LA TROBE UNIVERSITY • AUSTRALIA

Project FORCe

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

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Australian Government National Health and Medical Research Council NHMRC

The University of Melbourne

The University of Queensland Australia

The Team

Peter Lawrenson

Dr Adam Semciw

Dr Kane Middleton

Prof Kay Crossley

Introduction

What is Femoroacetabular Impingement Syndrome?


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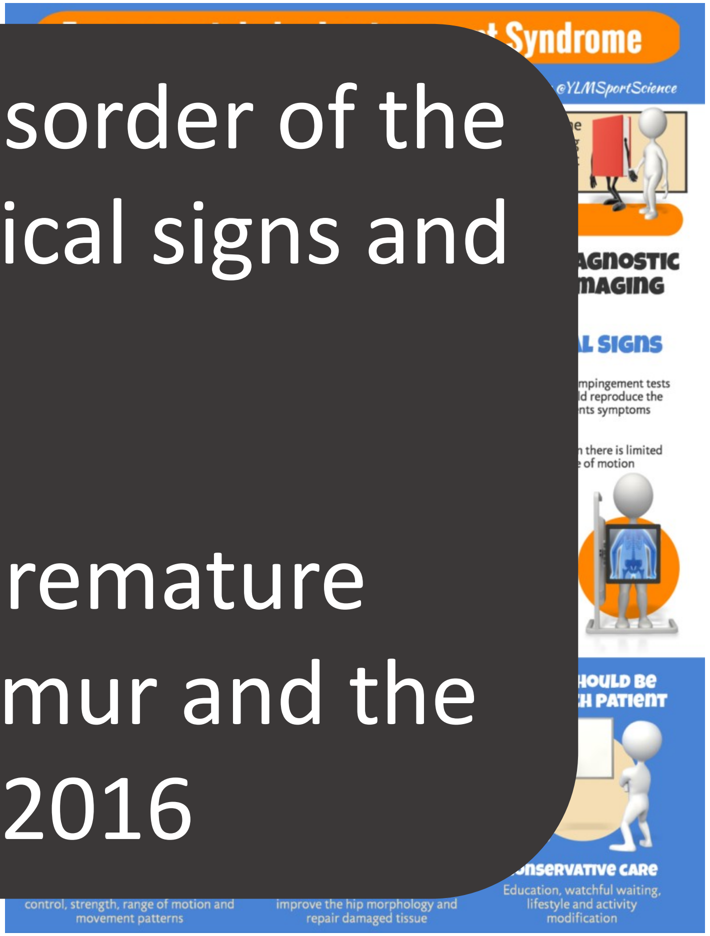
D R Griffi
J C Clohis
A Kassarj
M P Reim

“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



@YLM SportScience

Introduction

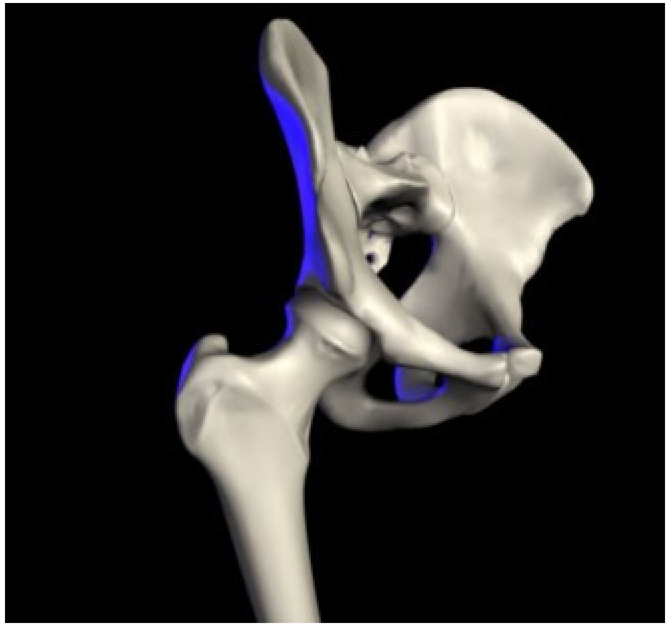
Imaging findings alone ≠ FAI

- 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

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)

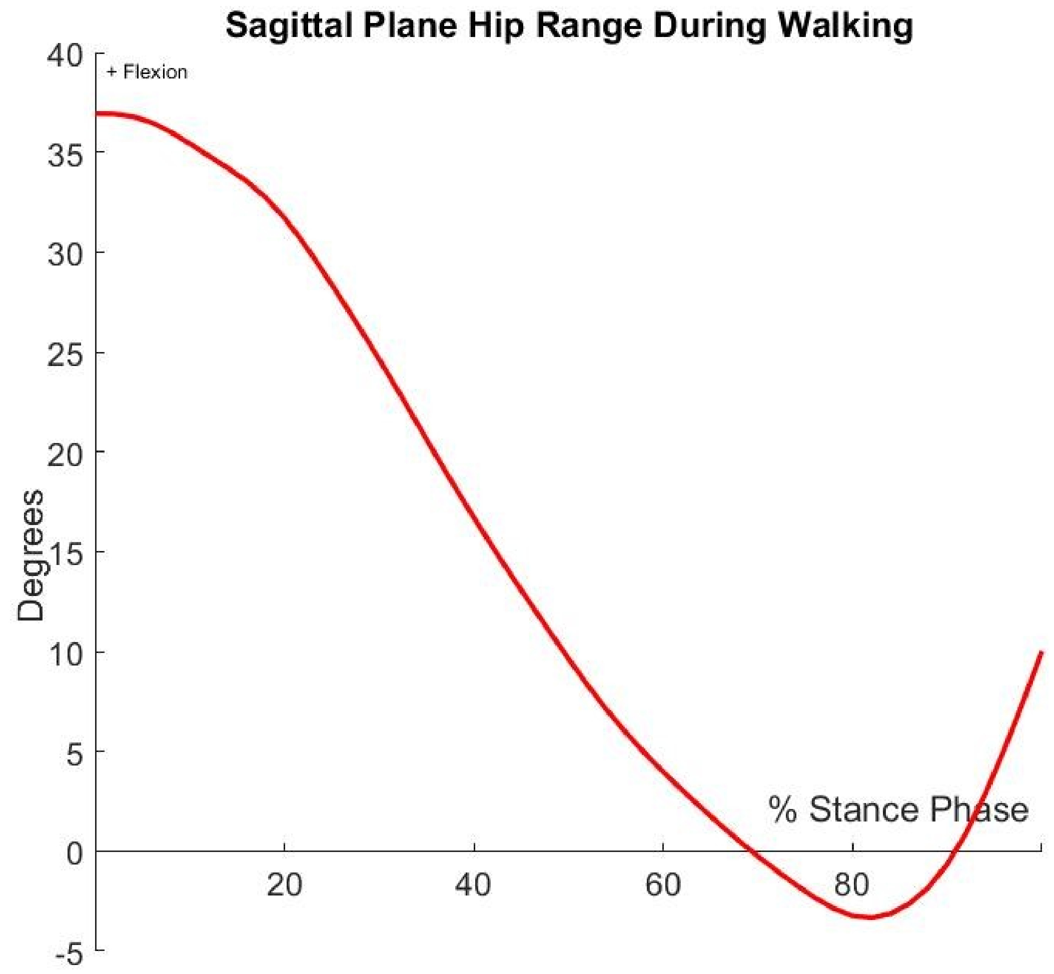
- Kinematics
- Joint Torques

Data Extraction

Kinematics
“Joint Range”

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

- Total range of motion
  - Sagittal, frontal, transverse



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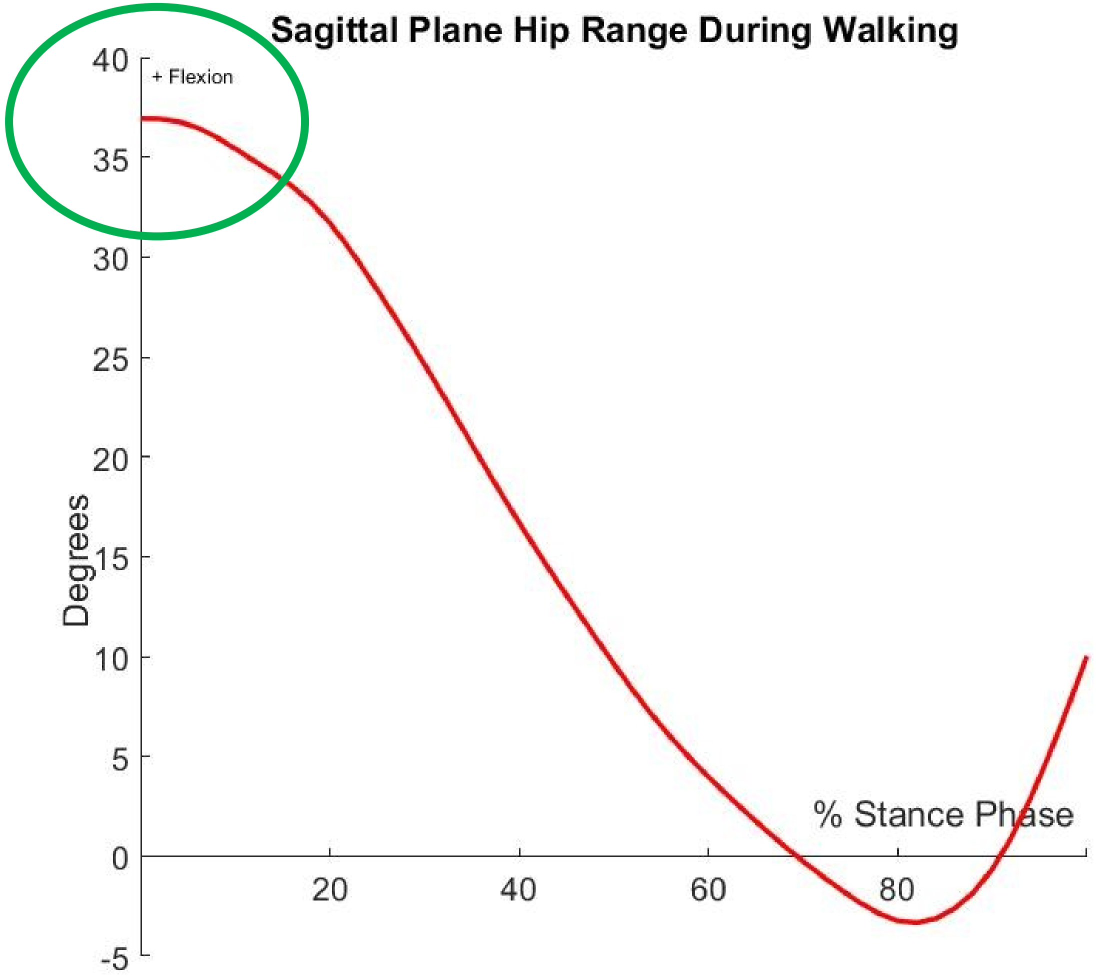

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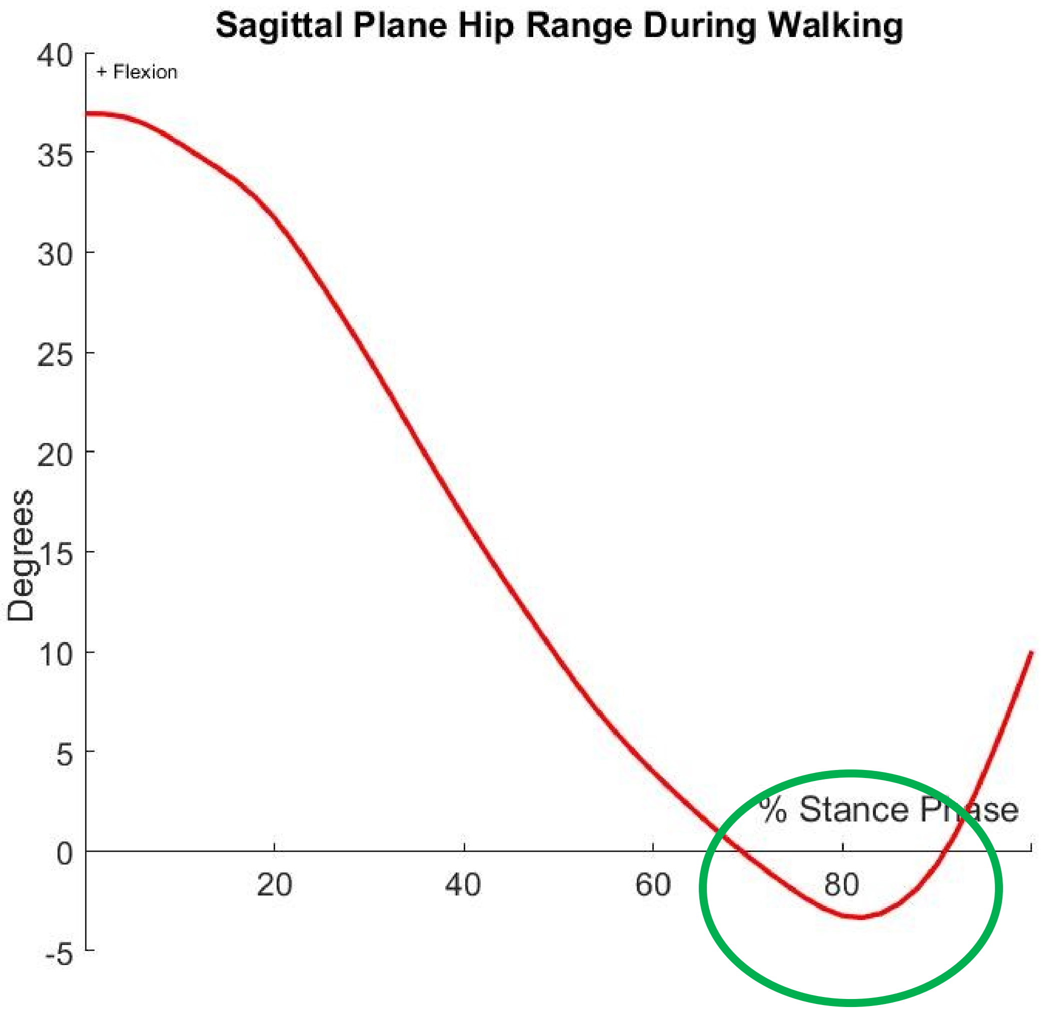

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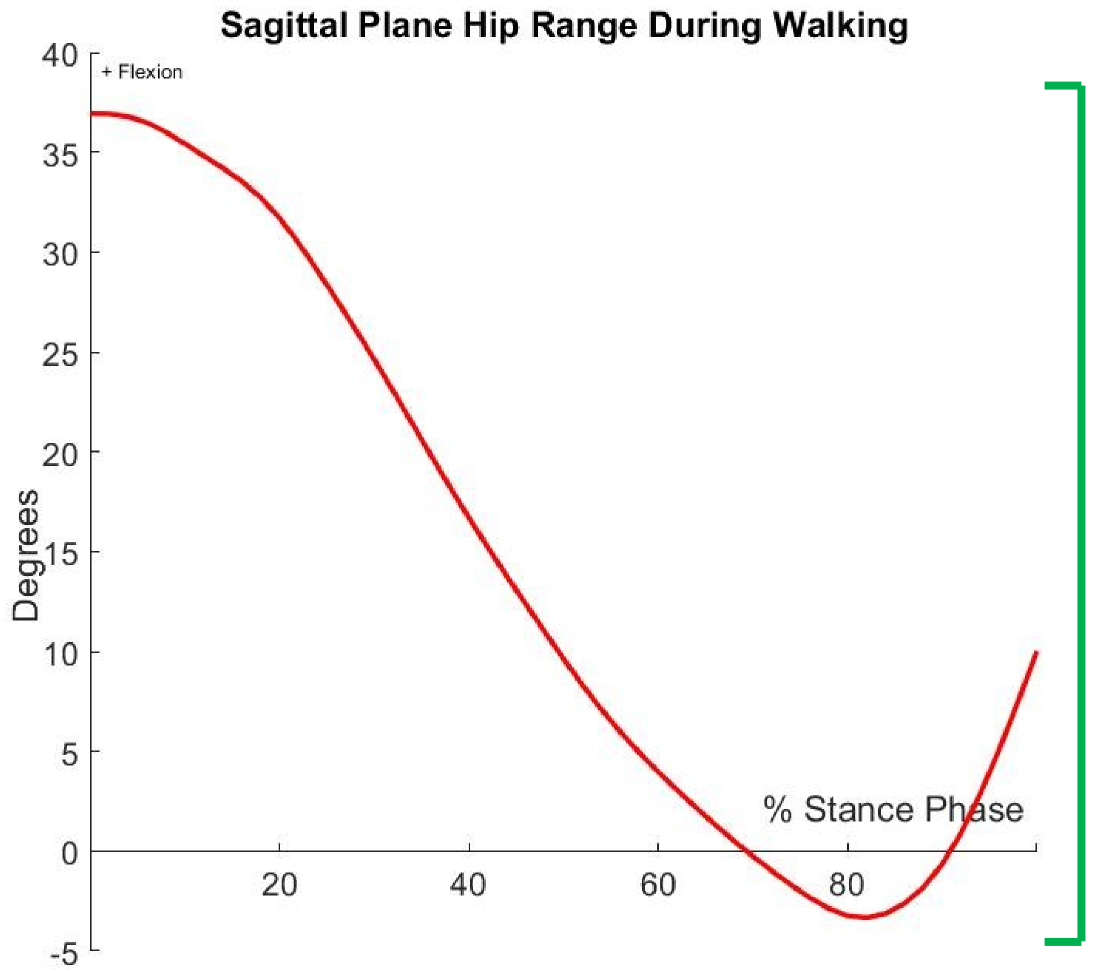
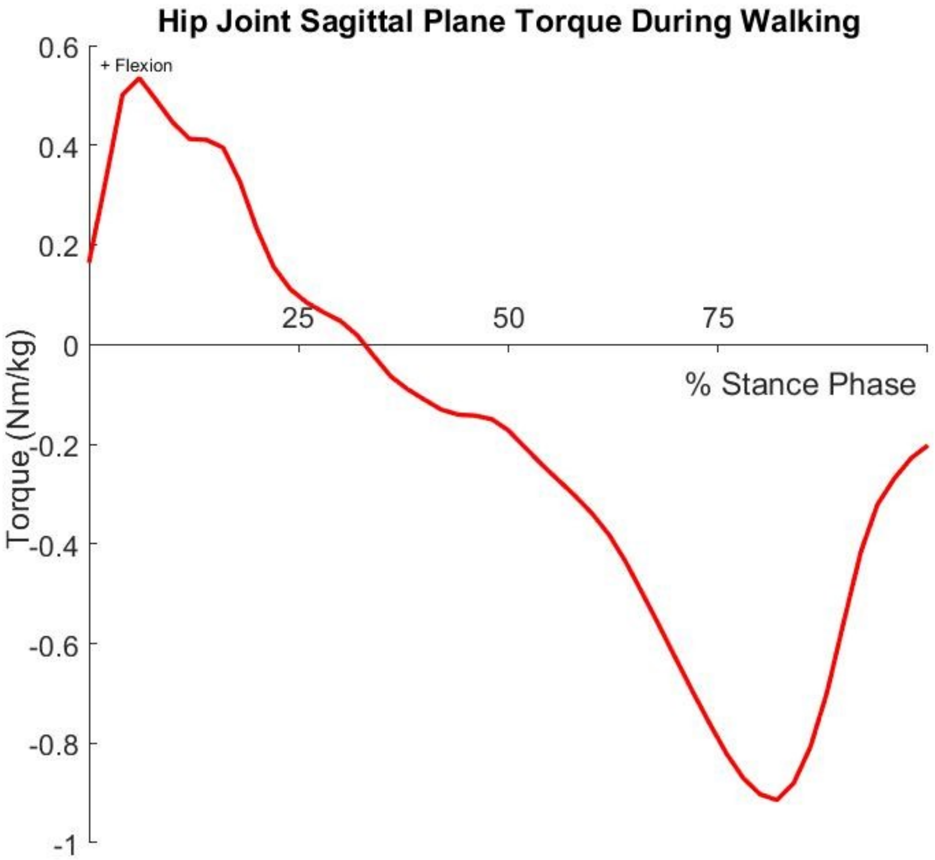


Data Extraction

Joint Torque
"External Joint Torque"

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



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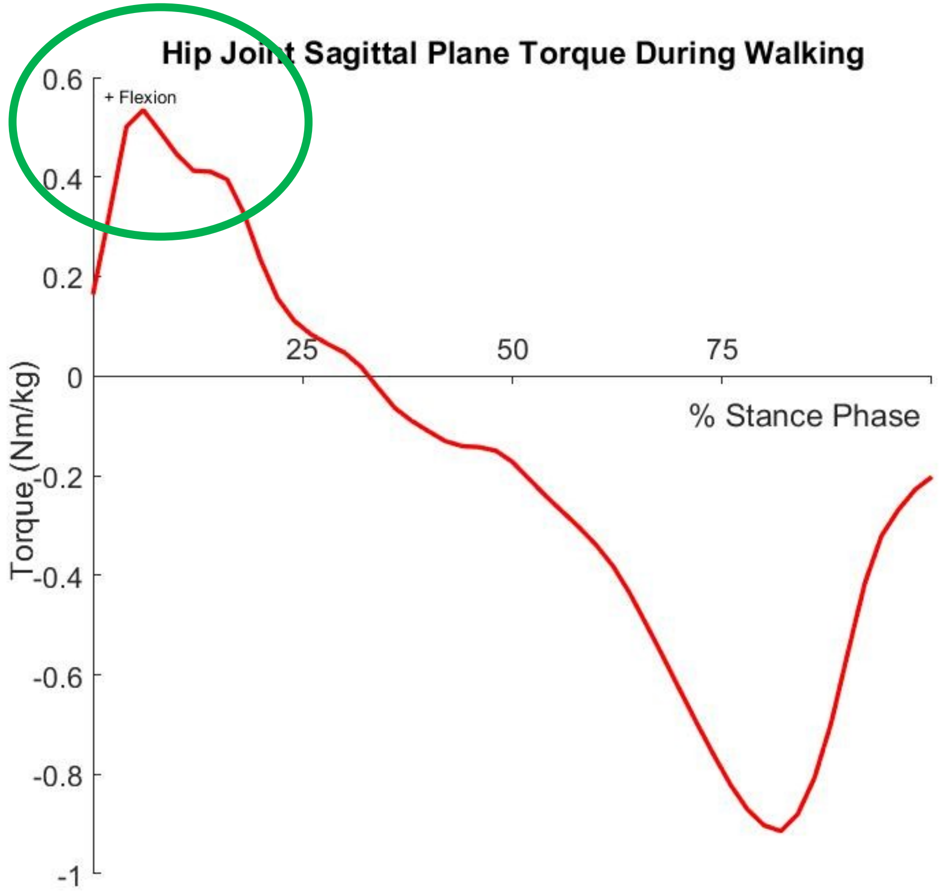

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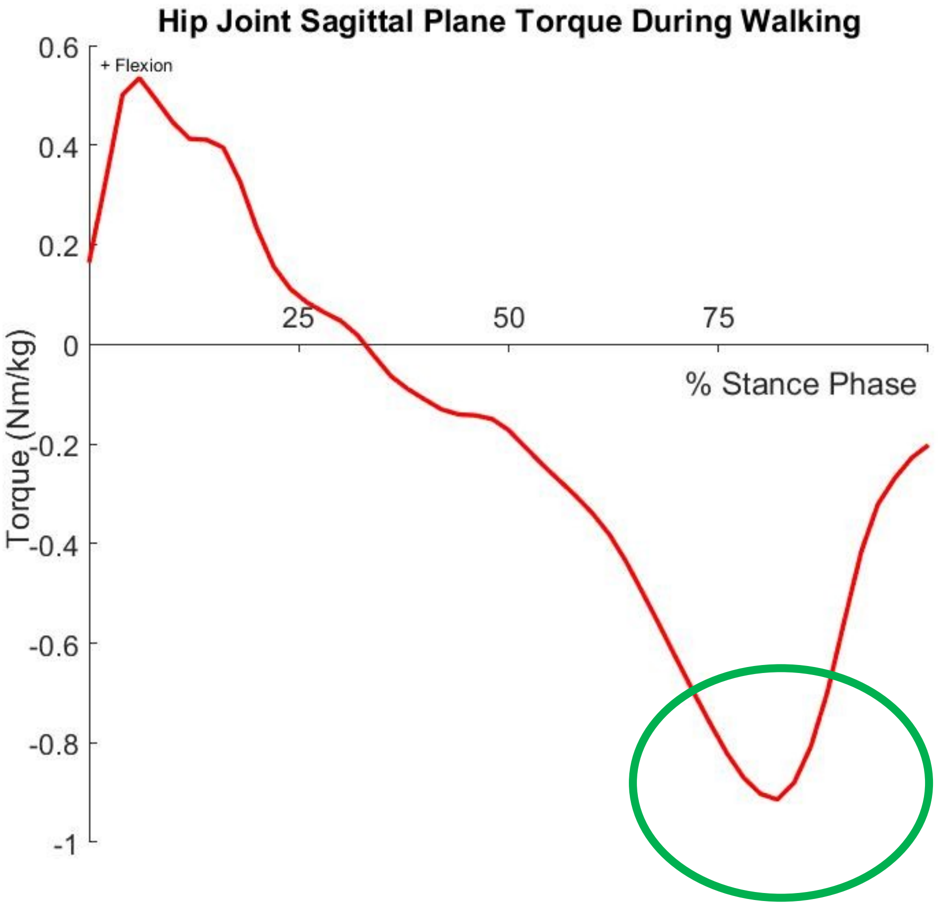

Data analysis

Reporting quality assessment:
Epidemiological Appraisal Instrument[6]

Data pooled in a meta-analysis

Unable to be pooled:
Qualitative synthesis

6. Genaidy et al, 2007

Results

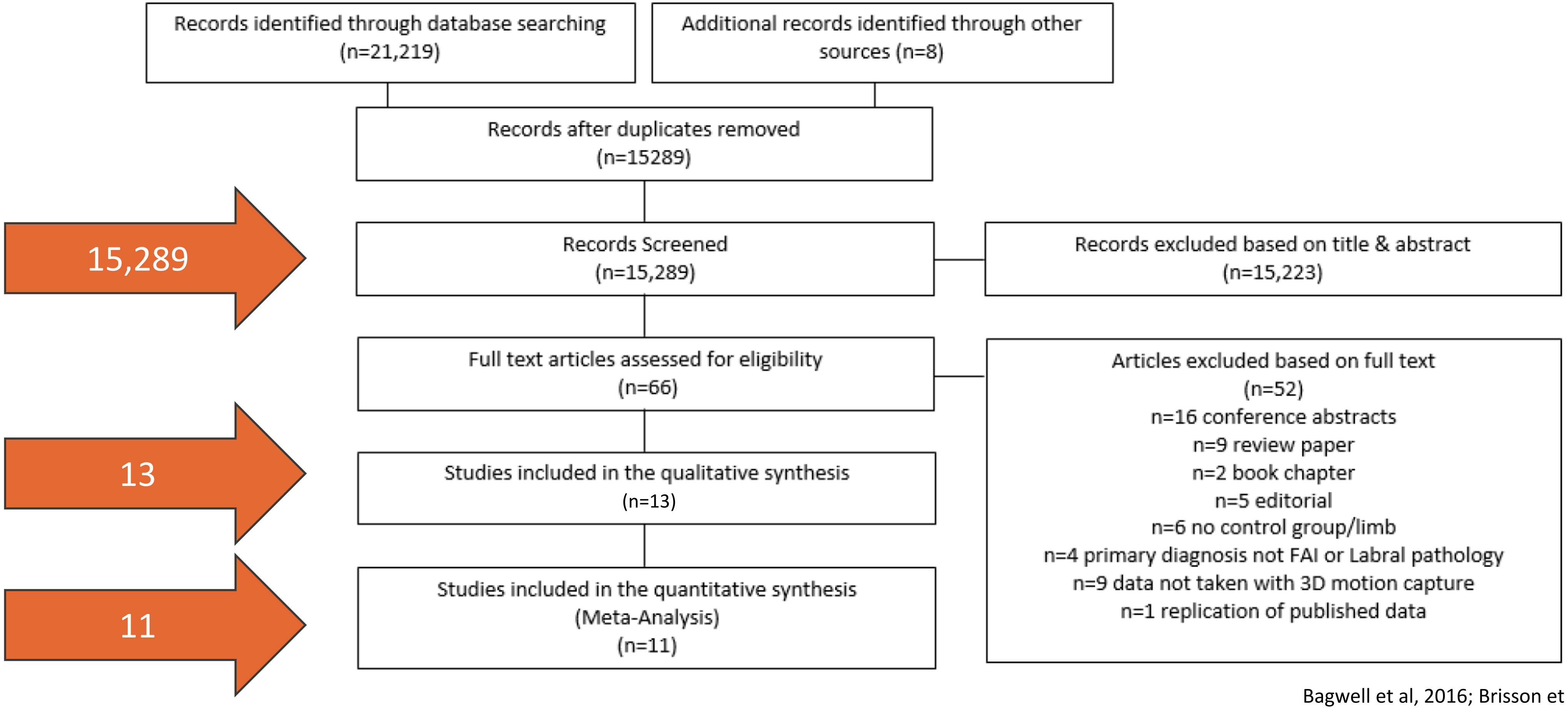

Figure 1: Study selection flow chart

Bagwell et al, 2016; Brisson et al, 2013; Diamond et al, 2016; Hammond et al, 2017; Hetsroni et al, 2015; Hunt et al, 2013; Kenned et al, 2009; Kumar et al, 2014; Lamontagne et al, 2009; Ng et al, 2015; Rylander et al, 2013; Samaan et al, 2016; Samaa et al, 2016

Results

Category	n
Studies	13
FAI Participants	205 (151 men)
Age Range	*24.1-40.1*
Control Participants	236 (158 men)
Age Range	*27.1-43.2*

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

Study or Subgroup	FAI Mean	FAI SD	FAI Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.1.1 Peak Hip Flexion Angle in Stance								
Diamond et al, 2016	28.6	6.8	15	31.4	7.1	14	13.8%	-0.39 [-1.13, 0.34]
Hetsroni et al, 2015	32.3	6.3	15	34.4	6.1	30	19.3%	-0.33 [-0.96, 0.29]
Hunt et al, 2013	31.8	6.6	30	31.2	6.5	30	29.3%	0.09 [-0.42, 0.60]
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Rylander et al, 2013	35.5	5.3	17	39	5.8	17	15.8%	-0.62 [-1.31, 0.07]
Subtotal (95% CI)			**101**			**113**	**100.0%**	**-0.19 [-0.47, 0.08]**
Heterogeneity: Tau² = 0.00; Chi² = 4.69, df = 5 (P = 0.45); I² = 0%								
Test for overall effect: Z = 1.37 (P = 0.17)								
2.1.2 Peak Hip Extension Angle in Stance								
Diamond et al, 2016	9.8	7	15	10.3	6	14	17.7%	-0.07 [-0.80, 0.65]
Hunt et al, 2013	7.4	6.7	30	12	7.2	30	34.7%	-0.65 [-1.17, -0.13]
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Subtotal (95% CI)			**86**			**83**	**100.0%**	**-0.40 [-0.71, -0.09]**
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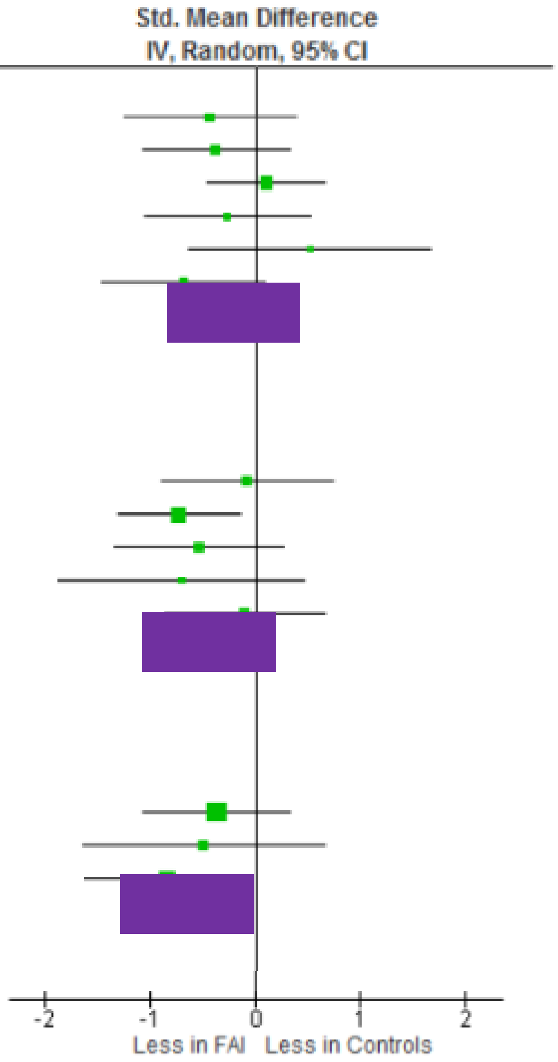

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Std. Mean Difference
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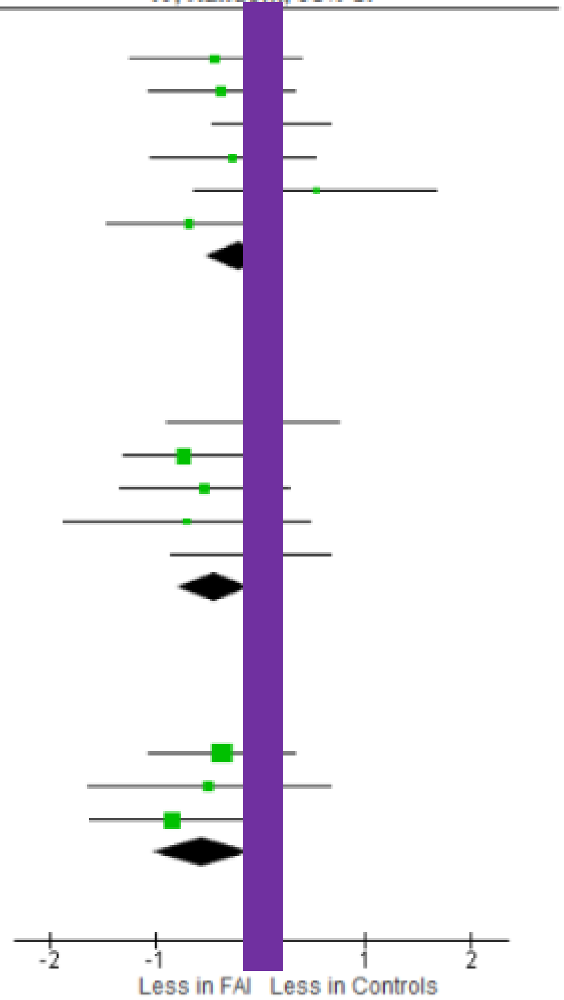

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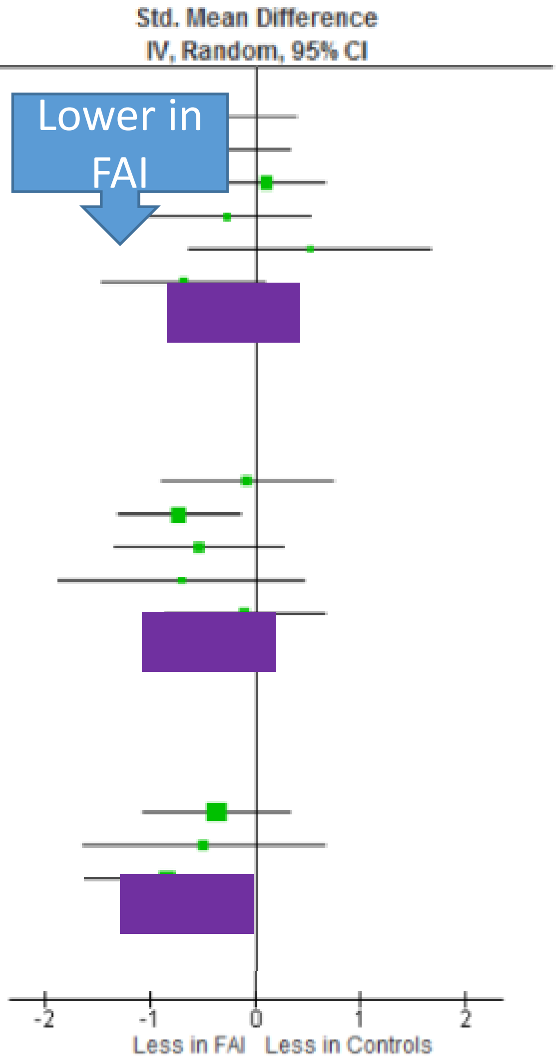

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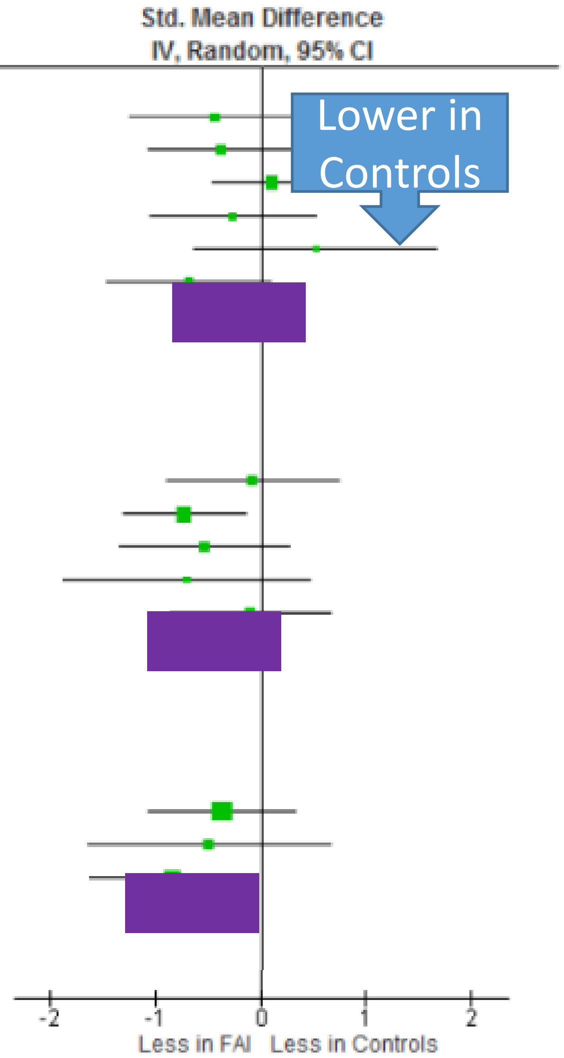

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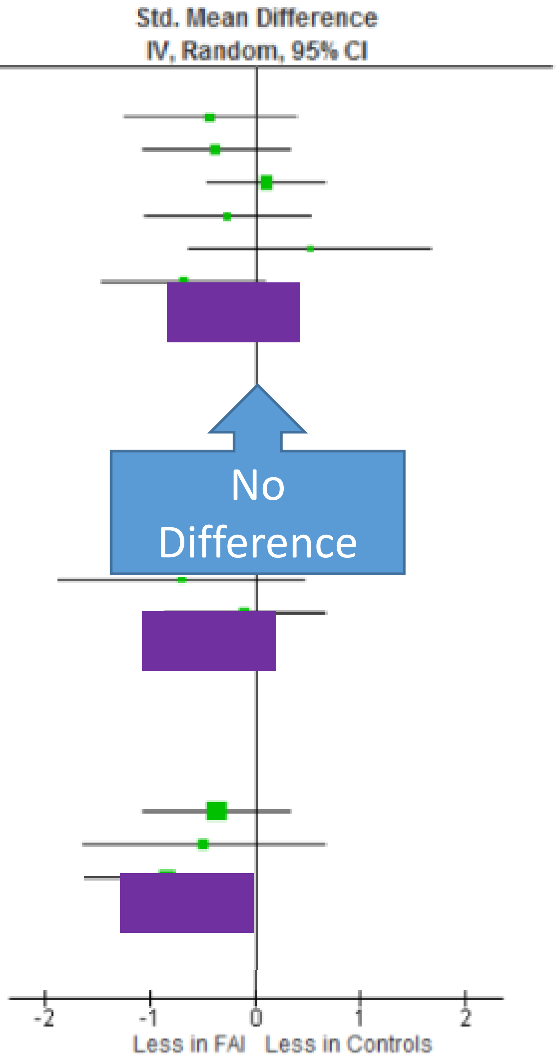
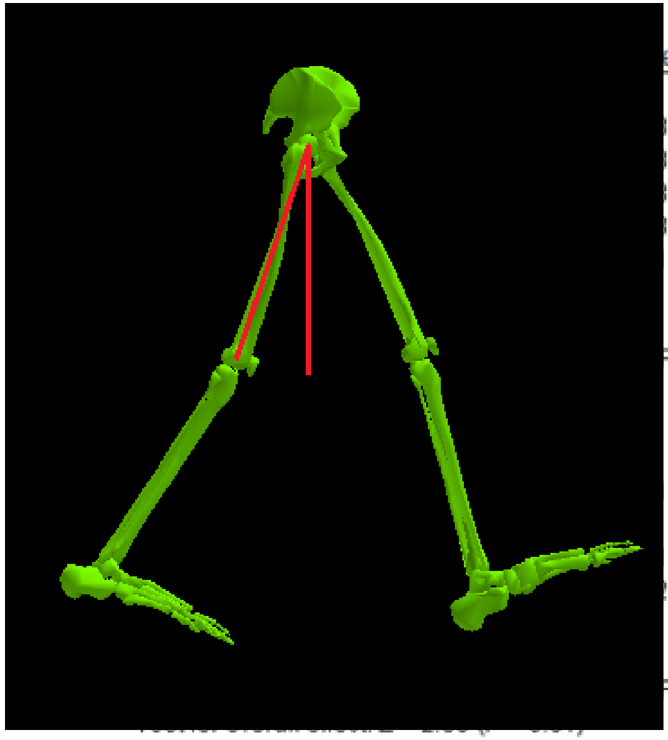
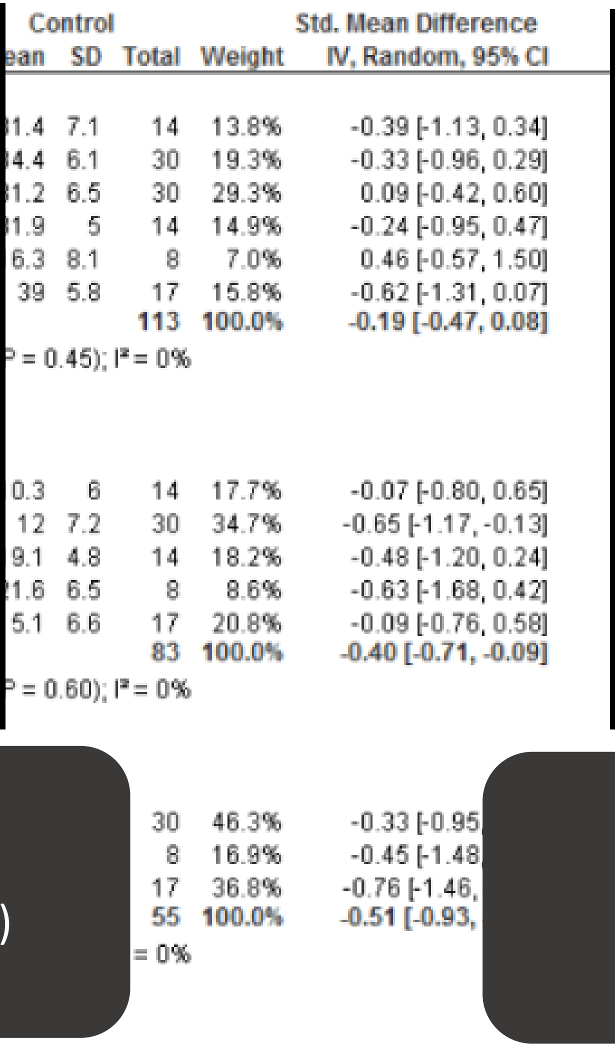
Heterogeneity: Tau² = 0.00; Chi² = 0.83, df = 2 (P = 0.66); I² = 0%								
Test for overall effect: Z = 2.34 (P = 0.02)								



Results: Walking - Sagittal plane





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

Study or Subgroup	FAI Mean	FAI SD	FAI Total	C… Mean	…nce …% CI	Std. Mean Difference IV, Random, 95% CI
2.2.1 Peak Hip Adduction Angle in Stance						
Diamond et al, 2016	9.7	2	15	9.7	0.73]	
Hunt et al, 2013	4.1	3.7	30	5.7	0.04]	
Kennedy et al, 2009	10.9	3	17	10.9	0.71]	
Kumar et al, 2014	7	3.3	7	4.6	1.99]	
Rylander et al, 2013	11.1	5.6	17	11.2	0.65]	
Subtotal (95% CI)			**86**		0.31]	
Heterogeneity: Tau² = 0.05; Chi² = 5.56, df = 4 (P =						
Test for overall effect: Z = 0.30 (P = 0.77)						
2.2.2 Peak Hip Abduction Angle in Stance						
Hetsroni et al, 2015	5.2	2.7	15	4.4	0.90]	
Hunt et al, 2013	2	3	30	2.2	0.44]	
Kennedy et al, 2009	1.4	3.3	17	4	0.00]	
Rylander et al, 2013	-1.1	5	17	2.2	0.06]	
Subtotal (95% CI)			**79**		0.20]	
Heterogeneity: Tau² = 0.14; Chi² = 6.98, df = 3 (P =						
Test for overall effect: Z = 1.16 (P = 0.25)						
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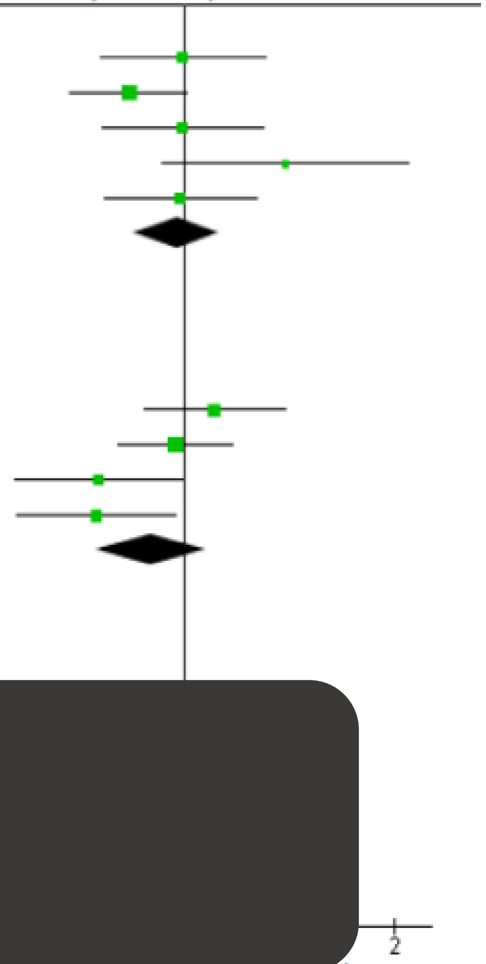
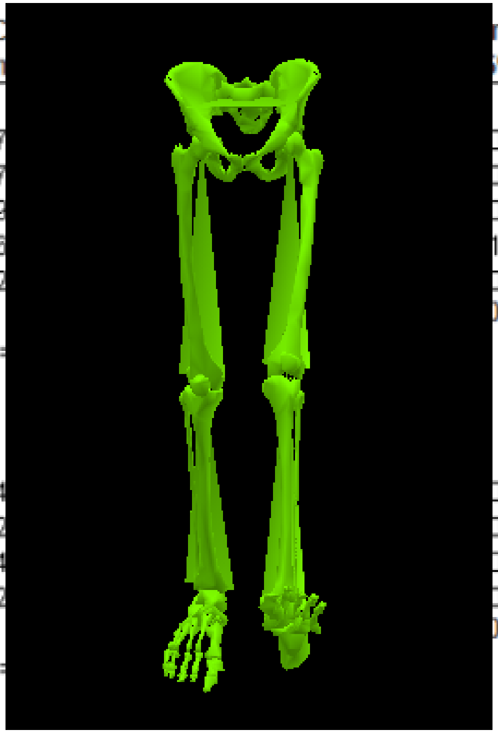
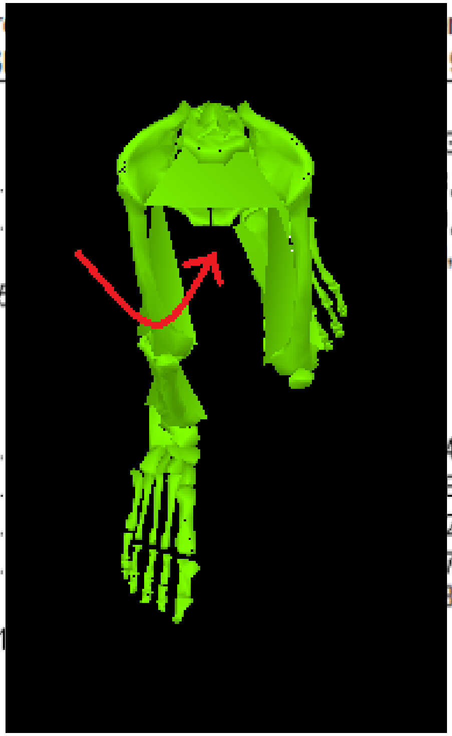


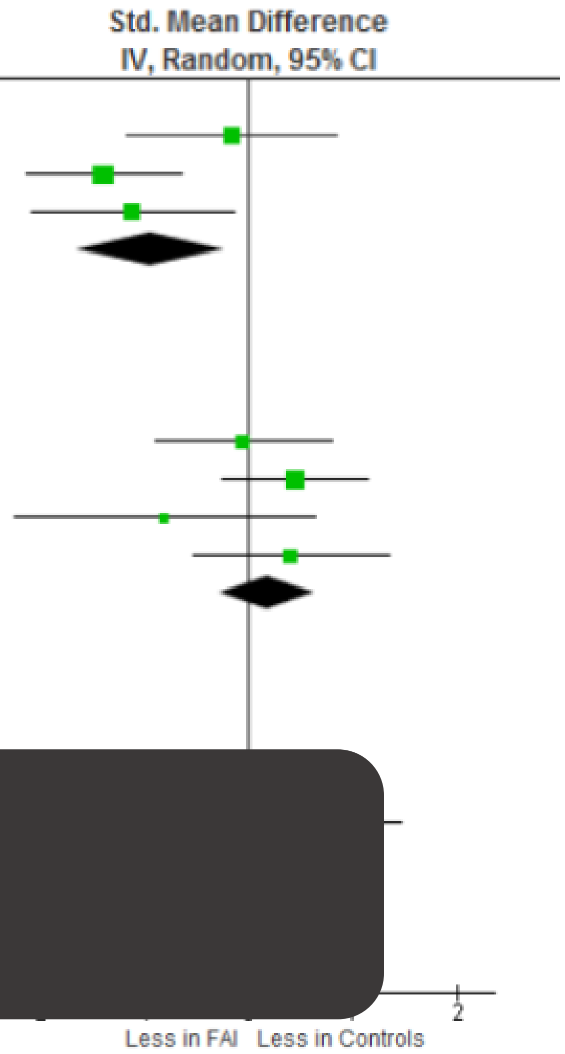


No difference in frontal plane kinematics

Results: Walking - Transverse Plane

Study or Subgroup	FAI Mean	SD	Total	Contr Mean	S	rence 95% CI
2.3.1 Peak Hip Internal Rotation Angle in Stance						
Diamond et al, 2016	0.4	5.3	15	1		3, 0.63]
Hunt et al, 2013	3.1	4.2	30	8.2	5.	, -0.46]
Rylander et al, 2013	6.5	5.6	17	11	5.	, -0.10]
Subtotal (95% CI)			**62**			**, -0.15]**
Heterogeneity: Tau² = 0.10; Chi² = 3.79, df = 2 (P = 0.15						
Test for overall effect: Z = 2.55 (P = 0.01)						
2.3.2 Peak Hip External Rotation Angle in Stance						
Hetsroni et al, 2015	14.8	8.9	15	15.1	13.	4, 0.60]
Hunt et al, 2013	9.7	7.8	30	7.1	7.	3, 0.84]
Kumar et al, 2014	4.6	5.9	7	7.7	4.	2, 0.47]
Rylander et al, 2013	4.7	5.6	17	3	5.	7, 0.98]
Subtotal (95% CI)			**69**			**3, 0.46]**
Heterogeneity: Tau² = 0.00; Chi² = 2.86, df = 3 (P = 0.41						
Test for overall effect: Z = 0.86 (P = 0.39)						
2.3.3 Total Transverse Plane ROM in Stance						
Hetsroni e						
Kumar et a						
Rylander e						
Subtotal (						
Heterogen						
Test for ov						



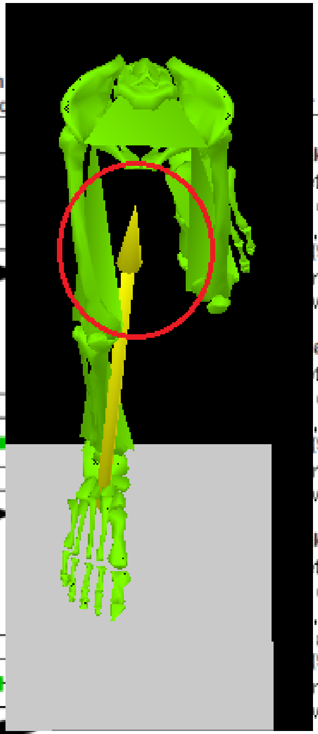


Smaller peak hip internal rotation angle
(-0.67, -1.19 to -0.16)

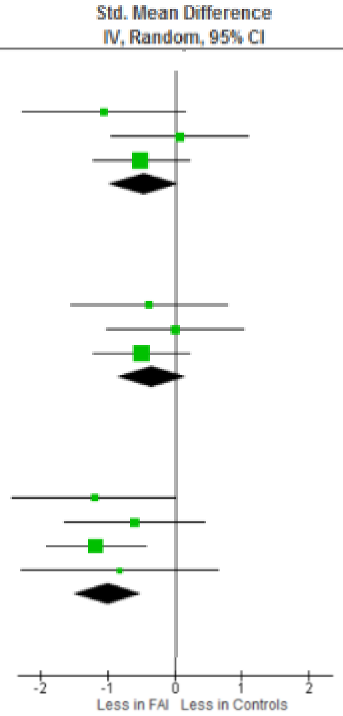
Results: Walking - Joint Torques

Study or Subgroup	FAI Mean	FAI SD	FAI Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.4.1 Peak Hip Flexion Torque								
Brisson et al, 2013	0.66	0.13	10	0.7	0.15	13	15.2%	-0.27 [-1.10, 0.56]
Diamond et al, 2016	7.1	3.2	15	6.4	4.1	14	18.7%	0.19 [-0.54, 0.92]
Hunt et al, 2013	0.48	0.15	30	0.56	0.16	30	31.4%	-0.51 [-1.02, 0.01]
Kumar et al, 2014	1.02	0.22	7	1.17	0.17	8	9.9%	-0.73 [-1.78, 0.33]
Samaan et al, 2016	1.36	0.26	15	1.29	0.39	34	24.8%	0.19 [-0.42, 0.80]
Subtotal (95% CI)			**77**			**99**	**100.0%**	**-0.19 [-0.54, 0.16]**
Heterogeneity: Tau² = 0.03; Chi² = 5.04, df = 4 (P = 0.28); I² = 21%								
Test for overall effect: Z = 1.06 (P = 0.29)								
2.4.2 Peak Hip Extension Torque								
Brisson et al, 2013	0.98	0.23	10	1.05	0.31	13	13.5%	-0.24 [-1.07, 0.59]
Diamond et al, 2016	4.3	2.2	15	5	2.3	14	17.3%	-0.30 [-1.04, 0.43]
Hunt et al, 2013	0.56	0.39	30	0.58	0.6	30	36.2%	-0.04 [-0.55, 0.47]
Kumar et al, 2014	0.71	0.19	7	0.83	0.1	8	8.2%	-0.76 [-1.82, 0.30]
Samaan et al, 2016	0.72	0.21	15	0.81	0.27	34	24.8%	-0.35 [-0.96, 0.26]
Subtotal (95% CI)			**77**			**99**	**100.0%**	**-0.25 [-0.55, 0.06]**
Heterogeneity: Tau² = 0.00; Chi² = 1.68, df = 4 (P = 0.80); I² = 0%								
Test for overall effect: Z = 1.60 (P = 0.11)								
2.4.3 Peak Hip Abduction Torque								
Brisson et al, 2013	0.2	0.05	10	0.23	0.08	13	17.6%	-0.42 [-1.26, 0.41]
Diamond et al, 2016	6	2.6	15	5.2	2.2	14	22.8%	0.32 [-0.41, 1.06]
Hunt et al, 2013	0.07	0.07	30	0.08	0.07	30	47.8%	-0.14 [-0.65, 0.37]
Kumar et al, 2014	0.89	0.23	7	0.84	0.12	8	11.8%	0.26 [-0.76, 1.28]
Subtotal (95% CI)			**62**			**65**	**100.0%**	**-0.04 [-0.39, 0.31]**
Heterogeneity: Tau² = 0.00; Chi² = 2.22, df = 3 (P …								
Test for overall effect: Z = 0.21 (P = 0.84)								

Std. Mean IV, Rando…



Subgroup	FAI Mean	FAI SD	FAI Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
k Hip Adduction Torque								
t al, 2013	0.68	0.11	10	0.79	0.16	13	19.2%	-0.75 [-1.61, 0.11]
et al, 2016	8.6	1.7	15	8.5	2.2	14	26.6%	0.05 [-0.68, 0.78]
, 2013	0.75	0.13	30	0.8	0.14	30	54.2%	-0.37 [-0.88, 0.15]
95% CI)			**55**			**57**	**100.0%**	**-0.33 [-0.71, 0.05]**
neity: Tau² = 0.00; Chi² = 2.00, df = 2 (P = 0.37); I² = 0%								
verall effect: Z = 1.72 (P = 0.09)								
ak Hip Internal Rotation Torque								
t al, 2013	0.11	0.04	10	0.12	0.03	13	20.3%	-0.28 [-1.11, 0.55]
et al, 2016	1	0.4	15	1	0.3	14	26.3%	0.00 [-0.73, 0.73]
, 2013	0.09	0.05	30	0.11	0.06	30	53.5%	-0.36 [-0.87, 0.15]
95% CI)			**55**			**57**	**100.0%**	**-0.25 [-0.62, 0.13]**
neity: Tau² = 0.00; Chi² = 0.63, df = 2 (P = 0.73); I² = 0%								
verall effect: Z = 1.30 (P = 0.19)								
k Hip External Rotation Torque								
t al, 2013	0.14	0.03	10	0.19	0.07	13	17.4%	-0.85 [-1.72, 0.01]
et al, 2016	1.2	0.4	15	1.4	0.5	14	24.0%	-0.43 [-1.17, 0.31]
, 2013	0.12	0.04	30	0.15	0.03	30	46.7%	-0.84 [-1.37, -0.31]
al, 2014	0.12	0.12	7	0.18	0.07	8	12.0%	-0.59 [-1.63, 0.46]
95% CI)			**62**			**65**	**100.0%**	**-0.71 [-1.07, -0.35]**
neity: Tau² = 0.00; Chi² = 0.93, df = 3 (P = 0.82); I² = 0%								
verall effect: Z = 3.96 (P = 0.0001)								



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

Squat

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

Study or Subgroup	FAI Mean	FAI SD	FAI Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Bagwell et al, 2016	70	18	15	51	14	15	35.0%	1.15 [0.37, 1.93]
Lamontagne et al, 2009	41.5	12.5	15	32.3	6.8	11	31.9%	0.85 [0.03, 1.67]
Ng et al, 2015	44	10	12	37	8	14	33.1%	0.76 [-0.05, 1.56]
Total (95% CI)			**42**			**40**	**100.0%**	**0.92 [0.46, 1.38]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.51$, $df = 2$ ($P = 0.77$); $I^2 = 0\%$
Test for overall effect: $Z = 3.91$ ($P < 0.0001$)

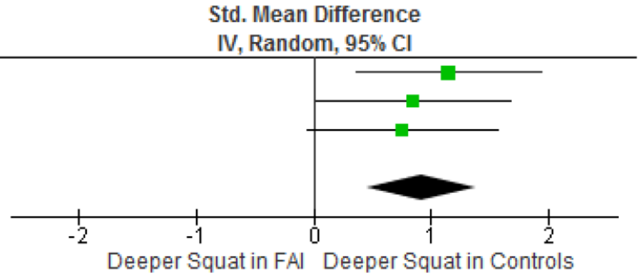


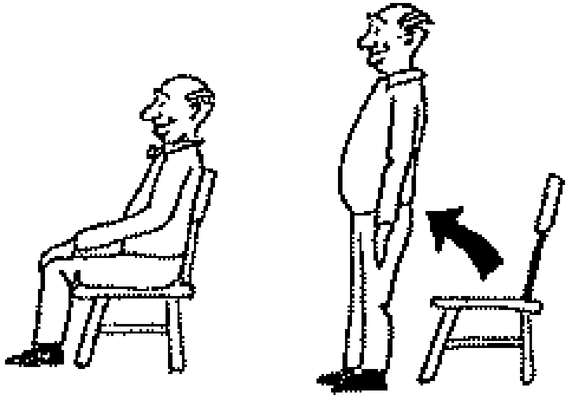
Figure 3 Meta-analysis of squat depth, FAI vs Controls

  - 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



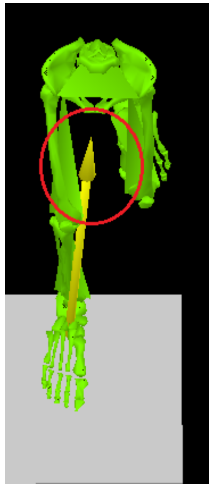
Drop Landing

Insufficient evidence to draw conclusions for clinical practice on these tasks

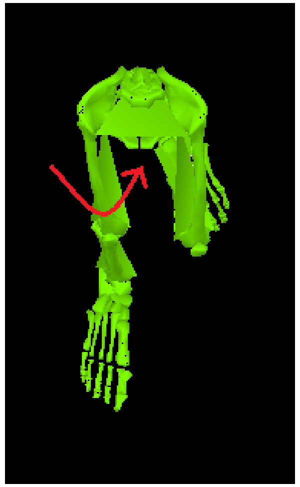
Image sources: Wikimedia, sketchite.com, Women's Running Magazine

Discussion: Walking

- Internal rotation is often reported as painful[21]
- Results



Smaller peak hip external rotation torque



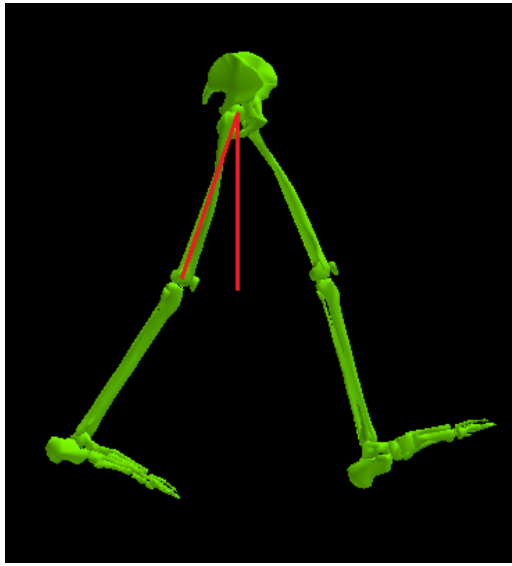
Smaller peak hip internal rotation angle

- May be strategies to avoid a painful position

21. Byrd, 2014

Discussion: Walking

- Lower peak hip extension during stance phase of walking
- Consistent with a variety of hip conditions
  - Early OA,[22] Late OA,[23, 24] THR[25]



- Reduce anterior hip joint contact force[26]

- Increase fatty infiltrate[27]
- Decrease hip stability over time[28, 29]

?

- Coping strategy or inherent movement pattern resulting in symptoms

22. Watelain et al. 2001
23. Constantinou et al. 2017
24. Hurwitz et al. 1997
25. Beaulieu et al. 2010
26. Lewis et al. 2010
27. Zacharis et al. 2016
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

Project FORCe

Thankyou and Questions?

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Project FORCe

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LA TROBE SPORT AND EXERCISE MEDICINE RESEARCH CENTRE

Australian Government
National Health and Medical Research Council
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