

# The Early Clinical Diagnosis of Osteoarthritis of the Hip

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Osteoarthritis of the hip is a common condition physical therapists see in the clinic. The fundamental radiological and pathological characteristic of osteoarthritis of the hip is joint space loss.<sup>36</sup> Consequently, the best radiological criterion used to detect osteoarthritis of the hip is by measuring joint space width.<sup>9,11</sup> Because most physical therapists do not have immediate access to radiographs and do not have the ability to order radiographs, they must either rely on a physician to order a hip radiograph or rely on a clinical method to diagnose osteoarthritis of the hip.

Radiographs, though usually helpful in the diagnosis of severe hip osteoarthritis, are not always beneficial in the diagnosis of mild or moderate hip osteoarthritis.<sup>30,38,41,42</sup> In patients with severe hip osteoarthritis, radiographs usually show joint space narrowing, subchondral sclerosis, or osteophytes.<sup>13,18,25,33</sup> However, patients with early osteoarthritis often do not show these kind of radiographic changes.<sup>30,38,41</sup> Thus, relying only on radiographs to determine osteoarthritis of the hip, especially in patients with early or mild hip osteoarthritis, can result in false-negative diagnosis. Using the clinical presentation (signs and symptoms) along with imaging findings will likely improve the diagnosis of osteoarthritis of the hip.

The ability to clinically determine osteoarthritis of the hip without a radiograph, especially in early cases, would be valuable to many clinicians, not just physical therapists. Finding a clinical method to detect osteoarthritis of the hip would give physical therapists an opportunity for early intervention. Early intervention may improve the chance of clinical success. A number of studies have suggested using a clinical method to diagnose hip osteoarthritis. Studies by Altman et al,<sup>1</sup> Birrell et al,<sup>4</sup> and Bierma-Zienstra et al<sup>3</sup> have recommended using clinical variables, such as pain location or duration, hip range of motion, age, or aggravating movement (Tables 1-3). Among the different clinical criteria, diminished hip range of motion is the most common component used to indicate the presence of hip joint osteoarthritis.

Using hip motion to diagnose hip problems is not new. Many studies have shown the relationship between different hip conditions and diminished hip motion.<sup>4,7,9,10,12,16,18,19,20,24,35,43,44,48-50</sup> For example,

osteoarthritis of the hip has been linked to patients with femoral neck retroversion, where hip external rotation is increased while hip internal rotation is limited.<sup>21,22,47-49,51</sup> In osteoarthritis of the hip, the first 2 motions that are diminished are usually hip internal rotation and hip flexion.<sup>1,4,36,51</sup> The purpose of this paper is to describe how we made a clinical diagnosis of osteoarthritis of the hip in a patient with diminished hip range of motion and hip pain.

## PATIENT INFORMATION

### History

The patient was a 43-year-old female (height, 162.5 cm; mass, 59 kg) who worked as an account executive, a mostly sedentary office job. She developed mild lateral (greater trochanter) right hip pain about 5 years ago that bothered her on and off, mostly after extended sitting (60 minutes or more), going up and down steps, and sometimes when she got out of bed in the morning. She sought treatment after she started limping about 4 months prior to initial visit. No history of trauma or other precipitating incident was reported. She described the pain as localized around the right greater trochanter and “deep,” which she could not localize to her skin. Her pain now develops mainly during weight-bearing activities and is relieved by non-weight bearing. Cur-

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**TABLE 1.** Birrell et al's<sup>4</sup> criteria for hip osteoarthritis.

Clinical Criteria	Reference Standard	Statistics		
		Sensitivity	Specificity	+LR
Restricted hip motion in number of planes	Joint space narrowing of 1.5 mm or less			
0		100	0	1.0
1		100	42	1.7
2		81	69	2.6
3		54	88	4.4
Restricted hip motion in number of planes	Joint space narrowing (Croft grade >2) <sup>11</sup>			
0		100	0	1.0
1		86	54	1.9
2		57	77	2.5
3		33	93	5.0

Abbreviation: +LR, positive likelihood ratio.

**TABLE 2.** Bierma-Zienstra et al's<sup>3</sup> criteria for hip osteoarthritis.

Clinical Criteria	Reference Standard	Sensitivity	Specificity
Age >60 y	Minimal joint space, <2.5 mm		
Tenderness over inguinal ligament			
Decreased external rotation <21°			
Decreased internal rotation <21°			
Decreased adduction <10°			
Bony restriction in 1 direction during passive hip movement			
Muscle weakness of the hip abductors			
4 of the above present		91%	45%
5 of the above present		98%	72%
6 of the above present		100%	40%
7 of the above present		100%	48%

**TABLE 3.** Altman et al's<sup>1</sup> criteria for hip osteoarthritis.

Clinical Criteria	Reference Standard	Sensitivity	Specificity
<ul style="list-style-type: none"> <li>• Hip internal rotation &lt;15°</li> <li>• Morning stiffness for &gt;60 min</li> <li>• Hip flexion &lt;115°</li> <li>• Pain with hip internal rotation</li> <li>• Age &gt;50 y</li> </ul>	Radiographic findings include: joint space narrowing, osteophytes, sclerosis, cyst, protrusion, and femoral head remodeling	86%	75%

rent pain was determined by using a 0-to-10 (0 as no pain and 10 as the worst pain imaginable) pain scale. Her present pain, while sitting, was 3 out of 10; however, walking in to the treatment room she reported a pain of 4/10. Activities limited by pain included going up and down stairs. She was not exercising regularly or involved with any routine physical activity; however, she stayed active by gardening and was a homemaker. An orthopedic surgeon referred her to physical therapy with a diagnosis of right hip bursitis. Prior intervention for her hip pain included only cortisone injections. She had received 1 injection to the right lateral hip each of the preceding 4 years, which was successful in easing her pain. However, with the most recent episode, the cortisone injection had no effect on her hip pain.

The Western Ontario McMaster University Osteoarthritis Index (WOMAC) outcome measure

administered prior to taking her history showed an initial overall score of 36%. The WOMAC is a self-reported patient response outcome measure designed to determine patient response on 3 different functional criteria or subsets, which include pain, stiffness, and physical function.<sup>2</sup> Pain is rated with items asking how severe the pain is when walking, stair climbing, at night, resting, and standing. Stiffness was scored by rating 2 items: morning stiffness and stiffness developing later in the day. While physical function was separated into items that included activities such as going up stairs, going down stairs, rising from sitting, standing, bending over, walking on flat surfaces, putting on socks, and other activities of daily living. Each item was scored on a scale ranging from 0 (no pain/problem) to 10 (worst imaginable pain/problem). A score of 36% is usually considered mild disability, suggesting moderate pain,

moderate stiffness, and moderate problems with activities of daily living (putting on socks, going up/down stairs, standing, bending over, etc). On the pain subcategory, the highest reported pain was with stair climbing, which the patient scored 5/10, and while both walking and standing scored 4/10. On the stiffness subcategory, morning stiffness was rated as 5/10. Finally, on the physical function subcategory, she scored going shopping, going up stairs, and heavy house chores as a 5/10, while rising from sitting was rated 4/10. Previous medical history, including a systems review questionnaire, was unremarkable and the only other problem she sought help for was shoulder tendonitis 4 years previously. This was treated successfully with physical therapy. She was not given any medications by her physician for her hip.

### Examination/Evaluation

During visual observation of her gait while walking on a level surface, the patient exhibited apparent decreased weight bearing on the right lower extremity, mainly during mid stance. The pelvis did not appear to drop (Trendelenburg sign) on either side during the stance phase of gait; however, a compensated Trendelenburg limp was noted where the patient's trunk leaned toward the side of the stance leg during gait. No other postural deviations were noted while the patient was standing.

Active and passive hip range of motion was measured with a 30-cm plastic goniometer. Active hip flexion, measured in supine, was 85° compared to 125° on the left side. Active hip range of motion for abduction and adduction, measured in supine, were normal bilaterally, but painful on the right hip at the end range of abduction. Passive hip flexion measured supine was 130° for the left hip and only 90° for the right hip, with a report of hip pain and an empty end feel on the right (Table 4). Passive hip internal and external rotation range of motion was measured prone with the knees flexed to 90° and the pelvis stabilized firmly. Passive left hip internal rotation was 60° and external rotation was 55°. Passive right hip internal rotation was 20°, and external rotation was 60°. Passive hip internal and external rotation ranges of motion were taken to where a firm end feel was obtained. Assessment of right hip internal rotation did create some deep right hip pain, but the pain did not interfere with attaining a firm end feel at the end

of movement. Overall, passive hip range of motion was diminished for right hip flexion and right hip internal rotation. Lumbar and knee range of motion was also assessed. The patient had full range of motion in both knees and was able to perform all trunk motions without reproduction of hip pain.

Manual muscle testing, as described by Kendall,<sup>26</sup> showed weakness, with no increase in pain for the right hip internal rotators, the right hip abductors, and the right hip flexors (all 3 muscle groups tested showed a fair-plus [3+/5] manual muscle testing grade). All other muscles tested on the right lower extremity tested normal (5/5), including hip adductors, external rotators, and extensors. The left hip showed normal (5/5) strength for all muscle groups.

Patrick's, also called FABER's test,<sup>32</sup> was negative on the left, but positive on the right with a report of deep hip pain that she could not localize to the skin. The pain during testing was perceived to be the same pain that she had when she walked. Reproduction of pain or symptoms in the hip with Patrick's test is indicative of hip pathology or arthritis.<sup>29,32</sup> Fitzgerald's acetabular labral tests were performed.<sup>17</sup> Testing was first performed by flexing, adducting, and then externally rotating the patient's hip and then extending, abducting, and internally rotating the hip. Pain, with or without a clicking sound, suggests a possible anterior labral tear.<sup>17</sup> A possible posterior labral tear is suspected by performing this maneuver in the reverse order by extending, abducting, and then internally rotating the hip and then moving the hip into a position of simultaneous flexion, adduction, and external rotation. Both Fitzgerald's tests produced similar hip pain but no clicking sound.<sup>17</sup> The impingement provocation test also reproduced symptoms similar to what the patient experienced when she had right hip pain during gait. The impingement provocation test is performed by having the patient supine, flexing the hip to 90°, adducting about 25°, and then internally rotating the hip fully. This test is described as a test for a possible torn acetabular labrum, acetabular rim, or snapping hip syndrome.<sup>24,27,37</sup> We have noted from previous experience that the Fitzgerald provocation test and the impingement provocation test are sometimes positive in patients with early or moderate osteoarthritis of the hip.

Leg lengths were checked supine by comparing the left and right medial malleolus for equality and by

**TABLE 4.** Passive hip range of motion in degrees preintervention and postintervention.

	Left (Uninvolved)		Right (Involved)	
	Preintervention	Postintervention	Preintervention	Postintervention
Internal rotation	60	60	20	55
External rotation	55	55	60	60
Flexion	130	130	90	125

palpating and visually comparing the horizontal heights of the left and right posterior superior iliac spines when sitting and then standing. No differences were noted. The Thomas test, performed supine on the edge of the treatment table, showed no difference in muscle length when comparing the left and right rectus femoris muscles, tensor fascia latae, and iliopsoas muscles. During the Thomas test, the end motions of hip extension with knee extension (for hip flexor length), hip extension with adduction (for tensor fascia latae and iliotibial band length), and hip extension with knee flexion (for rectus femoris length) were all examined. When testing the left side for muscle length using the Thomas test, the right hip was slightly painful and flexion was limited. We do not believe that the limitation of right hip flexion when testing the left side affected the outcome or validity of the tests. Ober's test showed normal and symmetrical iliotibial band length when comparing the left to the right side. Additional testing, including vital signs and a neurological screen, were not performed given the patient's past medical history, current chief complaints, and that the physical examination had so far revealed nothing that would suggest a neurological problem.

## DIAGNOSIS

The history, including symptoms of lateral hip (greater trochanter) pain,<sup>1,3,37</sup> morning stiffness,<sup>1,3</sup> stiffness after sitting,<sup>3</sup> and hip pain with weight bearing,<sup>1,3</sup> suggested the possibility of osteoarthritis of the right hip. The absence of severe hip pain (reported pain of 5/10), absence of fever, and onset that was not acute and short in duration diminished the probability of transient synovitis of the hip.<sup>14,15,23</sup> No history of long-term steroid use or alcohol abuse reduced the possibility of avascular necrosis of the hip. Hip bursitis is usually not consistent with a history of lateral hip pain of 5 years duration and limited hip flexion and internal rotation range of motion. She did not have exertional hip pain (pain only on significant athletic activity), nor did the patient have groin pain, or a history of a sudden increase in the intensity of her activity, which ruled out a femoral neck stress fracture.<sup>5,8,31,52</sup> Patients with femoral neck stress fractures are usually runners or persons who have a vigorous lifestyle.<sup>5,8,31,52</sup> The likelihood of pain referral from the lumbar spine was low because she had full trunk range of motion in all directions without complaint of pain or limitation of movement. Also, she had no pain in the lumbar spine or posterior superior iliac spine regions. The pretest probability, or the prior probability that the patient had the condition before any diagnostic tests that have good measurement properties (eg, high sensitivity, specificity, or high likelihood ratios) were performed, was derived from our own clinical experience and also from ruling out other potential

hip conditions using the best evidence available.<sup>40</sup> We estimated this patient's pretest probability as 60% that she had early hip osteoarthritis.

According to Birrell et al,<sup>4</sup> a patient with diminished hip internal rotation less than 23° and diminished hip flexion less than 94° has a likelihood ratio of 2.5 of having osteoarthritis of the hip. Our patient had a range of 20° of hip internal rotation and 90° of hip flexion. Using mathematical calculations described by Sackett et al,<sup>39,40</sup> the combination of a 2.5 likelihood ratio with a pretest probability of 60% that hip osteoarthritis is present results in a 80% posttest probability that she does have osteoarthritis of the hip.

Radiographs of the right hip were taken on the day of her initial examination. We received the radiologist's report and copies of the radiographs 2 days later (Figure). The radiographs confirmed our clinical diagnosis. The radiologist's narrative report stated, "Normal bone alignment with normal articulations, no evidence of fracture or dislocation. There is minimal superior joint space narrowing with minimal subchondral bone sclerosis of the right acetabulum." The radiologist's opinion was "mild right osteoarthritis of the hip joint, no evidence of acute fracture or dislocation."

## Intervention

The goals of our intervention were to restore normal right hip range of motion and right hip muscle strength, diminish pain, and eliminate the observed gait deviations noted during the stance phase on the right lower extremity. Strengthening of the right hip abductors and flexors were performed in standing using an Alliance Rehabilitation System multi hip machine (Chattanooga Group, Hixson, TN). Five sets of 12 repetitions, starting with 9 kg and increasing as tolerated, with the goals of creating right hip muscle fatigue with only minor pain, were performed every other day. Also, gentle stretching, by



**FIGURE.** Anterior/posterior radiograph taken of the left and right hip taken on physical therapy evaluation day showing joint space narrowing of her right hip.

the supervising clinician of the right hip posterior capsule and hip external rotator muscles was performed by moving the right hip into the direction of internal rotation while the patient was lying prone with the hip in the anatomically neutral position in the frontal and sagittal planes. The stretch was achieved by stabilizing the pelvis with a therapy belt or by firmly holding the left posterior superior iliac spine and grasping the ankle or foot with the knee flexed to 90° while slowly internally rotating the femur. The stretch was repeated 6 times using a contract-relax method followed by holding 3 stretches for 30 seconds at the end of right hip internal rotation. The patient was instructed to avoid sitting on her right leg in a position that held her hip in maximal external rotation, which was her favorite position she used during sitting. The patient was also told to continue with all other activities unless hip pain increased to greater than a rating of 4/10 on the pain scale. After 6 visits (over 16 days), passive hip flexion was 125°, right hip internal rotation was 55°, and muscle grades for the right hip internal rotator and abductor muscles were painless and were rated good-plus (4+/5). Such improvement in muscle grades were remarkable in such a short time. We believe such improvement occurred because of her diminished hip pain, as opposed to muscle hypertrophy. Her overall WOMAC score was now 16% and no limp was observed during gait and she no longer sat on her right leg where her right hip was maximally externally rotated.

## DISCUSSION

The ability to diagnose hip osteoarthritis by examining hip joint range of motion provides an interesting opportunity for physical therapists. Not surprising, Birrell et al<sup>4</sup> notes that as the number of restricted planes of hip motion increases, the specificity, or ruling in the diagnosis of hip osteoarthritis increases (Table 1). As specificity increases, sensitivity, or ruling out a diagnosis of hip osteoarthritis, decreases in patients with mild to moderate and severe osteoarthritis of the hip. This trade-off, where sensitivity decreases while specificity increases, is common with sensitivity and specificity. The diagnostic value of decreased range of motion is best when present in 2 or 3 planes of motion (positive likelihood ratio of 2.5-5), as compared to just 1 plane of motion (positive likelihood ratio of 1.9). In addition to the diminished hip range of motion in 2 planes, this patient also had symptoms of morning stiffness, pain more than 3 months duration, primary pain during weight bearing, and greater trochanter pain, which were all suggestive of osteoarthritis of the hip. Physical therapists should always carefully consider assessing hip motion in all 3 planes when evaluating a painful hip joint.

Two other published studies have examined the relationship between patients with clinical signs and symptoms of hip osteoarthritis and radiographic findings (Tables 2 and 3); however, the criteria used in these articles did not suggest an increased likelihood of hip osteoarthritis in the patient we just described. The clinical diagnosis of early hip osteoarthritis according to Bierma-Zeinstra et al<sup>3</sup> includes such variables as decreased external rotation, no pain aggravation with sitting, and over 60 years of age. Altman et al's<sup>1</sup> criteria included hip internal rotation less than 15° and an age of over 50 years. Age appears to be the main factor that limits using Bierma-Zeinstra et al's<sup>3</sup> and Altman et al's<sup>1</sup> specific criteria for clinical diagnosis of hip osteoarthritis, because our patient was under 50 years old. Using Bierma-Zeinstra et al's<sup>3</sup> and Altman et al's<sup>1</sup> criteria would have resulted in a false-negative finding in this patient, because she did have osteoarthritis of the hip defined by radiographic joint space narrowing. Diagnostic measurement properties, like sensitivity, specificity, and likelihood ratios, are probabilistic statistics; consequently, false-positive and false-negative results will always be potentially possible.

Few randomized clinical trials have been performed on interventions for patients with hip pain or hip osteoarthritis. Weigl et al<sup>54</sup> showed that strengthening exercises, flexibility, relaxation, and endurance training decreased pain and improved physical function in patients with osteoarthritis. van Baar et al<sup>53</sup> showed that exercise improved function and reduced pain in patients with hip osteoarthritis, but later found that the beneficial effect of exercise declined over time. In a randomized control trial that included athletes with hip pain, Cibulka et al<sup>6</sup> demonstrated short-term improvement in reducing hip pain after mobilizing the sacroiliac joint. Patients with sacroiliac joint dysfunction often have ipsilateral diminished hip joint internal rotation.<sup>7</sup> While restoring hip range of motion appears to be an important part of the intervention for osteoarthritis of the hip, further confirmation requires appropriately designed studies.

Decreases or changes in hip joint range of motion have been associated with different hip problems.<sup>4,7,17,28,34,44,48</sup> In subjects without hip joint pathology, passive hip joint range of motion, for a specific motion like hip internal rotation, has consistently been shown to be symmetrical from the left to right side.<sup>44-46</sup> The normal discrepancy between left to right side for a specific motion like hip internal rotation rarely exceeds 16°.<sup>45,46</sup> In this case, left internal rotation was 60° compared to 20° on the right. Also, hip flexion was 130° on the left compared to 90° on the right. Both of these hip motions had differences of 40° when comparing the left to the right side. We believe that identifying diminished hip motion can be used to diagnose early osteoarthritis of the hip, especially when coupled with other cogent

signs and symptoms. Future studies that carefully examine hip motion in patients with hip osteoarthritis are needed.

Osteoarthritis of the hip is diagnosed most often in patients over 60 years of age. Our patient was only 43 years of age at the time she was diagnosed. Her osteoarthritis was considered mild, judging from the mild radiographic signs of minimal hip joint space narrowing. In addition, her hip ranges of motion were restricted in 2 planes (internal rotation and flexion), which according to Birrell et al<sup>4</sup> is diagnostic of hip osteoarthritis. She also walked with a compensated Trendelenburg limp. Altman et al<sup>1</sup> data show that patients who have a Trendelenburg limp have a diagnostic specificity of 81%. Her past medical history included a 5-year history of hip pain, which was relieved repeatedly with lateral hip injections. Based on these findings, we believe she may have been in the very early stages of hip osteoarthritis for the last 5 years.

We believe that making an early clinical diagnosis is important in patients with hip joint pain and osteoarthritis. We realize that this is a description of just 1 case and future studies are needed to verify this method of clinical diagnosis. Nevertheless, this resident's case problem demonstrates the often quiescent nature of early osteoarthritis of the hip and identifies the key role physical therapists can play in the early diagnosis and treatment of hip range of motion in patients with mild to moderate hip pain.

## REFERENCES

- Altman R, Alarcon G, Appelrouth D, et al. The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip. *Arthritis Rheum*. 1991;34:505-514.
- Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol*. 1988;15:1833-1840.
- Bierma-Zeinstra SM, Oster JD, Bernsen RM, Verhaar JA, Ginai AZ, Bohnen AM. Joint space narrowing and relationship with symptoms and signs in adults consulting for hip pain in primary care. *J Rheumatol*. 2002;29:1713-1718.
- Birrell F, Croft P, Cooper C, Hosie G, Macfarlane G, Silman A. Predicting radiographic hip osteoarthritis from range of movement. *Rheumatology (Oxford)*. 2001;40:506-512.
- Boden BP, Osbahr DC. High-risk stress fractures: evaluation and treatment. *J Am Acad Orthop Surg*. 2000;8:344-353.
- Cibulka MT, Delitto A. A comparison of two different methods to treat hip pain in runners. *J Orthop Sports Phys Ther*. 1993;17:172-176.
- Cibulka MT, Sinacore DR, Cromer GS, Delitto A. Unilateral hip rotation range of motion asymmetry in patients with sacroiliac joint regional pain. *Spine*. 1998;23:1009-1015.
- Clough TM. Femoral neck stress fracture: the importance of clinical suspicion and early review. *Br J Sports Med*. 2002;36:308-309.
- Conrozier T, Jousseume CA, Mathieu P, et al. Quantitative measurement of joint space narrowing progression in hip osteoarthritis: a longitudinal retrospective study of patients treated by total hip arthroplasty. *Br J Rheumatol*. 1998;37:961-968.
- Crane L. Femoral torsion and its relation to toeing-in and toeing-out. *J Bone Joint Surg Am*. 1959;41-A:421-428.
- Croft P, Cooper C, Wickham C, Coggon D. Defining osteoarthritis of the hip for epidemiologic studies. *Am J Epidemiol*. 1990;132:514-522.
- Davids JR, Benfanti P, Blackhurst DW, Allen BL. Assessment of femoral anteversion in children with cerebral palsy: accuracy of the trochanteric prominence angle test. *J Pediatr Orthop*. 2002;22:173-178.
- Dougados M, Gueguen A, Nguyen M, et al. Radiographic features predictive of radiographic progression of hip osteoarthritis. *Rev Rhum Engl Ed*. 1997;64:795-803.
- Dzioba RB, Barrington TW. Transient monoarticular synovitis of the hip joint in adults. *Clin Orthop*. 1977;190-192.
- Eich GF, Superti-Furga A, Umbricht FS, Willi UV. The painful hip: evaluation of criteria for clinical decision-making. *Eur J Pediatr*. 1999;158:923-928.
- Ellison JB, Rose SJ, Sahrman SA. Patterns of hip rotation range of motion: a comparison between healthy subjects and patients with low back pain. *Phys Ther*. 1990;70:537-541.
- Fitzgerald RH, Jr. Acetabular labrum tears. Diagnosis and treatment. *Clin Orthop*. 1995;60-68.
- Fox KM, Hochberg MC, Resnik CS, et al. Severity of radiographic findings in hip osteoarthritis associated with total hip arthroplasty. *J Rheumatol*. 1996;23:693-697.
- Gelberman RH, Cohen MS, Desai SS, Griffin PP, Salamon PB, O'Brien TM. Femoral anteversion. A clinical assessment of idiopathic intoeing gait in children. *J Bone Joint Surg Br*. 1987;69:75-79.
- Gelberman RH, Cohen MS, Shaw BA, Kasser JR, Griffin PP, Wilkinson RH. The association of femoral retroversion with slipped capital femoral epiphysis. *J Bone Joint Surg Am*. 1986;68:1000-1007.
- Giunti A, Moroni A, Olmi R, Rimondi E, Soldati D, Vicenzi G. The importance of the angle of anteversion in the development of arthritis of the hip. *Ital J Orthop Traumatol*. 1985;11:23-27.
- Halpern AA, Tanner J, Rinsky L. Does persistent fetal femoral anteversion contribute to osteoarthritis?: a preliminary report. *Clin Orthop*. 1979;213-216.
- Hart JJ. Transient synovitis of the hip in children. *Am Fam Physician*. 1996;54:1587-1591, 1595-1586.
- Ito K, Minka MA, 2nd, Leunig M, Werlen S, Ganz R. Femoroacetabular impingement and the cam-effect. A MRI-based quantitative anatomical study of the femoral head-neck offset. *J Bone Joint Surg Br*. 2001;83:171-176.
- Kellgren JH, Lawrence JS. Radiological assessment of osteoarthrosis. *Ann Rheum Dis*. 1957;16:494-502.
- Kendall F, McCreary E, Provance P. *Muscles: Testing and Function*. Baltimore, MD: Williams & Wilkins; 1993.
- Klaue K. Determination of acetabular coverage of the femoral head with use of a single anteroposterior radiograph. *J Bone Joint Surg Am*. 1995;77:153-154.

28. Kozic S, Gulan G, Matovinovic D, Nemec B, Sestan B, Ravlic-Gulan J. Femoral anteversion related to side differences in hip rotation. Passive rotation in 1,140 children aged 8-9 years. *Acta Orthop Scand*. 1997;68:533-536.
29. LeVeau B. Hip. In: Richardson J, Iglarsh ZA, eds. *Clinical Orthopaedic Physical Therapy*. Philadelphia, PA: W. B. Saunders Company; 1994.
30. Locher S, Werlen S, Leunig M, Ganz R. [Inadequate detectability of early stages of coxarthrosis with conventional roentgen images]. *Z Orthop Ihre Grenzgeb*. 2001;139:70-74.
31. Lynch SA, Renstrom PA. Groin injuries in sport: treatment strategies. *Sports Med*. 1999;28:137-144.
32. Magee D. *Orthopedic Physical Assessment*. Philadelphia, PA: W. B. Saunders Company; 1994.
33. Meisel A, Bullough P. *Atlas of Osteoarthritis*. Philadelphia, PA: W. B. Saunders Company; 1984.
34. Pitkow RB. External rotation contracture of the extended hip. A common phenomenon of infancy obscuring femoral neck anteversion and the most frequent cause of out-toeing gait in children. *Clin Orthop*. 1975;139-145.
35. Reikeras O, Bjerkreim I, Kolbenstvedt A. Anteversion of the acetabulum in patients with idiopathic increased anteversion of the femoral neck. *Acta Orthop Scand*. 1982;53:847-852.
36. Resnick N, Niwayama G. *Degenerative Diseases. Diagnosis of Bone and Joint Disorders*. Philadelphia, PA: W. B. Saunders Company; 1988.
37. Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum. A cause of hip pain. *J Bone Joint Surg Br*. 1999;81:281-288.
38. Roos E. [Clinical criteria best foundation for diagnosis of mild to moderate arthritis. Symptoms, not radiological results, dictate choice of treatment]. *Lakartidningen*. 2002;99:4362-4364.
39. Sackett DL, Haynes RB, Tugwell P. *Clinical Epidemiology: A Basic Science for Clinical Medicine*. Little, Brown, and Company; 1985.
40. Sackett DL, Straus S, Richardson S, Rosenberg WM, Haynes RB. *Evidence-Based Medicine: How to Practice and Teach EBM*. Edinburgh, UK: Churchill Livingstone; 1998.
41. Shih TT, Su CT, Chiu LC, Erickson F, Hang YS, Huang KM. Evaluation of hip disorders by radiography, radionuclide scanning and magnetic resonance imaging. *J Formos Med Assoc*. 1993;92:737-744.
42. Spector TD, Hochberg MC. Methodological problems in the epidemiological study of osteoarthritis. *Ann Rheum Dis*. 1994;53:143-146.
43. Staheli LT. In-toeing and out-toeing in children. *J Fam Pract*. 1983;16:1005-1011.
44. Staheli LT, Corbett M, Wyss C, King H. Lower-extremity rotational problems in children. Normal values to guide management. *J Bone Joint Surg Am*. 1985;67:39-47.
45. Svenningsen S, Terjesen T, Auflem M, Berg V. Hip motion related to age and sex. *Acta Orthop Scand*. 1989;60:97-100.
46. Svenningsen S, Terjesen T, Auflem M, Berg V. Hip rotation and in-toeing gait. A study of normal subjects from four years until adult age. *Clin Orthop*. 1990;177-182.
47. Terjesen T, Benum P, Anda S, Svenningsen S. Increased femoral anteversion and osteoarthritis of the hip joint. *Acta Orthop Scand*. 1982;53:571-575.
48. Tonnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. *J Bone Joint Surg Am*. 1999;81:1747-1770.
49. Tonnis D, Heinecke A. [Decreased acetabular anteversion and femur neck antetorsion cause pain and arthrosis. 1: Statistics and clinical sequelae]. *Z Orthop Ihre Grenzgeb*. 1999;137:153-159.
50. Tonnis D, Heinecke A. [Decreased acetabular anteversion and femur neck antetorsion cause pain and arthrosis. 2: Etiology, diagnosis and therapy]. *Z Orthop Ihre Grenzgeb*. 1999;137:160-167.
51. Tonnis D, Heinecke A. Diminished femoral antetorsion syndrome: a cause of pain and osteoarthritis. *J Pediatr Orthop*. 1991;11:419-431.
52. Tountas AA, Waddell JP. Stress fractures of the femoral neck. A report of seven cases. *Clin Orthop*. 1986;160-165.
53. van Baar ME, Dekker J, Oostendorp RA, Bijl D, Voorn TB, Bijlsma JW. Effectiveness of exercise in patients with osteoarthritis of hip or knee: nine months' follow up. *Ann Rheum Dis*. 2001;60:1123-1130.
54. Weigl M, Angst F, Stucki G, Lehmann S, Aeschlimann A. Inpatient rehabilitation for hip or knee osteoarthritis: 2 year follow up study. *Ann Rheum Dis*. 2004;63:360-368.