Hip-related pain and femoroacetabular impingement syndrome: How common is it? How does it impact on biomechanics? How does it affect muscle function?

Heerey JJ, King MG, Lawrenson P, Semciw A, Kemp JL, Crossley KM

La Trobe University, Melbourne, Australia

Introduction by the editor Mario Bizzini

Joshua Heerey (La Trobe University, Melbourne) präsentierte an der #SportSuisse2018 seine Arbeit «What is the prevalence and relationship of bony morphology and features associated with early hip osteoarthritis in subelite footballers with and without hip and groin pain» und gewann den JOSPT Award für das beste Poster in Bern: Glückwünsche!

Die Ziele dieser Studie waren, die Prävalenz der knöchernen Morphologie bei Fussballspielern mit und ohne hüftbezogene Leistenschmerzen zu beschreiben und den Zusammenhang zwischen Schmerz und knöcherner Morphologie bei diesen Athleten (Fussball- und australische Fussballspieler; Subeliteniveau; Durchschnittsalter: 26 Jahre, 80% Männer; 187 symptomatisch und 55 asymptomatisch) zu bestimmen. Alle Probanden wurden einer spezifischen Röntgenuntersuchung unterzogen (liegendes AP-Becken, Dunn 45°) und füllten das International Hip Outcome Tool (IHOT-33). Die Ergebnisse zeigten, dass bei Subelite-Fussballspielern $^{2}/_{3}$ aller Hüften eine schmerzunabhängige Cam-morphologie haben (Pincer Morphologie und Hüftgelenkdysplasie wurden in dieser Kohorte selten beobachtet), und dass hüftbezogene Leistenschmerzen nicht mit knöcherner Morphologie verbunden sind.

Dies stärkt erneut die Bedeutung der Verwendung anderer klinischer Einheiten (wie von Per Hölmich beschrieben) und der sorgfältigen/kritischen Betrachtung und Bewertung der intraartikulären Pathologien bei subelitären Fussballspielern mit langjährigen Hüft- und Leistenschmerzen.

Schlüsselwörter: Hüftgelenk, Leiste, Schmerz, Cam/Pincer Morphologie

Joshua Heerey (La Trobe University, Melbourne) presented at the #SportSuisse2018 his work "What is the prevalence and relationship of bony morphology and features associated with early hip osteoarthritis in sub-elite footballers with and without hip and groin pain", and won the JOSPT award for the best poster in Bern: congratulations!

The aims of this study were to describe the prevalence of bony morphology in football players with and without hip related groin pain, and to determine the association between pain and bony morphology in these athletes (soccer and Australian football players; subelite level; mean age: 26 years old, 80% men; 187 symptomatic and 55 asymptomatic). All subjects underwent specific x-rays exams (supine AP pelvis, Dunn 45°) and filled the International Hip Outcome Tool (IHOT-33). The results showed that in sub-elite football players: $^{2}/_{3}$ of all hips have cam morphology independent of pain (pincer morphology and acetabular dysplasia were rarely seen in this cohort), and that hip related groin pain is not associated with bony morphology.

This strengthen again the importance of to use other clinical entities (as described by Per Hölmich) and to carefully/critically consider and evaluate the intra-articular pathologies in sub-elite football players with long standing hip and groin pain.

Keywords: hip joint, groin, pain, cam/pincer morphology

Joshua Heerey

This article was originally published in Sports Medicine Australia Sport Health Magazine.

Introduction

Hip-related pain is common in active young and middle-aged individuals. Femoroacetabular impingement (FAI) syndrome, a frequent cause of hip pain, consists of a triad of imaging findings, pain, and clinical signs. [1] Femoroacetabular impingement can have a large impact on the quality of life of those affected. It is thought to be characterised by altered femoral or acetabular morphology, such as excessive bone formation at the femoral head-neck junction known as cam-morphology, which can create aberrant joint forces during hip movements and potentially damage intra-articular structures. At present, the prevalence of intra-articular hip pathology in those with and without hip pain, including FAI syndrome, is unknown. It is also unclear whether hip related pain (including FAI syndrome) is associated with alterations in biomechanics or muscle characteristics. This article will discuss key aspects of the PhD work of physiotherapists Joshua Heerey, Matthew King (both La Trobe University) and Peter Lawrenson (University of Queensland), all of whom are working on Project FORCe (the Femoroacetabular impingement OsteoaRthritis Cohort study) [2] under the guidance of Professor Kay Crossley (see http://www.latrobe.edu.au/sport-and-exercise-medicine/research/projects for more information).

Part one: The prevalence of intra-articular hip pathologies in people with and without hip pain*

With Joshua Heerey
***Adapted from:** Heerey JJ, Kemp JL, Mosler AB, et al. What is the prevalence of imaging-defined intraarticular hip pathologies in people with and without pain? A systematic review and meta-analysis 2018. British Journal of Sports Medicine, 2018, Epub ahead of print doi.10. 1136/bjsports-2017-098264

We know that hip and groin related pain affects an individual's ability to participate in personal and recreational activities. [3,4] Intra-articular hip conditions are now recognised as a cause of hip and groin related pain. [5] In particular, FAI syndrome, labral tears and cartilage defects are thought to be implicated in the development of hip and groin related pain. [5–7] Arthroscopic surgery is often considered for individuals with pain, appropriate clinical assessment findings and intra-articular hip pathologies identified on imaging. [8] However, if we look at other areas of the body, such as the shoulder and spine, we see that pathology (e.g. rotator cuff tears or disc bulges) identified on imaging is seen similarly in individuals with and without symptoms. [9–11] In light of this, and the increasing rates of surgery for intra-articular hip conditions identified with imaging [12], it is important to better understand the prevalence of such pathologies in individuals with and without hip and groin related pain. Having a better understanding of the relationship between symptoms and imaging findings may improve management of individuals with intra-articular hip pathologies.

The aim of this systematic review was to determine the prevalence of intra-articular hip pathologies in individuals with and without hip-related symptoms. A comprehensive review of electronic health databases was undertaken for studies with a primary aim of investigating the prevalence of imaging defined intra-articular hip pathologies using commonly used imaging modalities such ass magnetic resonance imaging (MRI) *(Figure 1)* without and with contrast agent and computed tomography (CT). PRISMA guidelines [13] were followed for this process. Twenty-nine studies reporting on the prevalence of intra-articular hip pathologies were identified. The studies were generally of moderate to high risk of bias, with only five of the 29 studies adjudged as having low risk of bias. Fifteen of the 29 studies investigated active or athletic populations. Importantly, none of the included studies investigated true community based populations. Pooled data indicate that labral tears were observed in 62% (95% confidence interval (CI) 47% to 75%) of symptomatic individuals and 54% (95%CI 41% to 66%) of asymptomatic individuals. Cartilage defects were reported in 64% (95%CI 25% to 91%) of symptomatic individuals, compared to 12% (95%CI 7% to 21%) of asymptomatic individuals. More, low risk of bias studies are needed to confirm or refine these values.
Conclusion. The prevalence of intra-articular hip pathologies appears highly variable in symptomatic and asymptomatic populations (confidence intervals range from 25% to 90%). The prevalence of intra-articular hip pathologies (especially cartilage lesions) appears to be higher in symptomatic individuals.

However, imaging defined intra-articular hip pathologies are also consistently seen in asymptomatic individuals, highlighting a potential discordant relationship between imaging defined pathology and symptoms.

Part two: How does FAI syndrome affect biomechanics?**

With Matthew King
****Adapted from:** King MG, Lawrenson PR, Semciw AI, et al. Lower limb biomechanics in femoroacetabular impingement syndrome: a systematic review and meta-analysis. British Journal of Sports Medicine, 2018, Epub ahead of print doi:10.1136/bjsports-2017-097839

Why do some people with morphological changes in their hips go on to develop FAI syndrome and others not? As FAI syndrome is a movement related condition, biomechanics may play a role in the establishment and persistence of symptoms. We recently conducted a systematic review to document differences in hip biomechanics in people with FAI syndrome and asymptomatic controls.

A systematic search of the literature was conducted around two main concepts; FAI syndrome and biomechanics and standard PRISMA guidelines were followed for the systematic review. [14] Studies were included if they compared the biomechanics of everyday tasks in people with and without (control) FAI syndrome, using three-dimensional motion capture devices. Standardised mean differences and 95% confidence intervals were calculated for all data by dividing the difference between groups by the pooled standard deviation and where able, the results were pooled in a meta-analysis.

Thirteen studies [15–27] were included in the review with 205 symptomatic participants (151 men), age range 24.1-40.1 years, and 236 controls (158 men), age range 27.1-43.2 years. Tasks investigated included walking, squatting, step ascent, sit-to-stand, and drop landing.

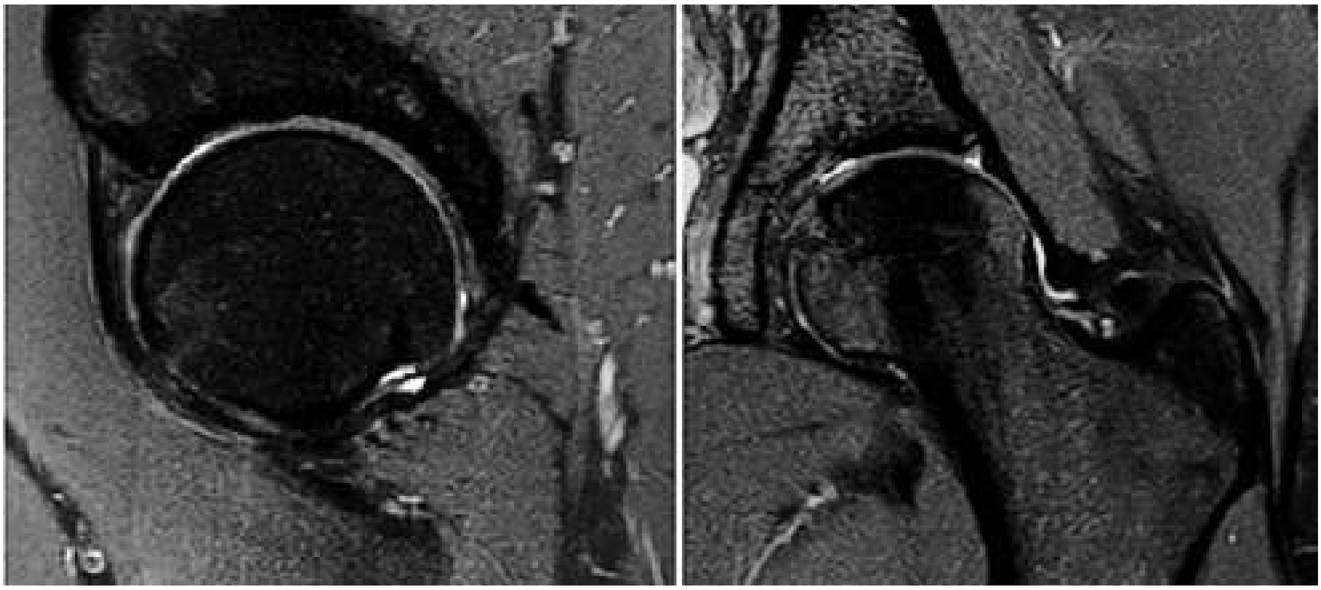

Figure 1: Hip 3t MRI images demonstrating cartilage deficits.

Walking:

People with FAI syndrome walked with lower: peak hip extension angle (SMD-0.40, 95% CI-0.71 to –0.09; I2= 0% p=0.60), [17,20–22,25] total sagittal plane range *(Figure 2)*, (–0.51, –0.93 to –0.08; I^2= 0% p=0.66) [19,22,25] peak hip internal rotation angle (–0.67 –1.19 to –0.16; I2= 47% p=0.15) [17,20,25] and peak external rotation joint torque (–0.71, –1.07 to –0.35; I^2= 0% p=0.82). [16,17,20,22,27]

Squatting:

People with FAI syndrome squatted to a lesser depth compared with controls (0.92, 0.46 to 1.38; I^2= 0%, p=0.77), [15,23,24] with no difference in peak hip flexion. [15,22,23]

Step ascent, sit-to-stand and drop landing

There was insufficient evidence to draw conclusions for clinical practice on these tasks
Conclusion. This review identified that people with FAI syndrome demonstrate differences in biomechanics during tasks such as walking and squatting. A lower peak hip extension angle is seen in a variety of hip conditions including osteoarthritis [28,29] and following total hip replacement. [30] This may be a strategy to reduce anterior hip contact force during walking, [31] however it may also have a negative effect on the anterior gluteal muscles over time [32] and reduce hip stability. [33,34] Furthermore, positions of internal rotation are often reported as painful in FAI syndrome. [35] Lower peak hip internal rotation and external rotation joint torque may be strategies to reduce internal rotation to avoid a potentially painful position. Squatting is a common daily task, the inability of people with FAI syndrome to squat as-deep-as controls may be due to poor performance of the task and not necessarily a loss in hip flexion range. The review indicates that further information on more sport specific activities such as running is needed, to determine if these tasks present a problem for those with FAI syndrome.

Part three: How does hip-related pain affect muscle function?

With Peter Lawrenson
Strength deficits are a common clinical feature in FAI syndrome, [36,37] and other articular hip pathology, yet our understanding of the mechanism behind these deficits is lacking. Interventions designed to address strength deficits in hip pathology are scarce and have mixed results. [38–40] In order to ensure future interventions are appropriately targeted an improved understanding of the mechanisms underlying deficits in strength is required.

Decreases in muscle size have been correlated to deficits in strength, although the nature of this relationship in hip joint pathology is inconsistent. [41] Alterations in muscle composition, such as increased fatty infiltration, may contribute to variations in the relationship between size and strength. [42] Fatty infiltration has been reported in joint pathology to occupy space within healthy muscle tissue and decrease its

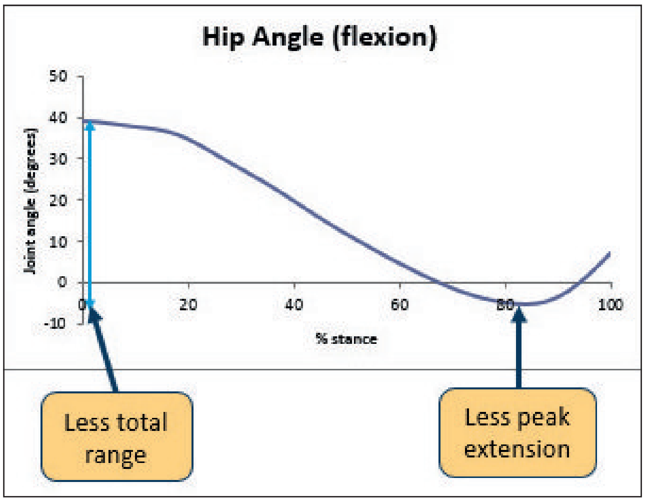

Figure 2: Diagrammatic representation of differences in hip joint kinematics in the sagittal plane for people with FAI syndrome compared with controls.

potential contractile force in relation to its overall size. [43] To ascertain whether changes in size and composition are evident in FAI syndrome and other hip pathology, a review of the literature was undertaken *(Figure 3)*.

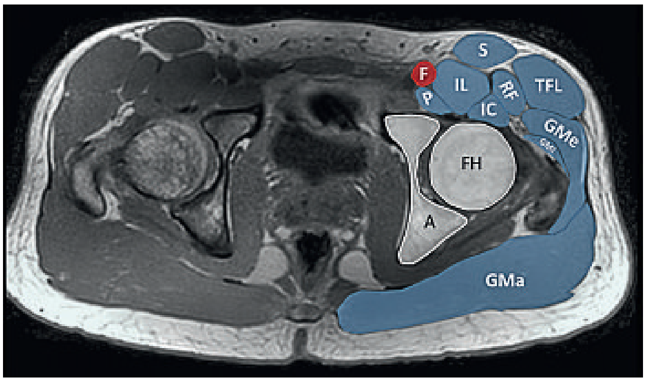

Figure 3: T3 MRI slice at the level of the femoral head, demonstrating muscle CSA. A, acetabulum; F, femoral neurovascular bundle; FH, femoral head; GMa, Gluteus maximus; GMe, Gluteus medius; GMi, Gluteus minimus; IC, Iliocapsularis; IL, Iliacus; P, Psoas major; RF, rectus femoris; S, Sartorius; and TFL, tensor fascia lata.

No studies have specifically investigated FAI syndrome, but two studies examined muscle size and composition in pincer morphology; a component of FAI syndrome, with comparisons to dysplasia and healthy controls. Iliocapsularis, a muscle proposed to play a role in active stability of the hip joint, was found to have a smaller size and greater fatty infiltration in people with pincer morphology. [44] In contrast, rectus femoris, was shown to have a significantly greater size. [45] These findings indicate there may be alterations in structure of the deep muscles surrounding the joint in populations with pincer morphology, although further studies with larger sample sizes are required to confirm these findings in diagnosed FAI syndrome.

Most studies examining size and fatty infiltration in hip pathology are focused on hip osteoarthritis (OA). Decreases in size of muscles around the hip as well as increases in fatty infiltration have been demonstrated in end stage hip OA across a number of studies, [46–48] yet magnitude of these changes may vary based on the specific muscle investigated and stage of pathology. [42]

There are few studies with large sample sizes, investigating muscle size and composition in intra-articular pathology. With the limited evidence seen in pincer morphology, and what was observed in OA, there are some indications of changes in size and composition of muscles across the spectrum of pathology that require further investigation. Cam FAI syndrome and other intra-articular pathology have been linked to the pathogenesis of hip OA [49,50] and thus, additional research to ascertain any commonalities between these groups is warranted. This may not only to improve our understanding of intra-articular pathology, but to also identify potential factors that may that play a role in disease progression.

Summary

Hip-related pain, including FAI syndrome, frequently affects active and sporting populations, yet we have limited understanding of its aetiology and interventions that can be employed to ameliorate symptoms. These systematic reviews indicate that people with hip-related pain are likely to demonstrate intra-articular pathology (~60% may have labral or cartilage lesions), but the clinical relevance of these lesions are not known. They are also likely to exhibit small to moderate differences in movement patterns (e.g. less hip extension, internal rotation) and smaller deep hip muscles. Combined with previous studies identifying lower hip muscle strength, [51] these studies indicate the impairments likely to be observed in people with hip-related pain. While the clinical relevance of these impairments cannot be ascertained, without longitudinal studies, the impairments in movement patterns, muscle size and strength may be targets for interventions.

Author contact

Josh Heerey, PhD Candidate
La Trobe Sport and Exercise Medicine Research Centre | College of Science, Health and Engineering | Health Sciences Building 3 | Room 523a / La Trobe University | Bundoora | Victoria 3086 Australia
E: J.Heerey@latrobe.edu.au

References

1. Griffin DR, Dickenson EJ, O'Donnell J, et al. The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. British Journal of Sports Medicine 2016;50(19):1169-76.
2. Crossley K, Pandy M, Majumdar M, et al. Femoroacetabular impingement and hip OsteoaRthritis Cohort (FORCe): protocol for a prospective study. Journal of Physiotherapy In Press.
3. Thorborg K, Rathleff MS, Petersen P, et al. Prevalence and severity of hip and groin pain in sub-elite male football: a cross-sectional cohort study of 695 players. Scand J Med Sci Sports 2017;27(1):107-14.
4. Kemp JL, Makdissi M, Schache AG, et al. Hip chondropathy at arthroscopy: prevalence and relationship to labral pathology, femoroacetabular impingement and patient-reported outcomes. Br J Sports Med 2014;48(14):1102-7.
5. Reiman MP, Thorborg K. Clinical examination and physical assessment of hip joint-related pain in athletes. International Journal of Sports Physical Therapy 2014;9(6):737-55.
6. Reiman MP, Mather RC, Hash TW, et al. Examination of acetabular labral tear: a continued diagnostic challenge. Br J Sports Med 2014;48(4):311-9.
7. Reiman MP, Thorborg K. Femoroacetabular impingement surgery: are we moving too fast and too far beyond the evidence? British Journal of Sports Medicine 2015;49(12):782-4.
8. Peters S, Laing A, Emerson C, et al. Surgical criteria for femoroacetabular impingement syndrome: a scoping review. British Journal of Sports Medicine 2017.
9. Teunis T, Lubberts B, Reilly BT, et al. A systematic review and pooled analysis of the prevalence of rotator cuff disease with increasing age. Journal of shoulder and elbow surgery 2014;23(12):1913-21.
10. Matsumoto M, Okada E, Ichihara D, et al. Age-related changes of thoracic and cervical intervertebral discs in asymptomatic subjects. Spine 2010;35(14):1359-64.
11. Wood KB, Garvey TA, Gundry C, et al. Magnetic resonance imaging of the thoracic spine. Evaluation of asymptomatic individuals. The Journal of bone and joint surgery American volume 1995;77(11):1631-8.

12. Montgomery SR, Ngo SS, Hobson T, et al. Trends and demographics in hip arthroscopy in the United States. Arthroscopy : the journal of arthroscopic & related surgery: official publication of the Arthroscopy Association of North America and the International Arthroscopy Association 2013;29(4):661-5.
13. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS medicine 2009;6(7):e1000100.
14. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg 2010;8(5):336-41.
15. Bagwell JJ, Snibbe J, Gerhardt M, et al. Hip kinematics and kinetics in persons with and without cam femoroacetabular impingement during a deep squat task. Clin Biomech 2016;31:87-92.
16. Brisson N, Lamontagne M, Kennedy MJ, et al. The effects of cam femoroacetabular impingement corrective surgery on lower-extremity gait biomechanics. Gait and Posture 2013;37(2):258-63.
17. Diamond LE, Wrigley TV, Bennell KL, et al. Hip joint biomechanics during gait in people with and without symptomatic femoroacetabular impingement. Gait Posture 2016;43:198-203.
18. Hammond CA, Hatfield GL, Gilbart MK, et al. Trunk and lower limb biomechanics during stair climbing in people with and without symptomatic femoroacetabular impingement. Clin Biomech 2017;42:108-14.
19. Hetsroni I, Funk S, Ben-Sira D, et al. Femoroacetabular impingement syndrome is associated with alterations in hindfoot mechanics: A three-dimensional gait analysis study. Clin Biomech 2015;30(10):1189-93.
20. Hunt MA, Guenther JR, Gilbart MK. Kinematic and kinetic differences during walking in patients with and without symptomatic femoroacetabular impingement. Clinical biomechanics (Bristol, Avon) 2013;28(5):519-23.
21. Kennedy MJ, Lamontagne M, Beaule PE. Femoroacetabular impingement alters hip and pelvic biomechanics during gait Walking biomechanics of FAI. Gait Posture 2009;30(1):41-4.
22. Kumar D, Dillon A, Nardo L, et al. Differences in the association of hip cartilage lesions and cam-type femoroacetabular impingement with movement patterns: a preliminary study. Pm R 2014;6(8):681-9.
23. Lamontagne M, Kennedy MJ, Beaulé PE. The effect of cam FAI on hip and pelvic motion during maximum squat. Clin Orthop 2009;467(3):645-50 6p.
24. Ng KCG, Lamontagne M, Adamczyk AP, et al. Patient-Specific Anatomical and Functional Parameters Provide New Insights into the Pathomechanism of Cam FAI. Clinical Orthopaedics and Related Research 2015;473(4):1289-96.
25. Rylander J, Shu B, Favre J, et al. Functional testing provides unique insights into the pathomechanics of femoroacetabular impingement and an objective basis for evaluating treatment outcome. J Orthop Res 2013;31(9):1461-8.
26. Samaan MA, Schwaiger BJ, Gallo MC, et al. Abnormal Joint Moment Distributions and Functional Performance During Sit-to-Stand in Femoroacetabular Impingement Patients. Pm R 2016;08:08.
27. Samaan MA, Schwaiger BJ, Gallo MC, et al. Joint Loading in the Sagittal Plane During Gait Is Associated With Hip Joint Abnormalities in Patients With Femoroacetabular Impingement. Am J Sports Med 2016:363546516677727.
28. Watelain E, Dujardin F, Babier F, et al. Pelvic and lower limb compensatory actions of subjects in an early stage of hip osteoarthritis. Arch Phys Med Rehabil 2001;82(12):1705-11.
29. Ida T, Nakamura Y, Hagio T, et al. Prevalence and characteristics of cam-type femoroacetabular deformity in 100 hips with symptomatic acetabular dysplasia: a case control study. J 2014;9:93.
30. Beaulieu ML, Lamontagne M, Beaule PE. Lower limb biomechanics during gait do not return to normal following total hip arthroplasty. Gait Posture 2010;32(2):269-73.
31. Lewis CL, Sahrmann SA, Moran DW. Effect of hip angle on anterior hip joint force during gait. Gait Posture 2010;32(4):603-7.
32. Zacharias A, Pizzari T, English DJ, et al. Hip abductor muscle volume in hip osteoarthritis and matched controls. Osteoarthritis Cartilage 2016;24(10):1727-35.
33. Semciw AI, Green RA, Murley GS, et al. Gluteus minimus: An intramuscular EMG investigation of anterior and posterior segments during gait. Gait Posture 2014;39(2):822-26.
34. Semciw AI, Pizzari T, Murley GS, et al. Gluteus medius: an intramuscular EMG investigation of anterior, middle and posterior segments during gait. J Electromyogr Kinesiol 2013;23(4):858-64.
35. Byrd JWT. Femoroacetabular impingement in athletes: Current concepts. Am J Sports Med 2014;42(3):737-51.
36. Diamond LE, Dobson FL, Bennell KL, et al. Physical impairments and activity limitations in people with femoroacetabular impingement: a systematic review. British journal of sports medicine 2015;49(4):230.
37. Freke MD, Kemp J, Svege I, et al. Physical impairments in symptomatic femoroacetabular impingement: a systematic review of the evidence. British Journal of Sports Medicine 2016.
38. Wall PDH, Fernandez M, Griffin DR, et al. Nonoperative Treatment for Femoroacetabular Impingement: A Systematic Review of the Literature. PM & R : the journal of injury, function, and rehabilitation 2013;5(5):418-26.
39. McNair PJ, Simmonds MA, Boocock MG, et al. Exercise therapy for the management of osteoarthritis of the hip joint: a systematic review. Arthritis Research & Therapy 2009;11(3):R98.
40. Fransen M, McConnell S, Harmer AR, et al. Exercise for osteoarthritis of the knee: a Cochrane systematic review. British Journal of Sports Medicine 2015.
41. Marshall AR, de Noronha M, Zacharias A, et al. Structure and function of the abductors in patients with hip osteoarthritis: Systematic review and meta-analysis. J Back Musculoskelet Rehabil 2016;29(2):191-204.
42. Loureiro A, Mills PM, Barrett RS. Muscle weakness in hip osteoarthritis: A systematic review. Hoboken, USA, 2013:340-52.
43. Goutallier D, Postel JM, Bernageau J, et al. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. Clinical orthopaedics and related research 1994(304):78.
44. Babst D, Steppacher SD, Ganz R, et al. The iliocapsularis muscle: an important stabilizer in the dysplastic hip. Clinical Orthopaedics And Related Research 2011;469(6):1728-34.
45. Haefeli P, Steppacher S, Babst D, et al. An increased iliocapsularis-to-rectus-femoris ratio is suggestive for instability in borderline hips. Clinical Orthopaedics & Related Research 2015;473(12):3725-34 10p.
46. Grimaldi A, Richardson C, Durbridge G, et al. The association between degenerative hip joint pathology and size of the gluteus maximus and tensor fascia lata muscles. Manual Therapy 2009;14(6):611-17.
47. Zacharias A, Pizzari T, English D, et al. Gluteal muscle atrophy and fatty deposits increase with advancing hip osteoarthritis, 2017:e30-e30.
48. Arokoski MH, Arokoski JPA, Haara M, et al. Hip muscle strength and muscle cross sectional area in men with and without hip osteoarthritis. The Journal Of Rheumatology 2002;29(10):2185-95.
49. Buckwalter JA, Anderson DD, Brown TD, et al. The Roles of Mechanical Stresses in the Pathogenesis of Osteoarthritis. Cartilage 2013;4(4):286-94.
50. Agricola R, Heijboer MP, Bierma-Zeinstra SMA, et al. Cam impingement causes osteoarthritis of the hip: a nationwide prospective cohort study (CHECK). Annals of the Rheumatic Diseases 2013;72(6):918.
51. Freke MD, Kemp J, Svege I, et al. Physical impairments in symptomatic femoroacetabular impingement: a systematic review of the evidence. Br J Sports Med 2016;50(19):1180.