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INVITED CLINICAL COMMENTARY

CLINICAL EXAMINATION AND PHYSICAL ASSESSMENT OF HIP JOINT-RELATED PAIN IN ATHLETES

Michael P. Reiman, PT, DPT, SCS, OCS, ATC, FAAOMPT, CSCS,[1,2]
Kristian Thorborg, PT, M. Sportsphysio, PhD[3,4]

ABSTRACT

Evidence-based clinical examination and assessment of the athlete with hip joint related pain is complex. It requires a systematic approach to properly differentially diagnose competing potential causes of athletic pain generation. An approach with an initial broad focus (and hence use of highly sensitive tests/measures) that then is followed by utilizing more specific tests/measures to pare down this imprecise differential diagnosis list is suggested. Physical assessment measures are then suggested to discern impairments, activity and participation restrictions for athletes with hip-join related pain, hence guiding the proper treatment approach.

Keywords: Athlete; diagnostic accuracy; examination; hip joint

Level of Evidence: 5

[1] Duke University Medical Center, Department of Orthopedic Surgery, Durham, NC, USA
[2] Co-Director Orthopaedic Fellowship, Duke University Medical Center, Durham, NC, USA
[3] Senior Researcher, Arthroscopic Centre Amager, Sports Orthopedic Research Centre - Copenhagen (SORC-C), Copenhagen University Hospital, Denmark.
[4] Physical Medicine & Rehabilitation Research - Copenhagen (PMR-C), and Departments of Orthopaedic Surgery and Physical Therapy, Copenhagen University Hospital, Denmark

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CORRESPONDING AUTHOR
Michael P. Reiman, PT, DPT, OCS, SCS, ATC, FAAOMPT, CSCS
Assistant Professor
Duke University School of Medicine
Department of Community and Family Medicine
Doctor of Physical Therapy Division
DUMC 104002
Durham, NC 27710
Phone: (919) 668-3014 ; Fax: (919) 684-1846
E-mail: reiman.michael@gmail.com

INTRODUCTION

The prevalence of hip pain in the general population is 10%, and increases with age.[1] Pain in the hip and groin region in athletes is usually characterised by longstanding symptoms that often do not resolve within 6-12 months.[2,3] Hip and groin pain has been reported to commonly occur in athletes who participate in soccer and ice hockey, and approximately 10-20% of all injuries in these sports are hip and/or groin injuries.[4-6] Pelvis, groin, hip and thigh injuries in sport include multiple, complex and longstanding conditions, causing great frustration among athletes and sports practitioners. Pain in these regions may originate from many anatomical structures such as muscle, tendon, ligament, cartilage or bone. Musculotendinous groin and hamstring injuries are the most frequent injuries, and are especially prevalent problems among different forms of football.[7-9] Moreover, the recurrence rates of these injuries are very high, and a major problem during the rehabilitation and return-to-sport phase.[8]

Intra-articular hip injuries are frequent sources of hip and groin pain in athletes that are not related to the musculotendinous structures around the hip and groin. In elite soccer athletes, intra-articular hip injuries account for up to 10% of all hip and groin injuries.[9] Intra-articular hip injuries include femoroacetabular impingement (FAI), acetabular labral tear (ALT), chondral injuries and synovitis. Intra-articular injuries of the hip joint have in recent years been recognised as an important differential diagnose in athletes with hip and groin pain. This is reflected in the 2012 injury-report from the Australian Football League (AFL), where the incidence of hip related injuries seem to have increased during the last ten years, whereas groin injuries seem to have decreased, which may reflect a better understanding or focus on the contribution of intra-articular hip injury to groin pain in athletes.[8] In clinical situations with signs of synovitis with no sign of any intra-articular injury this may reflect hip joint overuse and will often tend to resolve fairly quickly. In situations where specific intra-articular injuries with damage to the labrum/cartilage are present, operative procedures may be necessary, as conservative treatment may not resolve the athlete's pain and/or disability. Furthermore, more serious and severe injury such as high and low energy fractures or pain generated from other anatomical areas such as the pelvis and spine also needs to be considered when examining the athlete with hip problems. Examining athletes with hip and groin pain is therefore complex. Consequently, the purpose of this clinical commentary is to introduce an evidence-based examination and physical assessment approach for athletes with hip joint-related pathology.

A succinct, systematic approach to clinical examination is always warranted. This is particularly the case for intra-articular pathology of the hip, which, unfortunately continues to suffer from the lack of high quality evidence support of various examination and testing measures. The approach suggested within this commentary is one of ruling out more medically serious pathology initially, by utilization of highly sensitive tests early in the examination, and narrowing down the differential diagnoses to improve the likelihood of a particular diagnosis (**Figure 1**). The athlete's history, observations of their movements, clinical examination and diagnostic imaging (components of a systematic examination) each have the ability to affect the identification of the existence of a particular diagnosis. Diagnostic accuracy values for special tests, diagnostic imaging, and occasionally subjective reports include sensitivity (SN), specificity (SP), positive likelihood ratio (+LR), and negative likelihood ratio (-LR). Tests with

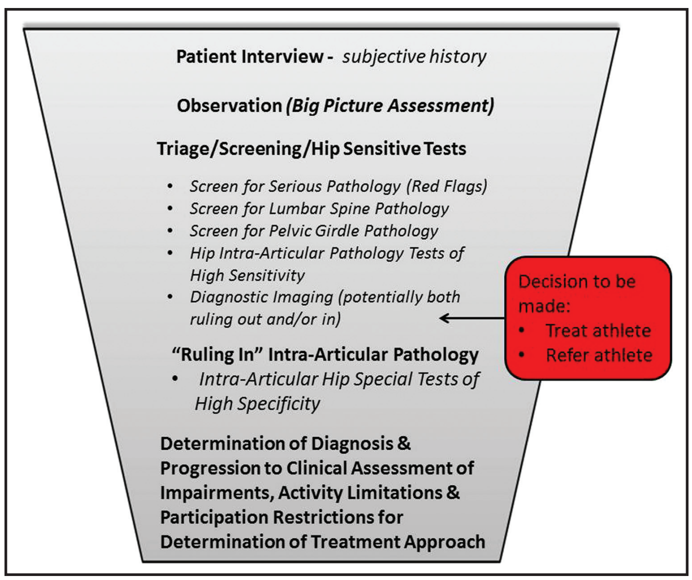

Figure 1. *Examination Sequence (Funnel Approach) for Hip-Joint Related Examination with Progression to Determination of Treatment Approach*

high SN will be positive for most people who actually have the problem and, therefore, have a low rate of false negatives (the test finding was negative, but the pathology is actually present). When it is important to "not miss" a positive case (such as in a fracture), utilization of tests with high SN is necessary. This is crucial for screening tests in which positive findings simply indicate the need for more investigation. Therefore, the most meaningful finding with a highly sensitive test is a negative finding, since it assists the clinician to rule out a disorder with confidence. A suggested useful acronym is SnNout, meaning a test with high **Sn** when **N**egative is used to help rule **out** the condition.[10,11] The potential for false positives (the test is positive, but the pathology is not actually present) exists with highly SN tests. Therefore, these tests, by their nature, are designed to capture several potential competing diagnoses, many of which may be not present (false positive). Again, the purpose of these tests is to ***not miss*** a positive case. These tests are therefore utilized early in the examination process to screen for the potential of more serious pathology and/or rule out other potential pain generators. Tests with high SP will be appropriately negative in clients who do not have the disorder and therefore have a low rate of false positives. Tests with high SP are best to rule in a disorder, and should be performed later in the examination to "rule in" the most likely diagnosis/diagnoses from the differential diagnosis list generated by the sensitive tests. The acronym SpPin is often used for these tests. A highly **Sp** test when **P**ositive is used to help rule **in** the condition.[10,11]

As the clinician systematically reasons through the broad to narrow focused clinical examination sequence (funnel approach) they should be able to reasonably determine a primary diagnosis and/or important differential diagnostic considerations including additional investigations that may be pertinent to proceed to, most notably assessment of specific impairments, activity limitations, and participation restrictions in order to optimize a structured and individualized rehabilitation for the individual athlete. Assessment of outcome and functional ability can be related to body functions and structure (impairments), activities (activity limitations) and participation (participation restrictions)

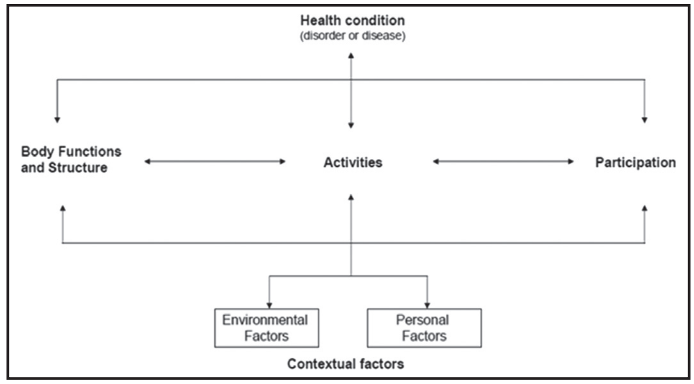

Figure 2. *ICF model of disability. Adapted from WHO, 2002.12*

according to the ICF model.[12] Environmental factors that interact with all these components are also included. Body functions are physiological functions of body systems (including psychological functions) and body structures are anatomical parts of the body (e.g. organs, limbs and their components). Activities are the execution of a particular task or action by an individual, such as running or kicking, while participation is the involvement in a "real life" situation, such as participating in a game of football. Therefore activity limitations are difficulties an individual may have in executing particular activities, while participation restrictions are problems an individual may experience in involvement in "real life" situations. Environmental factors make up the physical and social environment in which people live and conduct their lives. Personal factors are also included in the model but are not classified (**Figure 2**).[12]

CLINICAL EXAMINATION OF THE HIP

It is important to begin the hip examination process as comprehensively as possible (including all potential diagnoses) and (as a result of each systematic step in the examination process) narrow the differential diagnosis list down as far as possible. Additionally, this broad to narrow approach of the hip examination is an approach of general to more isolated examination procedures. For example, in the client interview the clinician asks broad, open-ended questions that are likely to include multiple potential diagnoses. As the examination continues, the examination process becomes more focused. This is particularly the case after the triage/screening/sensitive tests section that is intended to rule out not only the potential for red flag/non-musculoskeletal disease processes, but to also rule out potential pain generators in other joints, as well as other potential diagnoses common to the pain generating joint(s). Determination of necessity of referral to a physician is also required at this stage of the examination.

If screening is conclusively negative the clinician then determines that it is appropriate to continue with the rest of the examination process. If screening is not conclusively negative, the clinician is required to make a clinically sound judgment on the appropriateness of referral out to the appropriate medical personnel immediately or whether an attempt at appropriate intervention will assist in determining the athlete's medical status.

Patient Interview - Subjective History

The subjective history has been suggested to be instrumental in determining 56-90% of diagnoses in various types of patients.[13-16] Physical examination components, on the other hand, only contributed to less than 30% of the diagnoses in the same studies.[13-16] In fact, it has been suggested that subjective history, physical examination, and radiographic examination each have their own limitations at each stage and an integrative approach is needed in making a medical diagnosis with more emphasis on subjective history.[17]

Age of the athlete will assist in differential diagnosis of hip pain. Pediatric and adolescent pathologies, such as Legg-Calve-Perthes (typical age of onset is 3 to 12 years old) and Slipped Capital Femoral Epiphysis (average age of 12.1 years for girls and 14.4 years for boys) will significantly differ in athlete age compared to acetabular labral tear (ALT) (adolescents to older adults) and hip osteoarthritis/osteoporotic femoral neck fractures (older athletes).

Differential diagnosis with regard to the lumbar spine, pelvis and hip is often difficult due to the inter-dependent relationship between these three regions.[18] A few variables have been shown to demonstrate a strong predilection to hip injury. The presence of a limp, groin pain, or limited internal rotation (IR) of the hip significantly predicted diagnosis of a disorder originating primarily from hip opposed to from the spine.[19] Athletes with limp were seven times more likely to have a hip disorder than spine disorder, while those with groin pain were seven times more likely to have hip disorder only or hip and spine disorder versus spine disorder only.[19] Limited IR in an athlete was 14 times more likely to suggest a hip disorder only or hip and spine disorder versus spine disorder only.[19]

Groin pain is a common location for multiple hip pathologies (as well as lumbar spine and pelvic girdle pathologies). Groin and thigh pain was found in 55% and 57% of athletes with hip joint pain, respectively.[20] Pain referral was also seen in the buttock and lower extremity distal to the knee in 71% and 22% respectively,[20] indicating the possibility of combined lumbar spine and hip pathology. The most common locations of pain for athletes with ALT were the central groin and lateral peritrochanteric area.[21] The lack of groin pain presentation helps rule out the potential for ALT/FAI with a SN ranging from 96-100%.[22,23]

Complaints of clicking, catching, snapping, etc. should cue the clinician to include ALT, intra-articular pathology, and snapping hip in the differential diagnosis.[24-27] Sharp pain with mechanical symptoms has a reported SN of 100%, and SP of 85% for ALT/intra-articular pathology.[25,28] Carefully delineating the source (and relevance) of such symptoms is imperative in determining a proper diagnosis in the athlete. For example, 91% of ballet dancers reported snapping hip, 60% of them could volitionally produce this snapping, yet only 7% were not able to continue dancing due to the snapping.[29]

Observation

Observation of the athlete presenting with hip pain should include general postural assessment (both statically and dynamically), gait, transfers, and potential limitations in strength and mobility with daily tasks from both the anterior-posterior view as well as laterally. Asymmetrical landmarks can alert the clinician to some potential structural dysfunctions that may be contributing to the athlete's hip pain. It is important to recognize that the presence of postural abnormality does not necessarily correlate with dysfunction.

The athlete with joint changes may have complaints with some combination of hip joint positions involving flexion, adduction, and/or internal rotation.[25] Pain with these motions is often described as deep in the groin region and indicative of potential intra-articular involvement.[30] Pain posturing on part of the athlete may be seen when sitting in chairs (especially lower level chairs), stepping up with the involved leg, squatting, and so forth as these motions will replicate the combinations of these movements in the hip.

Range-of-motion (ROM) of the hip can also be observed without formal assessment. In the supine position, the clinician can generally assess for anterior capsular laxity. If an athlete lying supine with relaxed legs demonstrates enough external rotation to have the lateral border of the foot touch the table, he/she likely has laxity of the anterior capsule[31] or hip retroversion. Alternatively, the athlete presenting with very little to no external rotation in this position should heighten the clinician's concern for limited anterior capsular mobility or anteversion.

Limitations in hip ROM can also be assessed with daily activities. Gait on level surfaces requires only 30 to 44^0 of hip flexion, while ascending and descending stairs requires 45 to 66^0 of hip flexion.[32,33] Sitting in a chair of an average seat height requires 112^0 of hip flexion. Putting on socks requires 120^0 flexion, 20^0 abduction and 20^0 of external rotation.[34] Athletes with FAI were not able to squat as deeply as those without FAI when measured using motion analysis.[35] Difficulty performing such daily tasks can alert the clinician as to which particular motions to more closely examine during the motion assessment.

Several hip muscles are active during gait, especially the gluteal muscles. Dysfunction of these muscles (primarily the gluteus medius and minimus) is depicted in an excessive drop of the contralateral (or non-weight-bearing "swinging") side of the pelvis, or Trendelenburg gait pattern.[36] Athletes with hip osteoarthritis[37] and slipped capital femoral epiphysis,[38] have demonstrated this type of gait dysfunction. Athetes with hip dysfunction involving the strength deficits of the gluteus maximus are likely to present with functional deficits during stair climbing, step-ups, and sit to stand maneuvers since these muscles generate torque in order to propel the upper body of a person upward and forward from a position of hip flexion.[36,39]

Triage/Screening

Ruling out Serious Pathology - Red Flags

Determining appropriateness for continuation of the examination with or without potential referral to a physician is a question that should be answered early in the examination. Presence of potential serious pathology requires referral to the most appropriate medical professional. The clinician must be aware of disorders affecting the abdominal and pelvic organs that can also refer pain to the hip region, mimicking a musculoskeletal dysfunction. Previous history of cancer, such as prostate cancer in men or any reproductive cancer or breast cancer in a woman is a red flag since these cancers may be associated with metastases to the hip joint.[40] Multiple sources of pain and pathology were discovered in a study examining females with groin pain, further suggesting the need for a detailed screen as part of the clinical examination.[41] Other red flags of concern with respect to the patient presenting with hip and/or groin pain include a history of trauma, fever, unexplained weight loss, burning with urination, night pain, and prolonged corticosteroid use.[42-44]

Special testing for potential red flags from non-musculoskeletal and musculoskeletal related causes (fracture/stress fracture) of the hip should utilize detailed subjective and objective findings. Testing to rule out (highly SN tests) non-musculoskeletal, serious hip pathology are suggested at this stage in the examination. Figure 3 is the suggested sequence of examination in the triage/screening section of the examination. Table 1 describes the suggested testing for femoral fracture/stress fractures. The patellar-pubic percussion test alters post-test probability of a femoral neck fracture not existing to an almost conclusive degree in pooled analysis,[45] while the fulcrum test alters post-test probability of a femoral stress fracture not existing from a very small[46] to almost conclusive[47] degree[10] in two studies of lower quality.

Screen for Lumbar Spine and Pelvic Girdle Pathology

Once red flags are ruled out, an efficient way to begin to differentiate the many potential pain referral sources is through the lower quarter screening examination. The traditional lower quarter screen consists of testing of dermatomes, myotomes, deep tendon reflexes, and possible upper motor involvement.

The clinician should also differentially diagnose the potential contribution of the pelvic girdle and lumbar spine as the primary pain generator for the

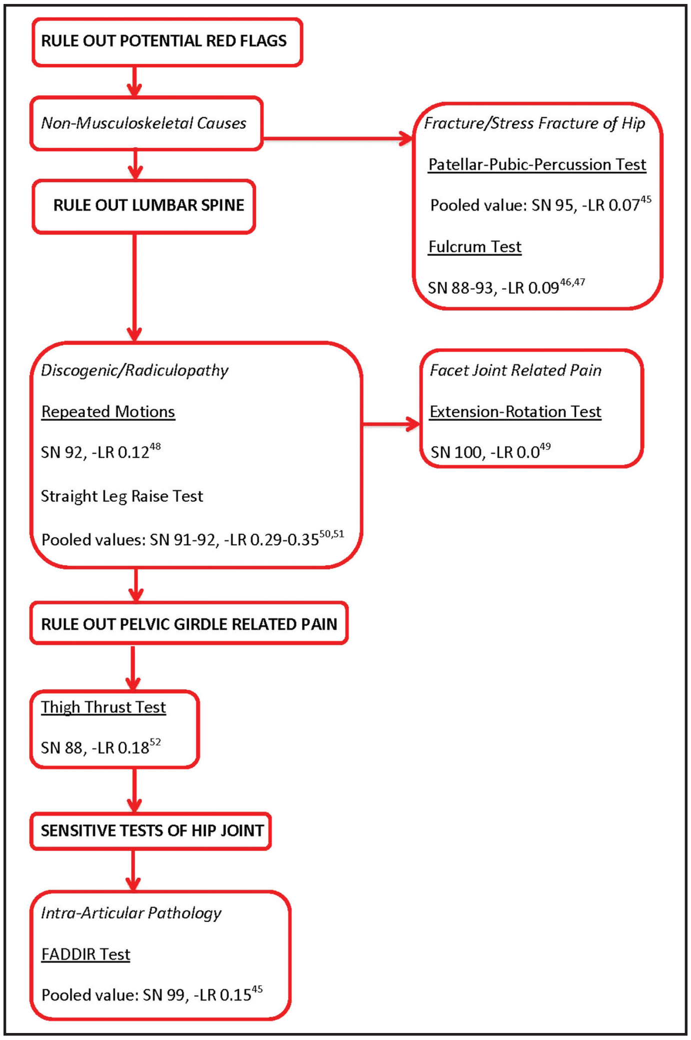

Figure 3. *Algorithm for Hip Pathology Screening in the Athletic Hip. SN = sensitivity, -LR = negative likelihood ratio, FADDIR = flexion-adduction-internal rotation test*

athlete's hip pain. Screening (highly SN) tests for these areas are employed to limit the extent of the differential diagnosis for pathology contributing to the athlete's hip pain (Table 2). Repeated motions almost conclusively alters post-test probability,[10] while straight leg raise only to a small degree assists with ruling out the existence of discogenic/radiculopathy pathology[10] in two pooled analyses.[50,51] Facet joint pathology is almost conclusively ruled out[10] with the seated extension-rotation test according to two studies[49,53] of low bias.[54]

Intra-Articular Hip Pathology Special Tests of High Sensitivity

Once serious pathology and the lumbar spine/pelvic girdle have been ruled out, the clinician should utilize highly SN hip tests to rule out competing diagnoses, as well as pare down the differential diagnosis of hip pathology (Table 3). The suggested tests/screening examination should focus on the potential presence of intra-articular pathology. The flexion-adduction-internal rotation (FADDIR) test is suggested for the potential determination of intra-articular pathology not existing (screening ability) as it has strong SN and -LR with poor SP and +LR, thereby serving appropriately as a screening test and not a diagnostic test with the ability to alter post-test probability of ruling out intra-articular pathology to a moderate degree. The diagnostic ability of this test though only alters post-test probability of the potential presence of an intra-articular pathology diagnosis to a very small degree or worse.[10]

Diagnostic Imaging (potentially for both ruling out and/or in)

Diagnostic imaging can also be a worthwhile tool to assist the clinician with both potentially ruling in and ruling out possible intra-articular pathology. Radiographic examination of the hip joint, like other regions of the body, is dependent on the type of pathology. Not unlike other portions of the examination of the hip joint, the value of diagnostic imag-

Table 1. *Screening for Serious Pathology Related to the Hip Joint.*

Special Test	Performance	Positive Result
	Fracture/Stress Fracture of the Hip	
Patellar pubic percussion test	The athlete is supine with bilateral legs relaxed. Clinician places stethoscope over pubic tubercle on ipsilateral side of lower extremity being tested. Clinician listens through stethoscope as they tap the ipsilateral patella. Tapping and placing a tuning fork over the patella can also be used in place of tapping the patella directly.	A diminished percussion noted on the side of pain.
Stress fracture/fulcrum test	The athlete is sitting on edge of table with bilateral feet off edge. Clinician places one forearm under athlete's thigh to be tested and other hand applies downward pressure to the proximal knee.	Reproduction of athlete's concordant pain.

Table 2. *Special Tests for Ruling out Lumbar Spine and Pelvic Girdle Contributions to Hip Pain.*

Special Test	Performance	Positive Result
Lumbar Spine Radiculopathy		
Repeated Motion	The athlete is standing (loaded spine) or prone/supine (unloaded spine). Athlete is asked to perform repeated flexion and extension motions of the lumbar spine. May also require repeated side-bending.	Repeated motion in one direction causes pain to centralize (move to the center of the spine) and repeated motion in another direction causes pain to peripheralize (move further down the involved leg).
Straight Leg Raise Test	The athlete is supine with legs relaxed. Clinician passively flexes, slightly adducts and internally rotates leg to be assessed while maintaining knee in extension.	Reproduction of athlete's concordant pain that is relieved by decreasing hip flexion, but then increased by passive head/neck flexion
Lumbar Spine Facet Joint Dysfunction		
Seated Extension-Rotation	The athlete is seated as clinician stabilizes their sacrum as athlete moves into end-range lumbar spine extension and rotation. If no pain, clinician can provide overpressure into further extension and rotation motion.	Reproduction of athlete's concordant pain either with active motion or passive overpressure.
SI Joint Dysfunction		
Thigh Thrust Test	The clinician places their caudal hand under the sacrum of the supine athlete and flexes the side to be assessed to 90^0 hip flexion. The clinician provides longitudinal load force through the femur for up to 30 seconds; if no pain 3-5 thrusts can be implemented.	Reproduction of athlete's concordant pain either with longitudinal overpressure load or thrust(s).

Table 3. *Sensitive Tests of the Hip Joint for Intra-Articular Involvement.*

Special Test	Performance	Positive Result
FADDIR Test	Clinician passively moves the supine athlete's leg to approximately 90^0 of hip and knee flexion. The leg is then passively adducted and internally rotated with overpressure to both motions.	Reproduction of athlete's concordant groin pain.

ing should be cautioned for some diagnosis, such as developmental hip dysplasia and FAI.[55] Several studies have found hip pathological changes in asymptomatic individuals.[56-59] Therefore, diagnosis made solely on diagnostic imaging interpretation is not advisable in clinical practice.

Radiographs

Anterior-posterior (AP) and lateral (axial "frog leg") views are the standard views utilized in plain film radiographs. As with all extremity joints comparison between sides is necessary. Assessment of particular aspects on the AP view includes:

- Hip dislocations and most fractures are often seen on AP and lateral views.
- An AP view with the hip internally rotated provides a necessary view of the femoral neck in those athletes in whom femoral neck fractures are suspected but standard radiographic findings are negative.
- Neck-shaft angle: An abnormal head neck offset (or pistol grip deformity) can be seen on these views.
- Alpha angle: a parameter typically measured with an AP or Dunn view (Figure 4) used to quantify the degree of femoral deformity and reflects the insufficient anterolateral head-neck offset and femoral head asphericity.[60] Alpha angles greater than 55-60^0 have been suggested to be associated with symptomatic impingement,[60,61] although recent findings have suggested much higher values to discriminate between subjects with pathology and controls.[62] A larger than normal alpha angle is associated with CAM morphology (not necessarily symptomatic CAM pathology).

Table 4. *Description of Suggested Special Tests for Hip Joint Ligamentous Laxity.*

Special Test	Performance	Positive Result	Interpretation
Dial Test	Athlete supine with the hip in a neutral flexion/extension and abduction/adduction position, the clinician grasps the client's leg at the femur and tibia and passively rolls it into full IR. The LE is released and allowed to ER.	A negative Dial test constitutes ER of the lower limb less than 45°, as measured vertically, with a firm endpoint.	*No reliability or diagnostic validity has been reported for this test*
Log Roll Test	Athlete supine with hip in a neutral flexion/extension and abduction/adduction position, the leg is passively rolled into full IR and ER.	A click reproduced during the test is suggestive of labral tear, while increased ER ROM may indicate iliofemoral ligament laxity.	Inter-rater reliability: ICC = 0.63;[92] κ = 0.61[93] *Good reliability; No diagnostic validity has been reported for this*

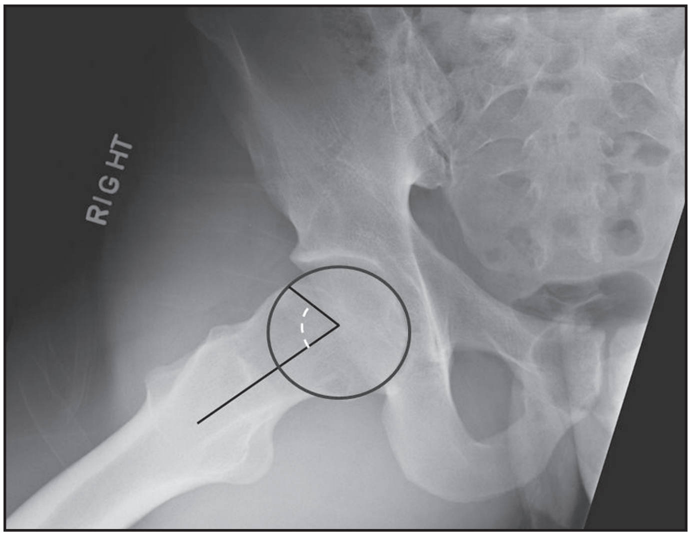

Figure 4. *Dunn lateral radiograph demonstrating α angle.*

Figure 5. *Crossover sign*

- Cross-Over Sign: a cross-over sign on the AP view is where a portion of the anterior wall of the acetabulum (dashed white line on Figure 5) projects further laterally, or "crosses over" the posterior wall (solid black line on Figure 5). This sign is associated with pincer morphology of the hip.
- Femoral head and acetabulum orientation: assessment for acetabular dysplasia, acetabular protrusio (acetabular overcoverage). Coxa profunda is the medialization of the medial wall of the acetabulum (red arrow in Figure 6) past the ilioischial line (black arrow in figure 6) while acetabular protrusio is when the medial most femoral head overlaps the ilioischial line.[63]
- Neck-shaft angle: assessment for coxa vara or coxa valga.

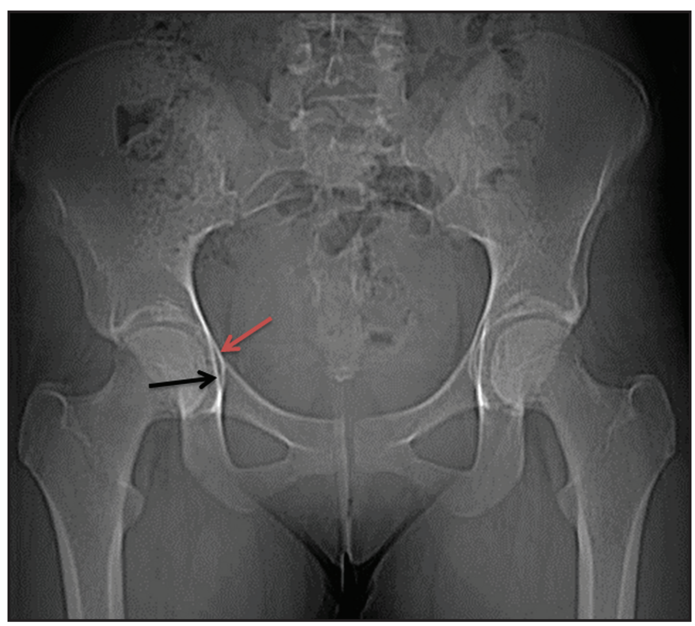

Figure 6. *Anteroposterior pelvic radiograph demonstrating coxa profunda.*

- Joint space width and osteophytes for assessment of osteoarthritis.
- Bone disease such as bony cysts (suggestive of OA), tumors, Legg-Calve-Perthes disease.

Lateral view radiograph: this view is performed with the athlete's hip flexed, abducted, and externally rotated while they are lying supine. This view allows for the capability to view for any possible pelvic obliquity or slipped capital femoral epiphysis. Children with suggestive groin symptoms should have hip AP and frog-leg lateral radiographs to rule out slipped capital femoral epiphysis.[64]

Measures of joint space, the maximum thickness of subchondral sclerosis, and the size of the largest osteophyte have been utilized to diagnose hip OA with radiographs. Minimal joint space (i.e., the shortest distance between the femoral head margin and the acetabulum) was the index most strongly associated with other radiologic features of OA.[64]

The diagnostic accuracy of radiography is much better for fractures, especially of the proximal femur (SN 90-95%/SP 68-100%)[65] than for other pathologies of the hip, particularly FAI. Furthermore, radiography of the hip has shown limited reliability,[55,66,67] meaning that disagreement between even experienced raters is not unusual.

Magnetic Resonance Imaging (MRI)

Both soft tissue (e.g. tendon, labral, and bursal lesions) and osseous tissue (e.g. stress fractures and osteonecrosis) can reliably be assessed with MRI. Since MRI is more SN to bone marrow edema, it is often used to assess subtle occult fractures and diagnosis such as sports related groin pain, pubic bone marrow edema and/or bone stress injuries of the pubis bone.[68] Combining arthrography [magnetic resonance arthrography (MRA)] has recently been shown to be both more SN and SP for the diagnosis of hip pathological lesions such as ALTs than MRI,[69] although less SN and SP for diagnosis such as gluteal tendinopathy.[70]

For imaging of intra-articular hip pathology, MRI/MRA represents the best technique because it enables clinicians to directly visualize cartilage, it provides superior soft tissue contrast, and it offers the prospect of multidimensional imaging. However, opinions differ on the diagnostic efficacy of MRI/MRA and on the question of which MRI/MRA technique is most appropriate.[71]

Diagnostic accuracy pooled analysis for FAI assessment with MRI revealed SN of 66% and SP of 79% while MRA pooled analysis was 91% SN and 80% SP.[69] Pooled analysis for detection of articular cartilage lesions in the hip was SN 59% and SP 94%.[72] The most recent diagnostic accuracy values for MRI for gluteal tendon tear range from 33-100% SN and 92-100% SP.[70] Also, similar to radiographs, MRI/MRA, have shown some limitations in inter-rater reliability.[73]

Computed Tomography (CT)

These scans are traditionally utilized for acetabular wall and femoral head fractures, as well as the more subtle hip dislocations. The assessment of osseous abnormalities, such as shape and size of the femoral head (as in a bony exostosis for cam impingement) and acetabulum, anteversion and retroversion measurements are important uses of CT scan.

Computed tomography generally shows stronger diagnostic accuracy for FAI and ALT (SN 92-97%, SP 87-100%)[74,75] than detection of articular cartilage lesions (SN 88%, SP 82%).[74] As with radiographs and MRI/MRA,[56,76] findings of abnormalities in asymptomatic individuals[57] require caution in diagnostic interpretation of CT findings in the hip joint. Additional radiation exposure is also a concern of CT.

Diagnostic Ultrasonography (US)

An advantage of US is that it does not involve radiation. It is typically used for the assessment of muscle and tendon pathology in the hip,[70] although it has also been suggested for its diagnostic utility of various other soft-tissue hip and lower extremity pathologies.[77] Ultrasonography has even been suggested for the use of screening for developmental hip dysplasia,[78] although a recent systematic review cautions its use in this manner due to weak evidence support for this clinical utility of US.[79] Generally, the clinical value of US has not been widely investigated scientifically in relation to hip and groin injuries in athletes, although many clinicians use this modality in their examination.[80,81]

The diagnostic accuracy of US for ALT (SN 82%, SP 60%)[82] is not equal to that of other utilized modalities such as MRI/MRA and CT. Additionally, although suggested for tendon assessment, limitations in diagnostic accuracy (SN 61%, SP 100%) seem to exist.[83]

Bone Scan (Scintigraphy)

Bone scans are typically utilized to help diagnosis tumors, necrosis and stress fractures of the hip. This is particularly the case with proximal femoral (femoral neck and inter-trochanteric) fractures (SN 91%, SP 100%).[84]

Intra-articular Joint Injection

Several authors have documented the diagnostic usefulness of an intra-articular hip injection in order to identify intra-articular hip abnormalities[85,86] although having stronger SN (85%) than SP (26%).[87] These injections are supported much more strongly as a better determinant of those athletes less likely to do well with surgical correction of FAI.[87]

"Ruling In" Intra-Articular Pathology

The use of SP clinical special tests, along with diagnostic imaging as outlined previously, is suggested at this point in the examination to rule in the particular hip joint pathology. The clinician is cautioned regarding study findings suggesting limitations in the clinical applicability of many hip special tests.[45,88-91] Clinical special tests are a very small component of the overall orthopedic/sports examination. Reliance of findings on special testing alone is unsatisfactory clinical practice. The recommended tests, description of their performance and diagnostic accuracy are outlined in Table 4 & 5.

PHYSICAL ASSESSMENT OF THE HIP (IMPAIRMENTS, ACTIVITY LIMITATIONS & PARTICIPATION RESTRICTIONS)

As mentioned previously, the tests included in the physical examination are not specifically aimed for establishing the athlete's diagnosis of intra-articular hip pain, but are extremely valuable in guiding the establishment of the treatment plan. While there are some correlative findings of these impairments in particular intra-articular pathologies, their diagnostic value is often limited.[95-97]

Motion tests (AROM, PROM, Accessory Motions, & Flexibility)

Motion and strength testing of the hip joint currently suffers from inconclusive findings in those with impairments in many instances. As such, it has been recommended these findings should be interpreted with caution.[96] These findings again underlie the importance of a comprehensive examination when assessing the athlete for hip pain. The hip joint motion assessment characteristics are listed in Table 6.

Patterns of lower extremity ROM deficits are often noticed in athletes with FAI and ALT. Most notably, athletes tend to exhibit reduced hip motions of flexion, internal/external rotation, and/or abduction,[28,98-101] although abduction was the only significant restriction in a recent higher quality study.[97]

Table 5. *Description of Suggested Special Tests for Intra-Articular Pathology.*

Special Test	Performance	Positive Result	Interpretation
Ligamentum Teres Tear Test	Clinician passively flexes hip fully, then extends 30^0, leaving the hip at about 70^0 flexion (knee is flexed 90^0). The hip is then abducted fully and then adducted 30^0, typically leaving it at about 30^0 abduction. The leg is then passively internally and externally rotated to available end-range.	Reproduction of concordant pain with either internal or external rotation.	SN 90%, -LR 0.11; SP 85%, +LR 6.5[94] *Both a (-) and (+) test alters post-test probability of a ligamentum teres tear not existing/existing to a moderate degree in one high quality study.*
Thomas Test	The athlete sits at the edge of the plinth. The athlete is then instructed to lie back, pulling both knees to his or her chest. One knee (the asymptomatic side) is held to the chest and the other is slowly lowered into extension of the hip by the clinician. The knee is allowed to extend. Internal and external rotation of the leg has also been suggested.	Reproduction of athlete's concordant pain with/without a click.	SN 89%, -LR 0.12, SP 92%, +LR 11.1[23] *A (-) test alters post-test probability of ALT not existing to a moderate degree, while a (+) test alters post-test probability of ALT existing to an almost conclusive degree with one high quality study.*

Table 6. *Hip Joint Motion Assessment Properties.*

Joint	Closed Packed Position	Resting Position	Capsular Pattern	ROM Norms	End Feel
Femoral-acetabular	Full extension, abuction, internal rotation	30^0 flexion, 30^0 abduction, slight external rotation	Flexion, abduction, internal rotation	Flexion: 140^0 with knee flexed Extension: 20^0 Internal rotation: 45^0 External rotation: 45^0 Abduction: 40^0 Adduction: 25^0	Firm for all motions

Additionally, since the greatest strain on the labrum occurs in the position of hip flexion and adduction,[102] assessment of hip joint mobility is suggested. Hip anterior-posterior glide (motions of hip flexion and internal rotation) and lateral glide (hip adduction) should be assessed.[103,104]

Functional limitations can be correlated with hip ROM limitations. Hip flexion ROM was shown to explain up to 95% of variance in the star excursion balance test (SEBT) performance.[105]

Muscle testing

Hip strength assessment plays an important role in clinical examination of the hip and groin region, and clinical outcome measures quantifying hip muscle strength are needed.[106] Decreased muscle strength seems to be a consistent finding in athletes with hip and groin pathology.[107,108] Manual muscle testing (MMT) is often used. The advantage of MMT is that no equipment is necessary. However, MMT has certain limitations when testing patients stronger than a grade 3 (able to raise body segment against gravity). In a classic study performed in 1956, Beasley showed that muscle-strength deficits up to 50%, assessed by quantitative measurement methods (dynamometer), could not be identified by MMT.[109]

In athletes with longstanding groin pain, a subjective manual assessment method during hip muscle testing by Hölmich et al has also been proposed.[106] This method divides muscle strength into one of three levels; weak, intermediate and strong. Kappa values of the intra-observer reliability of this procedure ranged from 0.58-0.72, and the kappa values of the inter-observer reliability ranges from 0-0.22, indicating that the procedure is observer-dependable.[106] As with the 0-5 assessment method, this kind of scale may be able to distinguish between weak and strong patients, but cannot quantify degrees of strength or weakness.

The squeeze test has recently been introduced which quantifies adduction strength by using the cuff of a sphygmomanometer placed between the athlete's knees with the instruction to squeeze the cuff as hard as they can using both legs. The highest pressure displayed on the sphygmomanometer dial (to the nearest 5 mmHg) during the test is then recorded. Malliaris et al, showed that athletes with groin pain had reduced hip adduction pressure (force) in the squeeze test of approximately 20%, compared to healthy controls.[107] However, when applying the squeeze test the measured pressure is produced by hip adduction of both legs. By introducing a hand-held dynamometer, a testing method that can be used for each leg individually, it would be possible to achieve a greater depiction of the actual muscle strength in hip adduction in both the injured and uninjured limb; therefore, a unilateral and reliable quantitative strength assessment method seems warranted for athletes with hip and groin pain.[108] The hand-held dynamometer (HHD) is a quantitative strength measurement method that has been used since the 1940's. It is a portable measurement device that has been shown to be reliable in assessing hip muscle strength.[110]

HHD using eccentric strength testing (break testing) has generally shown greater strength values than isometric testing (make testing),[111,112] about the hip,[108] but a high correlation exists between the two types of tests (contraction types).[111,113] This means that the make and break test presumably measure the same construct (maximal voluntary strength), just under different conditions. Both tests have clinical advantages and disadvantages that should be considered before use. An advantage of the make test is that isometric loading induces less stress to the musculoskeletal system than eccentric loading, thus minimising the risk of injury and delayed-onset muscle soreness.[114,115] In situations in clinical practice where eccentric testing is not feasible due to the pathological state of the athlete, isometric testing should be preferred.

Strength data obtained by HHD can be used clinically in different ways. One possibility is to use normative values. However, normative values do not often exist for different age groups and levels of physical activity, and is therefore not always an option.[116] Another possibility is to use the unaffected limb as a control. A lower limb symmetry index (LSI) can then be calculated by dividing the strength of the affected limb by the unaffected limb. Generally, it has been suggested that leg strength deficits of less than 10% on the injured side compared to the uninjured side should be considered the clinical milestone before returning an athlete to sport following an injury.[117,118] However, Thorborg et al showed that eccentric hip adduction symmetry cannot be assumed in injury-free soccer players.[7,119] In fact, the dominant side was 14% stronger than the non-dominant side with regards to eccentric hip adduction strength, although hip abduction strength was similar.[119] This finding of asymmetric eccentric hip adduction strength in injury-free soccer players, between the dominant and non-dominant leg, indicates that using contralateral eccentric hip adduction strength as a reference-point for hip adductor muscle recovery may be questionable.[119]

Hip muscle performance deficits have been demonstrated in athletes with symptomatic FAI,[120] as well as osteoarthritis.[121] Athletes with symptomatic FAI have demonstrated hip muscle weakness and an impaired ability to produce maximal hip strength when compared to healthy controls.[120] Additionally, gluteus medius and maximus muscle weakness[37,121,122] and atrophy[121,123,124] have been correlated with hip joint osteoarthritis.

Physical performance measures

Physical performance measures (PPMs) of the hip joint are applicable to the lumbar spine/pelvis and lower extremities. A recent systematic review[125] supports the use of the single-leg stance, single-leg squat, and the Star Excursion Balance Test (SEBT) for athletes with hip pathology. Athletes with FAI had decreased mean peak squat depth compared to controls, suggesting that maximal squat depth is a potentially valid measure of assessment for FAI.[35] The SEBT, a purported measure of balance, range-of-motion, and muscle performance,[105,126,127] recruited the gluteus medius at 49% of maximal volitional isometric contraction with a medial reach.[128] The single-leg squat also demonstrated a relationship to hip abductor function.[129] Dysfunction in any of these PPMs should alert the clinician to perform measures previously discussed (motion tests, muscle performance tests, and so on).

Normative and discriminatory values for involved to non-involved lower extremities on various hop, speed and agility tests have been reported.[130] Most of these tests are reported for either normative values or on knee and ankle pathologies. The reliability of these measures specifically for hip dysfunction has not been established.

The "Sport Test" has been advocated by Wahoff et al to objectively assess an athlete's readiness to return to sport following hip arthroscopy.[131] Rather than measuring isolated movements, it analyzes an individual's coordinated movement patterns and power of an involved extremity. The Sport Test includes single knee bends, side-to-side lateral movement, diagonal side-to-side movement, and forward box lunges. Athletes must score 17/20 or higher to pass each of the four components of the test.[131] Although the application of this test on those with ALT has not been investigated, it seems plausible that this test could function as an advanced assessment of sport-related ability for those athletes with ALT since it replicates most components of sporting activity. However, it is worth noting, that there is a lack of diagnostic accuracy/prediction of the use of the Sport Test in relation to return to sport.

Patient-reported outcome measures (PROs)

Investigation of the most traditional hip PROs for hip arthroscopy athletes suggest that the Non-arthritic Hip Score (NAHS), the Hip Outcome Score (HOS), and the modified Harris Hip Score (mHHS) are commonly used for patients who have undergone hip arthroscopy.[132,133] The NAHS was the only PRO with content validity, while the HOS scored best on agreement, internal consistency, and responsiveness, of these three PROs.[132,133]

However, recently newer and more promising PROs have been developed for patients with hip and groin problems. The 33-item International Hip Outcome Tool (iHOT-33) has been developed for hip related problems in younger patients. This questionnaire uses a visual analog scale response format designed for computer self-administration by young, active athletes with hip pathology. The iHOT-33 has been shown to be reliable, has demonstrated face, content, and construct validity, and is highly responsive to clinical change.[134] Furthermore, a short version of the International Hip Outcome Tool (iHOT-12) has been developed. It has very similar characteristics to the original rigorously validated 33-item questionnaire, losing very little information despite being only one-third the length. It is valid, reliable, and responsive to change. It has been suggested to be used for initial assessment and postoperative follow-up in routine clinical practice.[135]

The Copenhagen Hip and Groin Outcome Score (HAGOS) was also recently developed for the assessment of symptoms, activity limitations, participation restrictions and quality of life in physically active, young to middle-aged athletes with long-standing hip and/or groin pain.[136] The HAGOS consists of six separate subscales assessing pain, symptoms, physical function in daily living, physical function in sport and recreation, participation in physical activities and hip and/or groin-related quality of life. It is also a valid, reliable, and responsive to change measure.[136] HAGOS includes a measure of the athletes' ability to perform at their usual and optimal pre-injury level, which is extremely relevant when dealing with athletes with longstanding problems, as their ability to perform is often impaired, even though they have returned to sporting activity.[136]

Both iHOT and HAGOS have shown to be reliable, valid and responsive measures for patients with hip and/or groin pain. Both of these measures have recently been translated and validated in different languages and by different research groups,[135-138] and reference values has been provided in different subgroups for these measures.[139,140] So far data from HAGOS indicate that this measures is sensitive to changes in hip and groin pain and functional status, with the ability to discriminate between athletes with and without previous injury.[140] Furthermore, substantial disability is more often reported when using iHOT and HAGOS due to the sports specific and patients-relevant questions asked in these questionnaires compared to the more traditional hip PROs (mHHS and NAHS) where content validity for athletes has never been addressed sufficiently.[136] Taken together, this means that athletes often report very few problems in these older PROs due to lack of sports-specific and more functionally demanding questions.

The tools recommended for use in athletes who have sustained a fracture is limited. The Short Musculoskeletal Function Assessment (SMFA) had good overall responsiveness in athletes with hip fractures and has been recommended for use as one of the measures to evaluate the outcome after a hip fracture.[141]

SUMMARY

This clinical commentary focuses on an evidence-based examination and physical assessment of hip joint-related pathology in athletes. Clinical examination of the athlete with hip pain is a diagnostic challenge requiring a clearly defined approach with sound clinical reasoning. Each component of this approach contributes to the identification of the potential existence/non-existence of a particular pathology. Furthermore, the athlete's functional ability in relation to important aspects of body functions and structure (impairments), activities (activity limitations) and participation (participation restrictions) is important to identify, in order to optimize and structure and individualized rehabilitation program. The strengths and limitations of each component of the proposed approach vary from athlete to athlete. This systematic, cogent, hip examination and assessment approach must therefore always be individualized to each particular athlete and situation.

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