Foot Orthotics Reduce The Navicular Drop - A Novel Method Allowing For In-Shoe Measurement

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My name is Birgitte Christensen, I am a physiotherapist and currently studying a master in Clinical Science and Technology at Aalborg University, an during my master one project we have been working on is this novel method allowing for in-shoe measurement of Navicular Drop.

The longitudinal medial arch is essential for energy absorption (Willems et al 2006).

A lowering of the arch is associated with pronation.

The amount of pronation can be quantified by measuring the Navicular Drop (ND) (Brody 1982; Magee 2008)

· Requires the subject to be in bare feet
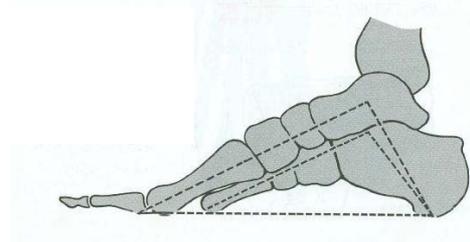
The feet's ability to absorb energy are essential for the strain on the body during walking and running and on element essential for this energy absorption is the longitudinal medial arch. The mobility of the arch determinates the amount of pronation and a lowering of the arch is associated with pronation (2).

The amount of pronation can be quantified by measuring the Navicular Drop (ND) (12,13). In the literature the ND is often used to quantify the amount of pronation. But the navicular drop test requires the subjects to be in bare feet

Malalignments can affect the energy absorption, and especially an increased amount of pronation is associated with load-related injuries (Willems TM, De Clercq D, Delbaere K, Vanderstraeten G, De Cock A, Witvrouw E. A prospective study of gait related risk factors for exercise-related lower leg pain. 2006(23):91.)

An increased amount of pronation increases the risk of overuse injuries in shin and knee (Willems et al 2006; Boling et al. 2009)

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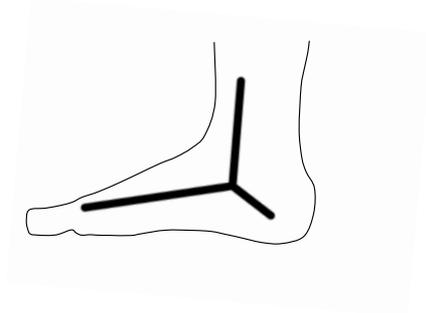
Even though pronation is essential for energy absorption, an increased amount of pronation increases the risk of developing over-use injuries in shin and knee

In this animation you can se how the medial longitudinel arch is lowered during walking.

It has been hypothesized that foot orthotics can limit the amount of pronation (Baxter et al 2011)

Orthotics has been found to prevent overuse injuries, however the mechanisms of effect are unknown (Franklyn-Miller 2010)

To date it has not been possible to measure ND when subjects are wearing shoes

Therefore in this study a novel method, a strain-sensor, to measure in-shoe ND was used, and the aim was to investigate
  1) The validity and reliability of the strain-sensor and
  2) If foot orthotics reduced the ND during walking measured with the strain-sensor.

It has been hypothesized that foot orthotics can limit the amount of pronation and thereby reduce the risk of developing overuse injuries.

Franklyn-Miller et al. demonstrated a positive effect of using orthotics to prevent overuse injuries with an absolute risk reduction of 0.49 when subjects were using orthotics (foot orthoses in the prevention of injury in initial military training).

Therefore orthotics is commonly used in the treatment of some overuse injuries, however the mechanisms of the effect of using orthotics are unknown (ibid). A possible explanation of the effect of orthotics is a reduced ND (and thereby pronation) provided by the orthotics, however to date it has not been possible to measure the navicular drop (ND) when subjects are wearing shoes.

Therefore in this study a novel method, a strain-sensor to measure in-shoe navicualr drop was used, and the aim of this study was to investigate:

The strain sensor:
• Thin, flexible and robust capacitative sensor
• Measures electrical capacitance
• Recordings in custom-made software program Datalogger
(Kappel 2012)

Placed between two points
• 20 mm posterior to malleolis medialis
• 20 mm posterior and 20 mm distal to tuberositas naviculare

The strain sensor is thin, flexible and robust capacitive sensor allowing for in-shoe measurements

The sensor is strainable in one direction and measures the electrical capacitance

The sensor is placed between two point.

and is secured with tape in the distal end and around the ankle with a velcro band. With this attachment, the sensor will be stretch when the longitudinel medial arch is lowered.
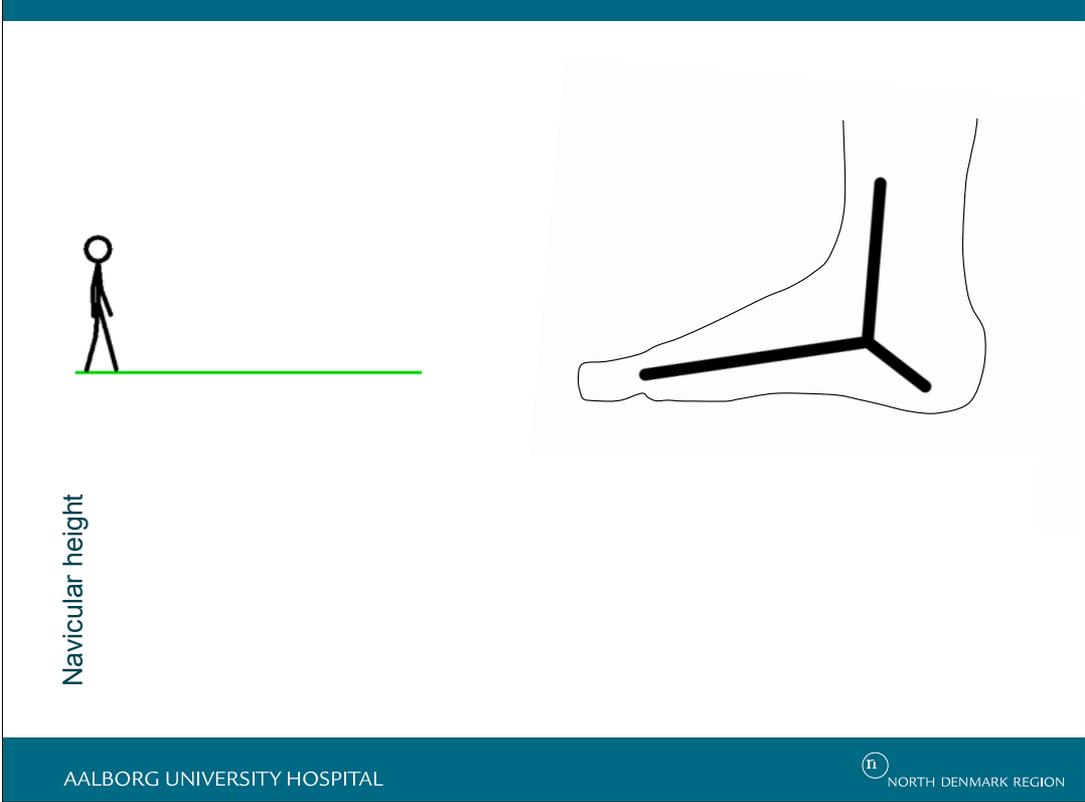
Here we have the previous animation with the movement of the medial longitudinel arch, and in this frame you can see how the strainsensor measures the ND during standing or walking

Validity was measured in two ways

1. Technical validation comparing the degree of stretch from a calibration slade with the stretch measured from the strain sensor (electrical capacitance).
   - Results calculated with a linear fitting and coefficient of determination
   - R^2 = 0,999 (Kappel 2012)

2. Comparing ND measured with the [   ]D measured ad modum Brody (static)
   - n = 24
   - Difference between the height of tuberositas [   ] neutral position and when subjects were sta[   ]ed position (Brody 1982)
   - The difference measured with the strain sens[   ]
   - Linear Regression Model performed in SPS[   ]
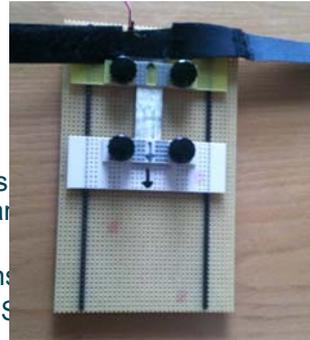
And the statistical analysis was a linear regression model

Reliability

- n = 27
- Subjects walked two times on a treadmill with one day between
- Intra- and interraterreliability was investigated
- Subjects walked 6 minutes on the treadmill followed by 1.5 minutes of recording (Matsas et al 2000)
- Results based on 10 consecutive steps identified after 30 seconds of recording in a costum-made program (DataAnalyzer)
- Intraclass Correlation Coefficient in SPSS 20.0

Subjects walked six minutes on the treadmill followed by 1,5 minutes of recording: The six minutes walking before the recording was made, was based on the result from Matsas et al, suggesting that no difference in kinematics is seen between treadmill and overground walking after a period of walking in six minutes.

The results was calculated based on 10 consecutive steps which was identified after 30 seconds of recording

And the statistical analysis was intraclass correlation coefficient

Foot orthotics (Formthotics)

· Full length, dual-density prefabricated Formthotic™

· n = 24

· Subjects walked 6 minutes on a treadmill with and without foot orthotics in a randomized order followed by 1.5 minutes of recording

· Results based on 10 consecutive steps identified after 30 seconds of recording in a custom-made software program (DataAnalyzer)

· Paired t-test in SPSS 20.0

The results was like in the reliability studie calculated based on 10 consecutive steps, which was identified after the first 30 sekunds of recording

A student paired t-test was performed to see whether or not the orthotics reduced the navicular drop.

Validity

• Linear correlation between ND measured with the strain sensor and ND ad modum Brody (p<0,001)

• R=0,745 (p<0,001)
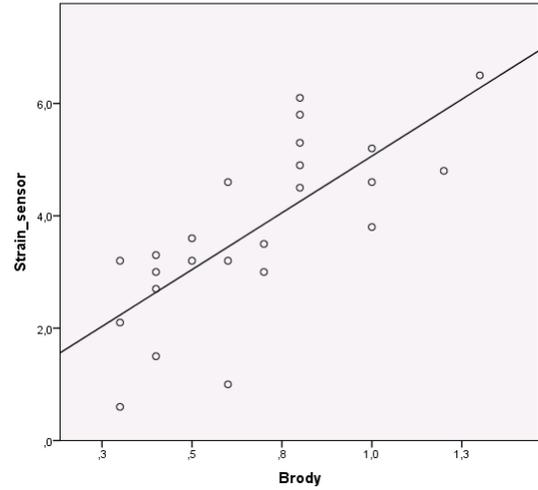
Reliability

	ICC
Intrarater, rater 1	0,77
Intrarater, rater 2	0,78
Interrater, day 1	0,84
Interrater, day 2	0,76
Interrater	0,80

Foot orthotics

• A reduction in ND when wearing orthotics (p=0.015)

• On average, orthotics reduced the ND by 0.4mm (95%CI: 0.1-0.7 mm, p=0,02) corresponding to 19.0% of the average ND without orthotics

The ICC values indikates that the strain sensor is reliabel both for intrarater and interrater

The strain sensor is

- Valid compared with ND measured ad modum Brody
- Reliable
- Capable of measuring a reduction in ND when subjects were wearing shoes

The potential of the strain sensor

- Measure movements of the midfoot when subjects are wearing shoes
- Simple and not time consuming which makes it applicable in clinical settings

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Capable of measuring of a reduction in ND when subjects were wearing shoes: This may explain why some studies find that orthotics decrease the risk of over-use injuries.

How can we validate the strain sensor when subjects are wearing shoes in dynamic measurements? We do not have methods to measure ND in shoe, so what method can we compare the strain sensor to, and how much do we know about the alterations in ND when subjects are walking bare footed compared with shoes? And is it necessary – we see that the strain sensor can measure a reduction in the ND when subjects are walking with orthotics, is that enough?

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One example is medial tibial stress syndrome (Bencke et al 2011, Bennett et al 2001, Couture 2002, Bandholm 2008, Williams 2004)