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Assessing risk factors for early hip osteoarthritis in activity-related hip pain: a Delphi study

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ABSTRACT

Objective: Hip pain and injury as a result of activity can lead to the development of early hip osteoarthritis (OA) in susceptible individuals. Our understanding of the factors that increase susceptibility continues to evolve. The ability to clearly identify individuals (and cohorts) with activity-related hip pain who are at risk of early hip OA is currently lacking. The purpose of this study was to gain expert consensus on which key clinical measures might help predict the risk of early hip OA in individuals presenting with activity-related hip pain. The agreed measures would constitute a standardised approach to initial clinical assessment to help identify these individuals.

Methods: This Dephi study used online surveys to gain concordance of expert opinion in a structured process of 'rounds'. In this study, we asked 'What outcome measures are useful in predicting hip OA in activity-related hip pain?' The Delphi panel consisted of experts from sport and exercise medicine, orthopaedics, rheumatology, physiotherapy and OA research.

Results: The study identified key clinical measures in the history, examination and investigations (plain anteroposterior radiograph and femoroacetabular impingement views) that the panel agreed would be useful in predicting future risk of hip OA when assessing activity-related hip pain. The panel also agreed that certain investigations and tests (eg, MR angiography) did not currently have a role in routine assessment. There was a lack of consensus regarding the role of MRI, patient-reported outcome measures (PROMs) and certain biomechanical and functional assessments.

Conclusions: We provide a standardised approach to the clinical assessment of patients with activity-related hip pain. Assessment measures rejected by the Delphi panel were newer, more expensive investigations that currently lack evidence. Assessment measures that did not reach consensus include MRI and PROMs. Their role remains ambiguous and would benefit from further research.

Strengths and limitations of this study

- This study provides expert consensus on the components of a routine clinical assessment for individuals with activity-related hip pain to help identify groups at risk of future hip osteoarthritis (OA).
- This study provides an overview of current available evidence for hip OA risk factors with summary tables of evidence.
- The literature review was performed as a narrative, not systematic, review.
- The lack of current evidence in young, active populations meant that the expert panel had to extrapolate evidence from studies involving older populations.

INTRODUCTION

The Arthritis Research UK Centre for Sport, Exercise and Osteoarthritis aims to reach a better understanding of the mechanisms linking sport, exercise, injury and osteoarthritis (OA) in order to develop strategies that will enable the whole community to safely and effectively exercise and participate in sport. A standardised approach to assessing patients with activity-related hip joint pain enables future research into identifying cohorts at risk of early hip OA, which then allows meaningful research into prevention and intervention. Currently, there is no general consensus on outcome measures that should be sought when assessing these patients. The aim of this paper is to seek agreement about a standardised approach to assessment from a panel of experts from the fields of OA research, sport and exercise medicine (Sport Advisory Group), physiotherapy, orthopaedic surgery and rheumatology.

The hip joint was identified as a key joint of interest for initial research by the Sports Advisory Group. This group was formed in 2013 of sports medicine experts including the Chief Medical Officers from the national governing bodies of football, rugby, cricket, horse racing, golf, tennis, athletics, dance, Paralympic sport, English Institute of Sport

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and the Ministry of Defence. The group advises the Arthritis Research UK Centre for Sport, Exercise and Osteoarthritis on key areas for sports-related research.

The burden of symptomatic hip OA is substantial and lifetime risk has been estimated as one in four.[1] Early hip OA in younger age groups is not insignificant. Prevalence in the 45–54-year age group has been found to be 1 in 20 for symptomatic hip OA and one in five for radiographic hip OA.[2] The prevalence was found to be slightly higher for men in the younger age groups and higher in women in the over 65s.[2]

Increasing activity levels is a key target for improving the general health of the nation.[3 4] A potential adverse consequence of activity is joint injury. There is good evidence that traumatic hip joint injury plays an important role in the development of early hip OA.[5] However, there are other well-recognised factors that influence an individual's risk of OA including non-modifiable factors such as gender, genetics and advancing age[6 7] and modifiable factors such as obesity and occupation.[5]

In addition to the well-established risk factors, there is evolving evidence of other potentially modifiable factors such as the shape of the femoral head and neck. A focused review of the literature by Harris-Hayes and Royer in 2011 found that an association exists between bony abnormalities found in femoroacetabular impingement (FAI) and acetabular dysplasia and hip OA. Since then, further studies have examined this relationship. A longitudinal cohort study of 455 women showed a 2.7-fold increase in risk of radiographic OA (not symptomatic OA) at 19 years in individuals with a CAM-type deformity at the femoral head/neck junction.[8] Agricola *et al*[9] investigated the association between hip shape and clinical OA and total hip replacement (THR) and found that hip shape could not predict clinical OA as defined by the American College of Rheumatism criteria but could predict risk of THR at 5-year follow-up. CAM-type deformities appear to develop in early adolescence and current thinking is that they develop in young individuals exposed to high-impact activity[10] due to alterations across the growth plate in the hip.[11] There is growing evidence that FAI predisposes to early onset hip OA. Evidence is not yet clear on the best way to manage FAI. There is a body of opinion that believes that early surgical intervention for treatment of FAI may decelerate the degenerative process in young patients.[12]

Other potentially modifiable risk factors of relevance to an active population is the type of sport or activity participated in and the intensity and volume of participation. These factors have been the focus of a number of systematic reviews and several smaller case–control studies that have found inconsistent results. Several case–control studies have found significantly increased prevalence of hip OA in exprofessional footballers.[13 14] One study controlled for injury and found a significant increase in hip OA despite the absence of notable hip injuries.[13 14] Other sports have also been shown to increase the risk of premature hip OA including ice hockey,[15] handball[16] and racquet sports.[17] However, not all the literature is in agreement. A recent systematic review found inconclusive results for the risk of developing hip OA with respect to levels of physical activity or sport specificity in the absence of hip joint injury.[5]

In order to research these modifiable risk factors for hip OA further, an initial step is to be able to accurately identify an at-risk cohort of people who present with activity-related hip pain. This relies on relevant information being obtained as standard at clinical assessment. This may include relevant history, examination, imaging, blood tests and patient-Reported outcome measures (PROMs). The detail of this assessment is not clear from available evidence and there are differences of opinion among specialists.

This study was designed to identify key elements that comprise a routine clinical assessment of a patient with activity-related hip to help predict the risk of early hip OA. This standardisation will enable identification of at-risk cohorts for future research. Since there is a paucity of evidence regarding a minimum standard for assessment, the study used the Delphi process of seeking expert consensus of opinion. The Delphi participants included the Sport Advisory Group and experts from the fields of OA research, sport and exercise medicine, orthopaedics, rheumatology and physiotherapy.

METHODS

A Delphi study is a structured process that invites experts to complete a series of 'rounds' (in this study via online surveys) to gather and refine information on the study question, until expert consensus is reached (4).

Study structure

The study structure is outlined in figure 1.

Definition of concordance

Expert consensus was reached for a clinical measure when there was adequate concordance. Concordance was defined as a clinical measure being accepted when ≥60% participants agree and a measure being rejected if ≤20% participants agree. This definition has been used in previous OARSI Delphi studies.[18 19]

Participant identification

Experts were selected from a wide range of representative bodies relevant to the fields of exercise, sport, sport injuries and OA. These include the Sport Advisory Group (see Introduction section), other sport-specific experts and allied professionals including orthopaedic hip surgeons, rheumatologists, physiotherapists and experts in OA research. The criteria agreed by the authors were the following:

- Chief Medical Officer (or equivalent) of Sporting National Governing bodies

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Pre-Delphi survey: Sport Advisory Group asked which joints are of particular interest with respect to predicting long-term risk of OA following activity-related pain or injury. The hip joint was identified as an initial priority.

Round 1: Survey asked two open-ended questions to collate all potentially relevant outcome measures used by a clinician when assessing activity or injury-related hip pain (history, examination, radiology, blood tests etc.):

- When assessing a patient with activity-related hip pain, what clinical tools would you currently use to help predict the risk of developing early OA in the hip joint?
- Are there any clinical tools that you are aware of (but may not routinely use) that help predict the risk of developing early OA following activity-related hip pain?

Round 2: Each suggestion was re-worded into a statement of fact as in the following example:

*'It is useful to routinely perform an **AP radiograph** in patients with injury or activity-related hip/groin pain when considering their future risk of osteoarthritis'.*

The expert was asked to accept or reject using a 5-point Likert scale (strongly agree, agree, unsure, disagree, strongly disagree). Concordance was sought - see definition below. Participants were asked to identify their own specialty and research background to enable sub-group analysis.
A literature search (PubMed, Cinahl, Embase, AMED and PEDro) was performed for each Round 1 suggestion in the context of hip OA. The available evidence was summarised in tables and provided to participants for this round.

Round 3: Suggestions that did not reach a consensus of opinion were sent back to participants in the third round. Participants were given the concordance from the previous rounds and invited to re-rate each test. Again the participants were asked to identify their specialty and research background.

Figure 1 Methodology overview (AP, anteroposterior; OA, osteoarthritis).

- Ten years clinical experience in relevant specialty (rheumatology, orthopaedics, physiotherapy, sports medicine)
- Researcher who has published in the area of activity-related hip pain or hip OA

An introductory letter and information sheet (Plain Language Statement) were emailed to 33 potential Delphi panel experts and 23 experts responded and participated. One non-clinical researcher declined to participate and there were a further nine non-respondents (5 clinicians, 3 clinical researchers and 1 non-clinical researcher).

The final panel consisted of 23 participants: 12 clinical researchers (3 orthopaedic surgeons, 3 sports medicine physicians, 3 rheumatologists, 3 physiotherapists), 8 clinicians (sports medicine) and 3 non-clinical OA researchers. It was an international panel from the UK, Australia, China, Japan, Sweden and Denmark.

One full-time researcher only completed round 1 and did not provide an identifying email and therefore could not be included in the Delphi study. By the end of the study, one further participant (clinician) had dropped out for unspecified reasons.

Inclusion/exclusion criteria for participants

All invited experts who completed round 1 and made themselves identifiable to the investigator were included in the study as Delphi participants. The expert panel was selected as detailed above. If the participant did not have access to a computer to complete the online surveys, they were excluded. There were no further exclusion criteria.

Informed consent

There was no explicit written consent for this study. By completing the round 1 online survey, we assumed there

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was an implied consent to participate. This was explained to participants in the introductory email.

Discontinuation/withdrawal of participants from study

Participation in the study was entirely voluntary and withdrawal from the study could occur at any point. The dropout rate was as follows: round 1: 23 participants, round 2: 22 participants and round 3: 21 participants.

Definition of end of study

The study ended after three rounds of online surveys.

Literature search

A literature search was performed between September and November 2013 by KAJ on all suggestions from round 1 (see online supplementary file 1). The authors did not identify additional risk factors from their knowledge of the literature or through the search of the current literature. The search was performed on five databases (PubMed, Cinahl, EMBASE, AMED and PEDro). Each literature search used a round 1 suggestion combined with the following core search terms: coxarthrosis, osteoarthritis, arthrosis, hip, risk, predict*.

Each search was performed systematically using the same core search terms on each of the databases listed above. Each study included was rated as per Centre for Evidence-Based Medicine Levels of Evidence guidelines.[20] This rating was performed by KAJ and reviewed by JLN. This reference was provided to the panel for those not familiar with its use. All studies level 4 and above were included in the evidence tables. In the absence of robust studies in young, active populations, the selection criteria for evidence included risk factors for hip OA in all populations (not restricted by age or activity level). The population characteristics were stated in the evidence tables to allow appropriate interpretation of the study results by the expert panel.

The results of the literature search were summarised in the tables. The tables of evidence were provided to the Delphi participants in round 2 to inform their decision-making process (see online supplementary file 2).

RESULTS

Round 1 results

Over 40 suggestions were provided by the Delphi panel in the first round (figure 2). Related suggestions were grouped together for simplicity. The suggestions were

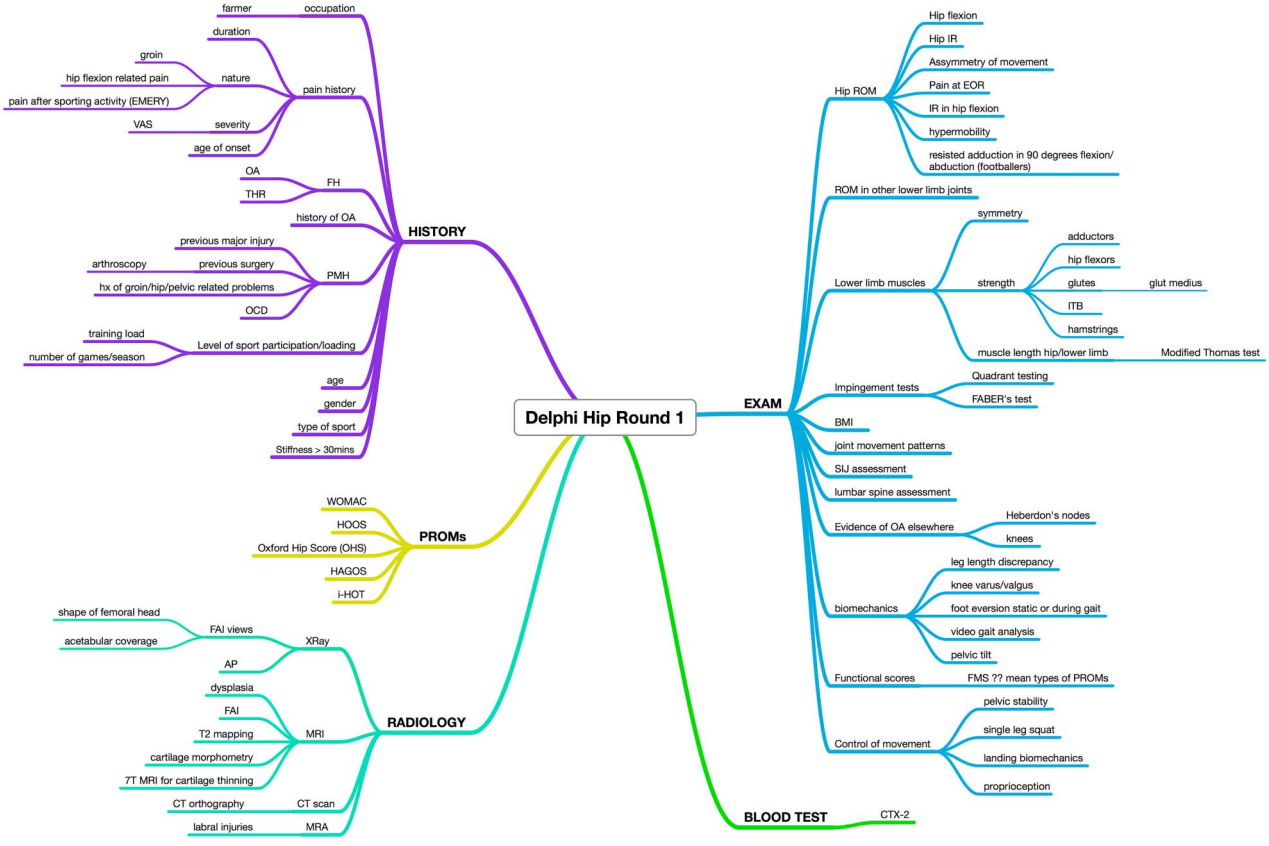

Figure 2 Delphi round 1 results (AP, anteroposterior; BMI, body mass index; EOR, end of range; FABER, flexion abduction and external rotation; FAI, femoroacetabular impingement; FH , family history; FMS, functional movement screen; HAGOS, Copenhagen Hip and Groin Score; HOOS, Hip Disability and Osteoarthritis Outcome Score; i-HOT, International Hip Outcome Tool; ITB, iliotibial band; OA, osteoarthritis; OCD, osteochondral defect; OHS, Oxford Hip Score; PMH, previous medical history; PROMs, patient-reported outcome measures; THR, total hip replacement; WOMAC, Western Ontario McMaster Universities Arthritis Index; VAS, visual analogue scale).

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categorised into history, examination, blood tests, radiology and PROMs. One suggestion from the surveys was not identifiable as an outcome measure and so thought to be a typing error and had to be omitted.

Round 2 results

The Delphi participants reached consensus of opinion on 29 statements (table 1): 25 statements were accepted that is, ≥60% agreed or strongly agreed and 4 statements were rejected that is, ≤20% agreed or strongly agreed (table 2). The remaining round 2 statements that did not reach consensus were sent back to the experts in the next round (table 3).

Table 1 Accepted suggestions following round 2

Suggestions reaching concordance for acceptance after round 2	Agreed/strongly agreed, %
Radiology	
1. AP radiograph	65
2. FAI views	68
History	
3. Occupation	100
4. Age	91
5. Gender	77
6. Type of sport	91
7. Level of sport participation	95
8. Family history of OA	82
9. Medical history of OA	95
10. Previous hip injury	100
11. Previous hip surgery (eg, arthroscopy)	95
12. Osteochondral defects	81
13. Nature of pain (eg, duration, severity, location)	82
14. History of aggravating movements (eg, flexion)	86
15. Stiffness	71
16. Timing of pain in relation to activity	67
Examination	
17. Absolute range-of-movement of hip	91
18. Pain-related hip movements	83
19. Impingement testing (eg, FADIR or FABER)	83
20. Hypermobility assessment	61
21. Muscle strength around hip and pelvis (eg, hip flexors, gluteal muscles, ITB, hamstrings, adductors)	70
22. BMI	96
23. Lumbar spine assessment	74
24. Evidence of OA elsewhere (eg, Heberden's nodes, knee OA)	83
25. Single leg squat assessment	70

AP, anteroposterior; BMI, body mass index; FABER, flexion abduction and external rotation; FADIR, flexion, adduction, internal rotation; FAI, femoroacetabular impingement; ITB, iliotibial band; OA, osteoarthritis.

Table 2 Rejected suggestions following round 2

Suggestions reaching concordance for rejection after round 2	Agreed or strongly agreed, %	Disagreed or strongly disagreed, %
Radiology		
1. CT scan	9	74
2. MRA	9	70
Blood tests		
3. CTX- II	14	36
Examination		
4. Video gait analysis	13	52

MRA, MR angiography.

Round 3 (final) results

The Delphi participants reached consensus of opinion on a further nine statements: seven more statements were accepted, two more statements were rejected. Twelve clinical measures failed to reach consensus following the final round. Figure 3 shows an overview of the final results and is divided into clinical measures that were accepted, rejected or failed to reach consensus. The final consensus level is in brackets.

Analysis of the uncertain suggestions by research background and specialty

The results were broken down for subanalysis by participant's research background and by the participant's specialty. To maintain anonymity, the sole non-clinical researcher was combined with the clinical researcher group. The numbers were too small for meaningful interpretation, but the subanalysis graphs are available (see online supplementary file 3).

DISCUSSION

The Delphi process has identified, through consensus of opinion, a standardised assessment in the form of history, examination and basic radiographic investigations that the expert panel would routinely perform in individuals with activity-related hip pain to help identify individuals at higher risk of early OA. This assessment is summarised in table 4.

History

The agreed points to note in the history include the non-activity-related OA risk factors (eg, family history) as well as factors particular to an individual's sport or exercise. Systematic reviews[5 21] have established the evidence base for several well-recognised risk factors for hip OA such as previous hip injury, occupations involving heavy lifting and obesity. A large US Defense epidemiological study by Scher *et al*[6] found increasing age (>40 years) and female gender to be risk factors for hip OA.

The heritability of hip OA has been calculated in twin studies as 50–60% for radiographic OA, independent of environmental or demographic confounding factors.[22 23] A recent study found that after adjustment

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Table 3 Suggestions that did not reach concordance following round 2

Suggestions failing to reach concordance after round 2	Agreed or strongly agreed, %	Disagreed or strongly disagreed, %	Uncertain, %
Radiology			
1. 1.5 T MRI	35	43	22
2. 3 T MRI	48	22	30
3. T2* MAPPING MRI	30	30	40
4. 7 T MRI	22	39	39
Proms			
5. WOMAC	30	48	22
6. OXFORD HIP SCORE	35	35	30
7. HOOS	48	17	35
8. HAGOS	48	9	43
9. i-HOT	35	9	57
History			
10. Age of onset of pain	57	5	33
Examination			
11. Sacroiliac joint assessment	39	30	31
12. Leg length discrepancy	57	22	21
13. Knee varus/valgus	44	26	30
14. Foot eversion	35	35	30
15. Landing biomechanics	30	40	30
16. Proprioception	35	22	43
17. Functional movement control	43	22	35
18. Range of motion of other lower limb joints	48	17	35
19. Symmetry of lower limb muscles	52	17	31
20. Lower limb flexibility/muscle length	43	13	44
21. Pelvic stability	39	17	44

HAGOS, Copenhagen Hip and Groin Score; HOOS, Hip Disability and Osteoarthritis Outcome Score; i-HOT, International Hip Outcome Tool; Proms, patient-reported outcome measures; WOMAC, Western Ontario McMaster Universities Arthritis Index.

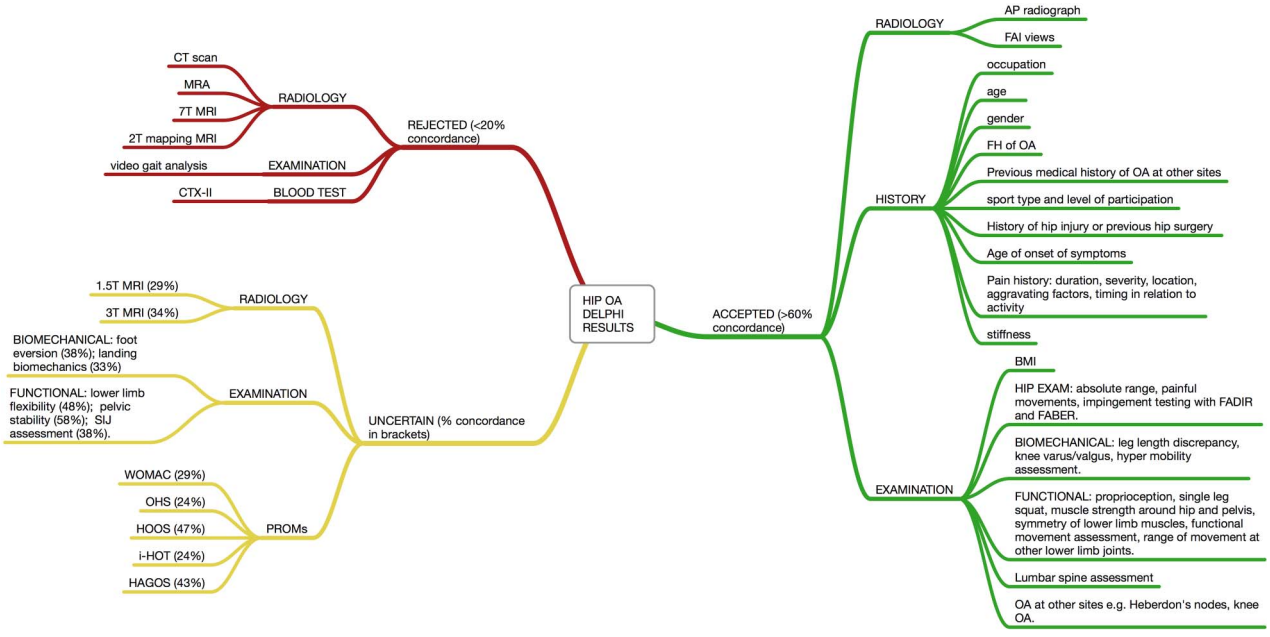

Figure 3 Overview of final Delphi results (AP, anteroposterior; BMI, body mass index; FABER, flexion abduction and external rotation; FADIR, flexion, adduction, internal rotation; FAI, femoroacetabular impingement; HAGOS, Copenhagen Hip and Groin Score; HOOS, Hip Disability and Osteoarthritis Outcome Score; i-HOT, International Hip Outcome Tool; IR, internal rotation; MRA, MR angiography; OA, osteoarthritis; OHS, Oxford Hip Score; PROMs, patient-reported outcome measures; ROM, range of motion; WOMAC, Western Ontario McMaster Universities Arthritis Index).

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Table 4 Overview of agreed standardised assessment following Delphi consensus

History	Examination	Investigations
Age	BMI	AP radiograph hip
Gender	Evidence OA other sites eg, knees	FAI view radiograph hip
Occupation	Leg length discrepancy	
Family history of OA	Knee varus/valgus	
History of hip problems, hip injury or hip surgery	Hypermobility	
History of OA at other sites	Hip absolute ROM/hip painful movement	
Age of onset of symptoms	FADIR impingement test	
Type of sport or exercise	FABER test	
Level of sporting participation	Proprioception	
Pain history (duration, severity, location, aggravating factors, timing in relation to activity)	Single leg squat	
	Lower limb muscle strength and symmetry	
	ROM other lower limb joints	
	Functional movement assessment	
	Lumbar spine assessment	

AP, anteroposterior; BMI, body mass index; FABER, flexion abduction and external rotation; FADIR, flexion, adduction, internal rotation; FAI, femoroacetabular impingement; OA, osteoarthritis; ROM, range of motion.

for confounders that cause secondary morphological change, individuals with a hereditary predisposition to end-stage hip OA had a higher prevalence of morphological abnormalities associated with hip OA.[24] Research into the genes responsible is challenging because candidate gene studies and genome-wide association studies show that OA is genetically heterogeneous with each individual common gene variant contributing only modestly to the risk of OA.[22]

Pollard *et al*[24] found that a family history of end-stage idiopathic OA increases the likelihood of an individual having a CAM deformity with an OR of 2.1 (95% CI 1.3 to 3.5).

There is good evidence that previous joint injury predisposes an individual to developing hip OA.[5 7 25] The definition of hip injuries varied between studies and included injuries that resulted in lost training time, injuries that resulted in medical consultations or injuries that resulted in fractures or internal derangement of the joint. Cooper *et al*'s study of 611 men and women defined hip injury as the inability to weight bear for at least 1 week and occurring at least 1 year prior to onset of hip pain. In this study, previous hip injury was associated with an overall 4.3-fold increase in the risk of hip OA, greater in men (OR=24.8, 95% CI 3.1 to 199.3) than women (OR=2.8, 95% CI 1.4 to 5.9).[25] There is also a strong association between congenital hip dysplasia and risk of hip OA.[26] Perthes disease has been shown to increase risk of subsequent THR.[27]

Level of activity and risk of OA was the subject of a recent systematic review by Richmond *et al*[5] The review found that joint injury was a clear risk factor for future hip OA, but the findings were inconclusive for level of activity mainly due to the heterogeneous small study designs. However, there are several case–control studies that suggest that an individual who plays sport at the elite level has an increased risk of hip OA even in the absence of hip injury.[13 14 16 28] In addition, there is evidence that the type of sport played appears to be relevant. The incidence of CAM-type hip morphology is increased in particular sports including football (soccer), basketball and ice hockey.[10 11 29]

Examination

The standardised examination includes body mass index (BMI), which is known to be a risk factor for lower limb OA (strong association for knee OA, weaker for hip OA) and standard hip range of movement, for which there is evidence that reduced internal rotation is associated with hip OA. The current evidence for BMI as a risk factor for hip OA appears to show a weak, population-based increase in risk. Increased BMI in early and middle adulthood has been shown in one large cohort study[30] to increase the risk of THR with an HR of 1.29 per 5 kg/m^2 (95% CI 1.21 to 1.37). Another large cohort study found that the risk of hip OA increased as the BMI increased from an HR of 1.46 if overweight, 1.75 if obese and 1.93 if morbidly obese.[31] The strength of association between obesity and OA was found to be greater for knee OA than hip OA.[5 30] Several cohort studies and a case–control study have failed to find a significant association between obesity and risk of hip OA.[32–34]

Restricted hip internal rotation has been shown to be predictive of the presence of hip OA in new presenters to primary care with hip pain.[35] It may also signify impingement from a CAM deformity as suggested by a number of small studies.[36 37] Impingement tests have been studied in the context of identifying labral tears or intra-articular pathology. A recent systematic review with meta-analysis concluded that when pretest probability of FAI or labral tear is high, few hip clinical tests

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actually make a significant change in post-test probability for the potential of FAI/acetabular labral tear existing. Two tests had enough data to support their use as screening tests for FAI or labral tears: FADIR (flexion, adduction, internal rotation) test and the Flex-IR (flexion, internal rotation) test.[38] Evidence is lacking for the use of any test in the context of predicting early hip OA directly. Biomechanical and functional assessments are included in the routine assessment by consensus of opinion. There is currently a lack of evidence for their use in this context.

One paper was identified regarding self-reported biomechanical abnormalities and risk of hip OA in 1901 men and women.[39] It found no significant association between knee valgus or varus and hip OA. Leg length inequality was not significantly associated with either hip symptoms or hip OA.[40 41]

Investigations

Investigations that the panel agreed should be routinely performed include anteroposterior (AP) radiograph of the hip and FAI impingement view radiograph of the hip. AP radiographs may well be considered fairly routine in this context, but FAI view radiographs may not be so widely considered. These views look for FAI by looking at the shape (α angle) of the head/neck junction of the hip. There is currently a lack of uniformity in the literature regarding the cut-off point for the α angle that is considered 'normal'. Radiological assessment of CAM deformity (also known as CAM lesion or pistol grip deformity) has been increasingly studied as a potentially relevant predictor of OA risk. Several cohort studies of non-elite populations have performed radiographic assessment of a CAM deformity through α-angle measurement. The α angle of Nötzli[42] estimates the degree at which the radius of curvature of the femoral head begins to increase.[43] The definition of a CAM deformity differs between studies varying from an α angle >50°[44 45] to an α angle >65°.[8 46–48] A recent study has tried to address this uncertainty by assessing the distribution of α angles in 2005 men and women aged 45–65 years from two large cohorts. The resulting distribution was used to determine a threshold of 60° for presence of a CAM deformity.[49]

A cohort study by Thomas *et al*[8] found that a CAM deformity defined as an α angle >65° on an AP radiograph was associated with a 2.7-fold increased risk of radiographic OA in women (95% CI 1.63 to 4.33, p<0.001). A nested case–control study by Thomas *et al*[47] found that a CAM deformity defined as an α angle >65° was associated with a sixfold increase in the risk of total hip arthroplasty in women (95% CI 2.04 to 17.59, p<0.001). A cross-sectional cohort study by Gosvig *et al*[50] found that a pistol-grip deformity (CAM deformity) was associated with a risk ratio for developing hip OA of 2.2 (95% CI 1.7 to 2.8).

Other smaller studies found that having a CAM deformity of the hip is associated with an increased risk of subsequent hip OA,[51 52] a fourfold risk (OR 4.0, 95% CI 1.26 to 12.71) of acetabular cartilage damage[48] or an increased risk of THR.[9]

Rejected assessment measures

The six rejected suggestions included newer, more sophisticated imaging, video gait analysis and CTX-II blood test. These procedures are costly or invasive or both. There is no current evidence to support their use in the context of routine assessment.

MRI is evolving with new technology allowing greater detail (eg, 7 T MRI) and increased information regarding damaged cartilage (eg, functional MRI). Functional MRI such as delayed gadolinium-enhanced MRI is being used to demonstrate cartilage damage. Normal cartilage has a high glycosaminoglycan (GAG) content and damaged cartilage a low GAG content. The uptake of gadolinium is inversely proportional to the GAG content of the cartilage, so damaged cartilage will take up a higher concentration. Although the relationship between cartilage damage and OA is not fully understood, there have been several small or preliminary studies looking at the potential for functional MRI to be used as radiological biomarkers for early hip OA.[53–59]

The only blood test defined by the expert group was serum CTX-II. The literature search did not identify any evidence for serum CTX-II as a potential predictor of hip OA. The ECHODIAH cohort was a 3-year longitudinal multicentre trial that identified urinary (not serum) CTX-II as a potential predictor of structural progression of hip OA.[60] The patients in the study already had established hip OA and were in the age group 50–75 years.

CTX-II is one of a number of potential wet biomarkers that has been researched with the hope of providing a diagnostic tool. The majority of OA wet biomarker studies have looked at knee OA, not hip OA. Recent editorials and reviews of wet biomarkers for OA prediction highlight their current poor sensitivity and specificity and, as a result, are currently still research tools.[61–63]

Measures that failed to reach consensus

PROMs are useful in clinical and research settings. However, they are often very detailed which precludes routine clinical use. To address this, there are attempts to provide validated shorter versions of some PROMs (eg, i-HOT 33 and the shorter i-HOT 12). None of the PROMs identified are currently validated for use as predictive tools for the future hip OA risk in active people. The Western Ontario McMaster Universities Arthritis Index (WOMAC), Hip Disability and Osteoarthritis Outcome Score (HOOS) and Oxford Hip Score (OHS) were developed and validated to monitor hip OA symptoms[64], hip disability symptoms[65] and to assess outcome after hip surgery,[66 67] respectively. The Copenhagen Hip and Groin Score (HAGOS) and the International Hip Outcome Tool (i-HOT) have been developed more recently to monitor hip and groin symptoms in young

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Box 1 Priorities for future research

- A need to develop prospective cohorts of young, active people with hip pain.
- Research to identify and validate a patient-reported outcome measures that can be used in this population to help identify and monitor those at higher risk of early hip osteoarthritis.
- Further research in imaging techniques to identify optimal investigations for patients with activity-related hip pain.

active populations[68–70] and, as such, may prove useful for researching risk of future hip OA.

The panel could not agree on the role of 1.5 T and 3 T MRI. MRI can identify abnormal hip morphology and pathology. Its role in identifying early hip OA is unclear. There is no available evidence that it is superior to plain radiographic FAI views for identifying CAM lesions, and therefore its comparative expense prevents it being a first-line investigation of choice for this purpose.[71] More research is needed to prove that the additional information is useful and cost-effective in routine clinical practice.

CONCLUSION

This Delphi study provides a standardised approach to the assessment of patients with activity-related hip. The final agreed assessment is summarised in table 4.

Assessment measures rejected by the Delphi panel were newer, more expensive investigations that currently lack evidence. Those that did not reach consensus include MRI and PROMs. Their role remains ambiguous and would benefit from further research (box 1).

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Data sharing statement The raw individual data is not available because this study was conducted with anonymity for the participants. Subanalysis of the results by research background and specialty are available in the additional data files.

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Additional Data File 1 – list of all search terms derived from Delphi experts' suggestions

SEARCH TERMS FROM ROUND 1 SUGGESTIONS				
HISTORY	**PROMs**	**RADIOLOGY**	**BLOOD TEST**	**EXAMINATION**
Age Gender Occupation Family history OA Family history THR History of OA History of hip surgery History of OCD History of hip injury Type of sport Level of sport Hip stiffness Hip pain (duration, nature, severity, age of onset)	WOMAC HOOS OHS HAGOS i-HOT	X-RAY/plain radiograph FAI view radiograph CT SCAN MRA/ MR arthrogram MRI/hip dysplasia/FAI/ T2 mapping/physiological MRI/3T MRI/7T MRI	CTX-II	Hip ROM (hip flexion, hip IR, asymmetry, painful end range movement, combined flexion/internal rotation, ROM knee, ROM ankle Muscle symmetry Muscle strength (adductors, hip flexors, gluteals, ITB, hamstrings) Impingement tests, (Quadrant testing, FADIR test, FABER test). Joint movement patterns SIJ assessment Lumbar spine assessment Heberdon's nodes Knee OA Functional Movement Scores Biomechanics (leg length discrepancy, knee varus, knee valgus, foot eversion, video gait analysis, pelvic tilt) Pelvic stability Single leg squat Landing biomechanics Proprioception Hypermobility BMI

Additional Data File 2 – Summary Tables of Current Evidence for Risk Factors for Hip OA

TABLE 1: XRAY AND PREDICTION OF HIP OA								
AP - anteroposterior, OA = osteoarthritis, FAI = femoracetabular impingement, K&L - Kellgren-Lawrence radiographic scale of OA, THA - total hip arthroplasty								
STUDY FINDINGS	**OVERVIEW**	**STUDY POPULATION**	**LEVEL OF EVIDENCE (CEBM 2009)**					**REFERENCE**
			1	2	3	4	5	
Hip morphology characteristics of FAI or mild dysplasia is predictive of OA development at 19 years follow-up	Longitudinal cohort study. AP radiographs compared at year 2 and year 20. CAM deformity defined by α angle >65° on AP pelvic radiograph was associated with a 2.7 fold increased risk of OA (95% CI 1.63-4.33, p<0.001). Dysplasia as identified by measurement of lateral centre edge angle was an independent predictor of OA development.	n=466, 100% women, age not provided.		2				Thomas, G. E., et al. (2012). "The association between hip morphology and 19-year risk of osteoarthritis in the hip." Osteoarthritis and Cartilage 20: S23-S24.
Osteoarthritis developed in 17.7% of patients with evidence of FAI. 82.3% of patients did not develop OA.	Retrospective long-term outcome study. Looked for radiographic evidence of FAI in asymptomatic contralateral hips of patients who had undergone surgery for unilateral hip disease (varied diagnoses including DDH, OA, trauma). Follow-up radiographs were examined to look for OA. (No further information about type of hip surgery performed or patient activity levels post-operatively in short-term or long-term)	n=96, (M=31, F=65), mean age 49.3yrs (16-65), mean follow-up time 18.5yrs (10-40yrs)		2				Hartofilakidis, G., et al. (2011). "An examination of the association between different morphotypes of femoroacetabular impingement in asymptomatic subjects and the development of osteoarthritis of the hip." J Bone Joint Surg Br **93**(5): 580-586.

Cam type deformity was strongly associated with end stage OA. OR for a severe cam type deformity (α angle > 83°) was high (10.88, 95% CI 5.21 22.69, p < 0.001). No association was found between a pincer deformity and the development of end stage OA. The risk of THR if cam type deformity with α- angle > 83° and > 60° was 23.3% and 9.6% respectively. No relation was found between any impingement parameter and the development of early OA.	A random subset of 865 from the CHECK cohort had standardized anteroposterior radiographs (AP) taken at both baseline and 5 years follow up. AP pelvic radiographs of sufficient quality were obtained in 723 subjects at baseline and in 770 subjects at the 5 years follow up. At baseline, 75% of the hips had no signs of OA (K&L1⁄40) whereas 25% had doubtful OA (K&L1⁄41). The shape of the proximal femur and acetabulum on the AP radiographs was assessed using statistical shape modelling (SSM).	n= 865, F= 682 (mean age 55.8), M= 183 (mean age 56.4).		2				Agricola, R., et al. (2012). "Cam-type deformities strongly predict total hip replacement within 5 years in those with early symptomatic OA: a prospective cohort study (check)." Osteoarthritis and Cartilage 20: S203.
Hip geometry has a moderate ability to predict HOA in participants with and without initial signs of osteoarthritis (OA), similar to and largely independent of the predictive value of clinical risk factors.	Results: The included individuals comprised 575 females and 148 males (mean age 55.9 ` 5.2 years). At baseline, 8% fulfilled the ACR criteria, 76% had no radiographic hip OA [Kellgren & Lawrence (K&L) 1⁄4 0] and 24% had doubtful OA (K&L 1⁄4 1). At follow-up, 147 hips (10.4%) fulfilled the ACR criteria and 35 hips (2.5%) had received THR. Five shape variants (modes) at baseline associated significantly with THR within 5 years. When combined in one GEE model, these shape variants resulted in a predictive power indicated by an area under the curve of 0.81. No shape variants associated with the presence of clinical OA at follow-up.	n=688 participants with no KL radiographic osteoarthritis score Randomly selected from the Rotterdam study cohort of 7983 people. Age >55yrs. Men and women.		2				Castano-Betancourt, M. C., et al. (2013). "The contribution of hip geometry to the prediction of hip osteoarthritis." Osteoarthritis Cartilage **21**(10): 1530-1536.

The data suggest that playing ice hockey at an elite level during childhood is associated with an increased risk for cam-type deformity and hip pain after physeal closure.	77 elite-level male ice hockey players were evaluated with a questionnaire, clinical examination, and MRI. Hip pain, internal rotation and α-angles were assessed. The α-angles were significantly higher in athletes with closed physes versus open physes. Symptomatic athletes had significantly higher α-angles compared with asymptomatic athletes. Internal rotation was significantly decreased in symptomatic compared with asymptomatic athletes. Higher α-angles in the anterosuperior quadrant were significantly associated with decreased internal rotation.	n=77 elite male hockey players. Mean age= 16.5 yrs (range, 9-36 yrs); 15 of 77 (19.5%) athletes had a history of hip pain and a positive impingement test finding.			3			Siebenrock, K. A., et al. (2013). "Prevalence of cam-type deformity and hip pain in elite ice hockey players before and after the end of growth." Am J Sports Med 41(10): 2308-2313.
Cam-type deformities were recognizable and present from the age of 13 years and were more prevalent in soccer players than in their nonathletic peers.	Cross-sectional study of adolescent footballers and asymptomatic controls using AP pelvic and frog-leg lateral hip radiographs. α angle > 60° used to define cam-type deformity. A cam-type deformity tended to be more prevalent in soccer players (26%) than in controls (17%, p=0.31). In 13% of soccer players a prominence was visible on radiographs (youngest - 13yrs). The anterosuperior flattening (56% vs18%, P=0.0001) and prominence (13% vs. 0%, p<0.03) were more prevalent in soccer players than controls.	n= 89 elite pre-professional soccer players, n= 92 controls. Age 12-19 years.			3			Agricola, R., et al. (2012). "The development of Cam-type deformity in adolescent and young male soccer players." Am J Sports Med 40(5): 1099-1106.
Patients with CAM-type FAI and an α-angle of >65° are at increased risk of substantial cartilage damage. Conversely, pincer-type FAI seemed to have a decreased risk.	Data collected on patients undergoing joint-preservation surgery for CAM-type FAI. Alpha angle greater than 65°had increased risk of Beck Type 3 or greater cartilage damage (OR 4, 95% CI 1.26-12.71, p=0.02)	n=167 (129 male, 38 female). Mean age 38yrs (17-59).			3			Beaule, P. E., et al. (2012). "Can the alpha angle assessment of cam impingement predict acetabular cartilage delamination?" Clin Orthop Relat Res **470**(12): 3361-3367.
A deep acetabular socket and pistol grip deformity were associated with increased risk of OA	Cross-sectional cohort study studying AP pelvic radiographs. Prevalence of pistol grip deformity was 19.6% for males and 5.2% for females. The risk ratio for OA associated with a deep acetabular socket (coxa profunda and/or protusio acetabuli) was 2.4 (95% CI 2-2.9) and associated with pistol grip deformity was 2.2 (95% CI 1.7-2.8).	n=3620 (1332 male, 2288 women). Mean age 62 (male), 65 (female)			3			Gosvig, K. K., et al. (2010). "Prevalence of malformations of the hip joint and their relationship to sex, groin pain, and risk of osteoarthritis: a population-based survey." J Bone Joint Surg Am **92**(5): 1162-1169.

The risk of OA increases as femoral head diameter, neck length, outer shaft diameter, inner shaft diameter and pelvic width decrease and as sourcil angle increase, whereas both extremes of neck shaft angle confer risk. Prospective studies are required to confirm these findings.	Nested case-control study. Unaffected hips of hip OA cases were compared to the same side hips of controls. Assumption made that the unaffected hip values in cases reflect the original measures on the affected side prior to development of OA. Standardized antero-posterior radiographs of pelvis were used to measure 10 morphological features. The ICC for intra-observer reliability for all the measurements was >0.84. In controls all morphological measures were symmetrical between right and left (ICC ranged from 0.80-0.95).	n=566 hips with unilateral OA, n-1108 controls from GOAL database.			3			Abdulrahim, H., et al. (2012). "Morphological measures of femur and pelvis on plain radiographs as risk for hip osteoarthritis." Osteoarthritis and Cartilage 20.
Hips with presumably idiopathic OA had more abnormalities at the femoral head-neck junction than did the control hips without OA	Measurement of α-angle in idiopathic OA hips and control hips. The α-angle was measured on Dunn view at 45 degrees flexion. Abnormal α-angle defined as >50°. 82% of OA hips had α-angles >50° (mean 66.4°, range 28°-108) vs. 30% of controls (mean 48.1°, 34°-68°).	n = 72 hips with idiopathic OA, n = 56 controls. Mean age 70 (60-84).			3			Barros, H. J., et al. (2010). "Femoral head-neck junction deformity is related to osteoarthritis of the hip." Clin Orthop Relat Res 468(7): 1920-1925.
Male sex, older age, Tonnis OA grade and alpha angle >50° on frog lateral radiograph were independently associated with increase risk of grade 3 or 4 acetabular chondromalacia (p<0.001). Pincer FAI and acetabular dysplasia not significantly associated.	Retrospective exam of radiographs on patients who had arthroscopy following 3 month history of hip pain not responding to conservative management	n=355 hips (338 patients). Average age 36.8yrs (15-68yrs)			3			Nepple, J. J., et al. (2011). "Clinical and radiographic predictors of intra-articular hip disease in arthroscopy." Am J Sports Med 39(2): 296-303.
Patients with THA had a higher prevalence of cam deformity than did their respective controls (median α-angle 88° versus 46°in controls.)	Nested case-control from a longitudinal cohort study of 1003 women (Chingford Study). Between year 8 and year 20, 22 THA procedures were performed for OA on study participants. Hip morphology of these participants as well as 100 randomly selected controls were analysed. An alpha angle of more than 65° was associated with a 6.0 fold increased risk of THA (95% CI 2.04- 17.59, p<0.001).	n=22 who had THA, n=100 controls.			3			Thomas, G. E., et al. (2012). "The association between hip morphology and end-stage osteoarthritis at 12-year follow up." Osteoarthritis and Cartilage **20**: S204.

60% (81/135) patients undergoing THA were classified as having an abnormal femoral head-neck-junction.	A consecutive series of 135 total hip arthroplasties were performed in patients aged less or equal to 60 years because of end-stage osteoarthritis. The pelvic-views and the corresponding Dunn-view of these patients were screened for ''pistol-grip-deformity'' by measuring head-ratio on pelvic-views and the α- angle on Dunn-views. An α-angle greater than 51◦ and/or a head-ratio greater than 1.16 were considered as pathological.	n=135 consecutive THA, patients <60yrs,				4		Ipach, I., et al. (2013). "The prevalence of acetabular anomalies associated with pistol-grip-deformity in osteoarthritic hips." Orthop Traumatol Surg Res **99**(1): 37-45.
Hips with presumably idiopathic OA had more abnormalities at the femoral head-neck junction than control hips without OA and may relate to risk of OA developing	Observational case-control study. Measured α angle on Dunn View radiograph. 82% vs. 30% controls had abnormal α angles (using a definition of abnormal α angle >50°)	n= 72 hips (controls = 56), mean age 70yrs (range 60-74),				4		Barros, H. J., et al. (2010). "Femoral head-neck junction deformity is related to osteoarthritis of the hip." Clin Orthop Relat Res **468**(7): 1920-1925.
Hip pain in young patients significantly correlated with radiograph findings of : increase in α angle on all views (p<0.0001),presence of a bump (CAM deformity) on the femoral head-neck transition (p<0.0001) on AP view. AP and Dunn 45° views were considered best for assessment of CAM deformity.	Comparative radiographic investigation of FAI in young patients with and without hip pain. All patients had an AP hip, Lequesne false profile view, Dunn view, Dunn view with 45° of flexion and a Ducroquet view. .	n=122 with groin pain (52% women), n=100 asymptomatic. (58% women). Age 20-50yrs.				4		Miguel, O. F., et al. (2012). "A comparative radiographic investigation of femoroacetabular impingement in young patients with and without hip pain." Clinics 67(5): 463-467.
Cam lesions were present in 68% (51/75) of men (76.5% [39/51] bilateral involvement) and 50% (10/20) of women (90% [9/10] bilateral involvement). Pincer lesions were present in 26.7% (20/75) of men and 10% (2/20) of women.	Observational study. Retrospective assessment of AP pelvis and frog-leg lateral radiographs of 95 elite male and female soccer players to determine the prevalence of hip abnormalities. Athletes with a history of hip or groin injuries. In total, 72% (54/75) of male and 50% (10/20) of female players demonstrated some evidence of radiographic hip abnormality. Abormal α-angle defined as ≥55°. The average male alpha angle overall was 65.6° . Cam-positive hips averaged 70.7° . The average female alpha angle overall was 52.9° , with cam-positive hips averaging 60.8° .	n=95 elite soccer player. Male (n=75_and female (n=20).				4		Gerhardt, M. B., et al. (2012). "The prevalence of radiographic hip abnormalities in elite soccer players." Am J Sports Med 40(3): 584-588.

Definite FAI was present in 36 % of subjects who had THR for hip OA below the age of 55yrs.	Retrospective prevalence study. Prevalence of FAI detected radiographically in a cohort that underwent THR for primary hip OA. 82 cases were randomly selected from 470 identified THR cases. Two radiologists independently assessed the retrospective preoperative radiographs (AP pelvis and lateral).	n=82 patients who underwent THR at young age <55 yrs				4		Lung, R., et al. (2012). "The prevalence of radiographic femoroacetabular impingement in younger individuals undergoing total hip replacement for osteoarthritis." Clin Rheumatol **31**(8): 1239-1242.

TABLE 2: MRI AND PREDICTION OF HIP OA

cam - short for camshaft (a reflection of shape of femoral head/neck junction), **CI** - confidence interval, **OR** - odds ratio, **dGEMRIC** - delayed gadolinium enhanced MRI of cartilage, **1.5T/3T** = 1.5 or 3 Tesla (unit of magnetic field strength), **FAI** – femoroacetabular impingement, **ρ** = rho (correlation coefficient)

STUDY FINDING	OVERVIEW	STUDY POPULATION	LEVEL OF EVIDENCE (CEBM 2009)					REFERENCE
			1	2	3	4	5	
The presence of a cam-type deformity is associated with MRI-detected hip damage in asymptomatic young men. cam-type deformity present in 24%. In the hips with cam-type deformity the odds ratio(OR) for labral lesions was 2.77 (95% CI 1.31,5.87), the OR for labral avulsions was 2.24 (95%CI 1.17, 4.28), the OR for impingement pits was 2.91 (95% CI 1.43, 5.93). Large majority of the damage identified occurred anterosuperiorly (91% cam-type deformities, 77% labral tears)	Cross-sectional population based study using the Sumiswald cohort of asymptomatic young men. Recent hip pain >3/5 on Likert scale excluded. Random selection of cohort invited for MRI exam.	n=244, average age 19.9yrs				4		Reichenbach, S., et al. (2011). "Association between cam-type deformities and magnetic resonance imaging-detected structural hip damage: a cross-sectional study in young men." Arthritis Rheum **63**(12): 4023-4030.
High-resolution 3D dGEMRIC at 3T has potential for assessing acetabular and femoral cartilage. They found significant differences in mean T1Gd values between symptomatic and asymptomatic hips.	Case-control MRI study using three-dimensional delayed gadolinium-enhanced MRI at 3T to identify cartilage abnormalities in symptomatic hips compared to asymptomatic controls.	n=40 symptomatic hips (18 male), n=31 asymptomatic hips (12 male). Mean age 32.8yrs (18-57) Hip symptoms = 35 FAI, 3 dysplasia, 2 coxa magna.			3			Zilkens, C., et al. (2012). "Three-dimensional delayed gadolinium-enhanced magnetic resonance imaging of hip joint cartilage at 3T: a prospective controlled study." Eur J Radiol **81**(11): 3420-3425.

Gradient-echo dGEMRIC's ability to identify cartilage degeneration was validated against histological analyses. The mean T1Gd values decreased significantly with increasing cartilage degeneration (p<0.001).	Histologically controlled *in vitro* validation study of gradient echo 3D dGEMRIC. The dGEMRIC index (T1Gd relaxation time in milliseconds) reflects the uptake of gadolinium within cartilage and is inversely proportional to the tissue glycosaminoglycan (GAG) content.	n=21 femoral head specimens (7 male, 14 female) from THR operations. Mean age 60.9 (37.6 - 77.3)				4		Zilkens, C., et al. (2013). "Validity of gradient-echo three-dimensional delayed gadolinium-enhanced magnetic resonance imaging of hip joint cartilage: a histologically controlled study." Eur J Radiol **82**(2): e81-86.
Feasibility study of the use of MRI T2* mapping in patients with clinical FAI suggests that it could be a useful MRI biomarker for early cartilage degeneration in FAI. However larger studies required with attention to timing of the mapping during the protocol (increased T2 values as protocol progressed presumed due to unloading of joint).	22 patients with clinical FAI and Tönnis grade ≤1 on AP radiograph. T2* mapping at 3T performed in both groups.	n=22 symptomatic hips (13 male, 9 female), mean age 28.1, n=35 asymptomatic controls				4		Apprich, S., et al. (2012). "Evaluation of articular cartilage in patients with femoroacetabular impingement (FAI) using T2* mapping at different time points at 3.0 Tesla MRI: a feasibility study." Skeletal Radiol **41**(8): 987-995.
d-GEMRIC index was significantly different between mild, moderate and severe dysplasia and might be a sensitive measure of early osteoarthritis, but further studies needed to determine whether can predict disease progression in different clinical scenarios.	dGEMRIC index correlated with pain (rs=-0.5, p<0.0001) and with lateral centre-edge angle (rs=0.52, p<0.001). dGEMRIC index was significantly different (p<0.0001) among three groups of severity of hip disease.	n= 68 dysplastic hips, mean age 30yrs (11-47),				4		Kim, Y. J., et al. (2003). "Assessment of early osteoarthritis in hip dysplasia with delayed gadolinium-enhanced magnetic resonance imaging of cartilage." J Bone Joint Surg Am **85-a**(10): 1987-1992.
Moderate correlation seen between WOMAC pain score and cartilage damage on MRI. For DDH ρ=0.457 (p=0.049). For FAI ρ= 0.528 (p= 0.014).	Retrospective study of hip pain patients with DDH or FAI who underwent MRI. 40 of 71 consecutive patients met the inclusion criteria (having WOMAC pain score, MRI and dGEMRIC,Tönnis OA grade 0 or 1).	n=40, mean age 28.6yrs (range 13-52yrs). FAI = 21 hips (9 male,12 female, DDH = 19 hips (0 male, 19 female).				4		Stelzeneder, D., et al. (2012). "Patterns of joint damage seen on MRI in early hip osteoarthritis due to structural hip deformities." Osteoarthritis Cartilage **20**(7): 661-669.

Study found that radial dGEMRIC able to assess cartilage damage in the entire hip including the anterior-superior quadrant of the acetabulum. It found that DDH and CAM type FAI have different T1 distribution of cartilage damage.	DDH and FAI cohorts consist of 20 consecutive cases each. The Western Ontario and McMaster Universities (WOMAC) index for pain18 was assessed in all patients at the time of MRI and was mean 6.6 ` 5.1 range 0e20.	n=40 (20 DDH, 20 FAI). Mean age = 28.1yrs (range 13-52). The Tönnis grade was 0 in 21, 1 in 17, and 2 in 2 cases, respectively.				4		Domayer, S. E., et al. (2010). "Radial dGEMRIC in developmental dysplasia of the hip and in femoroacetabular impingement: preliminary results." Osteoarthritis Cartilage **18**(11): 1421-1428.
Pattern of zonal T1 variations appears to exist that is unique to different sub-groups of FAI. In cam-types this was located in the anterosuperior portion. In pincer-types the changes were found in a generalized circumferential distribution.	Preliminary study assessing cartilage damage in FAI using standard MRI and dGEMRIC .	n = 26 symptomatic FAI, controls = 10.				4		Bittersohl, B., et al. (2009). "Cartilage damage in femoroacetabular impingement (FAI): preliminary results on comparison of standard diagnostic vs. delayed gadolinium-enhanced magnetic resonance imaging of cartilage (dGEMRIC)." Osteoarthritis Cartilage **17**(10): 1297-1306.
Magnetic resonance images of asymptomatic participants revealed abnormalities in 73% of hips, with labral tears being identified in 69% of the joints. A strong correlation was seen between participant age and early markers of cartilage degeneration such as cartilage defects and subchondral cysts.	Forty-five volunteers with no history of hip pain, symptoms, injury, or surgery underwent an MRI scan with a Siemens 3.0-tesla scanner. All MRI scans were reviewed by 3 fellowship-trained musculoskeletal radiologists. The scans were mixed randomly with 19 scans from symptomatic patients to blind the radiologists to the possibility of patient symptoms. An abnormal finding was considered positive when 2 of 3 radiologists agreed on its presence.	n = 45, 60% men, average age 37.8yrs (range 15-66yrs).			3			Register, B., et al. (2012). "Prevalence of abnormal hip findings in asymptomatic participants: a prospective, blinded study." Am J Sports Med **40**(12): 2720-2724.

TABLE 3: MR ARTHROGRAM AND PREDICTION OF HIP OA

OA – osteoarthritis, **CAM** - short for camshaft (a reflection of shape of femoral head/neck junction), **OR** - odds ratio, **dGEMRIC** - delayed gadolinium enhanced MRI of cartilage, **1.5T/3T** = 1.5 or 3 Tesla (unit of magnetic field strength), **FAI** - femoracetabular impingement, **Mra or MRA** = magnetic resonance arthrogram, **PPV** = positive predictive value, **NPV** = negative predictive value.

STUDY FINDING	OVERVIEW	STUDY POPULATION	LEVEL OF EVIDENCE (CEBM 2009)					REFERENCE
			1	2	3	4	5	
Labral tears and cartilage loss are common in patients with mechanical symptoms in the hip (prevalence 66% and 76% respectively). There was a significant correlation between the grade of cartilage abnormality and the grade of labral tear, (r=0.29; P< or =0.01).	Case series of 100 patients undergoing MR arthrography for mechanical hip symptoms (clicking, locking, sharp pain, giving way)	n=100 patients with mechanical symptoms, women=76, men=24, mean age 39 yrs (range 17-76)				4		Neumann, G., et al. (2007). "Prevalence of labral tears and cartilage loss in patients with mechanical symptoms of the hip: evaluation using MR arthrography." Osteoarthritis Cartilage **15**(8): 909-917.
Indirect-MRa can be considered a valid method of assessing endoarticular damage related to FAI, in comparison to d-MRa.	To assess the effectiveness of indirect MRa in the detection of chondral and labral lesions related to FAI compared with standard MRI and direct-MRa. There was good agreement between i-MRa and d-MRa in detection of chondral lesions, labral damage and early osteoarthritic changes.	n = 21 hips (17 patients) with clinical FAI				4		Pozzi, G., et al. (2009). "Femoro-acetabular impingement: can indirect MR arthrography be considered a valid method to detect endoarticular damage? A preliminary study." Hip Int **19**(4): 386-391.

The diagnostic test accuracy for the detection of hip joint cartilage lesions is currently superior for MRI compared with MRA. MRI indicated a pooled sensitivity of 0.59 (95 % CI: 0.49-0.70) and specificity of 0.94 (95 % CI: 0.90-0.97). MRA pooled sensitivity was 0.62 (95 % CI: 0.57-0.66) and specificity was 0.86 (95 % CI: 0.83-0.89). There were insufficient data to perform meta-analysis for MDCT or CTA protocols.	A review of the published and unpublished literature databases was performed to identify all studies reporting the diagnostic test accuracy (sensitivity/specificity) of MRI, MRA or MDCT for the assessment of adults with chondral (cartilage) lesions of the hip with surgical comparison (arthroscopic or open) as the reference test.	18 studies. 648 hips from 637 patients.			3			Smith, T. O., et al. (2013). "The diagnostic test accuracy of magnetic resonance imaging, magnetic resonance arthrography and computer tomography in the detection of chondral lesions of the hip." Eur J Orthop Surg Traumatol **23**(3): 335-344.
The diagnostic accuracy of MRA in detecting labral tears was as follows: sensitivity 81%, specificity 51% and accuracy 58%. For chondral wear: sensitivity 17%, specificity 100%, and accuracy 55%.	Study aim was to assess the diagnostic accuracy of MRA in detecting labral tears and chondral wear in compared to arthroscopy. . All patients underwent pre-operative MRA and then subsequent hip arthroscopy.	n = 69 hips with symptomatic FAI				4		Banks, D. B., et al. (2012). "Magnetic resonance arthrography for labral tears and chondral wear in femoroacetabular impingement." Hip Int **22**(4): 387-390.
MRA better at detecting cam-type deformities, os acetabuli and labral tears than the diagnosis of cartilage abnormalities in the hip. The sensitivity, specificity, PPV and NPV in the presence of reported cam-type deformity or an os acetabuli were 100%. In the presence of cartilage lesions of the femoral head, the values were 46, 81, 55 and 73%, respectively. For labral tears, the values were 91, 86, 97 and 67%. In the presence of acetabular cartilage injuries, the values were 69, 88, 78 and 81%, respectively. .	The purpose of this study was to assess the diagnostic correlation between MRA and findings at arthroscopic and open surgery. MRA reports of 41 hips with symptomatic FAI were reviewed and compared with subsequent intraoperative findings. Each case was assessed for the presence of a cam deformity, a cartilage lesion of the femoral head, an os acetabuli, an injury to the labrum and injury to the acetabular cartilage.	n = 41 with symptomatic FAI				4		Aprato, A., et al. (2013). "Magnetic resonance arthrography for femoroacetabular impingement surgery: is it reliable?" J Orthop Traumatol **14**(3): 201-206.

TABLE 4 - CT SCAN AND PREDICTION OF HIP OA

CT - computed tomography, **HCTA** - helical computed tomography arthrogram, **KL** = Kellgren Lawrence radiographic scale, **MSK** = musculoskeletal.

STUDY FINDINGS	OVERVIEW	STUDY POPULATION	LEVEL OF EVIDENCE (CEBM 2009)					REFERENCE
			1	2	3	4	5	
In patients with hip pain and normal radiographs, helical computed tomography arthrograms (HCTA) can show evidence of developing osteoarthritis with cartilage lesions	Retrospective review of abnormal CHTA in mechanical hip pain with normal AP and oblique radiographs	n=18 (14 women, 4 men), Mean age 47.8 (18-62 yrs)				4		Alvarez, C., et al. (2005). "Contribution of helical computed tomography to the evaluation of early hip osteoarthritis: a study in 18 patients." Joint Bone Spine **72**(6): 578-584.
Isotropic high-resolution CT arthrography is accurate at simultaneously identifying labral tears (sensitivity 997%, spec 87%, accuracy 92%) and cartilage disorder of the acetabulum (sensitivity 88%, spec 87%, accuracy 92%).	Retrospective study of ability of CT arthrography to identifying labral tears and articular cartilage damage (gold-standard: findings at arthroscopy).	n=41 hips (27 women, 2 men) with hip dysplasia, symptomatic hip pain and pre- or early osteoarthritis. Age 33 (12-58)				4		Nishii, T., et al. (2007). "Disorders of acetabular labrum and articular cartilage in hip dysplasia: evaluation using isotropic high-resolutional CT arthrography with sequential radial reformation." Osteoarthritis Cartilage 15(3): 251-257.
CT arthrography used to identify early cartilage damage associated with labral tears. A lowered lateral-medial (LM) ratio of cartilage thickness in the anterosuperior region was associated with more extensive labral tears.	Retrospective observational study of dysplastic hips using isotropic, high resolution CT arthrography. No control group.	n=31 hips (26 women). Inclusion if KL grade 0 (21 hips) or grade 1 (11 hips).				4		Tamura, S., et al. (2012). "Three-dimensional patterns of early acetabular cartilage damage in hip dysplasia; a high-resolutional CT arthrography study." Osteoarthritis Cartilage 20(7): 646-652.

TABLE 5: PATIENT REPORTED OUTCOME MEASURES AND PREDICTION OF HIP OA

PROM (PATIENT REPORTED OUTCOME MEASURE)	SUMMARY	VALIDATED FOR OA?	VALIDATED FOR HIP PAIN IN YOUNG, ACTIVE POPULATION?	VALIDATED AS PREDICTIVE TOOL FOR OA FOLLOWING SPORT-RELATED INJURY?	REFERENCE
OA -osteoarthritis, **ADL** - activity of daily living, **QOL** - quality of life.					
WOMAC (Western Ontario and McMaster Universities Arthritis Index)	Validated for measurement of symptoms and disability in hip OA and knee OA. 24 questions: pain (5), disability (17) and joint stiffness (2).	Y	N	N	Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW.(1988). Validation study of WOMAC: A health status instrument for measuring clinically important patient relevant outcomes following total hip or knee arthroplasty in osteoarthritis. J Orthop Rheum 1988;1:95–108.
HOOS (Hip Disability and Osteoarthritis Outcome Score)	Validated for measurement of hip disability with or without OA in middle-aged and older patients. 40 questions: symptoms (3), stiffness (2), pain (10), ADLs (17), sport and recreational activity (4), QOL (4).	Y	N	N	Klassbo, M. (2003). "Hip disability and osteoarthritis outcome score. An extension of the Western Ontario and McMaster Universities Osteoarthritis Index." Scandinavian Journal of Rheumatology 32(1): 46-51.
OHS (Oxford Hip Score)	Validated as an outcome measure following total hip replacement. 12 questions.	Y	N	N	Dawson J, Fitzpatrick R, Carr A, Murray D (1996). Questionnaire on the perceptions of patients about total hip replacement. J Bone Joint Surg Br. 1996 Mar;78(2):185-90. Link
HAGOS (The Copenhagen Hip and Groin Outcome Score)	Validated for measurement of symptoms and QOL in young to middle-aged, active patients with hip and/or groin pain. 37 questions: symptoms (5), stiffness (2), pain (10), ADL (5), function (8), physical activity (2), QOL (5)	N	Y	N	Thorborg, K., P. Holmich, R. Christensen, J. Petersen and E. M. Roos (2011). "The Copenhagen Hip and Groin Outcome Score (HAGOS): development and validation according to the COSMIN checklist." Br J Sports Med **45**(6): 478-491.

PROM (PATIENT REPORTED OUTCOME MEASURE)	SUMMARY	VALIDATED FOR OA?	VALIDATED FOR HIP PAIN IN YOUNG, ACTIVE POPULATION?	VALIDATED AS PREDICTIVE TOOL FOR OA FOLLOWING SPORT-RELATED INJURY?	REFERENCE
OA -osteoarthritis, **ADL** - activity of daily living, **QOL** - quality of life.					
i-HOT 33 (international Hip Outcome Tool)	Validated for measurement of health-related quality of life in young, active patients (18-60yrs, Tegner activity level ≥4) with hip pathologies such as FAI or articular cartilage degeneration. 33 questions: symptoms and functional limitations (16), sports and recreational activities (6), job related concerns (4), social, emotional and lifestyle concerns (7).	N	Y	N	Mohtadi, N. G., D. R. Griffin, M. E. et al (2012). "The Development and validation of a self-administered quality-of-life outcome measure for young, active patients with symptomatic hip disease: the International Hip Outcome Tool (iHOT-33)." Arthroscopy **28**(5): 595-605; quiz 606-510 e591.
i-HOT 12 (international Hip Outcome Tool)	Shorter version of i-HOT33. Validated against i-HOT33 for measurement of health-related quality of life in young, active patients (18-60yrs, Tegner activity level ≥4) with hip disorders. 12 questions.	N	Y	N	Griffin, D. R., N. Parsons, N. G. Mohtadi and M. R. Safran (2012). "A short version of the International Hip Outcome Tool (iHOT-12) for use in routine clinical practice." Arthroscopy **28**(5): 611-616; quiz 616-618.

TABLE 6 - BLOOD TESTS AND PREDICTION OF HIP OA

uCTX-II = urinary crosslinking telopeptides of collagen types I and II, **sHA** = hyaluronan**, OA** = osteoarthritis.

STUDY FINDING	OVERVIEW	STUDY POPULATION	LEVEL OF EVIDENCE (CEBM 2009)					REFERENCE
			1	2	3	4	5	
Paper concludes that uCTX-II and sHA are potential predictors of structural progression of hip OA. The results showed patients in whom uCTX-II and sHA were in the upper tertile had a relative risk of progression of 3.73 (95% CI 2.48 to 5.61) compared with patients with markers in the two lower tertiles.	ECHODIAH cohort. 3-year multicentre trial. The following information was collected at entry: demographics, characteristics of hip OA, and 10 markers: N-propeptides of collagen types I and III, cartilage oligomeric matrix protein, YKL-40, hyaluronan (sHA), matrix metalloproteinases-1 and -3, C reactive protein, C-terminal crosslinking telopeptides of collagen types I and II (uCTX-II). Radiographs were obtained at entry and every year. Structural progression was defined as a joint space decrease >0.5 mm or requirement for total hip replacement.	n = 333		2				Mazieres, B., et al. (2006). "Molecular markers of cartilage breakdown and synovitis at baseline as predictors of structural progression of hip osteoarthritis. The ECHODIAH Cohort." Ann Rheum Dis **65**(3): 354-359.

Note: further studies regarding potential biomarkers exist using knee osteoarthritis as outcome

TABLE 7: HISTORY AND PREDICTION OF HIP OA

STUDY FINDING	OVERVIEW	STUDY POPULATION	LEVEL OF EVIDENCE (CEBM 2009)					REFERENCE
			1	2	3	4	5	
OCCUPATION								
There is an association between long-term exposure to heavy lifting and risk of hip OA. Long-term exposure to standing at work might also increase the risk of hip OA.	Systematic review of epidemiological studies on workload or occupation and osteoarthritis of the hip were identified through database and bibliography searches. Study results were too heterogeneous to develop pooled risk estimates by specific work activities.	30 studies.		2				Sulsky, S. I., et al. (2012). "Epidemiological evidence for work load as a risk factor for osteoarthritis of the hip: a systematic review." PLoS One **7**(2): e31521.
Joint injury, obesity, and occupational activity are associated with an increased risk of knee and hip OA.	Systematic review to identify risk factors for osteoarthritis of the knee, hip, and ankle, including joint injury, sport, physical activity, overweight/obesity, and occupational activity, in all age groups.	43 studies		2				Richmond, S. A., R. K. Fukuchi, A. Ezzat, K. Schneider, G. Schneider and C. A. Emery (2013). "Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review." J Orthop Sports Phys Ther **43**(8): 515-B519.
FAMILY HISTORY - OA								
After adjustment for confounders that cause secondary morphological change, individuals with an hereditary predisposition to end-stage hip OA had a higher prevalence of morphological abnormalities associated with hip OA	'Sibkids' (see study population) had an odds ratio of 2.1 (95%CI 1.3-3.5) for cam deformity. There were no differences in the prevalence of dysplasia or pincer deformities. In both groups, hips with cam deformities or dysplasia were more likely to have clinical features than normal hips (OR 4.46 (1.8- 11.3), and 4.40 (1.4-14.3) respectively). "	n =123 'sibkids' (individuals from families in which two female siblings in the previous generation had undergone total hip arthroplasty for idiopathic end-stage OA). Controls = 80 spouses.			3			Pollard, T. C., R. N. Batra, A. Judge, B. Watkins, E. G. McNally, H. S. Gill, G. E. Thomas, S. Glyn-Jones, N. K. Arden and A. J. Carr (2013). "The hereditary predisposition to hip osteoarthritis and its association with abnormal joint morphology." Osteoarthritis Cartilage **21**(2): 314-321.

OA at five joint sites including the hip were heritable. Genetic influences were strongly correlated among joints in the hand; however, there was little evidence of common genetic pathways to account for the co-occurrence of OA at the hand, hip and knee.	Study to identify whether a shared genetic influence accounts for the occurrence of OA at different skeletal sites. Methods. Multivariate modelling of data on prevalent radiographic OA at the hand (DIP, PIP and CMC joints), hip and knee joints assessed in 992 monozygotic and dizygotic female twin participants from the Twins UK Registry.	n = 992 monozygotic and dizygotic female twins			3			Macgregor, A. J., Q. Li, T. D. Spector and F. M. Williams (2009). "The genetic influence on radiographic osteoarthritis is site specific at the hand, hip and knee." Rheumatology (Oxford) 48(3): 277-280.
PMH HIP PROBLEMS								
Joint injury, obesity, and occupational activity are associated with an increased risk of knee and hip OA.	Systematic review to identify risk factors for osteoarthritis of the knee, hip, and ankle, including joint injury, sport, physical activity, overweight/obesity, and occupational activity, in all age groups.	43 studies		2				Richmond, S. A., R. K. Fukuchi, A. Ezzat, K. Schneider, G. Schneider and C. A. Emery (2013). "Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review." J Orthop Sports Phys Ther **43**(8): 515-B519.
Hip dysplasia is associated with the development of hip osteoarthritis in men and women.	Cross-sectional survey. Hip dysplasia (HD) prevalence ranged from 5.4–12.8% depending on the radiographic index applied. Logistic regression analyses showed hip dysplasia to be significantly associated with hip OA prevalence in women (P<0.001 for right hips and P=0.004 for left hips) and men (P<0.001 in right hips and P = 0.001 in left hips).	2232 women and 1336 men (age range 20–91yr)		2				Jacobsen, S. and S. Sonne-Holm (2005). "Hip dysplasia: a significant risk factor for the development of hip osteoarthritis. A cross-sectional survey." Rheumatology (Oxford) **44**(2): 211-218.
Patients with Perthes Disease have an increased risk of having THA compared with a gender- and age-matched control group.	Copenhagen City Heart Study: the Osteoarthritis Sub- study. 167 patients with Perthes Disease treated with a Thomas splint.	167 patients with LCPD treated with a Thomas splint. Gender- and age- matched control subjects			3			Froberg, L., F. Christensen, N. W. Pedersen and S. Overgaard (2011). "The need for total hip arthroplasty in Perthes disease: a long-term study." Clinical orthopaedics and related research **469**(4): 1134-1140.

A history of hip injury was a predictor of increased incidence of hip OA.	Baseline (1991-1997) and first follow up (1999-2005) data from Johnston County Osteoarthritis Project participants. The incidence of 4 hip OA-related outcomes ranged from 0.3 to 5.5% each year. For each outcome, older age, being female, and having a history of hip injury were all predictors of increased incidence.	n=1,423; aged > 45 years.						Do, B. T., L. Murphy, C. G. Helmick, K. E. Barbour, Y. J. Cheng and J. M. Jordan (2011). "Incidence of hip symptoms and radiographic and symptomatic hip osteoarthritis in African Americans and Caucasians: The Johnston county osteoarthritis project." Arthritis and Rheumatism **63**(10 SUPPL. 1).
Previous hip injury and the presence of Heberden's nodes were independent risk factors for hip osteoarthritis among men and women. Hip injury was more closely related to unilateral as compared with bilateral disease.	Population-based case-control study looking at individual risk factors for OA. The study was performed in two English health districts (Portsmouth and North Staffordshire) from 1993 to 1995. Questionnaire administered at interview and a short physical examination. Previous hip injury (OR = 4.3, 95% CI 2.2-8.4), and the presence of Heberden's nodes (OR = 1.6, 95% CI 1.2-2.2) were identified as risk factors.	A total of 611 patients (210 men and 401 women) listed for hip replacement because of osteoarthritis over an 18-month period were compared with an equal number of controls selected from the general population and individually matched for age, sex, and family practitioner.			3			Cooper, C., H. Inskip, P. Croft, L. Campbell, G. Smith, M. McLaren and D. Coggon (1998). "Individual risk factors for hip osteoarthritis: obesity, hip injury, and physical activity." Am J Epidemiol 147(6): 516-522.
SPORTING PARTICIPATION - LOAD, TYPE etc.								
Inconclusive results for risk of developing hip OA with respect to levels of physical activity or sport specificity in individuals who do not suffer an injury.	Systematic review to identify risk factors for osteoarthritis of the knee, hip, and ankle, including joint injury, sport, physical activity, overweight/obesity, and occupational activity, in all age groups.	43 studies		2				Richmond, S. A., R. K. Fukuchi, A. Ezzat, K. Schneider, G. Schneider and C. A. Emery (2013). "Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review." J Orthop Sports Phys Ther **43**(8): 515-B519.

There is moderate evidence for a positive association between sporting activities and the occurrence of hip OA.	Systematic review of the influence of sporting activities on the development of OA of the hip	22 articles met selection criteria (1 cohort and 21 case-controlled).		2				Lievense, A. M., et al. (2003). "Influence of sporting activities on the development of osteoarthritis of the hip: a systematic review." Arthritis Rheum **49**(2): 228-236.
Weight-bearing sports activity in women is associated with a 2-3 fold increased risk of radiologic OA (particularly the presence of osteophytes) of the knees and hips. The risk was similar in ex-elite athletes and in a subgroup from the general population who reported long-term sports activity, suggesting that duration rather than frequency of training is important.	A retrospective cohort study to estimate the risk of osteoarthritis (OA) of the hip and knee due to long-term weight-bearing sports activity in ex-elite athletes and the general population. A retrospective cohort study was conducted of	81 female ex-elite athletes (67 middle- and long-distance runners, and 14 tennis players), currently ages 40-65. 977 age-matched female controls.		2				Spector, T. D., P. A. Harris, D. J. Hart, F. M. Cicuttini, D. Nandra, J. Etherington, R. L. Wolman and D. V. Doyle (1996). "Risk of osteoarthritis associated with long-term weight-bearing sports: A radiologic survey of the hips and knees in female ex-athletes and population controls." Arthritis and Rheumatism **39**(6): 988-995.
Increasing levels of total physical activity are positively associated with the risk of primary knee but not hip replacement due to OA. Note: no differentiation made between weight-bearing and non-weight-bearing activity and activity levels measured only once at baseline.	Cohort study to estimate prospectively any association between measures of physical activity and the risk of either primary knee or hip replacement due to osteoarthritis. A total physical activity level was computed, incorporating both intensity and frequency for different forms of physical activity obtained by questionnaire at baseline attendance (1990-1994). Primary knee and hip replacement for OA during 2001-2005 was determined by linking the cohort records to the National Joint Replacement Registry.	n =39,023.		2				Wang, Y., J. A. Simpson, A. E. Wluka, A. J. Teichtahl, D. R. English, G. G. Giles, S. Graves and F. M. Cicuttini (2011). "Is physical activity a risk factor for primary knee or hip replacement due to osteoarthritis? A prospective cohort study." Journal of Rheumatology **38**(2): 350-357.
The risk of hip OA was doubled (OR, 2.0; 95% CI, 1.5-2.8) and hip arthroplasty was 2.5 times higher (OR, 2.5; 95% CI, 1.6-3.7) in former athletes than in controls.	Case-control study looking at the prevalence of OA and arthroplasty of the hip and knee in former male elite athletes compared to controls. Higher risk found in former impact athletes.	n = 709 male retired elite athletes. Median age 70 (range 50-93). N = 1368 matched controls.			3			Tveit, M., et al. (2012). "Former male elite athletes have a higher prevalence of osteoarthritis and arthroplasty in the hip and knee than expected." Am J Sports Med **40**(3): 527-533.

Significantly higher prevalence of OA in ex-footballers compared to controls. The ex-professional footballers with OA of the hip had not sustained any recognised hip injury nor had undergone previous hip surgery.	The managers of league and premiership football clubs in England and Wales were selected as a study group for the pilot investigation. Questionnaire. OA in 9/68 (13%) ex-professionals vs. 2/136 (1.4%) of controls. 6/9 ex-players with OA had undergone THR.	n= 68 ex-professional footballers. Mean age =44 years (range 32–59), mean playing career length was 16 years (5–25), and the mean number of appearances was 474. n=136 age and sex-matched controls.			3			Shepard, G. B., AJ ; Ryan, WG (2003). "Ex-professional association footballers have an increased prevalence of osteoarthritis of the hip compared with age matched controls despite not having sustained notable hip injuries." British Journal Of Sports Medicine **37**(1): 80-81.
Increased prevalence of hip OA in ex-footballers. 14% of elite ex-football players had hip OA compared to 4.2% of age-matched controls and non-elite players.	Case-control study.	n=286 male former football players. Mean age = 55yrs. Age-matched control group.			3			Lindberg, H., H. Roos and P. Gardsell (1993). "Prevalence of coxarthrosis in former soccer players: 286 players compared with matched controls." Acta Orthopaedica Scandinavica **64**(2): 165-167.
4% of ex-football players developed OA left hip at an average age of 42.4yrs, 1.7% developed OA of right hip at an average age of 43.7yrs..	Observational study via questionnaire.	n=185 former football players registered with the English Professional Footballers' Association. Mean age - 47.6 (20-84)				4		Drawer, S. and C. W. Fuller (2001). "Propensity for osteoarthritis and lower limb joint pain in retired professional soccer players... including commentary by Waddington I." British Journal of Sports Medicine 35(6): 402-409.
Men with high exposure to sports of all kinds had a relative risk to develop osteoarthrosis of the hip of 4.5 compared to those with low exposure. Track and field sports and racket sports seemed to be the most hazardous to the hip join	Case-control study to investigate if participation in sports increases the risk of developing osteoarthritis of the hip, .	n =233 men < 49yrs who had recently had total hip replacement for idiopathic OA 302 controls.			3			Vingard, E., L. Alfredsson, I. Goldie and C. Hogstedt (1993). "Sports and osteoarthritis of the hip: an epidemiologic study." American Journal of Sports Medicine 21(2): 195-201.

Vigorous sporting activity during the growth years is associated with an increased risk of having a cam-type deformity develop. This study suggests that a cam-type abnormality in athletes is a consequence of an alteration of the growth plate rather than reactive bone formation.	Case-control comparative analysis of young (age range, 9-22 years) male elite basketball athletes with age-matched non-athletes, substratified by whether they had open or closed physes. Measurement of epiphyseal extension on radial-sequence MRI cuts throughout the cranial hemisphere from 9 o'clock (posterior) to 3 o'clock (anterior). Epiphyseal extension was correlated to alpha angle measurements at the same points. Epiphyseal extension was increased in all positions in the athletes compared with the control group.	n = 37 elite basketball players + 38 controls			3			Siebenrock, K. A., I. Kaschka, L. Frauchiger, S. Werlen and J. M. Schwab (2013). "Prevalence of cam-type deformity and hip pain in elite ice hockey players before and after the end of growth." Am J Sports Med **41**(10): 2308-2313.
The most frequent intra-articular hip diagnoses in ice-hockey players are hip labral tear (69.1%), followed by hip osteoarthritis (13.8%), hip loose body (6.3%), and hip femoroacetabular impingement (5.3%).	A database containing the injury surveillance of National Hockey League (NHL) players from the years 2006 to 2010 was used to identify athletes who had sustained a hip or groin injury.	n=980 hip/groin pain of which n=94 intra-articular injuries.				4		Epstein, D. M., M. McHugh, M. Yorio and B. Neri (2013). "Intra-articular hip injuries in national hockey league players: a descriptive epidemiological study." The American journal of sports medicine **41**(2): 343-348.
The risk of developing premature hip OA seems high for retired handball players and significantly greater than for the general population. 60% of the handball players were diagnosed with OA in at least one of the hip joints compared with 13% of the control subjects.	Case-control study. A questionnaire yielded personal details, loading patterns during physical activity, and previous lower limb joint injury. Bilateral radiographs were analysed to diagnose and classify hip OA. Passive hip ROM was measured bilaterally with a goniometer. Passive ROM measured in the handball players was significantly lower for hip flexion and medial rotation and higher for abduction, extension, and lateral rotation than the control values. The handball players with OA reported less pain in the hip joints during daily activities than the control subjects with OA.	n= 20 former elite handball players, n= 39 control subjects were collected. A questionnaire yielded personal details, loading patterns during physical activity, and previous lower limb joint injury. Bilateral radiographs were analysed to diagnose and classify hip OA. Passive hip ROM was measured bilaterally with a goniometer.			3			L'Hermette, M., G. Polle, C. Tourny-Chollet and F. Dujardin (2006). "Hip passive range of motion and frequency of radiographic hip osteoarthritis in former elite handball players... including commentary by Klassbo M." British Journal of Sports Medicine **40**(1): 45-50.

89% (8/9) of former elite water polo players had α angle ≥60◦ consistent with the presence of cam lesion morphology in one or both hips. All five players with a reported history of "hip" or "groin" pain had MR evidence of cam lesion morphology	Small case-series looking at ex-elite level water polo players. Examined with 3T MRI.	n =9 former male high performance Water Polo players (4 asymptomatic, 5 with self-reported hip or groin pain). Average age= 30, 16+5 years playing history.				4		Melville, P., C. Engstrom, D. Bailey and S. Daley (2012). "Femoroacetabular impingement in former high performance male Water Polo players." Journal of Science and Medicine in Sport **15**: S243.
AGE								
Increased incidence of hip OA with age.	Epidemiological study using US Defence Medical Epidemiology Database (DMED). Poisson regression used to estimate the rate of hip OA per 100,000 person-years by sex, race, age, rank, and service (unadjusted rates). The highest incidence rate was seen in the > 40 years age group with an incidence rate of 140 per 100,000 person-years. The adjusted rate ratio for the >40 years age group compared with the 20 years age group was 22.21 (95% CI 17.54 –28.14).	A total of 4,262 cases of hip OA were documented in population at risk of 12,096,304 person-years.		2				Scher, D. L., P. J. Belmont, Jr., S. Mountcastle and B. D. Owens (2009). "The incidence of primary hip osteoarthritis in active duty US military service members." Arthritis Rheum 61(4): 468-475.
Increasing age was associated with the development of hip OA in women.	Cross-sectional survey. Hip OA prevalence was 1.0–2.5% in subjects <60 yr of age and 4.4–5.3% in subjects >60 yr of age. Logistic regression analyses showed age (P<0.001) to be significantly associated with hip OA prevalence in women.	2232 women and 1336 men (age range 20–91yr)				4		Jacobsen, S. and S. Sonne-Holm (2005). "Hip dysplasia: a significant risk factor for the development of hip osteoarthritis. A cross-sectional survey." Rheumatology (Oxford) **44**(2): 211-218.
Older age was a predictor of increased incidence of hip OA.	Baseline (1991-1997) and first follow up (1999-2005) data from Johnston County Osteoarthritis Project participants. The incidence of 4 hip OA-related outcomes ranged from 0.3 to 5.5% each year. For each outcome, older age, being female, and having a history of hip injury were all predictors of increased incidence.	n=1,423; aged > 45 years.			3			Do, B. T., L. Murphy, C. G. Helmick, K. E. Barbour, Y. J. Cheng and J. M. Jordan (2011). "Incidence of hip symptoms and radiographic and symptomatic hip osteoarthritis in African Americans and Caucasians: The Johnston county osteoarthritis project." Arthritis and Rheumatism **63**(10 SUPPL. 1).
GENDER								

Increased incidence of hip OA in women compared to men in all age groups.	Epidemiological study using US Defence Medical Epidemiology Database (DMED). Poisson regression used to estimate the rate of hip OA per 100,000 person-years by sex, race, age, rank, and service. Women - 54/ 100,000 person-yrs; men 32/ 100,000 person-yrs. Women had a significantly increased adjusted incidence rate ratio for hip OA of 1.87 (95% confidence interval [95% CI] 1.73–2.01) compared to men.	A total of 4,262 cases of hip OA were documented in population at risk of 12,096,304 person-years.		2				Scher, D. L., P. J. Belmont, Jr., S. Mountcastle and B. D. Owens (2009). "The incidence of primary hip osteoarthritis in active duty US military service members." Arthritis Rheum 61(4): 468-475.
Female sex was a predictor of increased incidence of hip OA.	Baseline (1991-1997) and first follow up (1999-2005) data from Johnston County Osteoarthritis Project participants. The incidence of 4 hip OA-related outcomes ranged from 0.3 to 5.5% each year. For each outcome, older age, being female, and having a history of hip injury were all predictors of increased incidence.	n=1,423; aged > 45 years.		2				Do, B. T., L. Murphy, C. G. Helmick, K. E. Barbour, Y. J. Cheng and J. M. Jordan (2011). "Incidence of hip symptoms and radiographic and symptomatic hip osteoarthritis in African Americans and Caucasians: The Johnston county osteoarthritis project." Arthritis and Rheumatism **63**(10 SUPPL. 1).
PAIN								
Painful hips had a statistically significant higher mean alpha angle than asymptomatic hips (69.9 degrees vs. 63.1 degrees, $p < 0.001$). Hips with an alpha angle of more than 60 degrees had an odds ratio of being painful of 2.59 (95% confidence interval 1.32 to 5.08, $p = 0.006$) compared with those with an alpha angle of less than 60 degrees .	Study to determine the prevalence of bilateral deformity in patients with symptomatic cam-type femoroacetabular impingement as well as the presence of associated acetabular abnormalities and hip pain. Bilateral cam-type deformity was present in 88 patients (77.8%) while only 23 of those (26.1%) had bilateral hip pain.	n = 113 patients (M=82, F=31) with a symptomatic cam-impingement deformity of at least one hip. Age <55 years. Mean age 37.9 (16-55). At least one anteroposterior and lateral pelvic radiograph available. All patients with dysplasia and/or arthritis were excluded.			3			Allen, D., P. E. Beaulé, O. Ramadan and S. Doucette (2009). "Prevalence of associated deformities and hip pain in patients with cam-type femoroacetabular impingement." Journal of Bone & Joint Surgery, British Volume **91**(5): 589-595.

Hip pain with combined clinical examination tools is predictive of osteoarthritis with increasing predictive power with increasing number of positive clinical findings.	Preliminary study to determine clinical prediction tool for accurately predicting osteoarthritis of the hip. The 5 variables that emerged from the subsequent logistic regression analysis were used to form the preliminary clinical prediction rule: (1) self-reported squatting as an aggravating factor; (2) active hip flexion causing lateral hip pain; (3) scour test with adduction causing lateral hip or groin pain; (4) active hip extension causing pain; and (5) passive internal rotation of less than or equal to 25°. If at least 4 of 5 variables were present, the positive Likelihood Ratio was equal to 24.3 (95% confidence interval: 4.4-142.1), increasing the probability of hip OA to 91%.	n=72 patients with unilateral pain in hip, groin or buttock. F=40 female, M=32. Mean age 56.8yrs. 29% had radiographic evidence of OA.			3			Sutlive, T. G., H. P. Lopez, D. E. Schnitker, S. E. Yawn, R. J. Halle, L. T. Mansfield, R. E. Boyles and J. D. Childs (2008). "Development of a clinical prediction rule for diagnosing hip osteoarthritis in individuals with unilateral hip pain." J Orthop Sports Phys Ther **38**(9): 542-550.

TABLE 8: EXAMINATION AND PREDICTION OF HIP OA

BMI - body mass index, **FAI** - femoroacetabular impingement, **HR** - hazard ratio, **LLI** - lower limb inequality, **OA** - osteoarthritis,

STUDY FINDING	OVERVIEW	STUDY POPULATION	LEVEL OF EVIDENCE (CEBM 2009)					REFERENCE
			1	2	3	4	5	
BODY MASS INDEX (BMI)								
BMI at early and middle adulthood is a risk factor for hip OA. Hazard ratio per 5 kg/m(2) = 1.29 (95% Confidence intervals 1.21- 1.37)]	At baseline interview participants were asked to recall their weight at age 18-21 years and had their middle age height and weight measured. Total knee and hip replacement for OA between 2001 and 2009 was determined by linking the cohort records to the Australian Orthopaedic Association National Joint Replacement Registry.	n = 38,149 (Melbourne Collaborative Cohort Study). Mean age 54.9yrs.		2				Wang, Y., et al. (2013). "Body weight at early and middle adulthood, weight gain and persistent overweight from early adulthood are predictors of the risk of total knee and hip replacement for osteoarthritis." Rheumatology (Oxford) **52**(6): 1033-1041.
Joint injury, obesity, and occupational activity are associated with an increased risk of knee and hip OA.	Systematic review to identify risk factors for osteoarthritis of the knee, hip, and ankle, including joint injury, sport, physical activity, overweight/obesity, and occupational activity, in all age groups.	43 studies		2				Richmond, S. A., R. K. Fukuchi, A. Ezzat, K. Schneider, G. Schneider and C. A. Emery (2013). "Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review." J Orthop Sports Phys Ther **43**(8): 515-B519.

Obesity (odds ratio (OR) = 1.7, 95% confidence interval (CI) 1.3-2.4; highest vs. lowest third of body mass index independent risk factors for hip osteoarthritis among men and women.	The authors explored individual risk factors for hip osteoarthritis in a population-based case-control study. The study was performed in two English health districts (Portsmouth and North Staffordshire) from 1993 to 1995. Information about suspected risk factors was obtained by a questionnaire administered at interview and a short physical examination. .	A total of 611 patients (210 men and 401 women) listed for hip replacement because of osteoarthritis over an 18-month period were compared with an equal number of controls selected from the general population and individually matched for age, sex, and family practitioner.			3			Cooper, C., H. Inskip, P. Croft, L. Campbell, G. Smith, M. McLaren and D. Coggon (1998). "Individual risk factors for hip osteoarthritis: obesity, hip injury, and physical activity." Am J Epidemiol 147(6): 516-522.
Greater weight and BMI at age 18-21 years and middle age, weight gain and persistent overweight during this time were associated with an increased risk of total knee and hip replacement in later life. (Associations were stronger for knee OA than hip OA).	A cohort study to examine the relationships between weight at early and middle adulthood and adult weight gain and the risk of total knee and hip replacement for OA.Melbourne Collaborative Cohort Study were asked to recall their weight at age 18-21 years and had their middle age height and weight measured. Total knee and hip replacement for OA between 2001 and 2009 was determined by linking the cohort records to the Australian Orthopaedic Association National Joint Replacement Registry. Hip results: Middle-age weight hazard ratio (HR) per 5 kg = 1.11 (1.09, 1.14), and BMI hazard ratio per 5 kg/m(2)= 1.29 (1.21, 1.37)] and adult weight gain hazard ratio per 5 kg 1.10 (1.07, 1.13)	n =38,149. Mean age 54.9yrs.		2				Wang, Y., A. E. Wluka, J. A. Simpson, G. G. Giles, S. E. Graves, R. N. de Steiger and F. M. Cicuttini (2013). "Body weight at early and middle adulthood, weight gain and persistent overweight from early adulthood are predictors of the risk of total knee and hip replacement for osteoarthritis." Rheumatology (Oxford) **52**(6): 1033-1041.
Increasing BMI is associated with a higher risk of hip osteoarthritis. Adjusted hazard ratio (HR) for hip OA with increasing BMI were; overweight HR= 1.46 (1.39-1.52); obese HR= 1.75 (1.66-1.83);morbidly obese HR= 1.93 (1.82-2.05).	Cohort study using computerized medical records from the SIDIAP Database to identify those aged 40 years or older with an incident diagnosis of hip OA. SIDIAP contains the anonymised medical records of >3,100 GPs in Catalonia (North-East Spain) with information on an 80% of the total population.	n = 12, 567 patients with hip OA.		2				Prieto-Alhambra, D., A. Pages-Castella, M. K. Javaid, A. Judge, C. Cooper, N. K. Arden and A. Diez-Perez (2012). "Incidence of knee, hip, and hand clinical osteoarthritis: A population-based cohort study." Arthritis and Rheumatism **64**: S397-S398.

A high BMI was significantly associated with knee OA and hand OA, but not with hip OA.	Norwegian study on musculoskeletal pain in both 1994 and 2004. When adjusting for age, gender, work status and leisure time activities, a high BMI (> 30) was significantly associated with knee OA (OR 2.81; 95%CI 1.32–5.96), and hand OA (OR 2.59; 1.08–6.19), but not with hip OA (OR 1.11; 0.41–2.97).	A total of n =1675. age at start of study = 24–76 yrs. No OA at start of study. The main outcome measure was OA diagnosis at follow-up based on self-report. Obesity was defined by a body mass index (BMI) of 30 and above. NOTE: Both diagnosis of OA and BMI estimation was based on self-report.		2				Grotle, M., K. B. Hagen, B. Natvig, F. A. Dahl and T. K. Kvien (2008). "Obesity and osteoarthritis in knee, hip and/or hand: an epidemiological study in the general population with 10 years follow-up." BMC Musculoskelet Disord **9**: 132.
HIP RANGE OF MOVEMENT (ROM)								
Internal rotation was significantly reduces in symptomatic and asymptomatic patients with radiological FAI compared to healthy controls.	The range of internal rotation on impingement testing was found to average 27.9° in the healthy control group compared with 21.1° in the asymptomatic control group with radiographic features specific to FAI (P < .001) and 12.3° in the patient group (P < .001). Cam size, acetabular coverage, and femoral version appeared to be predictive variables for the range of internal rotation. Seventy-five percent of variance between patients could be attributed to the combined effect of these 3 variables (R = .86).	n= 30 patients (10 per subgroup). All male, 18-35 yrs.			3			Audenaert, E. A., I. Peeters, L. Vigneron, N. Baelde and C. Pattyn (2012). "Hip morphological characteristics and range of internal rotation in femoroacetabular impingement." Am J Sports Med **40**(6): 1329-1336.
Restriction in range of movement was predictive of the presence of OA in new presenters to primary care with hip pain	New hip pain attenders with radiographic OA had restricted movement at the hip compared with those without radiographic change. Restriction in internal rotation was the most predictive and flexion the least predictive of radiographic OA.	n =195 patients with hip pain presenting to general practice, median age = 63yrs, female = 68%.			3			Birrell, F., P. Croft, C. Cooper, G. Hosie, G. Macfarlane and A. Silman (2001). "Predicting radiographic hip osteoarthritis from range of movement." Rheumatology **40**(5): 506-512.

Internal rotation correlated to radiographic (but not necessarily symptomatic) cam FAI. Authors suggest that football players with diminished internal rotation in whom hip pain develops should be evaluated for underlying cam FAI abnormalities.	The objective of this study was to determine whether physical examinations (flexion–abduction–external rotation [FABER], impingement, range-of-motion profiles) could be used to detect the bony abnormalities of femoroacetabular impingement (FAI) in an athletic population. Although 95% of the hips had at least 1 radiographic sign of FAI, pain was reported in only 8.5% and 2.3% during the impingement and FABER tests, respectively.	n = 65 collegiate football players.				4		Kapron, A. L., A. E. Anderson, C. L. Peters, L. G. Phillips, G. J. Stoddard, D. J. Petron, R. Toth and S. K. Aoki (2012). "Hip internal rotation is correlated to radiographic findings of cam femoroacetabular impingement in collegiate football players." Arthroscopy - Journal of Arthroscopic and Related Surgery **28**(11): 1661-1670.
Reduced internal rotation in professional footballers compared to controls. The authors suggest this may be an indication of early degenerative change.	Case-control observational study. Bilateral measurements of passive hip internal rotation (IR), external rotation (ER), flexion, abduction and extension were made together with Faber's test and the hip quadrant test. Footballers had significantly less IR and Faber's range and significantly higher abduction than their respective controls ($p < 0.001$). Senior footballers also had significantly reduced IR ($p < 0.05$) and Faber's ($p < 0.001$) than the youth team. A higher proportion of senior footballers had positive hip quadrants (45% of all hips) compared to all other groups. No significant difference in hip ROM was found between dominant and non-dominant legs.	40 asymptomatic male professional footballers: 20 youth (age 16-18) and 20 senior team (>19yrs) and 40 matched control subjects.				3		Manning, C. and Z. Hudson (2009). "Comparison of hip joint range of motion in professional youth and senior team footballers with age-matched controls: An indication of early degenerative change?" Physical Therapy in Sport **10**(1): 25-29.
IMPINGEMENT TESTS								
35 of 480 (7.3%) healthy men and 32 of 672 (4.8%) healthy women had positive impingement tests.	Population based study looking at prevalence of FAI in healthy young adults. Correlated with activity levels, history of hip symptoms and radiographic findings. Positive impingement tests were associated with history of hip pain in women and in high activity levels and radiographic CAM lesions in men.	n = 1152 healthy young adults. Men =480, women =672. Ages 18 to 20 years old. Part of the follow-up of the population- based '1989 Bergen Birth Cohort'				4		Laborie, L. B., T. G. Lehmann, I. O. Engesaeter, L. B. Engesaeter and K. Rosendahl (2013). "Is a positive femoroacetabular impingement test a common finding in healthy young adults?" Clin Orthop Relat Res **471**(7): 2267-2277.

Impingement test(FADIR) had best diagnostic ability to diagnose labral tears clinically. (sensitivity 59%, spec 100%, PPV - 100%, NPV - 13%)	Testing diagnostic validity of impingement test (FADIR test - hip flexion, adduction, internal rotation), FABER test (hip flexion, abduction, external rotation), resisted straight leg raise test and ultrasound compared to MR arthrography for identifying labral tears.	n = 18 hips, male = 2, female = 16. Median age 43 (range 32-56yrs)				4		Troelsen, A., et al. (2009). "What is the role of clinical tests and ultrasound in acetabular labral tear diagnostics?" Acta Orthopaedica **80**(3): 314-319.
The most sensitive clinical test) for detecting intra-articular hip pathology were flexion abduction external rotation (FABER) test and the internal rotation over pressure (IROP) manoeuver	Diagnostic study looking at four clinical tests for detecting intra-articular pathology: FABER, internal rotation over-pressure, Stinchfield manoeuvre, Scour manoeuvre. Study group were patients undergoing hip injection for suspected pathology. Indications for injections were: OA (64%), FAI For the FABER test, sensitivity was 0.82 (95% CI 0.57-0.96); sensitivity for the IROP manoeuvre was 0.91 (95% CI 0.68-0.99). The most specific test was the Stinchfield manoeuver, with specificity at 0.32 (95% CI 0.14-0.55). FABER and IROP had the highest positive predictive value, with 0.46 (95% CI 0.28-0.65) and 0.47 (95% CI 0.29-0.64), respectively. IROP had the highest negative predictive value at 0.71 (95% CI 0.25-0.98). NOTE: There was no comparison with a control group without suspected intra-articular pathology.	n = 50 (male =20, female =30). Average age = 60.2yrs.				4		Maslowski, E., W. Sullivan, J. Forster Harwood, P. Gonzalez, M. Kaufman, A. Vidal and V. Akuthota (2010). "The diagnostic validity of hip provocation manoeuvres to detect intra-articular hip pathology." PM R **2**(3): 174-181.
The maximal squat test was found to have marginal incremental diagnostic ability for CAM-type FAI. The authors conclude that its utility in the diagnostic evaluation of FAI remains limited.	Pilot study to determine relationship between maximal squat test and FAI. Maximal squat test was compared to MRI and MRA findings of CAM-type FAI deformity. The sensitivity and specificity of the maximal squat test were 75 % (56.6-88.5 %) and 41 % (27.0-56.8 %), respectively, for CAM-type FAI deformity. The positive and negative likelihood ratios were modest at 1.3 (0.9-1.7) and 0.6 (0.3-1.2), respectively. This means that a 30 % pre-test probability is improved to 36 % following a positive squat test and reduced to 20 % with a negative squat test.	n= 76 consecutive patients with pre-arthritic hip pain, recruited from an outpatient clinic at McMaster University.				4		Ayeni, O., R. Chu, B. Hetaimish, L. Nur, N. Simunovic, F. Farrokhyar, A. Bedi and M. Bhandari (2013). "A painful squat test provides limited diagnostic utility in CAM-type femoroacetabular impingement." Knee Surg Sports Traumatol Arthrosc.

The impingement test had the best diagnostic ability to identify labral tears with a sensitivity of 59% and a specificity of 100%.	Small study comparing clinical diagnostic tests for labral tears(impingement test, FABER test, resisted straight leg raise test) with MRA findings. Acetabular labral tears were identified in 17 of the 18 hip joints on MR arthrograms. Impingement tests were positive in 10 of 17 confirmed cases. NOTE: population all had dysplasia of the hip, unclear whether patients were symptomatic or asymptomatic prior to study.	n = 18 patients. Women = 16, men =2. Median age =43yrs. All had had previous periacetabular osteotomies due to symptomatic, acetabular dysplasia. All hips showed no or only slight signs of osteoarthritis (Tönnis grade 0–1).				4		Troelsen, A., I. Mechlenburg, J. Gelineck, L. Bolvig, S. Jacobsen and K. Søballe (2009). "What is the role of clinical tests and ultrasound in acetabular labral tear diagnostics?" Acta Orthopaedica **80**(3): 314-319.
BIOMECHANICS								
Varus knee, valgus knee, and toe-in/out angles were **not** significantly associated with increased risk of isolated hip OA. Adjustments for age, sex, and BMI did not alter these findings	Participants in the Genetics of Osteoarthritis and Lifestyle case–control database were sent a questionnaire containing line-drawing instruments for self-reported knee and foot alignment at ages 20–29 years. Respondents were categorized as having straight, valgus, or varus knee, and straight, toe-in, or toe-out feet.	n=1901 (n = 672 with hip OA), 50% women, mean age 67.4.			3			McWilliams, D. F., S. Doherty, R. A. Maciewicz, K. R. Muir, W. Zhang and M. Doherty (2010). "Self-reported knee and foot alignments in early adult life and risk of osteoarthritis." Arthritis Care and Research **62**(4): 489-495.
LEG LENGTH INEQUALITY (LLI)								
LLI was moderately associated with chronic knee symptoms and less strongly associated with hip symptoms.	Cross-sectional study examining the association of limb length inequality (LLI) with chronic joint symptoms at the hip and knee in a large, community-based sample, adjusting for the presence of radiographic osteoarthritis (OA) and other confounders. . Participants with LLI were more likely than those without LLI to have knee symptoms (56.8% vs. 43.0%, P < 0.001), and hip symptoms (49.5% vs. 40.0%, P = 0.09). In adjusted models, knee symptoms were significantly associated with presence of LLI (adjusted odds ratio [aOR] = 1.41, 95% confidence interval, [95% CI] 1.02-1.97), but the relationship between hip symptoms and LLI (aOR = 1.20, 95% CI 0.87-1.67) was not statistically significant.	n = 3007 patients with hip symptoms, n = 206 patients with LLI ≥2c m.				4		Golightly, Y. M., K. D. Allen, C. G. Helmick, J. B. Renner and J. M. Jordan (2009). "Symptoms of the knee and hip in individuals with and without limb length inequality." Osteoarthritis and Cartilage **17**(5): 596-600.

LLI was associated with radiographic knee OA but not hip OA.	This study examined the relationship of limb length inequality (LLI) with radiographic hip and knee osteoarthritis (OA) in a large, community-based sample. Methods: The total study group comprised 926 participants with radiographic knee OA, 796 with radiographic hip OA, and 210 (6.6%) with LLI >=2 cm. . In multiple logistic regression models, knee OA was significantly associated with presence of LLI but there was no significant relationship between hip OA and LLI (aOR = 1.20, 95% CI 0.86-1.67).	n = 796 radiographic hip OA, n = 926 radiographic knee OA, n = 210 with LLI ≥2cm.				4		Golightly, Y. M., K. D. Allen, J. B. Renner, C. G. Helmick, A. Salazar and J. M. Jordan (2007). "Relationship of limb length inequality with radiographic knee and hip osteoarthritis." Osteoarthritis and Cartilage **15**(7): 824-829.
LOWER LIMB MUSCLE STRENGTH/SYMMETRY/FLEXIBILITY								
Patients with symptomatic FAI presented muscle weakness for all hip muscle groups, except for internal rotators and extensors.	Small case-control study comparing hip muscle strength between patients with symptomatic FAI and healthy controls.FAI patients had significantly lower MVC strength than controls for hip adduction, flexion, external rotation and abduction. Tensor fascia lata EMG activity was significantly lower in FAI patients compared with controls (P < 0.048), while rectus femoris EMG activity did not differ significantly between the two groups (P< 0.056).	n=22 FAI patients n = 22 controls matched for gender, age, and body mass.				4		Casartelli, N. C., N. A. Maffiuletti, J. F. Item-Glatthorn, S. Staehli, M. Bizzini, F. M. Impellizzeri and M. Leunig (2011). "Hip muscle weakness in patients with symptomatic femoroacetabular impingement." Osteoarthritis Cartilage **19**(7): 816-821.
Strength was significantly reduced on the injured side compared to the non-injured side of patients with a hip labral tear.	Small case-control study to investigate hip flexor muscle size and strength in patients with hip labral pathology compared to control subjects. All participants underwent examination of their lumbo-pelvic region with magnetic resonance imaging. Muscle cross- sectional area of the iliopsoas, sartorius, tensor fascia latae and rectus femoris muscles on both sides were measured and added together to give hip flexor muscle size. Hip flexion strength was measured on both sides by a hand-held dynamometer.	n =12 participants (8 females, 4 males), aged 20–53 years, with a unilateral acetabular labral tear. n=12 control participants matched for age and gender.				4		Mendis, D., S. Wilson, D. Hayes, M. Watts and J. Hides (2011). "Hip flexor muscle strength but not size is reduced in patients with hip labral tears." Journal of Science and Medicine in Sport 14, Supplement 1(0): e19.
LUMBAR SPINE ASSESSMENT								

Low back pain predicted subsequent OA-related pain and disability in those with hip disease, but not knee disease.	Study of a population-based cohort of Ontario residents who were 55 years or older and reported symptomatic hip/knee OA at baseline (between 1996 and 1998). The sample was followed-up between 2000 and 2001. Multivariable linear regression was used to model the association between baseline back pain and pain and disability (Western Ontario and McMaster Universities Osteoarthritis Index scores) at follow-up while controlling for confounders.	n=983, mean age=71.7 years, and 72.3% were female. Mean BMI at baseline=29.1 kg/m2.			3			Stupar, M., P. Côté, M. R. French and G. A. Hawker (2010). "The association between low back pain and osteoarthritis of the hip and knee: a population-based cohort study." Journal of Manipulative & Physiological Therapeutics **33**(5): 349-355.

ADDITIONAL DATA FILE 3 – SUBGROUP ANALYSIS OF RESULTS BY RESEARCH BACKGROUND AND SPECIALTY

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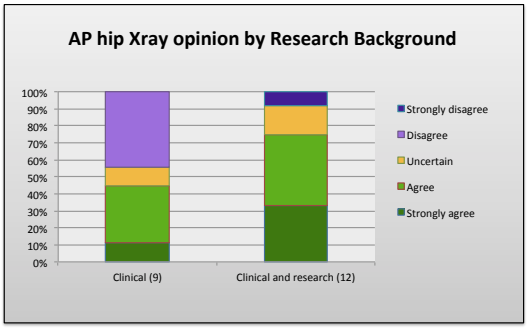

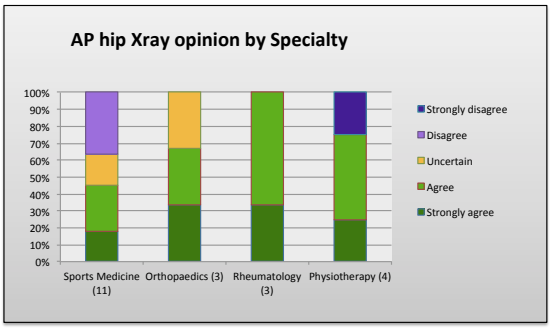

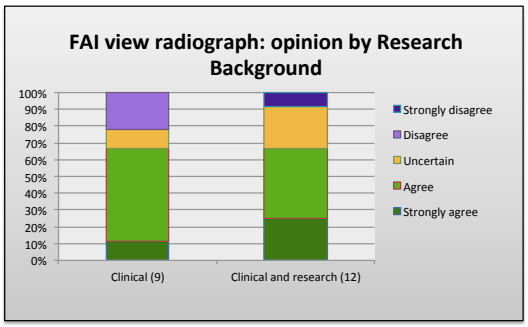

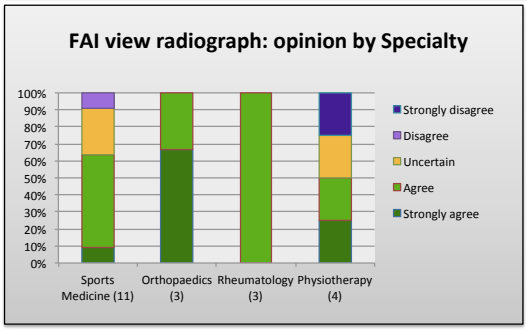

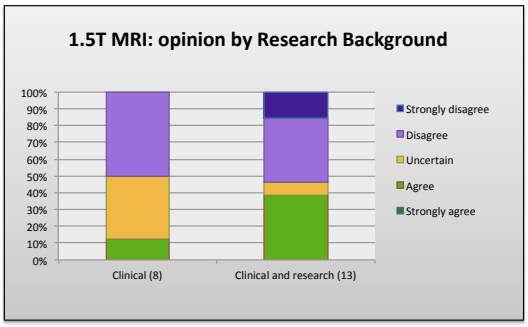

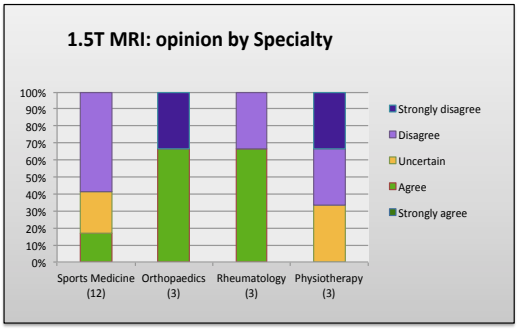

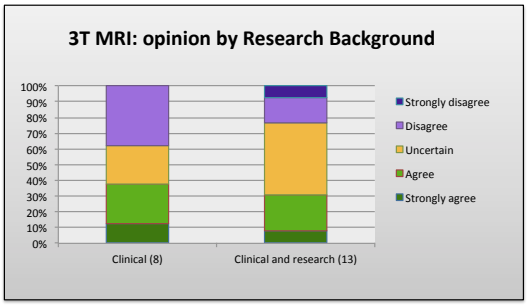

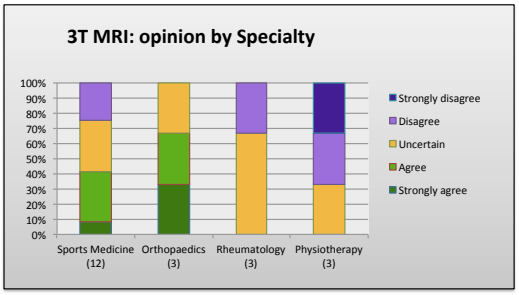

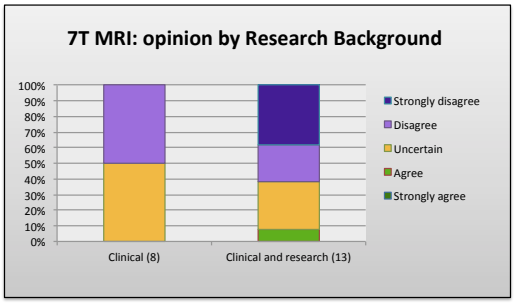

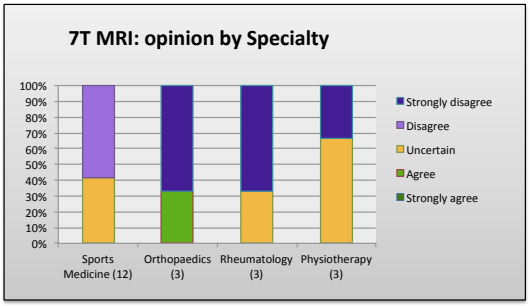

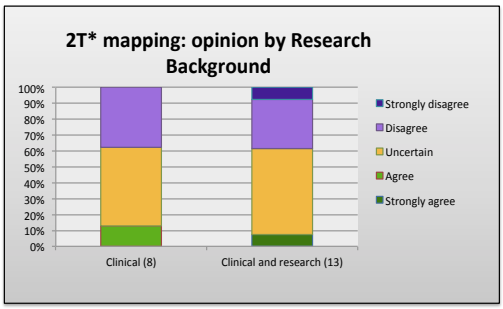
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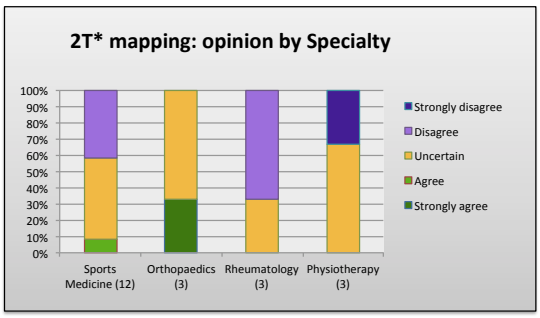
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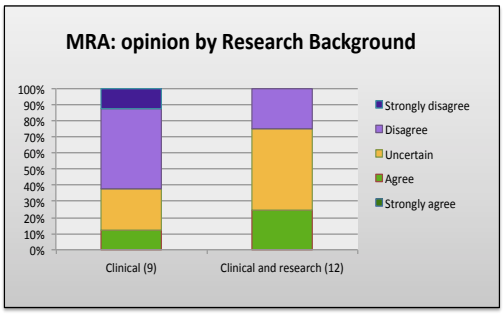
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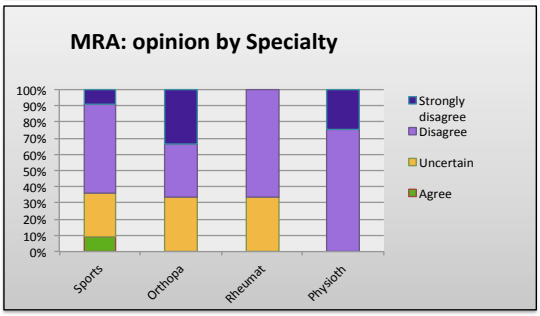
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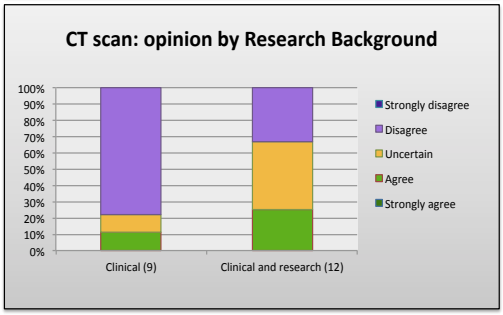
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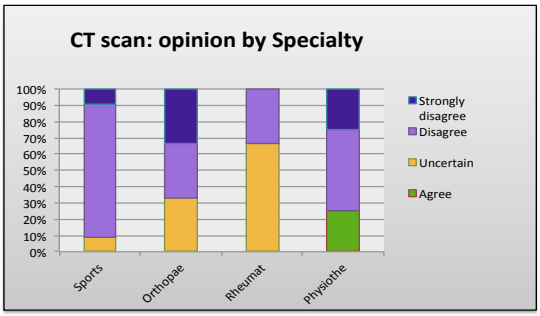
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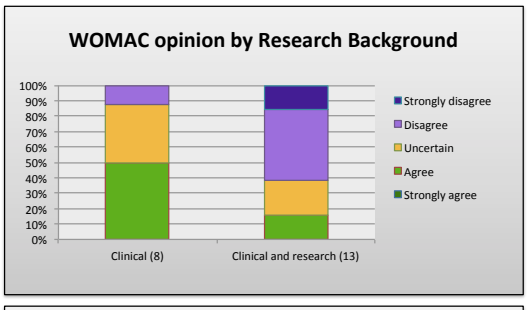
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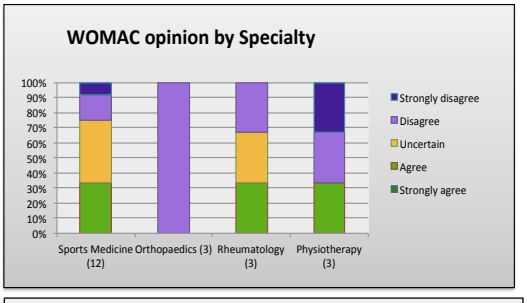
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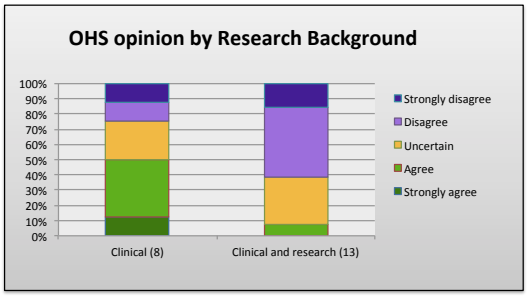
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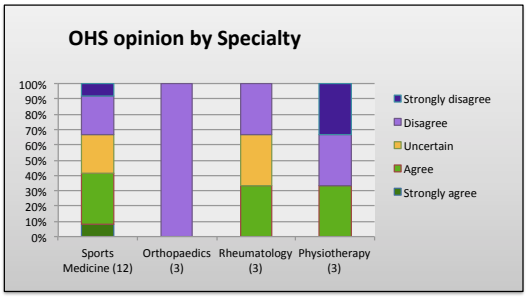
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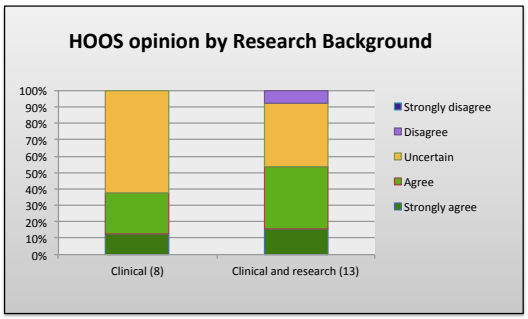
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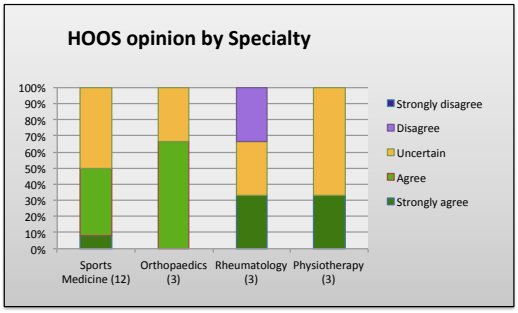
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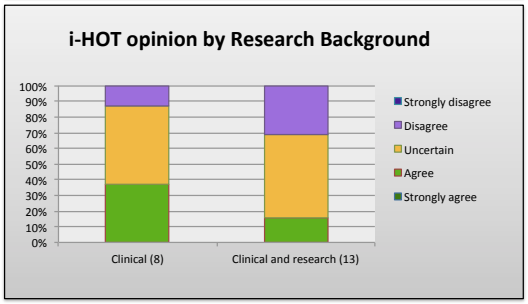
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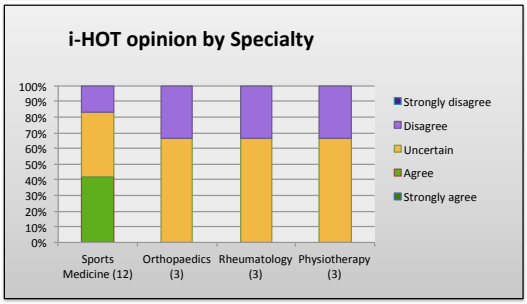
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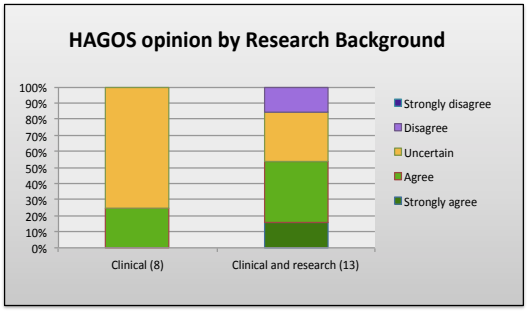
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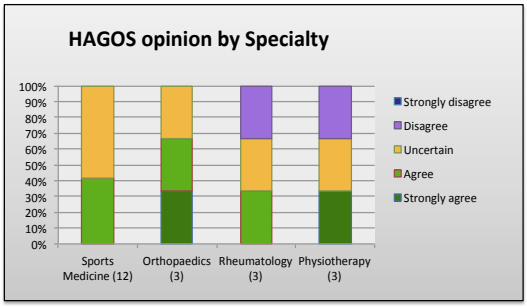
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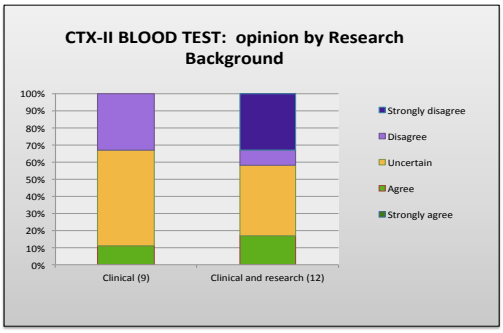
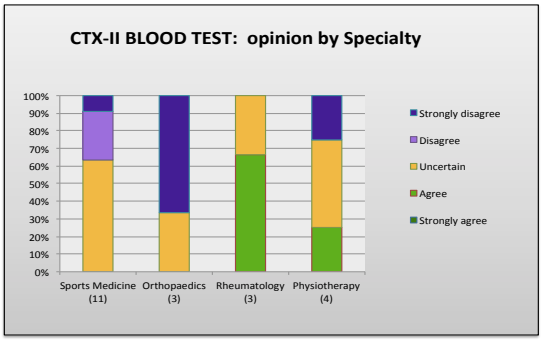
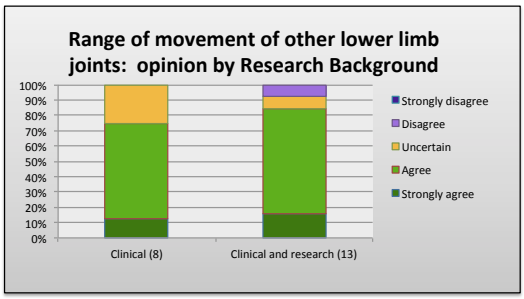
Strongly agree

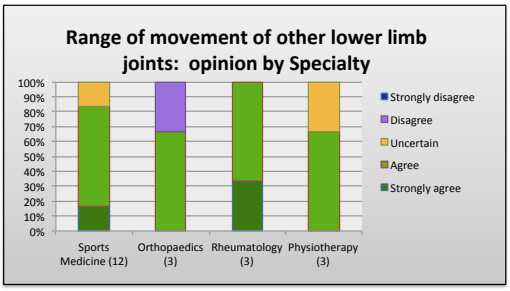
Blood Test

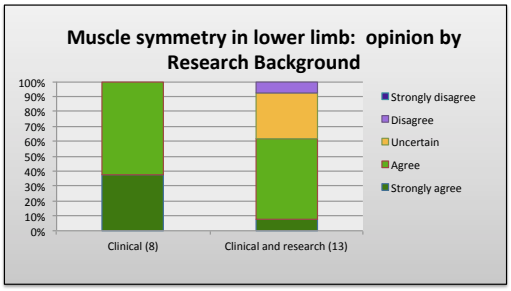

CTX-II BLOOD TEST: opinion by Research Background
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree

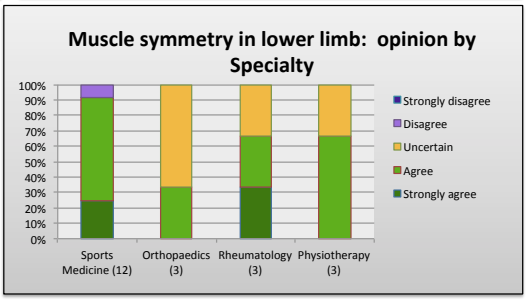

CTX-II BLOOD TEST: opinion by Specialty
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree

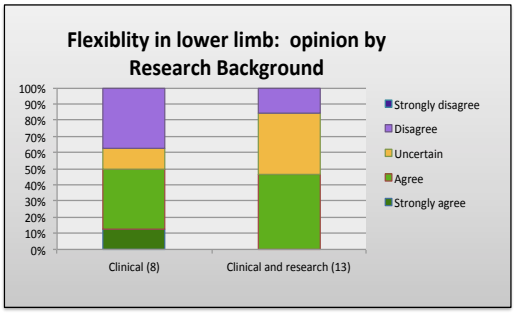
Examination

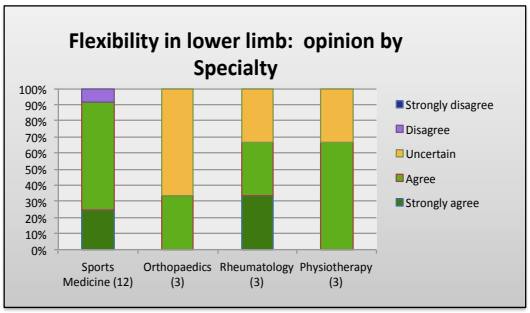


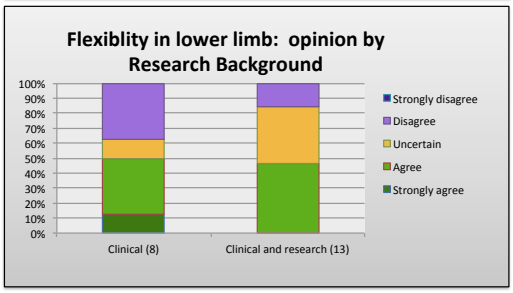


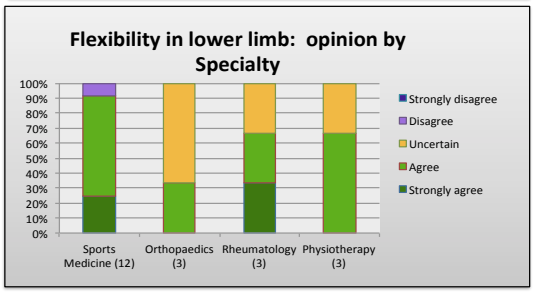


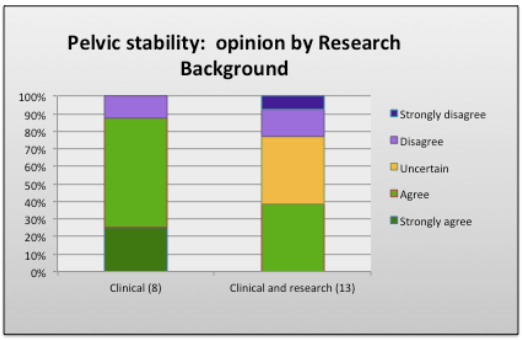


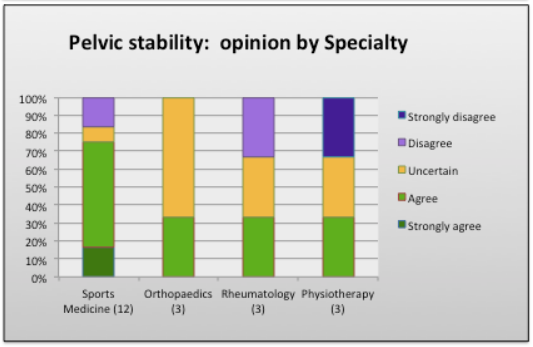


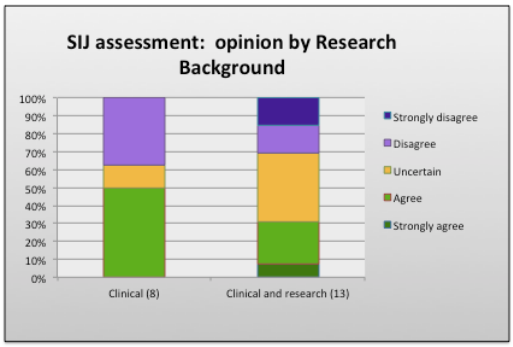


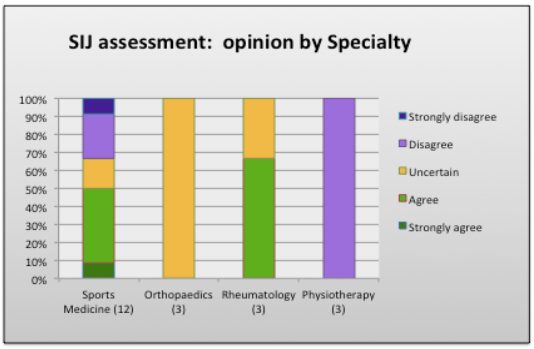


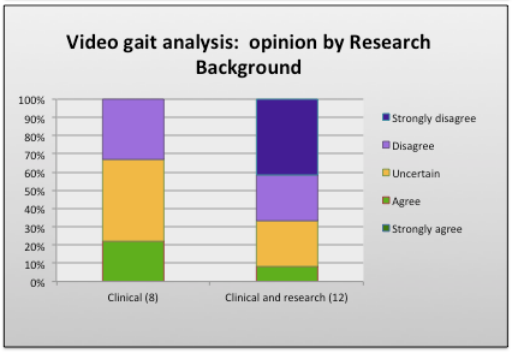







SIJ assessment: opinion by Research Background
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Clinical (8)
Clinical and research (13)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


SIJ assessment: opinion by Specialty
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


Video gait analysis: opinion by Research Background
100%
90%
80%
70%
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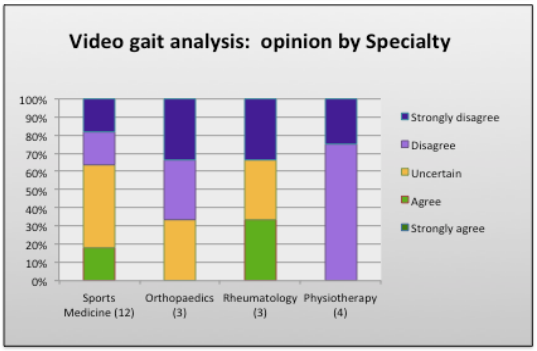
20%
10%
0%
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


Video gait analysis: opinion by Specialty
100%
90%
80%
70%
60%
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30%
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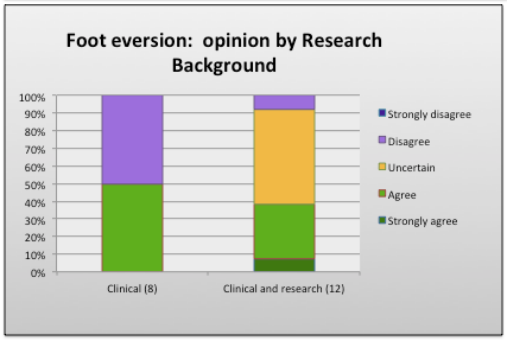
10%
0%
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


Foot eversion: opinion by Research Background
100%
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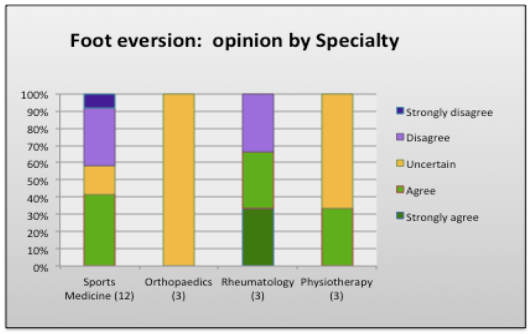
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


Foot eversion: opinion by Specialty
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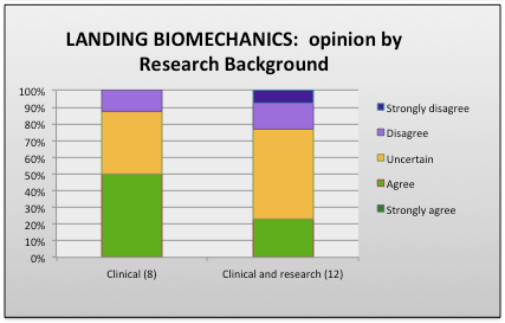
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LANDING BIOMECHANICS: opinion by Research Background
100%
90%
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70%
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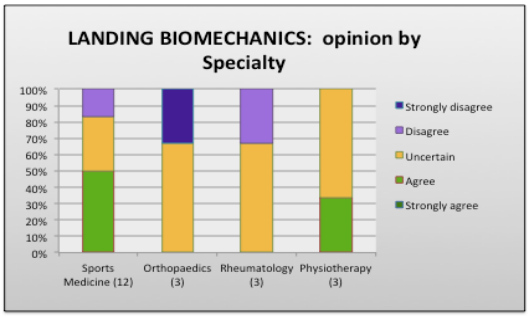
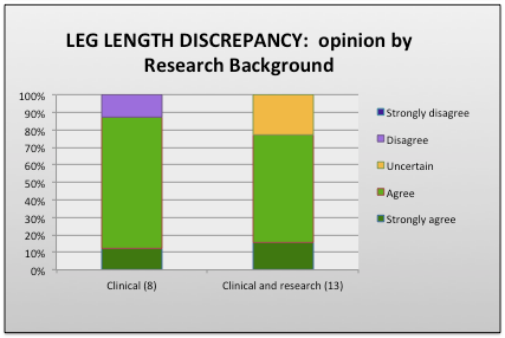
10%
0%
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LANDING BIOMECHANICS: opinion by Specialty
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LEG LENGTH DISCREPANCY: opinion by Research Background
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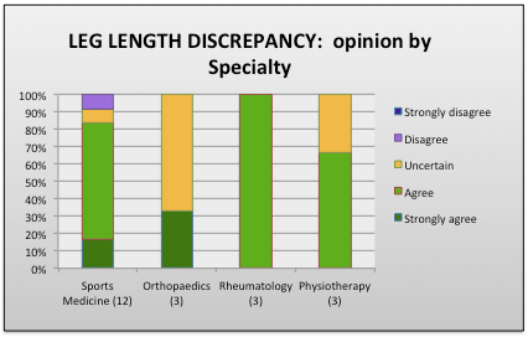
0%
Clinical (8)
Clinical and research (13)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LEG LENGTH DISCREPANCY: opinion by Specialty
100%
90%
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60%
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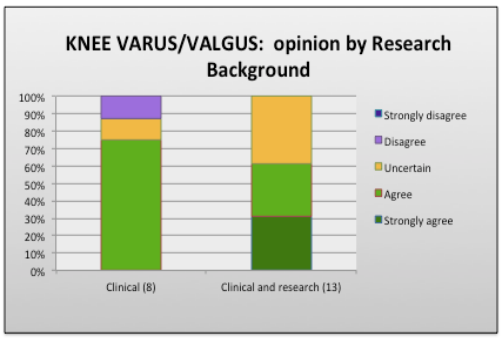
40%
30%
20%
10%
0%
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


KNEE VARUS/VALGUS: opinion by Research Background
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90%
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70%
60%
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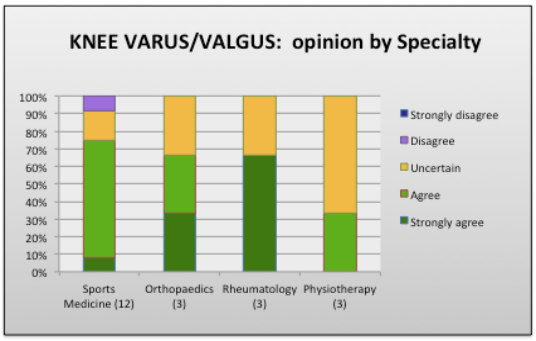
40%
30%
20%
10%
0%
Clinical (8)
Clinical and research (13)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


KNEE VARUS/VALGUS: opinion by Specialty
100%
90%
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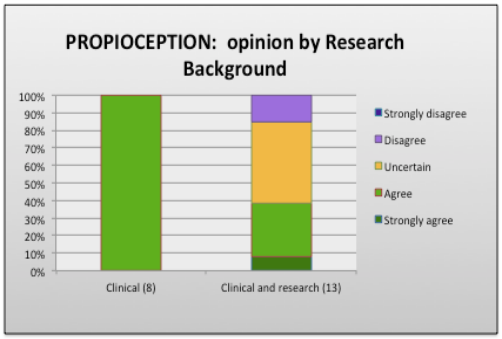
70%
60%
50%
40%
30%
20%
10%
0%
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


PROPIOCEPTION: opinion by Research Background
100%
90%
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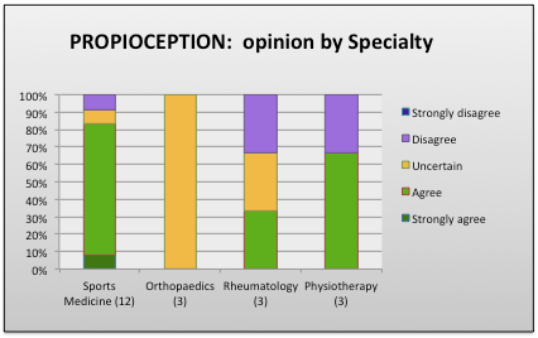
30%
20%
10%
0%
Clinical (8)
Clinical and research (13)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


PROPIOCEPTION: opinion by Specialty
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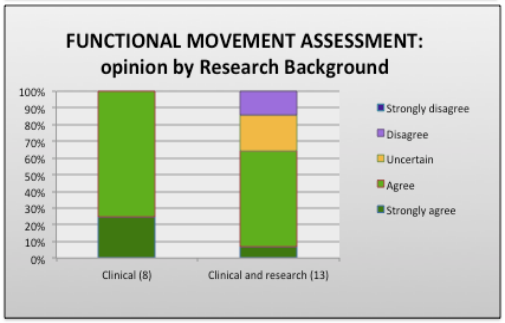
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


FUNCTIONAL MOVEMENT ASSESSMENT: opinion by Research Background
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90%
80%
70%
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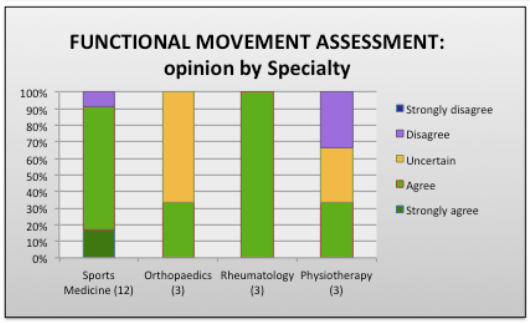
20%
10%
0%
Clinical (8)
Clinical and research (13)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


FUNCTIONAL MOVEMENT ASSESSMENT: opinion by Specialty
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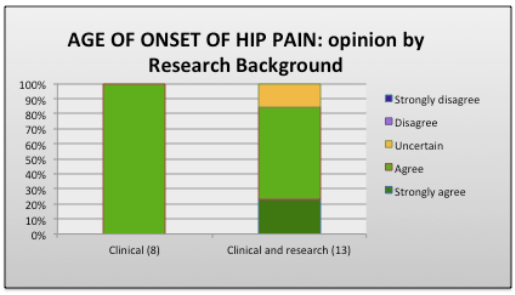
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree

History


AGE OF ONSET OF HIP PAIN: opinion by Research Background
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70%
60%
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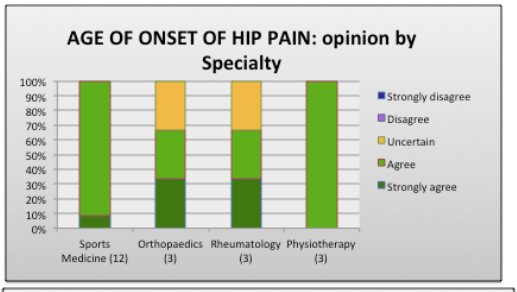
40%
30%
20%
10%
0%
Clinical (8)
Clinical and research (13)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


AGE OF ONSET OF HIP PAIN: opinion by Specialty
100%
90%
80%
70%
60%
50%
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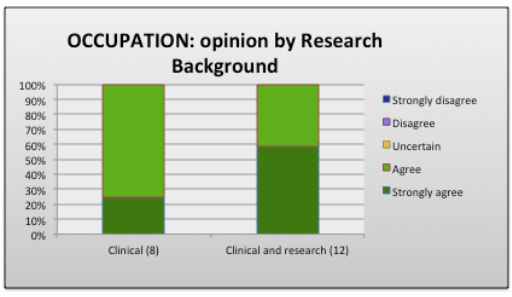
30%
20%
10%
0%
Sports Medicine (12)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


OCCUPATION: opinion by Research Background
100%
90%
80%
70%
60%
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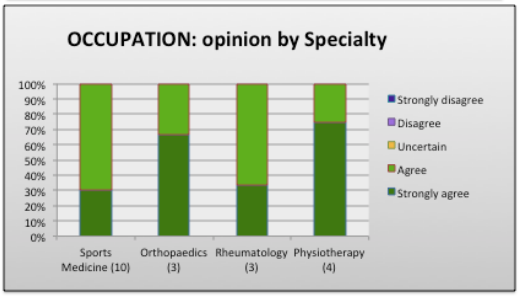
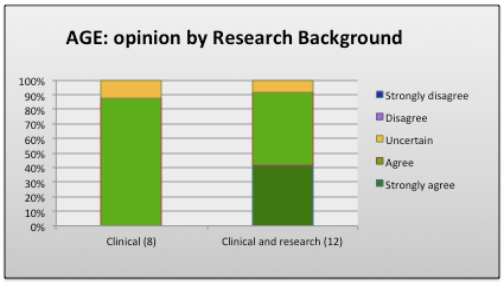
30%
20%
10%
0%
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


OCCUPATION: opinion by Specialty
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


AGE: opinion by Research Background
100%
90%
80%
70%
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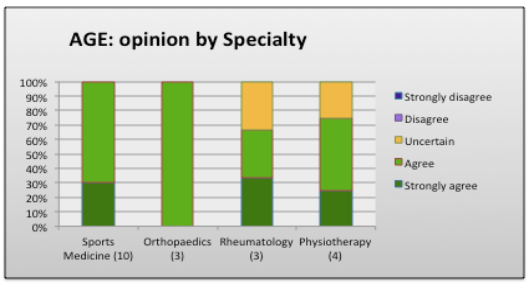
0%
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


AGE: opinion by Specialty
100%
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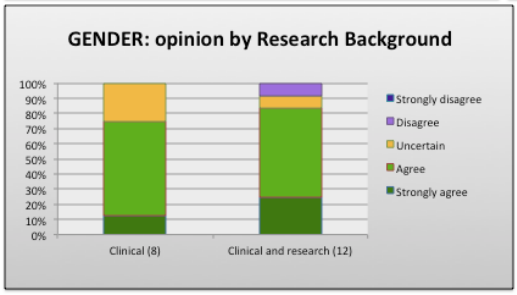
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


GENDER: opinion by Research Background
100%
90%
80%
70%
60%
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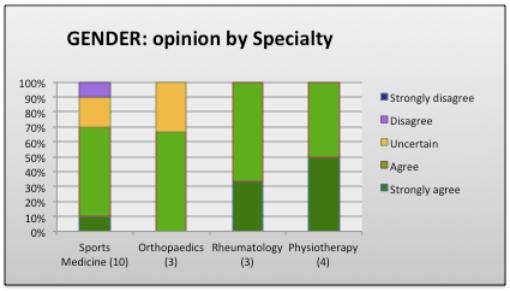
10%
0%
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


GENDER: opinion by Specialty
100%
90%
80%
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60%
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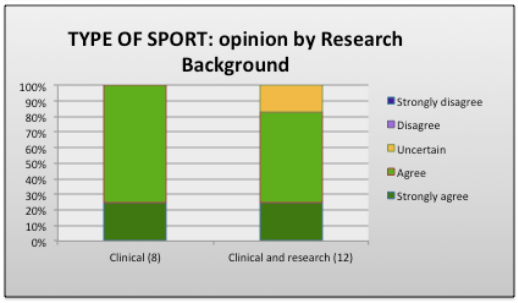
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


TYPE OF SPORT: opinion by Research Background
100%
90%
80%
70%
60%
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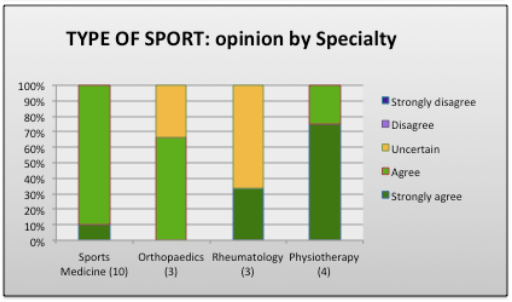
0%
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


TYPE OF SPORT: opinion by Specialty
100%
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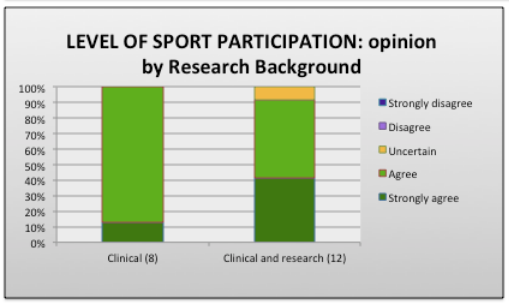
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LEVEL OF SPORT PARTICIPATION: opinion by Research Background
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90%
80%
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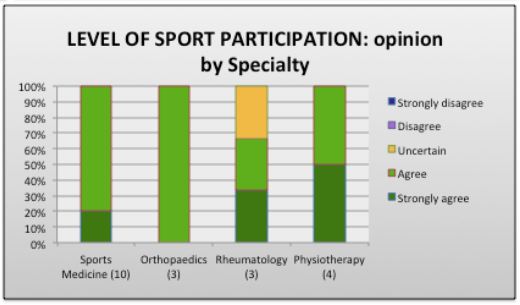
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LEVEL OF SPORT PARTICIPATION: opinion by Specialty
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60%
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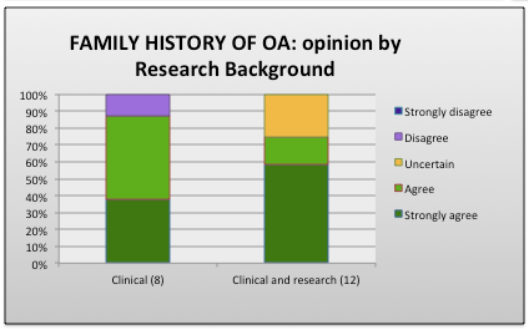
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


FAMILY HISTORY OF OA: opinion by Research Background
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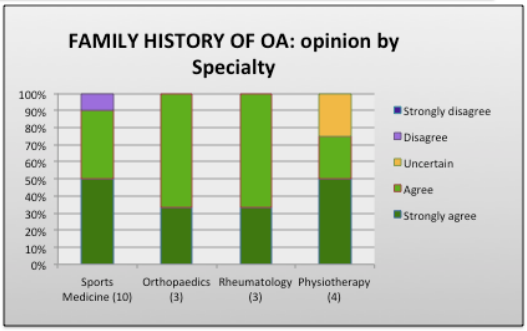
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


FAMILY HISTORY OF OA: opinion by Specialty
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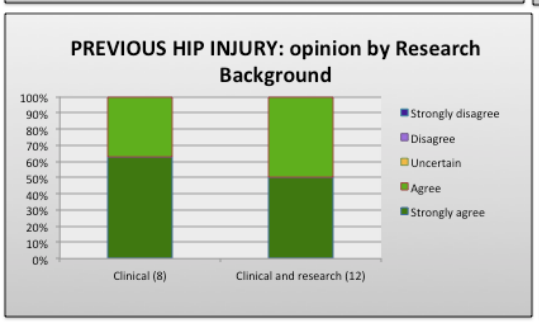
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


PREVIOUS HIP INJURY: opinion by Research Background
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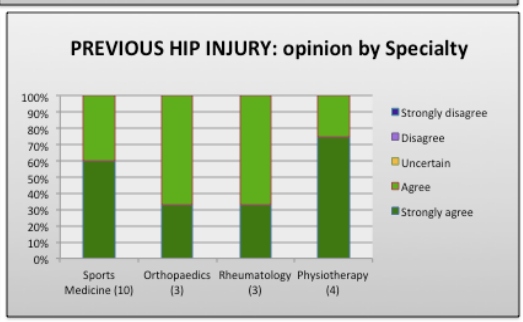
Clinical (8)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


PREVIOUS HIP INJURY: opinion by Specialty
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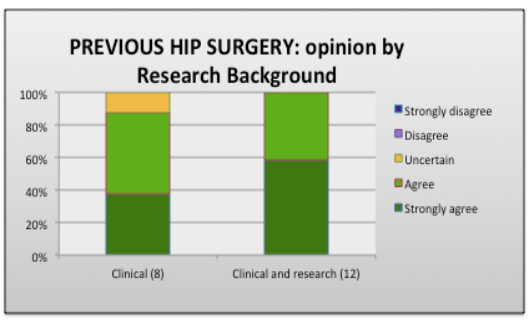
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


PREVIOUS HIP SURGERY: opinion by Research Background
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Clinical (8)
Clinical and research (12)
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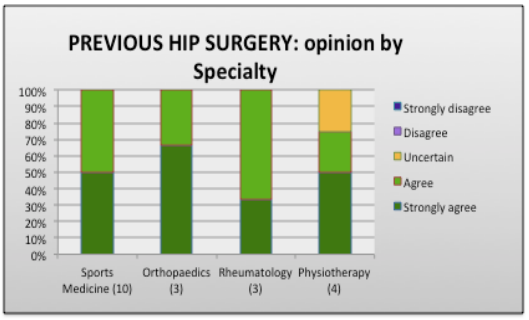
Disagree
Uncertain
Agree
Strongly agree


PREVIOUS HIP SURGERY: opinion by Specialty
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20%
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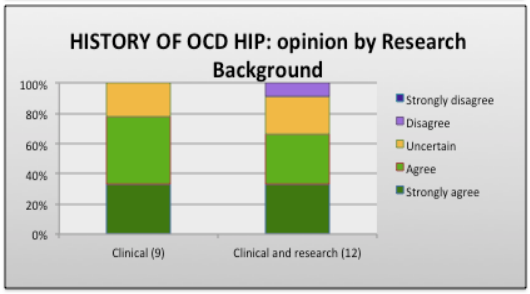
Sports Medicine (10)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


HISTORY OF OCD HIP: opinion by Research Background
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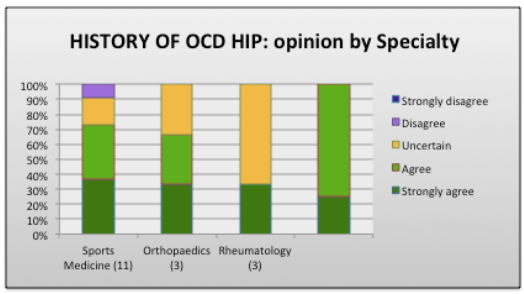
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


HISTORY OF OCD HIP: opinion by Specialty
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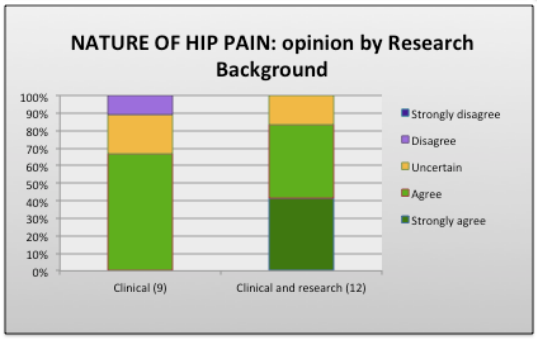
0%
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


NATURE OF HIP PAIN: opinion by Research Background
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70%
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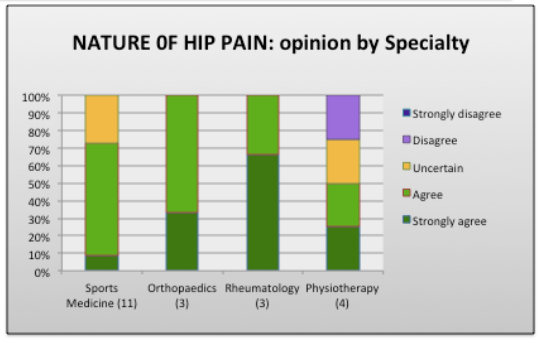
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


NATURE 0F HIP PAIN: opinion by Specialty
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20%
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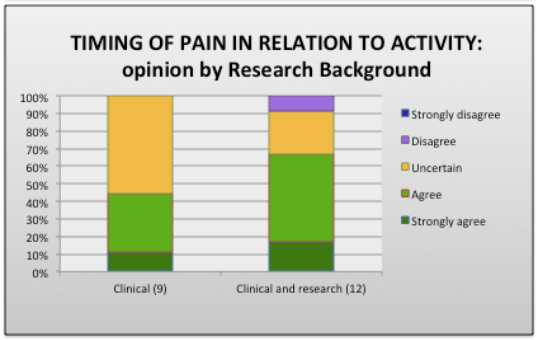
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


TIMING OF PAIN IN RELATION TO ACTIVITY: opinion by Research Background
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90%
80%
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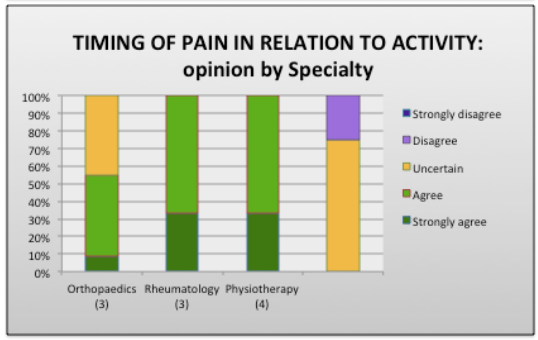
30%
20%
10%
0%
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


TIMING OF PAIN IN RELATION TO ACTIVITY: opinion by Specialty
100%
90%
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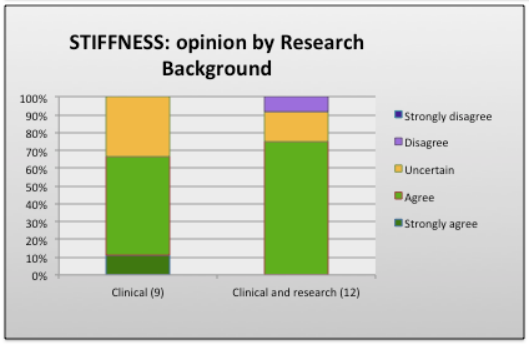
0%
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


STIFFNESS: opinion by Research Background
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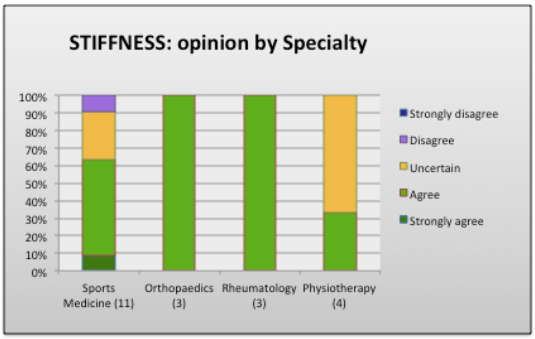
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


STIFFNESS: opinion by Specialty
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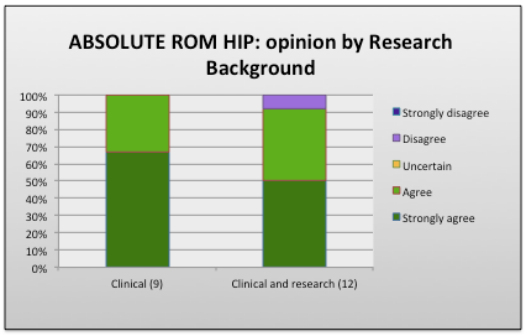
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


ABSOLUTE ROM HIP: opinion by Research Background
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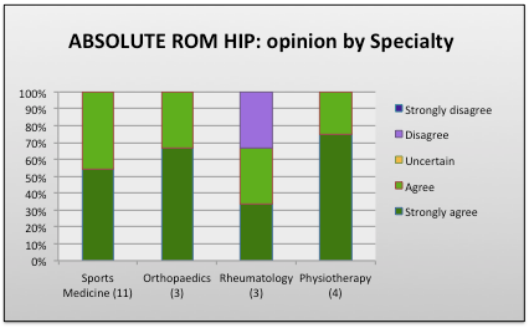
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


ABSOLUTE ROM HIP: opinion by Specialty
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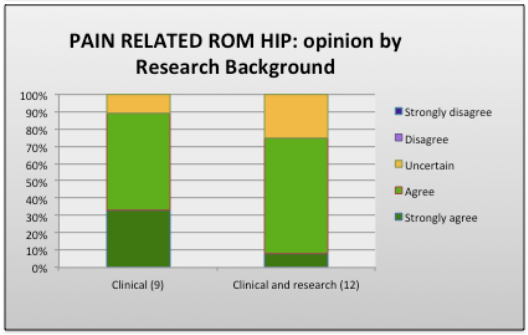
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


PAIN RELATED ROM HIP: opinion by Research Background
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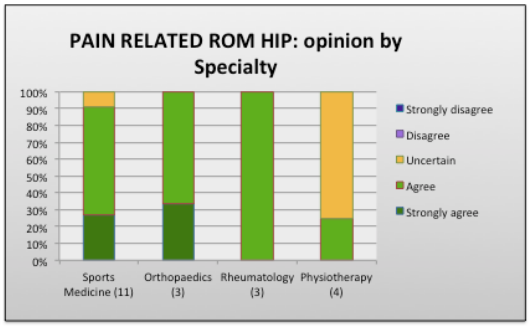
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


PAIN RELATED ROM HIP: opinion by Specialty
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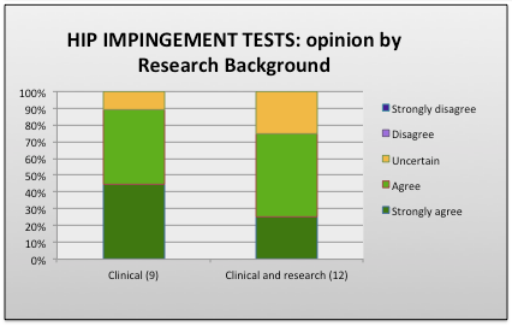
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


HIP IMPINGEMENT TESTS: opinion by Research Background
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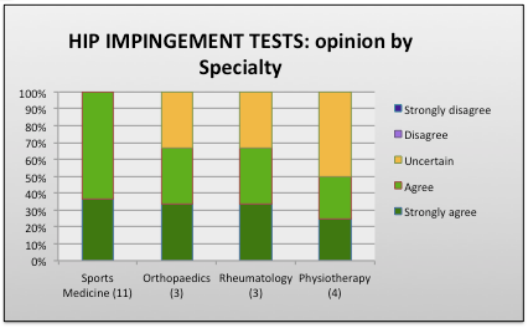
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


HIP IMPINGEMENT TESTS: opinion by Specialty
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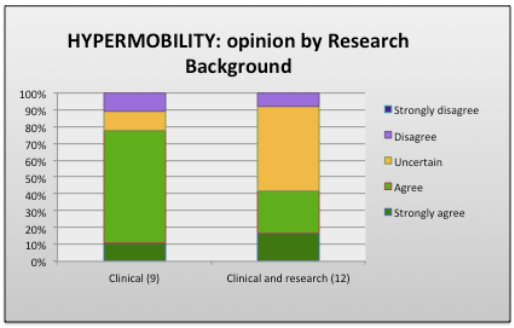
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


HYPERMOBILITY: opinion by Research Background
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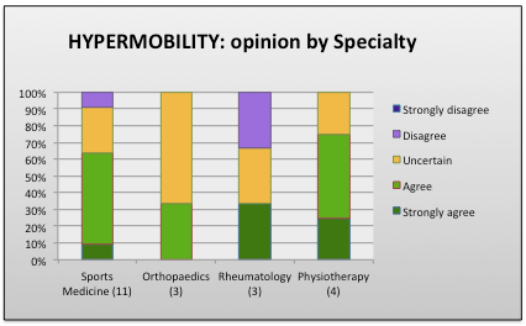
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


HYPERMOBILITY: opinion by Specialty
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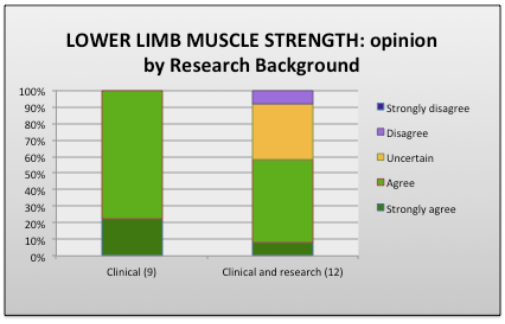
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LOWER LIMB MUSCLE STRENGTH: opinion by Research Background
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60%
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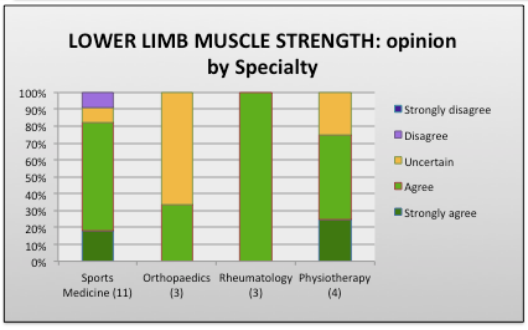
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LOWER LIMB MUSCLE STRENGTH: opinion by Specialty
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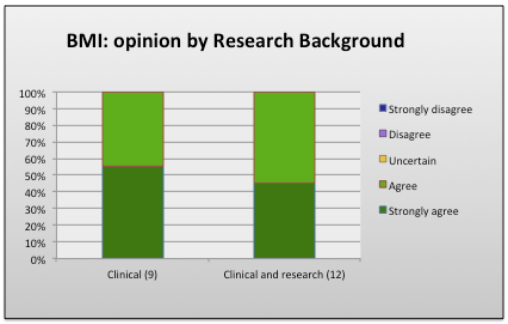
10%
0%
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


BMI: opinion by Research Background
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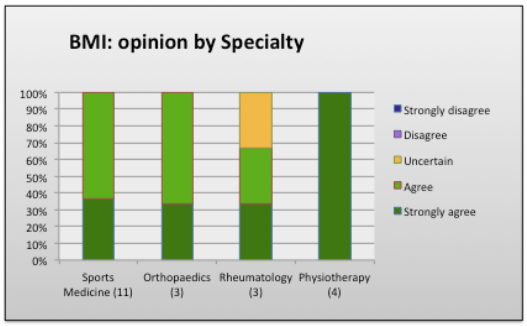
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


BMI: opinion by Specialty
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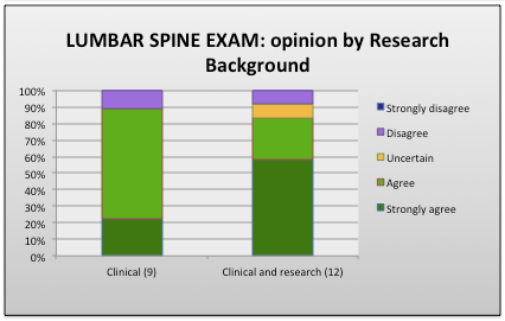
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LUMBAR SPINE EXAM: opinion by Research Background
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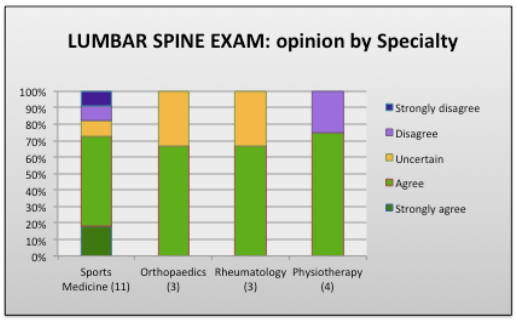
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


LUMBAR SPINE EXAM: opinion by Specialty
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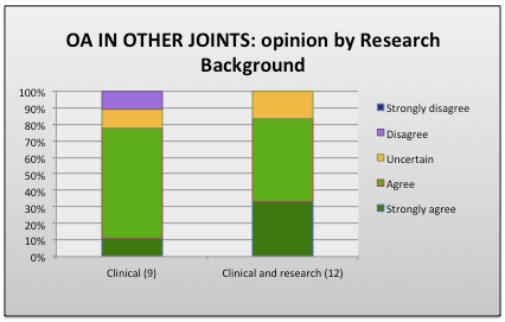
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


OA IN OTHER JOINTS: opinion by Research Background
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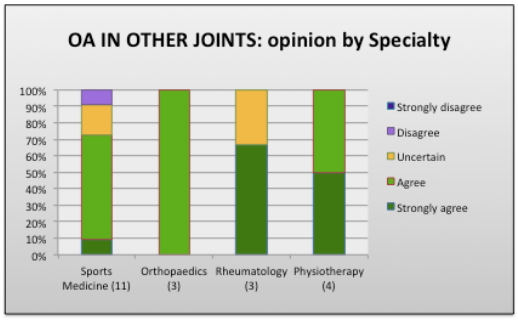
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


OA IN OTHER JOINTS: opinion by Specialty
100%
90%
80%
70%
60%
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40%
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20%
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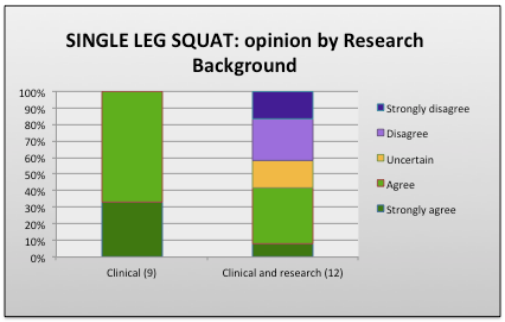
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


SINGLE LEG SQUAT: opinion by Research Background
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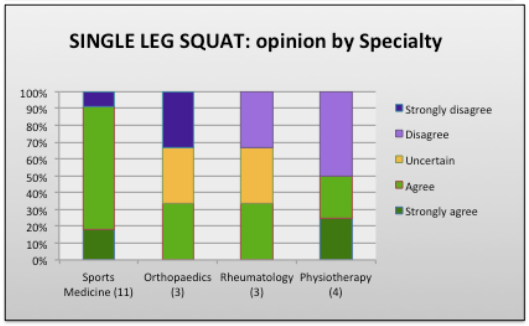
0%
Clinical (9)
Clinical and research (12)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree


SINGLE LEG SQUAT: opinion by Specialty
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sports Medicine (11)
Orthopaedics (3)
Rheumatology (3)
Physiotherapy (4)
Strongly disagree
Disagree
Uncertain
Agree
Strongly agree