Biomechanical Impairments in Femoroacetabular Impingement Syndrome: A Systematic Review and Meta-analysis

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The Team

Peter Lawrenson
Dr Adam Semciw
Dr Kane Middleton
Prof Kay Crossley
Introduction

What is Femoroacetabular Impingement Syndrome?

“FAI is a motion-related clinical disorder of the hip with a triad of symptoms, clinical signs and imaging findings.

It represents a symptomatic premature contact between the proximal femur and the acetabulum” Griffin et al 2016
Introduction

Cam morphology: prevalent in 60%-90% of athletic populations$^{2-5}$

Why do some develop FAI and others not?

Since FAI is a movement related condition
  • Do biomechanical impairments play a role in symptom development

Imaging findings alone $\neq$ FAI

2. Johnson et al 2012
3. Agricola et al 2012
4. Siebenrock et al 2011
5. Lahner et al 2014
Aim

Identify differences in hip biomechanics in people with FAI compared with controls during everyday activities (e.g. walking and squatting)
Methods

Systematic review of the literature
Medline, CINAHL, Scopus, SPORTDiscuss and Embase

Femoroacetabular Impingement
“cam morphology”
“pincer morphology”
“FAI”

Biomechanics
“kinematics”
“kinetics”
“joint torque”

Reference checking, citation tracking and manual searching of ahead of print listing
Inclusion/Exclusion Criteria

Inclusion
- Investigated people with FAI, compared with:
  - Asymptomatic control group OR;
  - Asymptomatic Limb
- Investigated everyday activities
- 3-D motion capture devices

Exclusion
- Data replicated as a smaller sample of previous research
- Editorials
- Reviews
- Book Chapters
- Abstracts
Data Extraction

Movement Patterns (in stance)

- Kinematics
- Joint Torques
Kinematics
“Joint Range”

- Peak range
  - Sagittal (flexion/extension)
  - Frontal (abduction/adduction)
  - Transverse (Internal/external rotation)

- Total range of motion
  - Sagittal, frontal, transverse
Data Extraction

Kinematics
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Kinematics “Joint Range”

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• Total range of motion
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Data Extraction

Joint Torque
“External Joint Torque”

• Peak joint torque
  • Sagittal (flexion/extension)
  • Frontal (abduction/adduction)
  • Transverse (Internal/external rotation)
Data Extraction

Joint Torque
“External Joint Torque”

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Data Extraction

Joint Torque
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• Peak joint torque
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  • Frontal (abduction/adduction)
  • Transverse (Internal/external rotation)
Data analysis

- Reporting quality assessment: Epidemiological Appraisal Instrument

- Data pooled in a meta-analysis

- Unable to be pooled: Qualitative synthesis

Results

Figure 1: Study selection flow chart

# Results

<table>
<thead>
<tr>
<th>Category</th>
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<tbody>
<tr>
<td>Studies</td>
<td>13</td>
</tr>
<tr>
<td>FAI Participants</td>
<td>205 (151 men)</td>
</tr>
<tr>
<td>Age Range</td>
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<tr>
<td>Control Participants</td>
<td>236 (158 men)</td>
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<td>Age Range</td>
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## Tasks Investigated
- Walking (7)
- Squatting (4)
- Sit to Stand (1)
- Step up (2)
- Drop Landing (1)
Results

Reporting Quality

• High (total score > 70%) = 0
• Moderate (50 > total score ≤ 70) = 9
• Low (total score ≤ 50) = 4
Limitations

Walking speed and cadence of walking were not included

Recruited from orthopaedic clinics
Results: Walking - Sagittal plane

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>FAI</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
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<tbody>
<tr>
<td>Diamond et al, 2016</td>
<td>28.6</td>
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Heterogeneity: Tau² = 0.00; Chi² = 4.69, df = 5 (P = 0.45); I² = 0%
Test for overall effect Z = 1.37 (P = 0.17)

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<td>83</td>
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<td>100.0%</td>
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<td>-0.40 [-0.71, -0.09]</td>
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Heterogeneity: Tau² = 0.00; Chi² = 2.73, df = 4 (P = 0.60); I² = 0%
Test for overall effect Z = 2.56 (P = 0.01)

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<td>0.51 [-0.93, 0.08]</td>
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Heterogeneity: Tau² = 0.00; Chi² = 0.83, df = 2 (P = 0.66); I² = 0%
Test for overall effect Z = 2.34 (P = 0.02)
Results: Walking - Sagittal plane

<table>
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<tr>
<th>Study or Subgroup</th>
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<td><strong>2.1.1 Peak Hip Flexion Angle in Stance</strong></td>
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<td>0.09 [0.02, 0.16]</td>
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<td>113</td>
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Heterogeneity: $\tau^2 = 0.00$; Chi$^2 = 4.69$, df = 5 ($P = 0.45$); $I^2 = 0$
Test for overall effect $Z = 1.57$ ($P = 0.17$)

**2.1.2 Peak Hip Extension Angle in Stance**

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Heterogeneity: $\tau^2 = 0.00$; Chi$^2 = 2.73$, df = 4 ($P = 0.60$); $I^2 = 0$
Test for overall effect $Z = 2.56$ ($P = 0.01$)

**2.1.3 Total Sagittal Plane ROM in Stance**

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>FAI Mean</th>
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<td>0.51 [0.03, 0.98]</td>
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Heterogeneity: $\tau^2 = 0.00$; Chi$^2 = 0.83$, df = 2 ($P = 0.60$); $I^2 = 0$
Test for overall effect $Z = 2.34$ ($P = 0.02$)
Results: Walking - Sagittal plane

---

### Peak Hip Flexion Angle in Stance

<table>
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</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$; Chi$^2 = 4.69$, df = 5 (P = 0.45); $I^2 = 0$

Test for overall effect $Z = 1.37$ (P = 0.17)

---

### Peak Hip Extension Angle in Stance

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>FAI Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamond et al, 2016</td>
<td>9.8</td>
<td>7</td>
<td>15</td>
<td>10.3</td>
<td>6</td>
<td>14</td>
<td>17.7%</td>
<td>-0.07 [-0.80, 0.66]</td>
<td></td>
</tr>
<tr>
<td>Hunt et al, 2013</td>
<td>7.4</td>
<td>6.7</td>
<td>17</td>
<td>12.7</td>
<td>2.3</td>
<td>17</td>
<td>34.7%</td>
<td>-0.65 [-1.17, -0.13]</td>
<td></td>
</tr>
<tr>
<td>Kennedy et al, 2009</td>
<td>16.7</td>
<td>4.9</td>
<td>17</td>
<td>19.1</td>
<td>4.8</td>
<td>14</td>
<td>18.2%</td>
<td>-0.48 [-1.20, 0.24]</td>
<td></td>
</tr>
<tr>
<td>Kumar et al, 2014</td>
<td>15.9</td>
<td>10.8</td>
<td>7</td>
<td>21.8</td>
<td>6.5</td>
<td>8</td>
<td>8.8%</td>
<td>-0.83 [-1.88, 0.24]</td>
<td></td>
</tr>
<tr>
<td>Rylander et al, 2013</td>
<td>4.5</td>
<td>5.6</td>
<td>6</td>
<td>5</td>
<td>1.6</td>
<td>6</td>
<td>20.9%</td>
<td>-0.09 [-0.76, 0.56]</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>85</td>
<td></td>
<td></td>
<td>83</td>
<td></td>
<td></td>
<td>100.0%</td>
<td>-0.40 [-0.71, 0.09]</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$; Chi$^2 = 2.73$, df = 4 (P = 0.60); $I^2 = 0$

Test for overall effect $Z = 2.56$ (P = 0.01)

---

### Total Sagittal Plane ROM in Stance

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>FAI Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hetsonri et al, 2015</td>
<td>41.5</td>
<td>4.1</td>
<td>15</td>
<td>43.4</td>
<td>6.3</td>
<td>30</td>
<td>46.3%</td>
<td>-0.33 [-0.95, 0.30]</td>
<td></td>
</tr>
<tr>
<td>Kumar et al, 2014</td>
<td>36</td>
<td>4</td>
<td>7</td>
<td>37.9</td>
<td>4</td>
<td>8</td>
<td>16.0%</td>
<td>-0.45 [-1.48, 0.58]</td>
<td></td>
</tr>
<tr>
<td>Rylander et al, 2013</td>
<td>40.5</td>
<td>5.7</td>
<td>17</td>
<td>44.1</td>
<td>4.8</td>
<td>17</td>
<td>36.8%</td>
<td>-0.75 [-1.46, -0.06]</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>39</td>
<td></td>
<td></td>
<td>55</td>
<td></td>
<td></td>
<td>100.0%</td>
<td>0.51 [0.03, 0.98]</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$; Chi$^2 = 0.83$, df = 2 (P = 0.66); $I^2 = 0$

Test for overall effect $Z = 2.34$ (P = 0.02)
Results: Walking - Sagittal plane

![Diagram showing results for Peak Hip Flexion Angle in Stance, Peak Hip Extension Angle in Stance, and Total Sagittal Plane ROM in Stance.](image)

**Peak Hip Flexion Angle in Stance**
- Diamond et al, 2016: Mean = 28.6, SD = 6.8
- Hetsroni et al, 2015: Mean = 32.3, SD = 6.3
- Hunt et al, 2013: Mean = 31.8, SD = 6.8
- Kennedy et al, 2009: Mean = 30.8, SD = 4.1
- Kumar et al, 2014: Mean = 20.3, SD = 0.1
- Rylander et al, 2013: Mean = 35.5, SD = 5.3

**Peak Hip Extension Angle in Stance**
- Diamond et al, 2016: Mean = 9.8, SD = 7.4
- Hunt et al, 2013: Mean = 7.4, SD = 6.7
- Kennedy et al, 2009: Mean = 16.7, SD = 4.9
- Kumar et al, 2014: Mean = 15.8, SD = 10.6
- Rylander et al, 2013: Mean = 4.5, SD = 6.6

**Total Sagittal Plane ROM in Stance**
- Hetsroni et al, 2015: Mean = 41.5, SD = 4.1
- Kumar et al, 2014: Mean = 36, SD = 4
- Rylander et al, 2013: Mean = 40.5, SD = 5.7

Lower in Controls
Results: Walking - Sagittal plane

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>FAI Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamond et al, 2016</td>
<td>28.6</td>
<td>6.8</td>
<td>15</td>
<td>31.4</td>
<td>7.1</td>
<td>14</td>
<td>13.8%</td>
<td>-0.39 [-1.13, 0.34]</td>
</tr>
<tr>
<td>Hetersoni et al, 2015</td>
<td>32.3</td>
<td>6.3</td>
<td>15</td>
<td>34.4</td>
<td>6.1</td>
<td>30</td>
<td>19.3%</td>
<td>-0.33 [-0.96, 0.29]</td>
</tr>
<tr>
<td>Hunt et al, 2013</td>
<td>31.8</td>
<td>6.6</td>
<td>30</td>
<td>31.2</td>
<td>6.5</td>
<td>30</td>
<td>29.3%</td>
<td>0.09 [0.42, 0.60]</td>
</tr>
<tr>
<td>Kennedy et al, 2009</td>
<td>30.8</td>
<td>4.4</td>
<td>17</td>
<td>31.9</td>
<td>5.1</td>
<td>14</td>
<td>14.9%</td>
<td>-0.24 [-0.95, 0.47]</td>
</tr>
<tr>
<td>Kumar et al, 2014</td>
<td>20.3</td>
<td>0.1</td>
<td>7</td>
<td>16.3</td>
<td>0.1</td>
<td>6</td>
<td>7.0%</td>
<td>0.66 [0.57, 1.50]</td>
</tr>
<tr>
<td>Rylander et al, 2013</td>
<td>35.5</td>
<td>5.3</td>
<td>17</td>
<td>39.8</td>
<td>5.8</td>
<td>17</td>
<td>15.8%</td>
<td>-0.82 [-1.31, 0.07]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>101</td>
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<td></td>
<td>113</td>
<td></td>
<td></td>
<td>100.0%</td>
<td>-0.19 [-0.47, 0.09]</td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$, $I^2 = 0.00$, $p = 0.00$, $df = 5$, $P = 0.45$, $I^2 = 0.00$.

Test for overall effect $Z = 1.37 (P = 0.17)$.

2.1.2 Peak Hip Extension Angle in Stance

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>FAI Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
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<tr>
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<td>17.7%</td>
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<td>30</td>
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<td>7.2</td>
<td>30</td>
<td>34.7%</td>
<td>-0.65 [-1.17, -0.13]</td>
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<tr>
<td>Kennedy et al, 2009</td>
<td>16.7</td>
<td>4.9</td>
<td>18</td>
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<tr>
<td>Kumar et al, 2014</td>
<td>15.8</td>
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<td>7</td>
<td>21.6</td>
<td>6.5</td>
<td>8</td>
<td>8.8%</td>
<td>-0.63 [-1.88, 0.62]</td>
</tr>
<tr>
<td>Rylander et al, 2013</td>
<td>4.5</td>
<td>6.6</td>
<td>17</td>
<td>5.1</td>
<td>6.6</td>
<td>17</td>
<td>20.6%</td>
<td>-0.09 [-0.76, 0.50]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>86</td>
<td></td>
<td></td>
<td>83</td>
<td></td>
<td></td>
<td>100.0%</td>
<td>-0.40 [-0.71, -0.09]</td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$, $I^2 = 0.00$, $p = 0.00$, $df = 4$, $P = 0.60$, $I^2 = 0.00$.

Test for overall effect $Z = 2.56 (P = 0.01)$.

2.1.3 Total Sagittal Plane ROM in Stance

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>FAI Mean</th>
<th>SD</th>
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<th>Control Mean</th>
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<td>7</td>
<td>37.9</td>
<td>4</td>
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<td>17</td>
<td>44.1</td>
<td>4.8</td>
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<td>36.8%</td>
<td>-0.76 [-1.46, -0.06]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>39</td>
<td></td>
<td></td>
<td>55</td>
<td></td>
<td></td>
<td>100.0%</td>
<td>0.51 [-0.63, 0.08]</td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$, $I^2 = 0.83$, $p = 0.02$, $df = 2$, $P = 0.66$, $I^2 = 0.00$.

Test for overall effect $Z = 2.34 (P = 0.02)$.
Results: Walking - Sagittal plane

- Smaller peak hip extension angle (SMD -0.40, 95% CI -0.71 to -0.09)
- Less total sagittal plane ROM (-0.51, -0.93 to -0.08)
Results: Walking - Frontal Plane

No difference in frontal plane kinematics
Results: Walking - Transverse Plane

Smaller peak hip internal rotation angle
(-0.67, -1.19 to -0.16)
Results: Walking - Joint Torques

Smaller peak hip external rotation torque
(-0.71, -1.07 to -0.35)
Squat

• People with FAI:
  • Unable to squat as deep as controls

Figure 3 Meta-analysis of squat depth, FAI vs Controls

• No difference in hip flexion ROM

• WHY?
  • Is it poor motor programming as opposed to a fear avoidance behaviour
Additional Tasks

- Stair ascent
- Sit to Stand
- Drop Landing

Insufficient evidence to draw conclusions for clinical practice on these tasks

Image sources: Wikimedia, sketchite.com, Women’s Running Magazine
Discussion: Walking

• Internal rotation is often reported as painful\textsuperscript{21}

• Results

\begin{itemize}
  \item Smaller peak hip external rotation torque
  \item Smaller peak hip internal rotation angle
\end{itemize}

• May be strategies to avoid a painful position

\textsuperscript{21} Byrd, 2014
Discussion: Walking

- Lower peak hip extension during stance phase of walking
- Consistent with a variety of hip conditions
  - Early OA, Late OA, THR

  - Reduce anterior hip joint contact force
  - Increase fatty infiltrate
  - Decrease hip stability over time

- Coping strategy or inherent movement pattern resulting in symptoms

22. Watelain et al. 2001
23. Constantinou et al. 2017
25. Beaulieu et al. 2010
26. Lewis et al. 2010
28. Semciw et al. 2011
29. Semciw et al. 2014
Where to from here?

• Review demonstrates:
  • Minimal biomechanical information on FAI
  • No literature available on sport specific activities

• Long term effects are unknown:
  • No studies evaluating changes in joint health
  • Longitudinal studies assist in understanding disease progression

Impairments

Protective

Watch this space
Thank you and Questions?

@mattgmking1

m.king@latrobe.edu.au


