a set of widely-used clinical and plantar pressure measures.

METHOD

Emed plantar pressure measurements, spatio-temporal gait gait parameters, lower limb range of motion and instrumented isometric strength, as well as static lower limb alignment and foot alignment are included in the comprehensive battery of items (Table 1). In addition, saliva DNA will be analysed for the *ACTN3* genotype - the 'gene for speed' which will contribute to a greater understanding of the influence epigenetic factors have on muscle phenotypes and planat pressure.

RESULTS

The 1000 Norms Project reliability study found inter-rater reliability to be excellent (ICC>.75) for all items assessed manually. Release of the final database to the international healthcare and research community via a secure, free online network is anticipated to occur in March 2016 and will include descriptive statistics, creating mean values and z scores. Quantile regression equations will be used to generate age charts and age specific centile values.

DISCUSSION

The 1000 Norms Project will provide a substantial contribution to our understanding of the range of normal reference values of a variety of plantar pressure parameters of 1000 individuals defined as healthy across the lifespan. The 1000 Norms Project reference dataset will help develop and validate sensitive clinical trial outcome measures and will provide a unique collection of healthy normative measures that will facilitate the diagnosis of musculoskeletal, neurological and biomechanical dysfunction and age-related pathological changes. It will offer reseachers the opportunity to explore relationships between plantar pressure and a wide range of musculoskeletal and neurological measures.

Items
Plantar pressure (Emed Novel, Germany)
Foot Posture Index
Static and dynamic lower limb alignment
Anthropometric and physical profile measures
Spatio-temporal gait analysis
Timed up and down stairs test
Bruininks-Oseretsky Test of Motor Proficiency
Star Excursion Balance Test
Functional Dexterity and Nine Hole Peg Tests
Six minute walk test
Active range of motion
Choice Stepping Reaction Time
Isometric muscle strength
Toe Flexor Strength
30-second Chair Sit to Stand Test
Countermovement and standing long jumps
Knee injury and Osteoarthritis Outcome Score
Cumberland Ankle Instability Tool
Nordic Musculoskeletal Questionnaire
International Physical Activity Questionnaire
Assessment of Quality of Life Questionnaire
General Self-Efficacy Scale
Workability

Figure 1: Items administered in the 1000 Norms Project

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P13

INFLUENCE OF SHOE CUSHIONING AND RUNNING EXPERIENCE ON PLANTAR PRESSURE DISTRIBUTION IN RECREATIONAL RUNNERS

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INTRODUCTION

The inexperience in running practice may be a risk factor for injuries[1], but a systematic review has pointed this finding as an uncertain evidence[2]. A recent study has shown using logistic regression analysis that running experience from 5 to 15 years had an association with the absence of previous injuries[3]. This relationship between running experience and history of injuries may be explained by the fact that greater runner's experience may improve the musculoskeletal response to mechanical loads during running[4]. Mechanical loads over the foot have been described as a risk factor for developing injuries that are common in runners, such as plantar fasciitis[5]. Depending on the material characteristics of the running shoes (viscous and elastic), runners may change their muscle activation prior to heel strike resulting in different plantar load distribution[6,7,8]. It is recommended for the runners to replace their shoes after 500-800 km run to lower the risk of injuries[6], due to the deterioration of shoes' viscoelastic properties. It is relevant to investigate how would be the plantar load distribution of runners with different running experience when using different sport shoes and cushioning systems. These findings would help to improve running practice, training and shoes recommendations. Thus, the purpose of the study was to evaluate the influence of two cushioning systems of running shoes and running times of practice on plantar loading in runners.

METHODS

Forty runners were evaluated and divided into 2 groups: 20 runners with running practice up to 4 years, considered a short time of experience (SEG) and 20 runners with equal to or above 5 years of running practice, considered a longer experience (LEG). The rationale for this classification was based on the fact that 55% of runners suffer injuries in the early year of running practice[3] and that runners experience (between 5-15 years) are associated with the absence of running-related injuries. The SEG showed an mean of running practice time of 2.2±1.2 years (33C7yr, 73.8±10.3kg, 1.7±7.9m) and LEG a mean of 9.1±2.8 years of running practice (39.8±6.5yr, 69.8±6.0kg, 1.7±3.2m). Each group was analyzed using two shoes cushioning systems: 10 runners using shoes with Gel (silicon/polyurethane composite) and 10 runners using shoes with EVA layers of various densities. All runners exhibited a heel strike pattern of running and shoes neutral. Maximum force and peak pressure over 3 plantar areas were acquired by Pedar X system during running in a 40 meters track at 12±5% km/h. Comparisons between groups and shoes were done using ANOVAs 2-way (group and shoes), followed by Newman Keuls post hoc tests (p<.05).

RESULTS AND DISCUSSION

The results showed that years of running practice and shoes cushioning system have influenced the peak pressure over the rearfoot, where LEG showed lower peaks when running with Gel shoes and higher peaks when running with EVA shoes. The shoes with Gel provided greater benefit in reducing plantar loads in runners with both shorter and longer running practice when compared to EVA shoes.

Table 1- Mean, standard deviation and comparison among groups and shoes.

Variable	*Group*	*Shoes*	*Rearfoot*	*Midfoot*	*Forefoot*
Maximum force (N)	*SEG* (1)	GEL	645.5±93.2	332.5±93.1	1031.2±221.5
		EVA	831.3±192.2	315.5±97.2	1137.0±133.4
	LEG (2)	GEL	675.7±113.9	327.8±58.7	1101.7±94.10
		EVA	848.3±126.6	341.2±77.2	1064.1±104.7
		p-valor	*0.025*$^{\&(1)}$ *0.021*$^{\&(2)}$	*0.317*	*> 0.05*
Peak Pressure (kPa)	*SEG* (1)	GEL	245.3±39.7	127.2±16.4	309,1±57,6
		EVA	572.3±293.5	145.5±45.2	502,7±137,0
	LEG (2)	GEL	231.3±34.9	153.3±52.4	318.3±66.8
		EVA	745.5±326.5	140.7±23.9	516.8±171.9
		p-valor	*0.003*$^{*(1x2)GEL}$ *0.001*$^{*(1x2)EVA}$ *0.001*$^{\&(1)}$ *0.009*$^{\&(2)}$	*0.246*	*0.016*$^{\&(1)}$ *0.014*$^{\&(2)}$

*Sign diff btw groups (SEG and LEG). $^{\&}$Sign diff btw shoes (GEL and EVA).

Although previous studies[7,9] have shown that stiffer shoes (EVA) resulted in smaller loading rates, we observed that Gel shoes, considered a soft cushioning/midsole, resulted in lower plantar loads, regardless the experience in running. The EVA shoes, considered a more rigid/stiffer cushioning, resulted in higher plantar loads in both groups of runners. These results confirm that the midsole hardness has an important influence on how the feet absorbs the external loads[10,11]. The experience time has influenced the load response during running and depending on the shoe system, LEG and SEG responded differently. More experienced runners (LEG) may have better ability of differentiating the shoe cushioning system, and consequently, change their musculoskeletal strategies avoiding higher plantar loads, and thus could have better conditions to prevent running-related injuries, as discussed recently in the literature[3].

CONCLUSION

The shoes with Gel cushioning system produced lower peak pressure in runners, regardless the running practice experience. The more experienced runners generated higher loads over the rearfoot while running with EVA cushioning system.

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P14

RESEARCH ON THE VERTICAL GROUND REACTION FORCE OF MIDSOLE HARDNESS IN HIGH HEELS

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INTRODUCTION

High heels can make women more attractive with a female gait (Morris, 2013). However, the plantar pressure shifted from heel area to medial forefoot and hallux when wearing high heels (Speksnijder, 2005). Excessive load on these area was associated with forefoot pain, hallux valhus deformity, and calluse et al. (Domjanic, 2013). The replace of midsole material may change the plantar pressure of high heels. Ground reaction force (GRF), the peak shoes-ground force, is important in gait analysis (Winter, 1991) and can reflect the plantar pressure. Therefore, the purpose of this study was to compare the vertical GRF of high heels with different midsole materials, and investigate the effect of midsole hardness on the vertical GRF.

METHODS

Three kinds of high-heeled shoes which differes only in midsole hardness of forefoot area were investigated, which named by H (Shore O:22, hard), HS (Shore O:18, hard-soft), and S (Shore O:12, soft) respectively. The vertical GRF was messured by footscan® plate system (Rsscan, Belguim; 1m×0.4m, 250Hz). The footprint were divided into five regions: toe, medial forefoot, lateral forefoot, midfoot, and heel. Only data for right foot was analysed. One-way ANOVAs was used to assess differences in GFR among the three conditions. All ststistical analysis were done by the software SPSS 17.0 and $p < 0.05$ was taken as a level of significance.

Forty women who wearing shoe size Euro 37 participated in this study (aged 25±3 years). All subjects had a normal arch and no history of lower extremity injury or foot pain. Informed consent was signed by all of them prior to testing.

RESULTS

Comparison of GRF was shown in Figure 1. The toe region displayed statistically significant increas in GRF in the HS condition (0.040) and S condition (0.006) compared to the H condition. The GRF was higher during the H midsole condition compared to both the HS and S midsole conditions in forefoot area (both medial and lateral forefoot), but no statistically significant difference was found. The GRF value of midfoot area was zero in all conditions, because there was no contact with the ground in this area. However, the GRF was lower during the H condition compared to the HS condition in heel region, but still higher than the S condition.

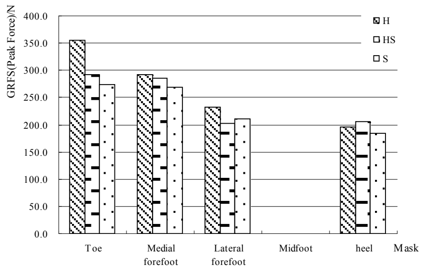

Figure 1. Comparison of the vertical GRF on shoes-ground interface

DISCUSSION AND CONCLUSIONS

The vertical GRF of H condition was higher in toe and forefoot regions, but lower in heel, which was contrary to HS condition， which suggests that softer midsole may relieve the excessive vertical GRF of the forefoot which caused by heel height. However, the range of midsole hardness was not enough in this study, furture research could expand the hardness range.

ACKNOWLEDGEMENTS

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P15

FUNCTIONAL AND CLINICAL EVALUATION OF A BIOMECHANICAL SHOE WITH SEMI-RIGID OUTSOLE

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INTRODUCTION

Several studies showed the advantages of using biomechanical shoes with semi-rigid outsoles in patients affected by diabetes and limited range of motion (Brown et al., Forghany et al.).

The improvement of gait abilities and balance leads to a decrease of falls which is one of the main causes of disability in elderly. Biomechanical shoes with semi-rigid outsole can support rolling of the gait cycle, reducing also energy expenditure and stress over ankles, pelvis and hips (Arazpour et al). These shoes are indicated in patients with limited range of motion, patients with rheumatic diseases or diabetes for primary prevention, patients that underwent foot surgery in order to accommodate swelling and sore foot.

The objective of this study was to compare data from gait analysis and baropodometry of patients walking with biomechanical shoes with semi-rigid outsole and those with normal shoes.

MATERIALS AND METHODS

10 patients (5 males, 5 females, mean age 60 ± 9.1) with deficiency of the ankle-foot complex were included in the study. Patients were assessed during walking at self selected normal speed, a minimum of three repetitions. Full gait cycles were collected along a 15-m long walkway while wearing normal shoes and then wearing biomechanical shoes (Activity, Podartis, Treviso, Italy). Gait analysis was performed using a stereophotogrammetric system with eight cameras (Vicon 612, Vicon Motion Capture, Oxford, UK), two dynamometric platforms (Kistler Instrument; Einterthur, Switzerland) and an established protocol (Leardini et al. 2007)

Pedobarographic data were obtained using the Pedar® cable system (Novel GmbH, Munich, Germany).

RESULTS

Regarding spatial-temporal parameters from gait analysis, improvements with the biomechanical shoe were observed: an increase of mean speed from 108 ± 9 cm/s with normal shoes to 119 ± 10 cm/s with semi-rigid shoes, an increase of mean cadence from 55 ± 6 to 59 ± 6 steps/min and a slight increase of mean stride length from 118 ± 11cm to 121 ± 12 cm.

Regarding kinematic data, a slight increase of the mean dynamic ankle range of motion on the sagittal plane was found, from 17° ± 5 with normal shoes to 23° ± 6 with biomechanical shoes.

Finally data from pedobarographic analysis showed a reduction of mean peak pressure of the forefoot from 510 ± 98 Kpa with normal shoes to 290 ± 39 KPa with biomechanical shoes. The mean total foot contact area increased from 117 ± 10 cm^2 with normal shoes to 124 ± 15 cm^2 with biomechanical shoes.

CONCLUSION

This biomechanical shoe with semi-rigid outsole showed more physiological gait parameters with improved spatial-temporal, kinematic, and pedobarographic data compared to the normal shoe. Therefore, this shoe is particularly indicated for subjects with limited ankle-foot range of motion and for diabetic patients in primary prevention.

Figure 1: Biomechanical shoes with Pedar insole system for baropodometric evaluation.

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P16

FOOT LOADING UNDER THE HEEL BONE OF SUBJECTS STANDING IN UNSTABLE SHOES

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INTRODUCTION

One of the most frequently hurt tarsal bones is the injury of the calcaneus. Patients usually load the injured foot significantly less than the healthy one. In the last couple of years, there has been an increase in promotion of unstable shoe constructions because of the health benefits of this footwear. Several studies have been conducted with subjects wearing shoes with the unstable sole construction to analyse biomechanical and neuromuscular changes occurring during gait and standing (Nigg et al., 2006; Demura et al., 2012; Price et al., 2013). One well known unstable shoe construction is the Masai Barefoot Technology (MBT). Nigg et al. (2006) introduce t MBT shoes worn during standing as a mechanical muscle training device. Boyer & Andriacchi (2009) mention potential therapeutic opportunities due to the different profile of pressure distribution to the flat-soled shoes. However, a few completed investigations have presented diverse results. That was the reason why the aim of this study was to examine whether the usage of MBT shoes influences the vertical load under the calcaneus.

MATERIAL AND METHODS

Measurements were performed in a group of ten healthy women (age: 35.1 ± 13.26 years, height 170 ± 5.72 cm, weight: 64.1 ± 7.66 kg). While using Pedar system (Novel, Munich, Germany), interactions between the sole and the insole were studied with subjects standing both in regular athletic shoes and shoes with unstable construction (manufactured by Masai Barefoot Technology, CH). Measurements were carried out for 20s with the frequency of 50 Hz. Outcome variables were the maximal pressure ($Y_{1,2}$), the maximal force in vertical direction ($Y_{3,4}$) and the maximal vertical force in the area under the calcaneus ($Y_{5,6}$). The data were processed by the Matlab programme.

RESULTS

Figure 1 presents the values of the vertical force component measured under the calcaneus ($Y_{5,6}$).

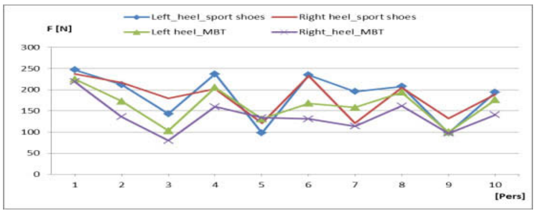

Figure 1: Comparison of forces under the calcaneus in MBT shoes and sport shoes (left and right)

To find the difference between the regular shoes and MBT, we used the paired t-test (Table 1). Normal distribution was verified by Lillieforse test.

Table 1: Results of the paired t-test

Variable	Aver. Z	Sz	p-value
Peak Pressure – left (Y_1)	7,30	11,78	0,082
Peak Pressure – right (Y_2)	-2,20	21,02	0,748
Max. Force- left (Y_3)	-7,10	25,26	0,397
Max. Force- right (Y_4)	-2,60	37,58	0,832
Force calcaneus –left (Y_5)	23,50	27,19	0,023
Force calcaneus – right (Y_6)	46,30	38,31	0,004

Z ... average difference between MBT and sport shoes
S_Z... sample standard deviation

CONCLUSIONS

The load values under the heel bone of subjects standing in MBT shoes are significantly lower than when standing in a pair of regular sports shoes. For other variables, we did not find any statistically significant differences.

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EVALUATION OF BALANCING ABILITY IN HEMIPLEGIC PATIENTS USING PLANTAR PRESSURE MEASUREMENT BASED ON TYPE OF ANKLE-FOOT ORTHOSIS

< PEDAR-X >

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INTRODUCTION

Hemiplegic patients generally exhibit abnormal balancing ability owing to muscle stiffness and spasticity. Thus, they use an ankle-foot orthosis that supports the paretic ankle to counteract muscle and nerve problems. The majority of previous studies on ankle-foot orthoses have dealt with the ambulation abilities of hemiplegic patients, and there is a dearth of research on their balancing abilities.

In this study, the evaluation of balancing abilities based on the type of ankle-foot orthoses has been performed.

METHOD

Subjects: 10 people participated in this experiment was hemiplegic patients, nine males and one female (55±8.63 years, 186.6±8.26cm, 70.3±9.31kg, and BMI: 24.68 ±2.86kg/m^3; mean±SD)

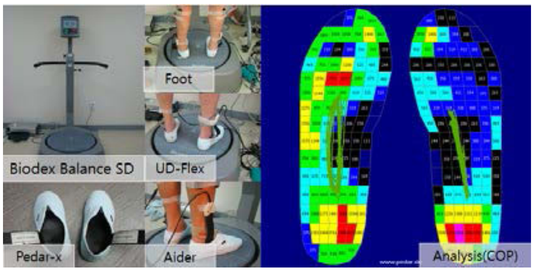

Figure 1: Experimental equipment, analysis(COP)

***Measurements and data analysis*:**

The subjects underwent the posture stability test of the Biodex Balance SD System, which is designed to test balancing ability, three times for 20 s each under the following three conditions: without an orthosis (Foot), using a plastic ankle-foot orthosis (UD-Flex), and using an elastic band-type ankle-foot orthosis (Aider).

In each test, the plantar pressure was measured with a plantar pressure sensor (pedar-X), and the total weight-bearing and travel distance of the center of pressure (: COP) were analyzed (Figure 1). During the posture stability test, it was verified through the analysis of the total COP travel distance that the degree of sway was directly proportional to the total COP travel distance.

RESULTS

Table 1: Results of plantar pressure analysis of paretic side ((A): COP total travel, (B): Weight bearing %)

(A) mean±SD(mm)

COP Total travel	**Foot**	**UD-Flex**	***P***
	1666.9 ±1839.4	1107.1 ±1262.5	0.004*
	Foot	**Aider**	***P***
	1666.9 ±1839.4	1277.5 ±1310.7	0.034*

(B) mean±SD(%)

Weight bearing	**Foot**	**UD-Flex**	***P***
	44.36 ±9.97	47.65 ±12.3	0.046*
	Foot	**Aider**	***P***
	44.36 ±9.97	49.12 ±9.88	0.002*

The travel distance was maximum under the Foot condition, followed by the Aider and UD-Flex conditions (Table 1(A)).

With regard to weight-bearing, the Aider condition showed the most evenly distributed weight-bearing, followed by the UD-Flex und Foot conditions (Table 1(B)).

DISCUSSION & CONCLUSION

It was observed that for a hemiplegic patient, wearing an elastic band-type ankle-foot orthosis to provide support to the paretic ankle was effective in inducing an even distribution of weight-bearing on both the paretic and non-paretic sides.

The analysis of the total COP travel distance revealed that the result was attributable to the effects of foot-drop correction and ankle support using orthoses, which led to enhancement of the rate of support to the weights of the midfoot and hindfoot.

This study verified that using an orthosis improved balancing ability in hemiplegic patients.

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P18

DATA-DRIVEN DIRECTIONS FOR EFFECTIVE FOOTWEAR PROVISION IN DIABETIC PATIENTS WITH A HISTORY OF FOOT ULCERATION.

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INTRODUCTION

High plantar peak pressures play an important role in causing foot ulcers in patients with diabetes mellitus. In patients who are at risk for developing a plantar foot ulcer these high-pressure areas are offloaded with custom-made footwear. However, in earlier studies this footwear showed to be suboptimal in relieving plantar foot pressure (Arts et al, 2012)

The aim of this study was to evaluate the offloading effectiveness of modifying custom-made footwear and to use this data to provide directions for effective footwear provision for at-risk diabetic patients to prevent foot ulceration

METHODS

Eighty-five diabetic patients with loss of protective sensation due to peripheral neuropathy, and a recently healed plantar foot ulcer, who participated in a multi-center randomized trial on footwear effectiveness (Bus et al., 2013), were provided with new custom-made footwear.

This footwear, and any other pair of custom-made footwear the patient had or was prescribed with during follow-up, was evaluated with in-shoe pressure measurements during walking using Pedar-X at three-monthly intervals for 15 months or until a foot ulcer developed. The footwear was modified when peak pressure at plantar regions was ≥200kPa.

The effect of single and combined footwear modifications on in-shoe peak pressure at these high-pressure target locations and at 8 anatomical foot regions was assessed and then summarized in an offloading-effect matrix. The shoe technician was free to choose type and number of footwear modifications.

RESULTS

A total of 1152 (combinations of) modifications were made over the course of the study in 304 shoes that showed a peak pressure >200kPa. Modifications of the shoe insole involved replacement of the top cover, addition of or repositioning of a metatarsal pad or bar, extra medical arch support, more cushioning or removal of insole material. Modification of the shoe involved adjustment of the pivot point of a rocker bar

The metatarsal heads were the target location for footwear modification in more than 50% of cases. All types of footwear modifications significantly reduced peak pressure at the target locations (range in peak pressure relief: -6.7% to -24.0%, $p<0.05$). Repositioning a metatarsal pad or trans-metatarsal bar in the insole (-15.9% peak pressure relief), applying local cushioning to the insole (-15.0%), and replacing the top cover of the insole (-14.2%), were the most effective single modifications. Combining the replacement of the top cover of the insole with a trans-metatarsal bar (-24.0%) or with local cushioning (-22.0%) were the most effective combined modifications.

DISCUSSION AND CONCLUSIONS

In diabetic patients with a recently healed plantar foot ulcer, significant offloading can be achieved at high-risk foot regions by modifying the custom-made footwear of these patients based on in-shoe pressure analysis.

These results provide data-driven directions for effective offloading to be used in custom-made footwear design and evaluation for diabetic patients and that may likely lower the risk for developing a plantar foot ulcer.

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P19

ANTHROPO-DYNAMIC RESEARCH OF DIABETICS' FEET IN GEORGIA

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INTRODUCTION

Diabetes is one of the most spread and heavy endocrine diseases causing substantial changes to human feet. Our pioneer study of diabetic feet in Georgia analyses the data gained from pedo- and anthropometric diagnoses of patients with the help of statistical methods.

METHODS

The quality orthopedic supports depends on the optimal distribution of pressure on the support surface in dynamic and static conditions. We have researched the overall picture of diabetic feet with the focus on shapes of plantar parts of feet, the parameters of pressure relief, functional and anthropometric diagnostics of our patients by using the emed® pedography platform by Novel.

RESULTS

The pedography platform (fig.1) allowed us to determine the pressure distribution on the plantar parts of feet in a dynamic condition

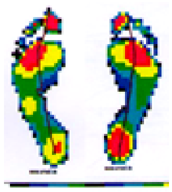

Figure 1: Pressure distribution in dynamics

Our study of diabetic feet in heavy forms (fig.1) has shown, that center of mass of abnormal feet inclined to the inner sides of the feet.

Pressure %	1 toe	2-5 toes	part of falanga junction	part of vault	Heel part
	7,37	10,68	32,49	26,63	22,83

Table 1: Pressure distribution on the plantar parts of diabetic feet

As shown in the table 1, in a dynamic condition the most pressure is put on the part of falanga junction in diabetic feet. The pressure on part of vault is less than on part of falanga junction of diabetic feet but more than on heel parts.

A pair of size features and characteristics	Correlation coefficient	
	female	male
Foot length – wrap in part of falanga junction (L_f– R_c.)	0,52	0,63
wrap and width in part of falanga junction (R_c.– W_c.)	0,75	0,86
Foot length - width in part of falanga junction (L_f– W_c.)	0,28	0,46
Width in heel part– width in part of falanga junction ($W_{h.p.}$ – W_c.)	0,59	0,66
Support area on the pedogram–the total dynamic pressure	0.81	0.83

Table 2: Correlative dependence of reseach parameters

As shown in the table 2, the ratio of longitudinal and magnitude of the wrap of outer part of falanga junction is essential, as for the foot length and width sizes, their connection is less, because the deviation of width sizes are is than in the length sizes. This approach leads to a high correlation between support part and total dynamic pressure.

CONCLUSIONS

While considering the individual pressure distribution, we will be able to reach an optimal pressure relief of parts of diabetic feet and project the respective footwear and thus, to reduce severe consequences of diabetes.

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P20

FOREFOOT PLANTAR PRESSURES IN MILD, MODERATE AND SEVERE HALLUX VALGUS.

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BACKGROUND

Hallux valgus has been linked to functional disability and increased falls risk in older adults, but mechanisms underpinning this functional disability are unclear. Previous studies have reported conflicting findings regarding plantar pressures in hallux valgus (Nix, 2013). Most plantar pressure studies to date have not considered the severity of hallux valgus or the presence of foot pain in their analyses. This study investigated forefoot plantar pressures in adults with mild, moderate, and severe hallux valgus compared to controls, while considering age, gender, body mass index and foot pain as covariates.

METHODS

Sixty adults with hallux valgus (classified as mild, moderate and severe on dorsoplantar radiographs) and 30 controls participated. The Novel Pedar-X system was used to capture in-shoe plantar pressure data. Participants walked at a self-selected comfortable speed along a 10 metre flat walkway, and five trials were completed. Five forefoot regions were identified using a relative mask based on prior work by Putti *et al* (2007): hallux, lesser toes, first metatarsal, second metatarsal, third to fifth metatarsals. Peak pressures (kPa) and pressure-time integrals (kPa*s) were calculated. Multiple analysis of covariance and pairwise comparisons (p<0.05, Bonferroni adjustment) were used to investigate differences between groups.

RESULTS

A significant reduction in hallux peak pressure and pressure-time integral was evident in moderate (peak pressure -90.8kPa, p<0.001) and severe hallux valgus (peak pressure -106.2kPa, p<0.001) compared to controls. This finding was significant after adjusting for covariates, including foot pain. However, our study found no significant differences in forefoot plantar pressures between participants with mild hallux valgus and controls (p>0.05). Furthermore, no signficant differences were found between groups in other forefoot regions (p>0.05).

CONCLUSIONS

Moderate to severe hallux valgus is associated with reduced hallux plantar pressures during walking, which may indicate less effective toe-off. Those with mild hallux valgus had similar loading patterns to control participants, indicating that toe-off may not be affected until hallux valgus deformity progresses to a moderate or severe state. These findings have important implications for clinical management. Future studies are needed to investigate whether early intervention strategies, such as foot orthoses, exercises or manual therapy, can alter deformity and associated functional changes in hallux valgus.

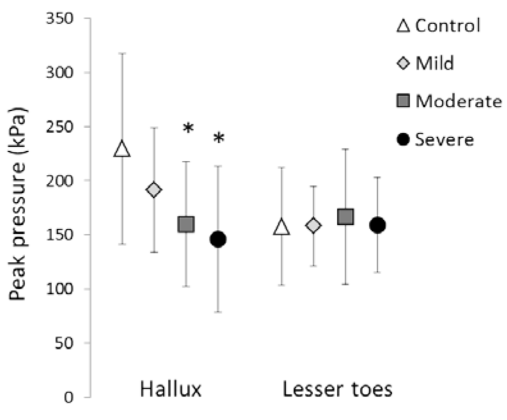

Figure 1: Peak pressures under the hallux and lesser toes in participants with mild, moderate and severe hallux valgus compared to controls. indicates a significant difference (p<0.001)*

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P21

PYRAMIDAL TRACT NEUROAXONAL INTEGRITY PREDICTS FUNCTIONAL STATUS IN CHRONIC STROKE PATIENTS WITH MILD PRIMARY INFARCTION

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BACKGROUND

There are subtle functional deficits in chronic stroke patients despite small volume primary infarction. These are difficult to characterize with standard neurological scales and conventional MRI. We used walking speed as a comprehensive tool for gait assessment and sensitive quantitative diffusion tensor based 3D tractographic approach to assess corticospinal tracts in patients with small volume anterior circulation infarcts that are either silent or have little stigmata of tissue damage on conventional MRI techniques.

METHODS

Chronic stroke patients (SS) (NIHSS<4) without significant gliosis or encephalomalacia in infarct territory and mild functional deficit, (mRS≤2) were compared with healthy age and gender matched controls [Age (yrs): SS, 66±9 (n=11) versus controls, 63±7 (n=8), p=0.5]. Diffusion Tensor Imaging based tractographic reconstruction of corticospinal tracts was performed. Trace constrained diffusion metrics were compared across groups. Walking speed, (m/s) was used for assessment of comprehensive functional status.

RESULTS

We found the walking speed to be significantly lower in chronic stroke patients, (mean±sd, stroke vs.controls: 0.99±0.2 vs 1.2±0.08, p value= 0.02). However, the walking speed did not correlate with NIHSS or mRS, (p>0.1). The ipsilesional and contralesional corticospinal tracts had significant differences in tract constrained Trace estimates compared to average CST control estimates , (p=0.001 and p=0.01). In stroke patients we found that the strongest predictor of walking speed after adjusting for height was contralesional CST FA, p=0.09, for the whole group using average CST for both groups we found a significant correlation with gait after adjusting for height, p=0.03. Same analyses in whole group substituting average CST for controls and using contralesional CST for stroke, we found a significant correlation with walking speed, p=0.01, after adjusting for height. There was no correlation with NIHSS or mRS, (p>0.1).

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CONCLUSIONS:

There are conventional MRI occult abnormalities in the contralesional and ispilesional CST in chronic stroke patients despite small volume primary infarcts. CST Trace was more sensitive to detect these changes. Both average CST and contralesional CST FA appear to predict some degree of motor function.

P22

THE RULE AND ITS EXCEPTIONS FOR COMPUTING THE CENTER OF PRESSURE EXCURSION INDEX (CPEI)

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BACKGROUND

The foot is an anatomically complex mechanism (28 bones, 33 joints, and 112 ligaments) that has been described by several measures of foot structure and function (Song, 1996, Hillstrom, 2013, Cavanagh, 1997, Stebbins, 2006, Leardini, 2007, Kidder, 2006). The center of pressure excursion index (CPEI), is a measure of dynamic foot function (over-pronating, normal, and over-supinating). It is the center of pressure curve concavity (Figure 1).

METHODS

The center of pressure (COP) at each instant of time (red) is superimposed with the maximum pressure throughout stance phase plot (Figure 1). CPEI (%) is calculated as follows;

$$\text{CPEI (\%)} = (\text{CPE}/\text{FW}) \times 100 \qquad (1)$$

where the center of pressure excursion (CPE, shown in white) is the displacement between the COP curve and the construction line (between the initial and final center of pressure points) at the anterior third of foot length and FW is the foot width at the CPE. Over-pronation is illustrated by a COP curve with diminished concavity. Over-supination is illustrated by excessive concavity of the COP curve (Hillstrom, 2013).

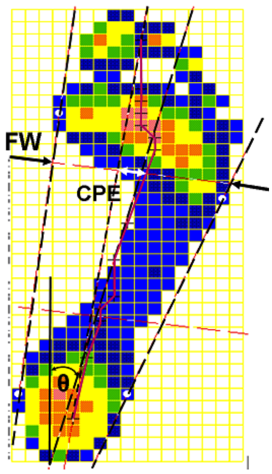
The following steps are required (Figure 1):

1. A foot coordinate system is established by medial and lateral tangents (white dots).
2. Perpendicular to the medial border the footprint is trisected (red dashed line).
3. A construction line is drawn from the most medial COP in the heel region to the most medial COP in the forefoot region.
4. FW is the line length between the medial to lateral borders of the foot coordinate system about the anterior trisection of the footprint (i.e. between forefoot and midfoot).
5. CPE (white) is the distance between the COP and the construction line drawn (#3).
6. CPEI is calculated as shown in equation 1.

Exceptions and Solutions

CPEI is not a valid measurement for in-shoe assessments due to the interaction of shoe and foot structures. CPEI is not valid for equinus or drop foot gait that does not exhibit a heel-toe gait pattern (e.g. example the 'reverse check mark' COP pattern that initiates beneath the mid-foot). When the first COP point is beneath the lateral heel due to initial pronation the construction line should not be initiated until the most medial COP is identified. These initial pronation COP values would confound the CPEI calculation. In 20% of people a Morton's second toe is exhibited (i.e. a longer 2nd toe than the 1st). These last few COP values at the end of stance phase will become laterally deviated which would also confound the CPEI calculation.

Figure 1: CPEI (%) = (CPE/FW) x 100



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P23

DIFFERENT RUNNING SHOE HEEL DESIGNS INFLUENCE FORCE DISTRIBUTION AT THE HEEL UPON IMPACT

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INTRODUCTION

The effect of impact loading at the heel during running for various shoe types has been studied extensively and is a subject of recent debate among the biomechanics community (Willy, 2013). However, the effect of running shoe heel pad design on force distribution at the heel has not yet been investigated. Such information could be used to influence the loading patterns on the heel through the shoe's heel design.

Therefore, the aim of this study was to determine the effect of different shoe heel constructions on force distribution at the heel during running.

METHODS

Forty-three habitual runners (22 males, 21 females, 18-55 years) accomplished 10 running trials (3.33± 0.50 m/s) in 3 different Mizuno branded shoes: (a) standard shoe (i.e., thick heel pad with middle groove), (b) minimalist shoe with a grooved heel pad, (c) minimalist shoe with a curved heel pad. Participants were heel strikers. Pressure data from 26 heel cells were collected at 200 Hz using an instrumented insole (pedar®, novel GmbH, Germany). One step per trial was considered for analysis. The mean force of each heel cell at the instant of peak heel pressure was calculated as the cell's pressure multiplied by its area.

RESULTS

Heel force distribution was different across shoes (Figure 1). Shoes (a) and (b) displayed medial and lateral pressure points, with this pattern being more distinct for shoe (b). Shoe (c) displayed a central pressure point.

DISCUSSION

The dual pressure points found for shoes (a) and (b), but not shoe (c), may be due to the central hollow groove pattern in the heel construction. The more pronounced pattern for shoe (b) may be due to the decreased heel pad thickness, and therefore it's reduced ability for energy absorption at impact.

CONCLUSION

These results demonstrate that a shoe's heel design influences force distribution patterns at the heel. Future studies should focus on determining the benefits of different heel force distributions.

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Willy R.W., Davis I.S., Med Sci Sports Exerc 46(2): 318-23, 2013.

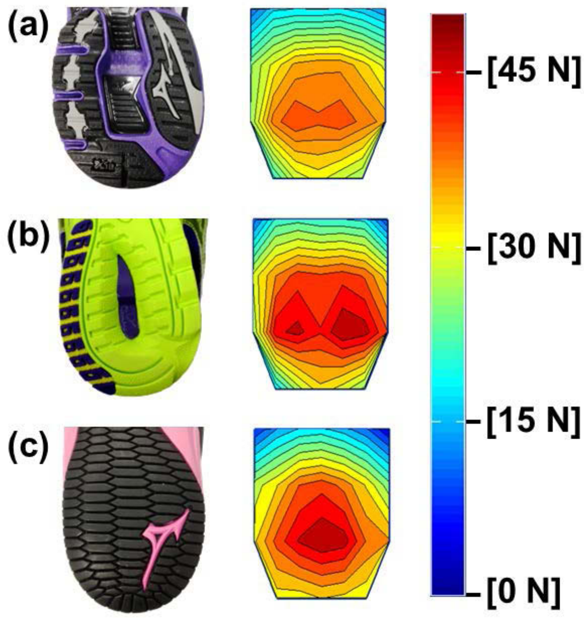

Figure 1: Force distribution across shoes: (a) standard shoe; (b) minimalist shoe with grooved heel pad; (c) minimalist shoe with curved heel pad.

ESM 2014 Program at-a-glance

Time		Wednesday, July 2nd	Thursday, July 3rd	Friday, July 4th	Saturday, 5th	Sunday, 6th	Time	
06:30	07:00		**Breakfast** until 8:30 Nubar Restaurant Sheraton	**Breakfast** until 8:30 Nubar Restaurant Sheraton Commander	**Breakfast** until 8:30 Nubar Restaurant Sheraton	**Breakfast** until 8:30 Nubar Restaurant Sheraton Commander	06:30	07:00
07:30	08:00		**Registration**				07:30	08:00
08:00	08:30		**Welcome**	NETWORKING DAY	**Registration**		08:00	08:30
08:30	09:00		**Keynote Lecture 1**	**Morning Cambridge Tours** (leaving Sheraton Commander Lobby): Cambridge Running Tour 8:15 - 9:30 Harvard Walking Tour 8:30 - 9:30 Longfellow House 8:45 - 10:15	**Keynote Lecture 3**	**Workshop I** 08:30 - 09:15	08:30	09:00
09:00	09:30					Break 09:15 - 09:30	09:00	09:30
09:30	10:00		**Session I: Rehabilitation** art in science award Finalist		**Session VII: Diabetes II** art in science award Finalist	**Workshop II** 09:30 - 10:15	09:30	10:00
10:00	10:30						10:00	10:30
10:30	11:00		**Coffee Break**	**10:45** Bus Departure (Sheraton to Fenway Park)	**Coffee Break**	**Break with snacks & coffee**	10:30	11:00
11:00	11:30		**Session II: Diabetes I**		**Invited Talk** Standards for PDMs	**Workshop III** 11:00 - 11:45	11:00	11:30
11:30	12:00			**Yawkey Way** activities upon arrival	**Session VIII: Pressure Assessment Instrumentation**	Break 11:45 - 12:00	11:30	12:00
12:00	12:30		**Session III: Shoes**		**Lunch** in Mount Vernon Room, Sheraton Commander	**Workshop IV** 12:00 - 12:45	12:00	12:30
12:30	13:00		**Lunch** in Mount Vernon Room, Sheraton Commander				12:30	13:00
13:00	13:30				**Keynote Lecture 4**	**Wrap up / catch up**	13:00	13:30
13:30	14:00		**Keynote Lecture 2**	**Boston Red Sox** **vs.** **Baltimore Orioles**			13:30	14:00
14:00	14:30		**Session IV:** **Normative Biomechanics**		**Invited Talk** Navigating NIH		14:00	14:30
14:30	15:00				**Session IX: Pathology** art in science award Finalist		14:30	15:00
15:00	15:30		**Session V: Poster Teaser 1** & Coffee Break				15:00	15:30
15:30	16:00				**Session X: Poster Teaser 2** & Coffee Break		15:30	16:00
16:00	16:30		**Session VI: Hand** art in science award Finalists				16:00	16:30
16:30	17:00			**16:30** Bus Depart (Fenway Park to Bay State Cruise)	**MPP** Award Presentations		16:30	17:00
17:00	17:30	**Registration** until 20:30 Sheraton Commander Lobby			Closing remarks		17:00	17:30
17:30	18:00			**17:45** Boat Boarding, Bay State C.			17:30	18:00
18:00	18:30			**Whale watching cruise** with dinner, drinks and fireworks			18:00	18:30
18:30	19:00		**Evening Event** Harvard Museum of Natural History Hors d'oeuvres, drinks, light dinner Tour Museum until 21:30		**Concert by Henriette Gärtner,** Pickman Concert Hall at the Longy School of Music		18:30	19:00
19:00	19:30	**Opening Reception** Nubar Restaurant Sheraton Commander					19:00	19:30
19:30	20:00			**22:15** Buses return to Sheraton Commander Hotel	**Banquett & Award Presentations** Sheraton Commander, George Washington Ballroom		19:30	20:00