Foot orthoses for knee pain
- Patellofemoral pain syndrome
- Medial knee osteoarthritis

Craig Payne
Department of Podiatry &
Musculoskeletal Research Centre
Patellofemoral Pain Syndrome (PFPS) (anterior knee pain)

• Commest problem of the knee
• Annual incidence in runners is 37-56%
• Aetiology not fully understood
• No consensus as to management; appears to be profession specific; distal vs proximal
Use of Orthotics in PFPS

Based on the model:

Proximal vs distal stability
Use of Orthotics in PFPS

Based on the model:

Proximal vs distal stability
How Successful are foot orthotics based on the model

Research Report

Evaluation of Soft Foot Orthotics in the Treatment of Patellofemoral Pain Syndrome

Background and Purpose. The effectiveness of soft foot orthotics in the treatment of patients who have patellofemoral pain syndrome was investigated. Subjects. Subjects were 20 adolescent female patients, aged 13 to 17 years ($\overline{X} = 14.8$, $SD = 1.2$), who were diagnosed with patellofemoral pain syndrome and who ex-
How Successful are foot orthotics based on the model

Evaluation of Soft Foot Orthotics in the Treatment of Patellofemoral Pain Syndrome

![Graphs showing reported pain for walking and running over weeks with control and treatment groups.](image)
Foot orthoses and physiotherapy in the treatment of patellofemoral pain syndrome: A randomised clinical trial

Bill Vicenzino*, Natalie Collins*, Kay Crossley*, Elaine Beller, Ross Darnell* and Thomas McPoil*

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2 School of Physiotherapy, The University of Melbourne, Melbourne, Australia
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* Contributed equally


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Foot orthoses and physiotherapy in the treatment of patellofemoral pain syndrome: randomised clinical trial

Natalie Collins, PhD candidate,1 Kay Crossley, principal research fellow,2 Elaine Beller, director, biostatistics,3 Ross Darnell, statistician,1 Thomas McPoil, regents professor,4 Bill Vicenzino, head of division, physiotherapy1

Results Foot orthoses produced improvement beyond that of flat inserts in the short term, notably at six weeks (relative risk reduction 0.66, 99% confidence interval 0.05 to 1.17; NNT 4 (99% confidence interval 2 to 51). No significant differences were found between foot orthoses and physiotherapy, or between physiotherapy and physiotherapy plus orthoses. All groups showed clinically meaningful improvements in primary outcomes over 52 weeks.
**WHAT IS ALREADY KNOWN ON THIS TOPIC**

Patellofemoral pain syndrome is highly prevalent in sports medicine and presents often to general practices

Foot orthoses are often prescribed despite a lack of evidence highlighted by systematic reviews

**WHAT THIS STUDY ADDS**

Foot orthoses produce earlier and larger improvements in patellofemoral pain syndrome than flat inserts

Adding foot orthoses to physiotherapy does not improve physiotherapy outcomes
Effect of inverted foot orthoses on EMG of vastus muscle timing

- Inverted foot orthoses
- Earlier onset of VMO considered good in PFPS
Effect of inverted foot orthoses on EMG of vastus muscle timing

- Inverted foot orthoses
- Earlier onset of VMO considered good in PFPS
Nigg et al, 2003

Medial foot wedge

Increases and decreases with same wedge
How well supported is the model?

Levinger & Gilleard (2004)

Table 1. Subjects profile and static rearfoot measurements. Data are presented in means (±SD).

<table>
<thead>
<tr>
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<th>Control</th>
<th>PFPS</th>
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<th>P value</th>
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<tbody>
<tr>
<td>Age (years)</td>
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<td>38.4 (10.1)</td>
<td>13.54</td>
<td>.001</td>
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<tr>
<td>Body mass (kg)</td>
<td>61.3 (7.5)</td>
<td>70.6 (18.2)</td>
<td>3.046</td>
<td>.109</td>
</tr>
<tr>
<td>Height (m)</td>
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<tr>
<td>Subtalar joint neutral position (°)</td>
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<td>4.716</td>
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<tr>
<td>2D RCS (°)</td>
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Negative values indicated inversion and positive values indicated eversion.

Cross-sectional
How well supported is the model?

Levinger & Gillear (2004)

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Negative values indicated inversion and positive values indicated eversion.
Abnormal foot pronation and subsequent rotation of the lower extremity has been hypothesized as being contributory to patellofemoral pain (PFP). The purpose of this study was to test the hypothesis that subjects with PFP would exhibit larger degrees of foot pronation, tibia internal rotation, and femoral internal rotation compared to individuals without PFP. Twenty-four female subjects with a diagnosis of PFP and 17 female subjects without PFP participated. Three-dimensional kinematics of the foot, tibia, and femur segments were recorded during self-selected free-walking trials using a six-camera motion analysis system (VICON). No group differences were found with respect to the magnitude and timing of peak foot pronation and tibia rotation. However, the PFP group demonstrated significantly less femur internal rotation compared the comparison group. **These results do not support the hypothesis that individuals with PFP demonstrate excessive foot pronation or tibial internal rotation compared to nonpainful individuals.**
“Arch height did not differ between groups”

Proximal and Distal Influences on Hip and Knee Kinematics in Runners With Patellofemoral Pain During a Prolonged Run

Tracy A. Dierks, Kurt T. Manal, Joseph Hamill, Irene S. Davis

DOI: 10.2519/jospt.2008.2490

STUDY DESIGN: Cross-sectional experimental laboratory study.

OBJECTIVES: To investigate the relationships between hip strength and hip kinematics, and between arch structure and knee kinematics during prolonged treadmill running in runners with and without patellofemoral pain syndrome (PFPS).

BACKGROUND: Hip weakness can lead to excessive femoral motions that adversely affect patellofemoral joint mechanics. Similarly, foot mechanics, which are influenced by foot structure, are also known to influence patellofemoral joint mechanics. Thus, proximal and distal factors should be considered when studying individuals with PFPS.

METHODS AND MEASURES: Twenty recreational runners with PFPS (5 male, 15 female) and 20 matched uninjured runners participated in the study. Hip abduction and hip external rotation isometric strength measurements were collected before and after a prolonged run, while the arch height index was recorded on all runners before the run. Lower extremity kinematic data were collected at the beginning and end of the run. Two-way repeated-measures analyses of variance (ANOVAs) were used for analysis.

RESULTS: Both groups displayed decreases in hip abductor and external rotator strengths at the end of the run. The PFPS group displayed significantly lower hip abduction strength [(kg x cm)/body mass] compared to controls (PFPS group: begin 15.3, end 13.5; uninjured group: begin 17.3, end 15.4). At the end of the run, the level of association between hip abduction strength and the peak hip adduction angle for the PFPS group was statistically significant, indicating a strong relationship ($r = -0.74$). No other associations with hip strength were observed in either group. Arch height did not differ between groups and no significant association was observed between arch height and peak knee adduction angle during running.

CONCLUSION: Runners with PFPS displayed weaker hip abductor muscles that were associated with an increase in hip adduction during running. This relationship became more pronounced at the end of the run.

LEVEL OF EVIDENCE: Therapy, level 5.
Cross-sectional vs prospective

• 2/3 cross-sectional studies do not support the model
• Can not determine causation from cross-sectional study designs
• Was the pronated foot a cause of PFPS or did PFPS cause the pronated foot?
Prospective

Youri Thijs, Dirk De Clercq, Philip Roosen and Erik Witvrouw (2008)

<table>
<thead>
<tr>
<th>FPI</th>
<th>PFP group (n)</th>
<th>PFP group (%)</th>
<th>Asymptomatic group (n)</th>
<th>Asymptomatic group (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>9</td>
<td>52.9</td>
<td>50</td>
<td>58.3</td>
</tr>
<tr>
<td>Pronated</td>
<td>6</td>
<td>35.3</td>
<td>22</td>
<td>26.2</td>
</tr>
<tr>
<td>Highly pronated</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3.6</td>
</tr>
<tr>
<td>Supinated</td>
<td>2</td>
<td>11.8</td>
<td>7</td>
<td>8.3</td>
</tr>
<tr>
<td>Highly supinated</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3.6</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>100</td>
<td>85</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4: Distribution (exact amount and in %) of the subjects of the patellofemoral pain (PFP) group and the asymptomatic group in the five categories (normal, pronated, highly pronated, supinated or highly supinated) of the foot posture index (FPI), (n = exact amount).
Prospective

A prospective biomechanical study of the association between foot pronation and the incidence of anterior knee pain among military recruits.


Excessive foot pronation has been considered to be related to anterior knee pain. We undertook a prospective study to test the hypothesis that exertional anterior knee pain is related to the static and dynamic parameters of foot pronation. Two weeks before beginning basic training lasting for 14 weeks, 473 infantry recruits were enrolled into the study and underwent two-dimensional measurement of their subtalar joint displacement angle during walking on a treadmill. Of the 405 soldiers who finished the training 61 (15%) developed exertional anterior knee pain. No consistent association was found between the incidence of anterior knee pain and any of the parameters of foot pronation. While a statistically significant association was found between anterior knee pain and pronation velocity (left foot, p = 0.05; right foot, p = 0.007), the relationship was contradictory for the right and left foot. Our study does not support the hypothesis that anterior knee pain is related to excessive foot pronation.
Prospective Study on Gait-related Intrinsic Risk Factors for Patellofemoral Pain

Youri et al (2007)

“Our findings suggest that the feet of the persons who developed anterior knee pain have a heel strike in a less pronated position and roll over more on the lateral side compared to the control group”
The relationship between the height of the medial longitudinal arch (MLA) and the ankle and knee injuries in professional runners

Z. Nakhae, A. Rahimi, M. Abae, A. Rezasoltani and K. Khademi Kalantari

Conclusion

The results of this study conveyed that having a lower or higher than a normal MLA is not a definite risk factor for sports-related injuries. This might be due to the complexity of the foot structure and its ability to accommodate with new situations routinely occurs in sport. Furthermore, although a high correlation was not found between the clinical navicular drop test and the foot pressure indices, due to the clinical entity of this test, the obtained association is relatively good. A significant correlation was found between the foot pressure distribution in single limb support (static) and the dynamic conditions, which provides an extrapolation of the results of this type static condition tests to the dynamic conditions.
What controls tibial rotation

- Foot or proximal?

Contributions of proximal and distal moments to axial tibial rotation during walking and running

T.L. Bellchamber\textsuperscript{a}, A.J. van den Bogert\textsuperscript{b,*}

\textsuperscript{a}Human Performance Laboratory, The University of Calgary, Calgary, USA
\textsuperscript{b}Department of Biomedical Engineering, (ND-20) The Cleveland Clinic Foundation, 9500 Euclid Avenue, Cleveland, OH 44195, USA

reaction force and kinematic data, and the power flow from foot to tibia associated with axial tibial rotation was calculated. In walking, all subjects exhibited a clear power flow from tibia to foot during most of the stance phase, indicating that the foot was following the body. This suggests that the use of foot orthoses to reduce knee pain associated with tibial rotation during walking will not be successful. During running, power flow was also mainly proximal to distal, but there were brief periods of opposite power flow.
• We have a theoretically coherent model for the use of foot orthoses in PFPS

• The prospective studies show that the model is NOT supported

• The foot does not control tibial rotation. Tibial rotation controls the foot!

• The randomised controlled studies show that the use of foot orthoses based on this model work

• Where does this leave “the model”?
Knee ABDuction Moments

Abduction Moment

Knee ABDuction Impulse

Knee Abduction Moment [Nm]

Stance Time
Knee ABDuction Moments

Effect of Inverted Orthoses on Lower-Extremity Mechanics in Runners

DORSEY S. WILLIAMS III¹, IRENE MCCLAY DAVIS²,³, and stephen p. baitch⁴

¹Department of Physical Therapy, East Carolina University, Greenville, NC; ²Joyner Sportsmedicine Institute, Mechanicsburg, PA; ³Motion Analysis Laboratory, University of Delaware, Newark, DE; and ⁴Union Memorial Hospital, Baltimore, MD
Maclean, Davis & Hamill (2006)

- Rearfoot motion (p=0.02) change of maximum rearfoot eversion of 1 degree (5.20º vs. 6.28º) (ES=0.32) (reduced in 10/15)

- Reduction in the ankle inversion moment (10-70%) (p<0.0001) (reduced in 14/15)
There were no significant differences between conditions for any of the knee kinematic variables \( (p < 0.05) \).

At the knee, CFO intervention resulted in significant increases in maximum internal knee extension \( (ES = 0.24, p = 0.04) \) and flexion moments \( (ES = 0.45, p = 0.03) \).
Proximal or Distal Control

• Maybe:
  – Reduce rearfoot inversion moment with a foot orthotic, then the proximal external rotation moment can be more effective
Take home message

- There is a paradox that leads to a cynicism of the approach to PFPS with foot orthoses
- Apply orthotic design parameters that change moments (~tissue stress model)
The Influence of Arch Supports on Knee Torques Relevant to Knee Osteoarthritis.

APPLIED SCIENCES

Medicine & Science in Sports & Exercise. POST AUTHOR CORRECTIONS, 9 April 2008
FRANZ, JASON R.; DICHARRY, JAY; RILEY, PATRICK O.; JACKSON, KEITH; WILDER, ROBERT P.; KERRIGAN, D. CASEY

Abstract:
Purpose: Changes in footwear and foot orthotic devices have been shown to significantly alter knee joint torques thought to be relevant to the progression if not the development of knee osteoarthritis (OA) in the medial tibiofemoral compartment. The purpose of this study was to determine if commonly prescribed arch support cushions promote a medial force bias during gait similar to medial-wedged orthotics, thereby increasing knee varus torque during both walking and running.

Methods: Twenty-two healthy, physically active young adults (age, 29.2 +/- 5.1 yr) were analyzed at their self-selected walking and running speeds in control shoes with and without arch support cushions. Three-dimensional motion capture data were collected in synchrony with ground reaction force (GRF) data collected from an instrumented treadmill. Peak external knee varus torque during walking and running were calculated.
“The addition of material under the medial aspect of the foot by way of a flexible arch support promotes a medial force bias during walking and running, significantly increasing knee varus torque”