# The Biomechanics of Sports Injuries and Prevention Strategies

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# Focus

- **Biomechanics of Anterior Cruciate Ligament Injuries and their Conservative Management**

- **Patellofemoral Pain in the athletic population**

# Biomechanics of ACL Injuries and their Conservative Management

# Background

- 250,000 ACL injuries per year in the USA
  - $1.5 billion annual cost

- 80 - 90% return to previous level of play
  - Typical recovery 6-9 months

- > 70% ACL injuries are NON-contact

Boden BP et al. Etiology and prevention of noncontact ACL injury. Phys Sports Med. 2000: 29(4)

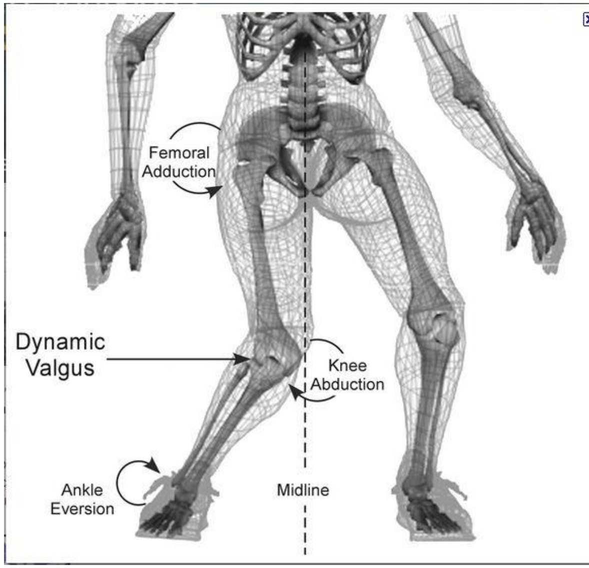
# Who is at risk?

# Females are more at risk than Males

- **Landing Tasks:** The literature is consistent in reporting that females display greater knee valgus angles (Malinzak et al., 2001; Kernozek et al., 2005;) and higher relative vertical ground reaction forces (Hewett et al., 2005; Kernozek et al., 2005).

- **Cutting Tasks:** Females typically perform cutting tasks with less knee flexion (Malinzak et al., 2001; James et al., 2004) and greater knee valgus (McClean et al., 2004; Sigward & Powers, 2007).

- All these increase the risk of ACL injury




Clinical Sports Medicine Update

# Anterior Cruciate Ligament Injuries in Female Athletes

## Part 2, A Meta-analysis of Neuromuscular Interventions Aimed at Injury Prevention

Timothy E. Hewett,[*†‡] PhD, Kevin R. Ford,[†] MS, and Gregory D. Myer,[†] MS, CSCS

- Female athletes have a 4 to 6 times higher incidence of anterior cruciate ligament injury than do male athletes participating in the same landing and pivoting sports.
- The gender gap in anterior cruciate ligament injury, combined with evidence that the underpinnings it indicates this a serious health problem.
- Injuries are neuromuscular in nature, which leads to the development of neuromuscular interventions designed to prevent injury.

# Can surgery bring back normal function?

British Journal of
Sports Medicine
Home | Full Text | PDF | Current Issue | Archive | Online First

*Br J Sports Med* **2015**;49:**188-195** *doi:10.1136/bjsports-2013-092982*

Original article

**Anterior cruciate ligament injury alters preinjury lower extremity biomechanics in the injured and uninjured leg: the JUMP-ACL study**

**Authors**

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- ACL injured and ACL reconstructive surgery show altered lower limb biomechanics in both the injured and non-injured limb compared to the pre-injured state.

- After ACL reconstruction increases in frontal plane movement (increased hip adduction and knee valgus) remain.

- These movement pattern alterations have previously shown to increase the risk for future non-contact ACL injury.

Goerger et al. (2015)

# So what can we do about this?

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Original Research

# Effects of prophylactic knee bracing on knee joint kinetics and kinematics during netball specific movements

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ABSTRACT

*Objective*

To investigate the effects of a prophylactic knee brace on knee joint kinetics and kinematics in netball specific movements.

*Design*

Repeated measures; Setting: Laboratory; Participants: Twenty university first team level female netball players.

*Outcome measurements*

Participants performed three movements, run, cut and vertical jump under two conditions (brace and no-brace). 3-D knee joint kinetics and kinematics were measured using an eight-camera motion analysis system. Knee joint kinetics and kinematics were examined using 2 × 3 repeated measures ANOVA whilst the subjective ratings of comfort and stability were investigated using chi-squared tests.

*Results*

The results showed no differences ($p > 0.05$) in knee joint kinetics. However the internal/external rotation range of motion was significantly ($p < 0.05$) reduced when wearing the brace in all movements. The subjective ratings of stability revealed that netballers felt that the knee brace improved knee stability in all movements.

*Conclusions*

Further study is required to determine whether reductions in transverse plane knee range of motion serve to attenuate the risk from injury in netballers.





# Nature of Netball

Netball is a physically demanding sport involving rapid acceleration, quick changes in direction, sudden breaking, pivots, jumps and balance, placing great demand on the body (Williams & O'Donoghue, 2005).

- Up to 70% of knee injuries occur as a result of non-contact movements (Boden et al., 2000).
- Occur during the landing or stance phase of a high impact task, that incorporates sudden deceleration and/or rapid changes in direction (Griffin et al., 2005).

# Aim

To investigate the effect of a 3D knitted knee sleeve during different functional sporting tasks:

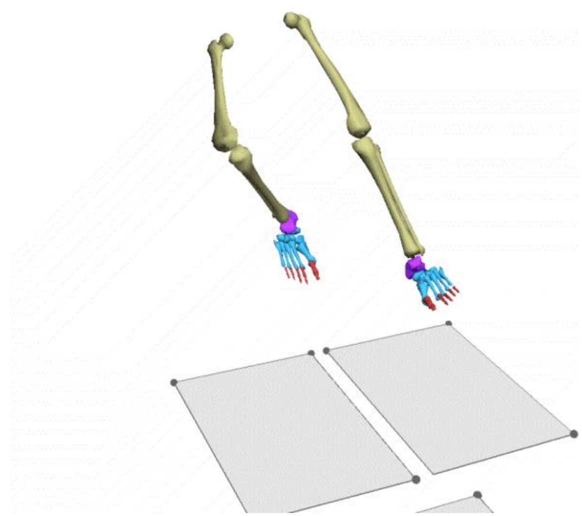
- To determine any changes in knee mechanics relevant to knee instability.

- To determine if perceived stability is improved.

# **Method:** Data collection

Data were collected using an 8 camera Qualisys system. Reflective markers were be placed on the foot, shank, thigh and pelvis.

The joint kinematics and kinetics were calculated using the Calibrated Anatomical System Technique (CAST) in Visual 3D.

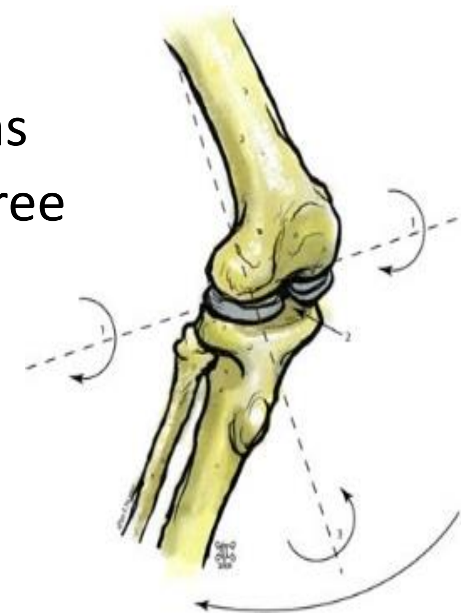


# **Method:** Data Analysis

Knee angles in all three planes were recorded at footstrike, peak angle and range of motion.

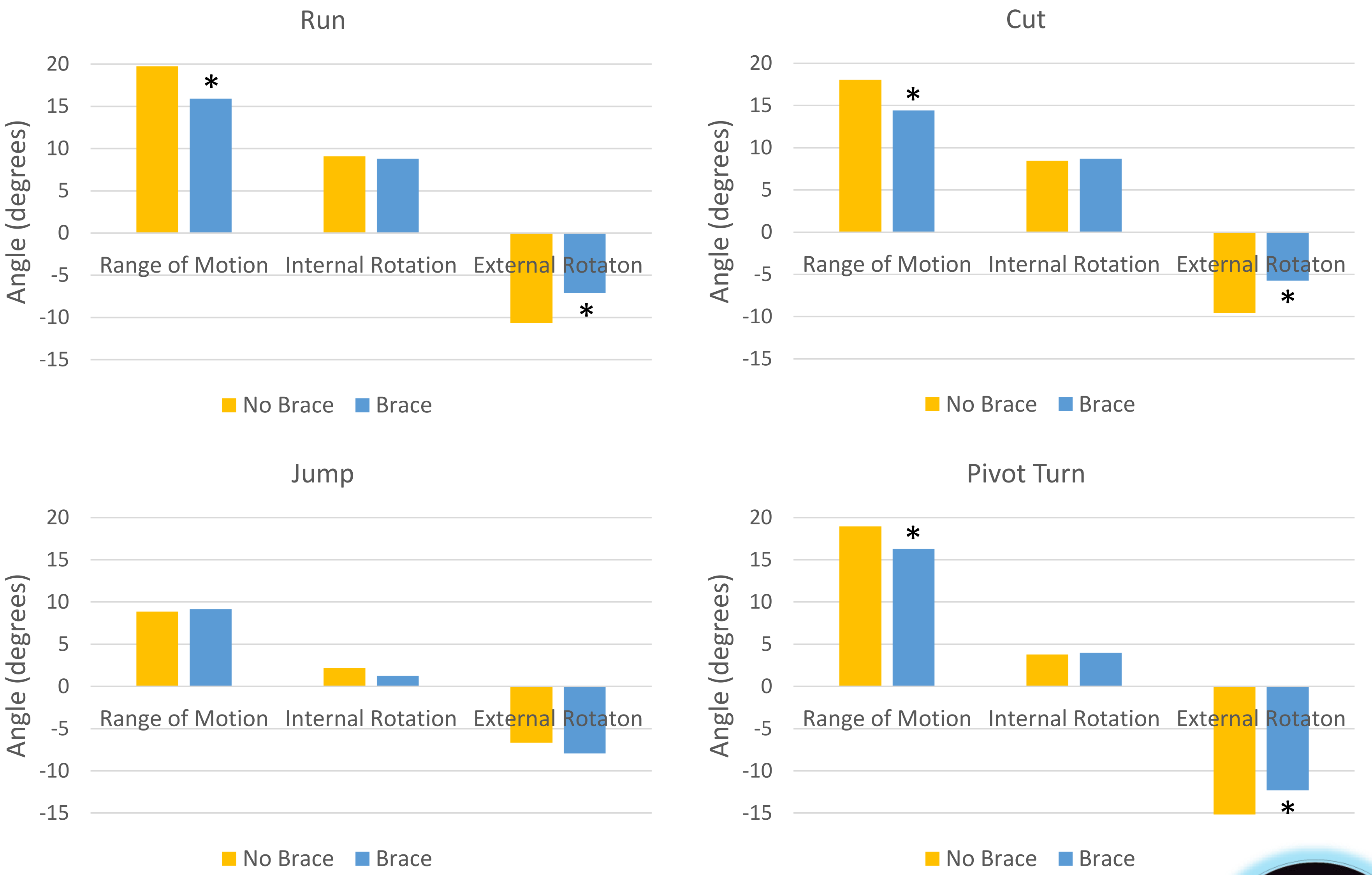
A Repeated measures analysis of variance (ANOVA) was conducted for knee joint angles and moments in all three planes.

- 4 tasks: Run, Jump, Cutting and Pivot turn
- 2 conditions: No brace and Trizone sleeve



In addition a Chi-squared test was conducted on self-reported knee stability during the run, jump and pivot movements when wearing the sleeve.

# Results




* Significant differences between Brace and No Brace p<0.05

- The cutting manoeuvre displayed significantly higher moments in sagittal and coronal planes during loading, whereas the pivot turn show significantly higher moments in the transverse plane.

- In addition a Chi-squared test results showed a significant improvement in self-reported knee stability during the run, jump and pivot movements when wearing the brace.

# Can taping and bracing help the Return to Sport post ACL Reconstruction?

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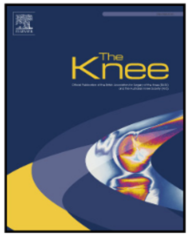


# External supports improve knee performance in anterior cruciate ligament reconstructed individuals with higher kinesiophobia levels

Gulcan Harput [a,*], Burak Ulusoy [a], Hamza Ozer [b], Gul Baltaci [c], Jim Richards [d]

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[b] *Gazi University, Faculty of Medicine, Department of Orthopaedic and Traumatology, Ankara, Turkey*
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# Use of knee bracing and taping help patients return to sport?

- Physical, psychological and demographical factors are shown to influence the rate of return to sport after ACL surgery
- Previous studies have focused on the biomechanical effects of knee bracing after ACLR
- However, knee bracing and taping may also improve functional performance during tasks such as single limb balance and self-reported knee function in ACLR individuals
- Although the use of knee bracing and taping after ACLR is still an area of discussion

# Aim

The aim of this study was to investigate the effects of a prophylactic knee bracing and kinesio taping on functional performance in individuals six months after ACL reconstruction who desired to return but could not due to higher levels of kinesiophobia.

# Methods

- Thirty ACLR patients who had significant levels of kinesiophobia levels patients were included.

- ACL surgery was performed by a single orthopaedic surgeon using a quadrupled semitendinosus–gracilis (single-bundle) autograft followed by an ACLR rehabilitation program.

# Methods

- Individuals were tested under three conditions in a randomized order with one week intervals between test conditions.
  - no intervention
  - knee brace
  - kinesio-taping

# Methods

- The Knee Brace and Kinesio Tape were worn for 30 min before beginning the tests.

- The data were collected for
  - concentric knee strength
  - hop distance
  - Star Excursion Balance Test (SEBT)
  - Global Rating Scale (GRS) for evaluating self-reported knee function

# Results

- The dynamic balance test (SEBT) showed significant differences between no intervention with Kinesio Tape and Knee Brace both increasing the reach distance.
- The hop test also showed significant increases in distance with Kinesio Tape and Knee Brace compared with no intervention.
- The quadriceps and hamstring strength tests showed that the Knee Brace increased quadriceps strength at both 180°/s and 60°/s compared with no intervention and Tape.

# Results

- The GRS score showed that individuals reported better knee function with knee bracing and kinesio tape when compared with no intervention
- The GRS score also showed better knee function with knee bracing over kinesio tape

# Conclusion

- Both knee bracing and kinesio tape can have positive effects in individuals post-ACLR
- These can assist in reducing kinesiophobia when returning to their pre-injury activity levels
- Knee bracing appearing to offer the participants better knee function compared to kinesio tape
- Future studies are needed to investigate the longer-term effects of such interventions to overcome kinesiophobia in ACLR individuals and to determine the longevity of these effects

# Patellofemoral Pain
# in the athletic population

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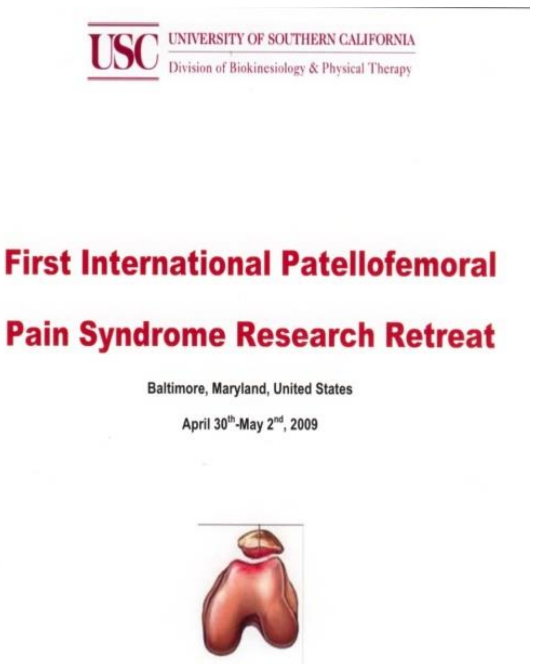
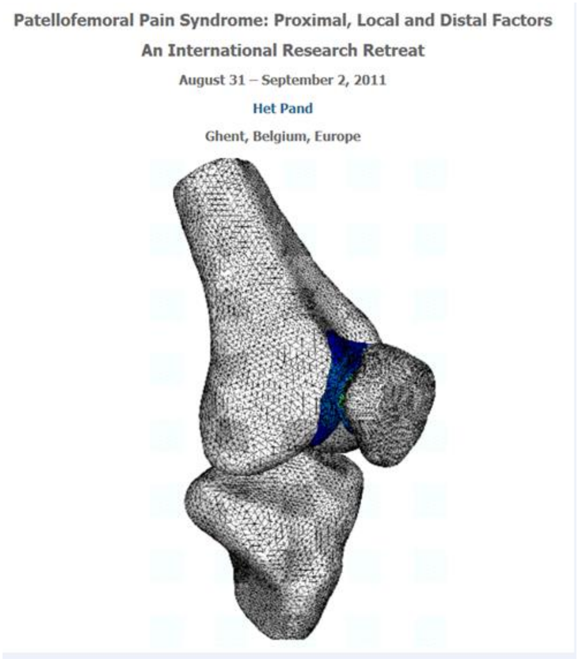
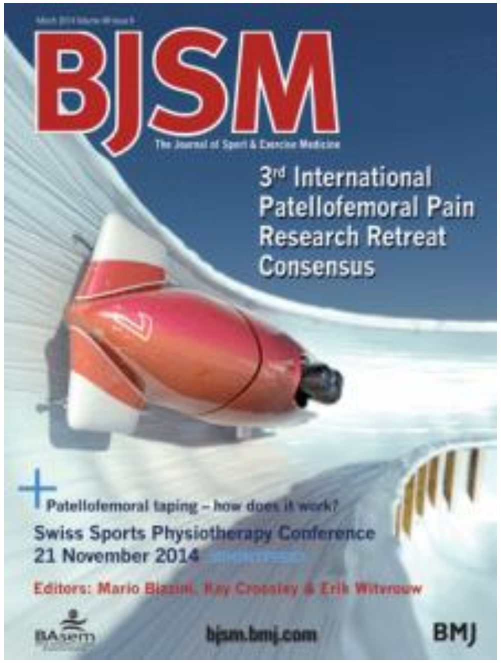
# International Patellofemoral Research Retreats

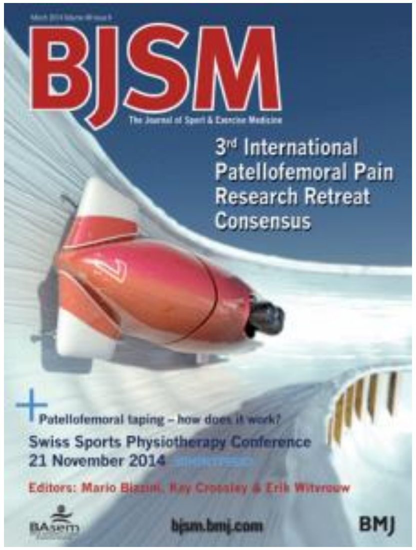


# What happens in the long term? (>1 year)

40% of people with PFP did not feel that exercise interventions moderately improved symptoms or led to full recovery from PFP




British Journal of Sports Medicine
An international peer-reviewed journal of sport and exercise medicine
Br J Sports Med 2016;**50**:844-852 doi:10.1136/bjsports-2016-096268

**Consensus statement**

**2016 Patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester. Part 2: recommended physical interventions (exercise, taping, bracing, foot orthoses and combined interventions)**

# Future advances required to understand PFP and its treatment


*"Identification of subgroups remains the 'holy grail' for PFP research"*

Open Access | Protocol

BMJ open

**Targeted interventions for patellofemoral pain syndrome (TIPPS): classification of clinical subgroups**


James Selfe,[1] Michael Callaghan,[2] Erik Witvrouw,[3,4] James Richards,[1] Maria Paola Dey,[5] Chris Sutton,[6] John Dixon,[7] Denis Martin,[7] Maria Stokes,[8] Jessie Janssen,[1] Elizabeth Ritchie,[9] David Turner[10]

British Journal of
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An international peer-reviewed journal of sport and exercise medicine



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Original article

**Targeted Intervention for Patellofemoral Pain studies**

# Are there three main subgroups within the patellofemoral pain population? A detailed characterisation study of 127 patients to help develop targeted intervention (TIPPs)

OPEN ACCESS

James Selfe[1], Jessie Janssen[1], Michael Callaghan[2], Erik Witvrouw[3], Chris Sutton[1], Jim Richards[1], Maria Stokes[4], Denis Martin[5], John Dixon[5], Russell Hogarth[1], Vasilios Baltzopoulos[6], Elizabeth Ritchie[7], Nigel Arden[8], Paola Dey[1]

# TIPPs Clinical Tests

| Proposed Clinical Group | Test |
|---|---|
| Hip Abductor weakness | Hand Held Dynamometry |
| Quadriceps weakness | Hand Held Dynamometry |
| Patellar Hypomobility | Patellar Glide Test |
| Patellar Hypermobility | Patellar Glide Test |
| Pronated Foot Posture | Foot Posture Index |
| Lower Limb Biarticular muscle tightness | Rectus femoris length test<br>Hamstrings length test<br>Gastrocnemius length test |

Screened 'anterior knee pain'
**N=1254**

**Excluded**
- Out of age bracket: 737
- Had surgery: 56
- Treatment started: 23
- Less than 3 months pain: 137

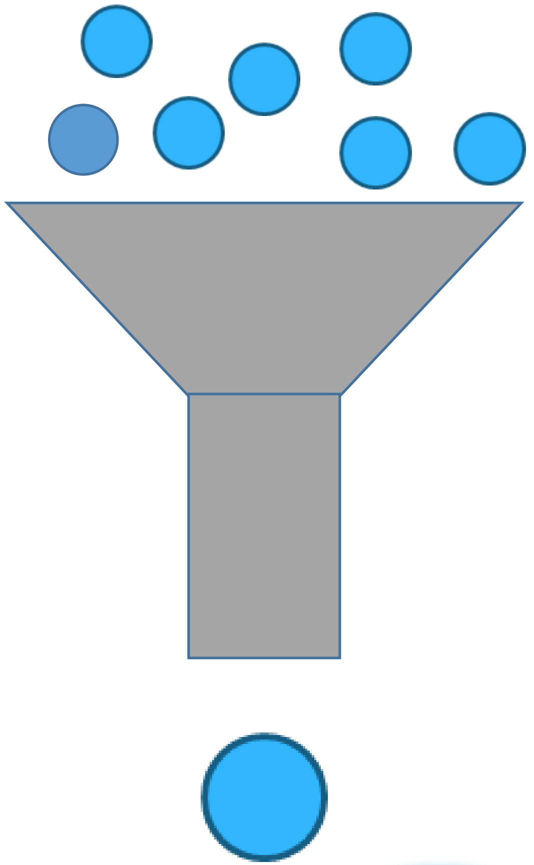
Potentially eligible
**N=301**

**Excluded**
- Could not contact: 112
- Did not attend: 17
- Were not eligible: 42

Recruited
**N=130**

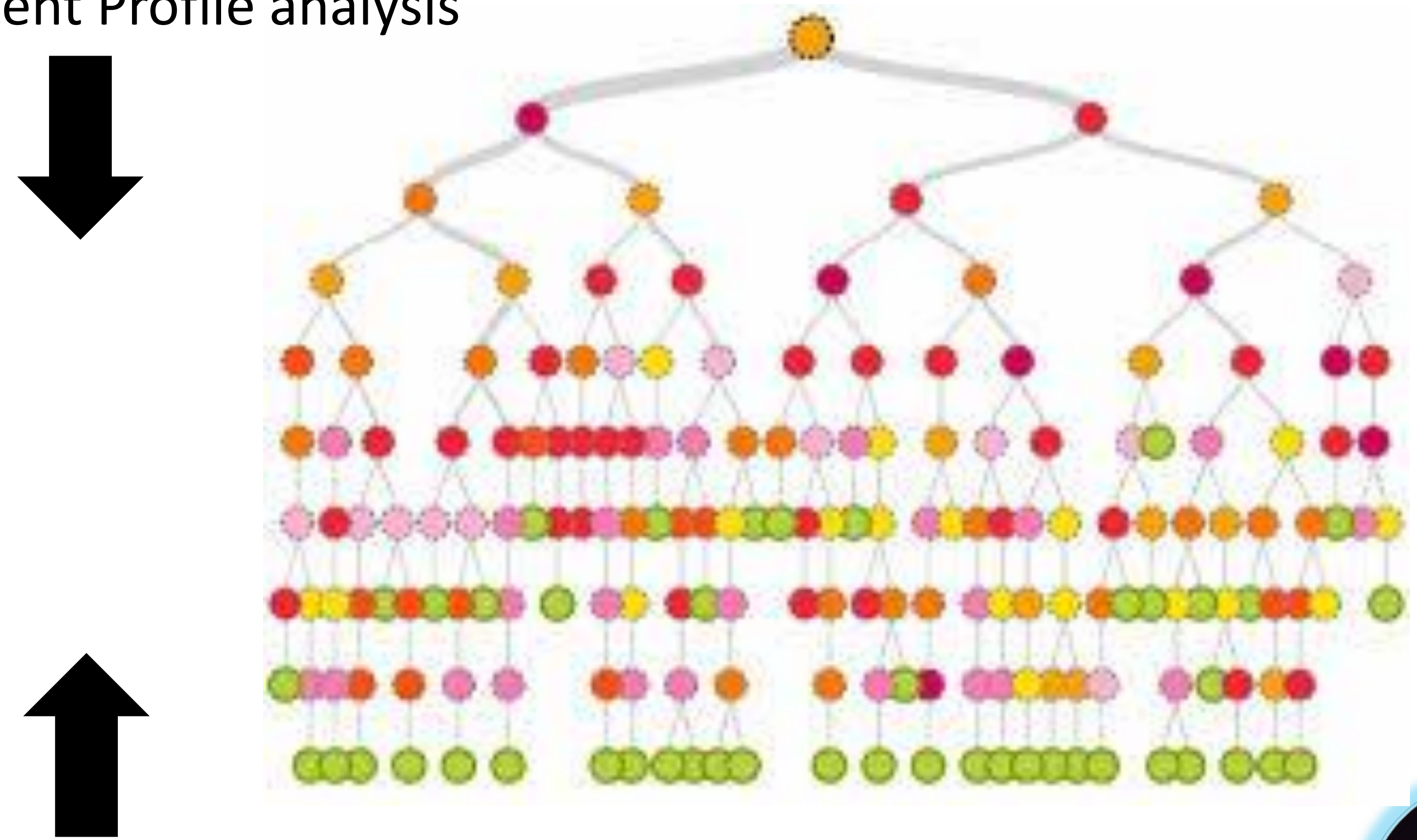
**Excluded**
- Incomplete clinical measures: 3

Analysis
**N=127**



# Modelling

Latent Profile analysis



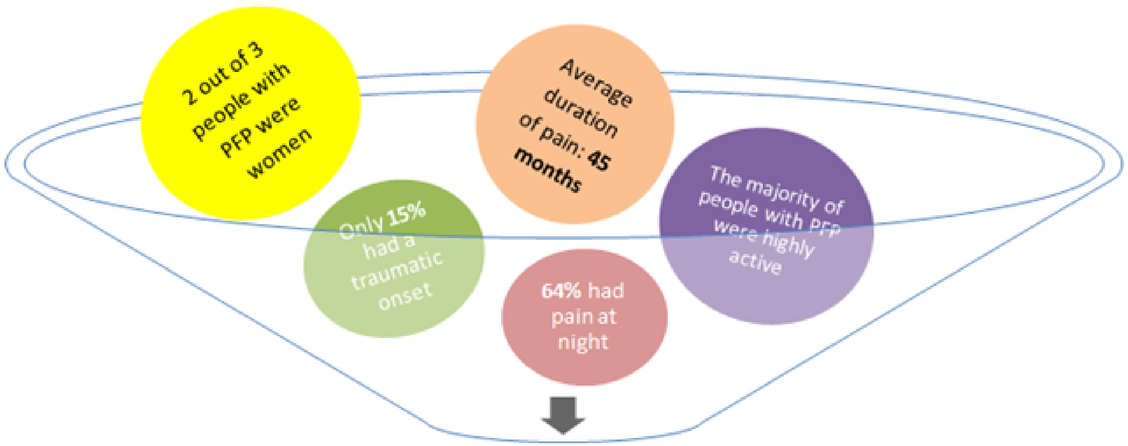
Hierarchical modelling

# TIPPs Grouping Results

TIPPS RESULTS

Subgrouping from clinical measures and questionnaires

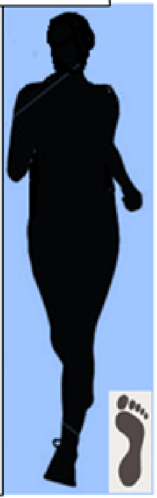
Results from 130 people with patellofemoral pain (PFP)




3 subgroups

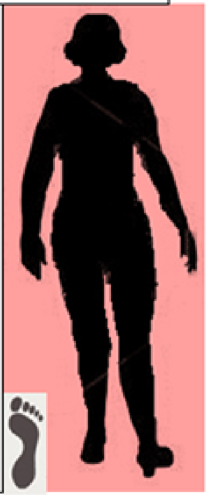
**STRONG (22%)**

- Strong leg muscles
- Higher level of function and Quality of Life
- More males
- Oldest group



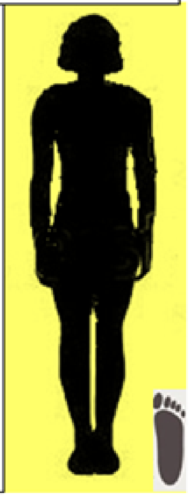
**WEAK AND TIGHT (39%)**

- Weak leg muscles
- Tight leg muscles
- Lower level of Function
- Higher BMI
- Highest level of neuropathic pain
- Low activity level
- Longest pain duration



**PRONATED AND WEAK (39%)**

- Pronated feet
- Weak leg muscles
- Young at first assessment
- Hypermobile patella
- Shortest pain duration



Thank you for participating

Is there a link between knee stability, knee forces and pain in patients with Patellofemoral Pain?

Clinical Biomechanics 37 (2016) 7–12

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

Lecture

# Influence of a knee brace intervention on perceived pain and patellofemoral loading in recreational athletes

Jonathan K. Sinclair [a,*], James Selfe [b], Paul J. Taylor [c], Hannah F. Shore [a], Jim D. Richards [b]

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ABSTRACT

*Background:* The current investigation aimed to investigate the effects of an intervention using knee bracing on pain symptoms and patellofemoral loading in male and female recreational athletes.
*Methods:* Twenty participants (11 males & 9 females) with patellofemoral pain were provided with a knee brace which they wore for a period of 2 weeks. Lower extremity kinematics and patellofemoral loading were obtained during three sport specific tasks, jog, cut and single leg hop. In addition their self-reported knee pain scores were examined using the Knee injury and Osteoarthritis Outcome Score. Data were collected before and after wearing the knee brace for 2 weeks.
*Findings:* Significant reductions were found in the run and cut movements for peak patellofemoral force/pressure and in all movements for the peak knee abduction moment when wearing the brace. Significant improvements were also shown for Knee injury and Osteoarthritis Outcome Score subscale symptoms (pre: male = 70.27, female = 73.22 & post: male = 85.64, female = 82.44), pain (pre: male = 72.36, female = 78.89 & post: male = 85.73, female = 84.20), sport (pre: male = 60.18, female = 59.33 & post: male = 80.91, female = 79.11), function and daily living (pre: male = 82.18, female = 86.00 & post: male = 88.91, female = 90.00) and quality of life (pre: male = 51.27, female = 54.89 & post: male = 69.36, female = 66.89).
*Interpretation:* Male and female recreational athletes who suffer from patellofemoral pain can be advised to utilise knee bracing as a conservative method to reduce pain symptoms.

# Method

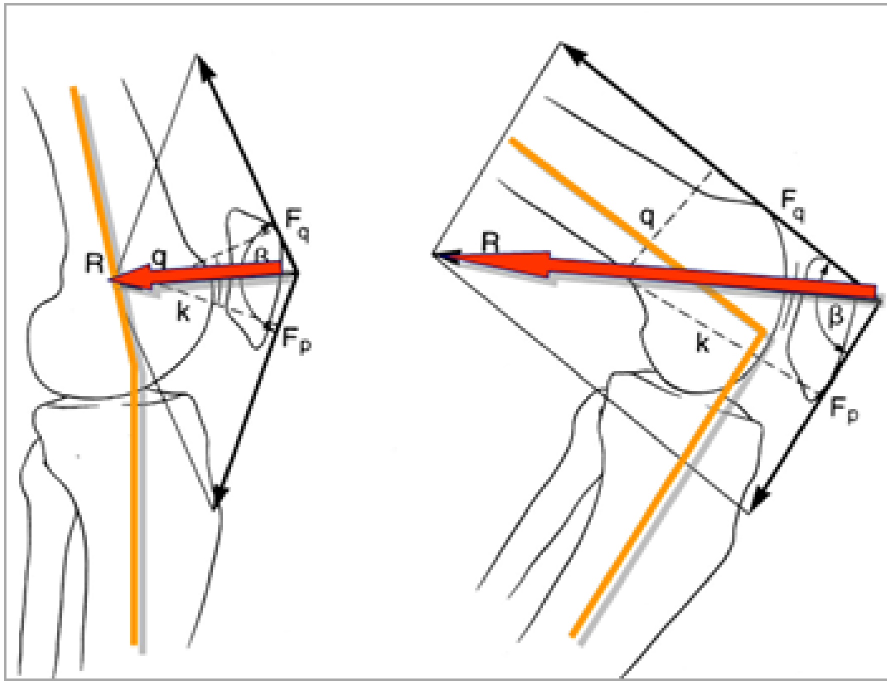
- Twenty participants (11 males & 9 females) with patellofemoral pain were provided with a knee brace which they wore for a period of 2 weeks.

- Lower extremity kinematics and patellofemoral loading were obtained during three sports specific tasks
  - Jog
  - Cutting maneuver
  - Single leg hop

- In addition their self-reported knee pain scores were examined using the Knee injury and Osteoarthritis Outcome Score (KOOS).

# Patellofemoral Joint Load

- The patellofemoral joint is capable in dealing with large forces during functional activities (Selfe, 2010).
- These can be between 0.5 to 9.7 x body weight during normal daily activities
- But can be as high as 20 x body weight during intensive sporting activities (Schindler & Scott, 2011).



# Results

Patellofemoral kinetics during running as a function of both knee brace intervention and gender.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Brace | | No-brace | | Brace | | No-brace | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| PTCF (B.W) | 3.21 | 0.93 | 3.40 | 0.68 | 2.98 | 0.78 | 3.82 | 0.56 |
| PTS (MPa) | 10.11 | 2.07 | 10.87 | 2.74 | 9.41 | 2.00 | 11.60 | 1.62 |
| PTCF loading rate (B.W/s) | 40.19 | 12.76 | 45.16 | 9.35 | 35.37 | 13.53 | 47.09 | 14.02 |
| Peak abduction moment (Nm/kg) | −0.89 | 0.30 | −1.01 | 0.26 | −0.86 | 0.21 | −0.94 | 0.14 |

# Results

Patellofemoral kinetics during cutting as a function of both knee brace intervention and gender.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Brace | | No-brace | | Brace | | No-brace | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| PTCF (B.W) | 3.47 | 1.01 | 3.76 | 0.65 | 3.25 | 0.79 | 3.95 | 0.84 |
| PTS (MPa) | 10.75 | 2.21 | 11.52 | 2.13 | 10.10 | 2.11 | 11.70 | 2.47 |
| PTCF loading rate (B.W/s) | 42.04 | 15.50 | 39.07 | 6.54 | 34.23 | 10.69 | 42.17 | 15.50 |
| Peak abduction moment (Nm/kg) | −0.61 | 0.29 | −0.81 | 0.23 | −0.86 | 0.31 | −0.94 | 0.11 |

# Results

Patellofemoral kinetics during the single leg hop as a function of both knee brace intervention and gender.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Brace | | No-brace | | Brace | | No-brace | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| PTCF (B.W) | 3.32 | 0.99 | 3.56 | 0.52 | 3.10 | 0.66 | 3.56 | 0.48 |
| PTS (MPa) | 10.31 | 2.12 | 11.13 | 2.49 | 9.75 | 1.57 | 10.77 | 1.59 |
| PTCF loading rate (B.W/s) | 37.76 | 9.99 | 39.21 | 5.40 | 36.82 | 9.75 | 40.99 | 11.29 |
| Peak abduction moment (Nm/kg) | −1.19 | 0.40 | −1.40 | 0.32 | −1.04 | 0.25 | −1.14 | 0.33 |

# Results

- Significant improvements were also shown for KOOS subscales:
  - 18% improvement in symptoms
  - 12% improvement in pain
  - 33% improvement in function during sport and recreation

# Final Thoughts….

- Clinical subgroups clearly exist in different patient populations
- All the treatments covered improve the control of the lower limb in active/athletic subgroups
- This can be explained by a proprioceptive or mechanoreceptive effect

# Final Thoughts….

- Any patient population has Responders and Non-Responders to different clinical interventions
- Does the response link to the different subgroups?
- Clinical Biomechanics needs to focus on improving our understanding of Targeted Interventions across different patient groups and different subgroups
- …….and to identify factors that can predict who responds and who doesn’t

# *Muito obrigado pela atenção*

Any Questions?

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