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Lateral Hip Pain: Findings From Magnetic Resonance Imaging and Clinical Examination

Lateral hip pain (LHP), which may also be referred to as "greater trochanteric pain syndrome," is commonly encountered by physical therapists. Exemplified by episodes of pain in the vicinity of the greater trochanter, due to its nonspecific nature, this condition has also been labeled a regional pain syndrome by some.[11,20,30,79] Differential diagnosis of LHP is complex, as pain may be referred to this area from the lumbar region, or may arise secondary to abnormalities of numerous intra-articular or periarticular structures.[42] Typically, diagnosis is based on findings from the patient history and physical examination, with trochanteric bursitis traditionally being considered the primary cause of symptoms.[50,71,80,84] However, findings from recent imaging studies[11,22,25,46,87] have raised questions about which structures are implicated in this condition, with interest shifting to the role that the gluteal tendons may truly have in producing LHP.

Few studies have systematically investigated gluteal tendon pathology as a cause of LHP, and the etiology and pathogenesis of this condition have yet to be determined. As ascertained from 5 imaging studies, each of which included at least 15 subjects, the prevalence of gluteal tendon pathology in patients with LHP is variable, ranging between 25.7%

• **STUDY DESIGN:** Prospective cross-sectional study.

• **OBJECTIVES:** To examine the radiological and physical therapy diagnoses of lateral hip pain (LHP), and to determine the validity of selected clinical variables for predicting gluteal tendon pathology.

• **BACKGROUND:** LHP is frequently encountered by clinicians. Further investigation is required to establish the specific pathologies implicated in the cause of LHP, and which clinical tests are useful in the assessment of this problem.

• **METHODS AND MEASURES:** Forty patients with unilateral LHP underwent a physical therapy examination followed by magnetic resonance imaging (MRI) studies. Three radiologists analyzed the images of both hips for signs of pathology. Interobserver reliability of the image analyses, the agreement between the physical therapy and radiological diagnoses, and the validity of the clinical tests were examined.

• **RESULTS:** Gluteus medius tendon pathology, bursitis, osteoarthritis, and gluteal muscle atrophy (predominantly affecting gluteus minimus) were all implicated in the imaging report of LHP. While prevalent in symptomatic hips, abnormalities were also identified in asymptomatic hips, particularly relating to the diagnosis of bursitis. The strength of agreement between radiologists was variable and little agreement existed between the physical therapy and radiological diagnoses of pathology. Nine of the 26 clinical variables examined in relation to gluteal tendon pathology had likelihood ratios above 2.0 or below 0.5, but the associated 95% confidence intervals were large.

• **CONCLUSIONS:** The diagnosis of LHP is challenging and our results highlight some problems associated with the use of MRI as a diagnostic reference standard. This factor, together with the imprecise point estimates of the likelihood ratios, means that no firm conclusions can be made regarding the diagnostic utility of the clinical tests used in the assessment of gluteal tendon pathology.

• **LEVEL OF EVIDENCE:** Diagnosis, level 4.
J Orthop Sports Phys Ther 2008;38(6):313-328. doi:10.2519/jospt.2008.2685

• **KEY WORDS:** *bursitis, gluteal, muscle atrophy, reliability, tendon pathology, validity*

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and 83.3%.[11,22,25,46,87] Problems in the region of the greater trochanter have often been likened to disorders of the rotator cuff complex of the shoulder,[10,14,35,42] and, therefore, it could be expected that tendon pathology in the vicinity of the hip may present in conjunction with bursitis. Indeed, in the aforementioned studies, tendon and bursal abnormalities were often identified concomitantly,[11,22,25,46,87] and an association between abductor tendon tears and trochanteric bursitis has been demonstrated.[25] While both abductor tendons may be affected,[14,36,41] it appears that the gluteus medius (GMed)[11,22,42,46,62,87,88] is more commonly implicated than the gluteus minimus (GMin).[25,46,88] Interestingly, it has been widely documented that tendon pathology does not necessarily culminate in symptoms,[23,31,77] but little is known about this factor as it relates to LHP.

Imaging modalities are not routinely used in the assessment of patients with LHP, meaning that physical therapists are reliant on clinical signs and symptoms to reach an accurate diagnosis and subsequently tailor appropriate treatment regimens. A variety of clinical tests have been described pertaining to the diagnosis of gluteal tendon pathology, trochanteric bursitis, or LHP in general. For example, it has been reported that palpation,[5,20,44,50,75,81] passive internal rotation,[5,49,81,84] or resisted hip joint abduction[5,6,43,44] may reproduce symptoms of LHP. In addition to standard procedures that examine range of movement or strength, other specialized tests such as Trendelenburg's,[11,42,62] Ober's,[15,53] or the Patrick-Faber[30,33,78,79] test may also be used. However, research surrounding the clinical assessment of this problem is tenuous; as in most cases, a reference standard has not been used to determine the underlying pathology. Furthermore, with only 1 study reporting the sensitivity and specificity of 3 tests used to predict gluteal tendon pathology,[11] there is little information available to assist clinicians.

The purpose of our study was 3-fold: (1) to determine which local anatomical structures are subject to pathology in the report of LHP, using magnetic resonance imaging (MRI) as a reference standard, (2) to investigate which structures physical therapists consider to be implicated in the cause of LHP, and (3) to determine the validity of selected clinical tests for predicting the presence of gluteal tendon pathology.

METHODS

Subjects

Forty patients (37 females and 3 males, between the ages of 33 and 78 [mean ± SD, 54.4 ± 9.5 years]) who presented to a health professional with unilateral LHP participated in this study. Patients were recruited prospectively by local physical therapists, family physicians, orthopaedic surgeons, rheumatologists, and an osteopath, between 19 January and 8 December, 2004.

Participants were excluded from the study if they were under 18 years of age, had received a steroid injection in the region of the greater trochanter in the preceding 6 months,[11] had undergone previous hip joint or pelvic surgery, demonstrated obvious lumbar pathology which may have manifested as referred LHP (as determined by the physical therapist), reported bilateral symptoms of LHP, or if MRI was contraindicated. With respect to the MRI scans, each participant was screened by 1 of the researchers and then by a medical radiation technologist prior to the investigations. Patients were ineligible for MRI if they had a cardiac pacemaker, clipped intracranial vessels, or any other small metal implants or wires that could be affected by a magnetic field, were claustrophobic or pregnant.[85] In addition to the 40 patients who were assessed, 15 potential participants did not meet the inclusion/exclusion criteria and 1 withdrew from the study prior to examination.

Ethical approval for this study was granted by the Otago Regional Ethics Committee, New Zealand Ministry of Health. Written informed consent was obtained from all participants and the rights of the participants were protected.

Clinical Examination

Eleven experienced physical therapists, each with a minimum of 3 years musculoskeletal specialization, were involved in assessing the participants. These physical therapists either recruited and assessed patients themselves, or, in the cases where participants were referred by other health professionals (n = 17), examined the participants when approached by 1 of the researchers. The examination comprised 2 parts: (*a*) a self-report questionnaire, which was completed by each participant prior to the physical examination, and (*b*) assessment by the physical therapist (physical examination).

Patient History A patient history self-report questionnaire was developed in consultation with physical therapists and included questions routinely asked in clinical practice. Questions regarding pain behavior, mode of onset of symptoms, and activities that aggravate and ease symptoms were included (**APPENDIX A**). The self-report questionnaire also contained a pain diagram, on which the participants sketched their area(s) of pain, and a visual analogue pain scale to assess the intensity of LHP on the day of assessment.[70]

Physical Examination Following completion of the self-report questionnaire, each participant was assessed in a standardized manner by a physical therapist. As is usual practice, comparisons were made between the symptomatic and asymptomatic limbs. The physical therapist also examined the lumbar spine and sacroiliac joints, ensuring to the best of his/her ability that the participants' symptoms were local in nature and not referred from structures in other areas. Many of the clinical tests incorporated into the examination are those routinely used by physical therapists in the assessment of hip pain and have been described in the LHP literature. The physical therapists were provided with written instructions, which included directions on how to correctly perform specific tests (a list of the clinical tests together with outcome measurements is shown in **APPENDIX B**).

One of the aims of this study was to determine the accuracy of clinical tests used in the physical therapy diagnosis of gluteal tendon pathology by comparing test outcomes to radiological diagnoses. Twenty-six variables (**APPENDIX C**) from the physical examination were selected from the original set of 48, and were examined in relation to the radiological diagnosis, which was considered the reference standard. The 26 variables (derived from 12 clinical tests) used in this analysis were selected for 1 of 2 reasons. Firstly, 19 were related to the reported actions of the gluteal muscles[60,89] and specifically assessed hip abduction and internal rotation (pain response, range of movement, or strength). The remaining 7 variables were included on the basis of the physical therapists' rankings of the 4 tests considered most provocative in reproducing the participants' symptoms of LHP.

Physical Therapy Diagnosis Once the physical examination was completed, the physical therapists then ranked in order the 3 clinical tests that they considered to have reproduced each participant's symptoms to the greatest extent. To establish a diagnosis, the physical therapist then had to determine whether the participant presented with gluteal muscle/tendon pathology and/or trochanteric bursitis. If the gluteal muscles were thought to be involved, the physical therapist listed the muscle(s) implicated and the type of pathology thought to be most likely (weakness, tendon tear, or tendinosis). An "other" category was provided for diagnoses not already considered (for example, osteoarthritis).

Magnetic Resonance Imaging

Following the physical therapy assessment, each eligible participant had a MRI study, with a mean (SD) time between the physical therapy assessment and imaging of 8.7 (3.9) days.

Equipment, Parameters, and Procedures MRI images were acquired on a 1.5-T Signa Infinity whole body system with Excite, Version 11 (General Electrical Medical Systems, Milwaukee, WI). Using similar parameters to those used by Bird et al,[11] axial and coronal images were taken of the pelvis and both hips simultaneously, with the patient lying supine. A torso phased array, receive-only coil, made of flexible foam was used to encode the signal. The imaging sequences were taken from, and encompassed, the following anatomical landmarks: from the anterior superior iliac spine superiorly to the upper shaft of the femur inferiorly, and from the anterior superior iliac spine anteriorly to the ventral surface of the sacrum posteriorly. The time taken for the imaging studies was approximately 30 minutes per patient.

Coronal T1-weighted, fast spin echo (repetition time, 600 milliseconds; echo time, 9.9 milliseconds; echo train length, 2; 5-mm slice thickness with 1-mm interslice gap; 36-cm field of view; 352 × 256 matrix), coronal fat-suppressed T2-weighted fast spin echo (repetition time, 3925 milliseconds; echo time, 85 milliseconds; echo train, 15; 5-mm slice thickness with 1-mm interslice gap; 36-cm field of view; 256 × 256 matrix) and axial fat-suppressed T2-weighted fast spin echo (repetition time, 3925 milliseconds; echo time, 85 milliseconds; echo train, 15; 5-mm slice thickness with 1-mm interslice gap; 34-cm field of view; 256 × 224 matrix) MRI images were obtained.

MRI Analysis and Criteria The images of the right and left hips from each participant were printed on separate films, and coded. They were then independently analyzed in a random order by 3 consultant radiologists with 3, 5, and 23 years of experience, respectively, who were blinded to clinical findings and symptomatic side. To familiarize the radiologists with the MRI appearance of pathologies related to LHP, each was provided with a copy of 3 relevant articles,[11,25,46] 1 of which became available not long after the study commenced.[25] While it is normal practice for radiologists to compare sides when reaching a diagnosis, the images were viewed in isolation because (1) the diagnostic criteria for pathologies of interest were clearly defined and did not necessarily require comparison with the other hip and (2) identifying pathology on 1 side might have influenced decisions regarding the other side. After the independent readings, if at least 2 of the 3 radiologists did not agree on a diagnosis within each subcategory, differences were resolved by consensus.[22,46]

The MRI images were viewed for the presence of gluteal tendon pathology, bursitis, osteoarthritis, and any other pathology observed in the region of the hip. The parameters described by Bird et al[11] were used to determine the presence or absence of gluteal tendon pathology (of the distal tendons of GMed and/or GMin). Tendinosis was defined as hyperintensity (increased signal intensity) on T2-weighted images and/or thickening of the distal tendon on T1-weighted images. Attenuation or thinning of the distal tendon on T1-weighted images, together with hyperintensity in a corresponding area on T2-weighted images, represented a partial tendon tear. In this instance, part of the distal tendon may have been replaced by intermediate or high signal. A complete tendon tear was recorded if the distal tendon was completely disrupted on T1-weighted images, accompanied by a marked increased signal on T2-weighted images. A further category was included for cases when it was not possible to differentiate between gluteal tendinosis and a partial tear.

Bursitis was recorded if a bursa appeared distended[11,46] and demonstrated isointensity relative to the contents of the urinary bladder on fat-suppressed T2-weighted images, with hypointensity (relative to fat) on T1-weighted images.[1,40] When bursitis was evident, the specific anatomical location of the pathological bursa(e) was recorded. If the area of altered signal intensity was lateral to the lateral surface of the greater trochanter, beneath the fascia lata and gluteus maximus, yet superficial to the distal tendon of GMed, the bursa(e) affected was reported as the "trochanteric bursa," representing any of the 3 bursae that may be present in this layer.[28] Altered signal in the bur-

sae associated with the superior border or apex of the greater trochanter and lying deep to the tendons of GMed and GMin at their insertion into the trochanter were identified as the "subgluteus medius" and "subgluteus minimus" bursae, respectively.[68] Subjective opinions regarding the severity of bursitis were also documented (mild, moderate, or severe).

The presence of joint space narrowing, osteophytes, subchondral sclerosis, and subarticular cysts[4,40] were recorded in the identification of hip osteoarthritis. In addition, as judged by each radiologist, the severity of the osteoarthritic changes was subjectively ranked as either mild, moderate, or severe. The radiologists were also requested to note any other abnormalities that presented in the region of the hip joint, including avascular necrosis, iliopsoas bursa enlargement, and effusion of the hip joint.[9,40]

Once all 80 hips had been independently analyzed, the images of the right and left hips from each participant were paired back together and reviewed for signs of gluteal muscle atrophy, with the radiologists remaining blinded to clinical findings and symptomatic side. Each radiologist was asked to determine firstly if there were general signs of significant muscle atrophy and fatty infiltration, and, if so, which of the gluteal muscles were involved. It was then noted whether or not the atrophy was symmetrical, and, if not, which hip was most affected. Based on clinical opinion, each radiologist recorded whether or not the difference between sides was significant.

Statistical Analysis

All statistical analyses were performed using STATA, Version 9.0 (STATA Corporation, College Station, TX), Vasserstats (VasserStats Website for Statistical Computation: http://faculty.vassar.edu/lowry/VassarStats.html), or SPSS, Version 13.0 (SPSS, Inc, Chicago, IL). Continuous variables are described using the mean (SD), and categorical variables using number (percentage).

Agreement Between the Radiologists Although the radiological diagnoses were made by consensus, it is also useful to determine the extent to which the radiologists agreed in their ratings. Interobserver reliability for the main categories of pathology was examined using the kappa (κ) statistic and its 95% confidence interval. The kappa statistic accounts for chance agreement with possible values ranging from –1 (where the 3 radiologists would be in perfect disagreement) to 1 (where the 3 radiologists would be in perfect agreement).[74] Once established, kappa values were interpreted using the categories suggested by Landis and Koch[48]: values less than 0.00 indicated poor agreement, values of 0.00 to 0.20 slight agreement, values of 0.21 to 0.40 fair agreement, values of 0.41 to 0.60 moderate agreement, values of 0.61 to 0.80 substantial agreement, and values of 0.81 to 1.00 almost perfect agreement.

Accuracy of the Clinical Tests One of the aims of this study was to investigate which of the diagnostic test variables were useful predictors of gluteal tendon pathology. The accuracy of the clinical tests used in the diagnosis of tendon pathology was tested by comparing the physical therapy diagnoses with the radiological diagnoses, the latter being considered the reference standard. To test the accuracy of the clinical tests, sensitivity, specificity, and positive and negative likelihood ratios (LRs) were calculated.[3,37] If an empty cell was encountered in the 2-by-2 tables, 0.5 was added to all cell values to allow calculation of LRs and their associated 95% confidence intervals.[86] LRs convey by how much a certain test result will either raise or lower the pretest probability of having a pathology. The value of a positive likelihood ratio (+LR) indicates the change in probability of having a pathology given a positive test result, while the value of a negative likelihood ratio (–LR) indicates the shift in probability of having a pathology given a negative test result.[39] Unlike sensitivity and specificity, the LRs do not depend on the prevalence of the outcome, hence, are better measures to determine the diagnostic value of a clinical test. Based on the guidelines of Jaeschke et al,[39] it is suggested that diagnostic test variables are useful as outcome predictors if the +LR is greater than or equal to 2.0 or if the –LR is less than or equal to 0.5.[86] These recommendations were adopted for use in our study. Associations between radiological diagnoses of gluteal tendon pathology and the test variables were also investigated using either the chi-squared test or Fisher's exact test.[2,37] Statistical significance was assessed at the 5% level.

Agreement Between Physical Therapists and Radiologists The kappa statistic and its 95% confidence interval were used to examine agreement between the diagnosis reached by the physical therapists and the consensus diagnosis obtained by the radiologists.

Analysis of Paired Data Debate in the medical and physical therapy literature has surfaced recently regarding analysis of paired data, namely whether or not the unit of analysis should be the whole person or individual limbs or body parts.[13,27,57,72] From both biological and statistical standpoints there are a number of specific reasons why authors have advocated the avoidance, where possible, of pooling of data.[57,72]

In our study, both the symptomatic and asymptomatic limbs of each participant were assessed by a physical therapist in the same session, meaning multiple observations were obtained from each person. This process reflects standard clinical practice and offers important insights into the nature of the problem. However, it could also be construed that, because both limbs were examined concurrently, observations from 1 limb may have influenced the physical therapist's decisions regarding the other. In addition, by including both limbs the sample size would double, thereby reducing variability and increasing the chance of detecting significant associations.[57] Therefore, to determine the precision of the clinical tests we chose to analyze only data from the symptomatic hips.

RESULTS

Items From the Self-Report Questionnaire

Descriptive statistics for the 40 individuals who participated in this study are summarized in **TABLE 1**. As evident from these data, most participants presenting with LHP were middle-aged women with symptoms that were of insidious onset and intermittent in nature. Sixteen (40%) of the participants indicated they had a medically confirmed, diagnosed disease of the musculoskeletal system, typically osteoarthritis affecting the joints of the spine and lower or upper limbs. In addition, 13 were taking anti-inflammatory medications, and 12 were using pain-relief medications regularly or as required. As expected, participants with LHP indicated that they experienced pain over the lateral aspect of the hip in the general vicinity of the greater trochanter. However, it became apparent that some also experienced low back, buttock, groin, or anterior thigh pain, and various patterns of referred lateral thigh pain that did not usually extend distal to the knee (**FIGURE 1**).

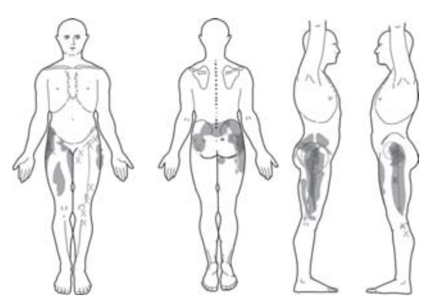

FIGURE 1. Composite pain drawing from participants with lateral hip pain (n = 40). Subjects were asked to sketch, by circling, crossing, or shading, the specific areas where they experienced pain. In these figures, the shading is darkest in regions where more than 1 subject indicated the presence of pain.

Physical Therapy Diagnosis

Reproduction of pain with palpation in and around the area of the greater trochanter was reported for the symptomatic hips of 38 of the 40 (95%) participants. The 2 hips exempt from this finding had

TABLE 1 Summary of Participant Characteristics (n = 40)

Participant Characteristics	Number (%)
Age (y)*	54.4 ± 9.5
Body mass index (kg/m²) (n = 36)*†	27.3 ± 4.9
Symptomatic hip, right	22 (55)
Duration of symptoms†	
<1 y	19 (48)
1-5 y	15 (38)
>5 y	5 (13)
Mode of onset	
Insidious	29 (73)
Minimal perturbation	5 (13)
Traumatic (fall)	6 (15)
Pain behavior since onset (n = 39)†	
Better	23 (58)
Same	11 (28)
Worse	5 (13)
Pain constancy: intermittent	36 (90)
Description of pain	
Ache	33 (83)
Sharp	10 (25)
Other	4 (10)
Deep	32 (80)
Superficial	8 (20)
Activities that aggravated symptoms	
Standing for longer than a few minutes	15 (38)
Sitting for longer than a few minutes	17 (43)
Walking for longer than a few minutes	21 (53)
Walking downstairs	6 (15)
Walking upstairs	15 (38)
Lying on symptomatic side	30 (75)
Other	15 (38)
Activities that eased symptoms	
Sitting down	6 (15)
Rest	14 (35)
Walk	6 (15)
Take medication	20 (50)
Stand up	6 (15)
Other	16 (40)
Past history of similar pain (n = 34)†	17 (43)
Pain in symptomatic hip	15 (38)
Pain in asymptomatic hip	2 (5)
Previous lower limb injury	20 (50)
To symptomatic limb	8 (20)
To asymptomatic limb	9 (23)
Both lower limbs	3 (8)
Low back pain	
Prior history (last 2 y)	30 (75)
Current	12 (30)
Previous corticosteroid injection, lateral hip‡	9 (23)
Pain level (visual analogue scale, mm)*	32 ± 22

** Data for these 3 variables are mean ± SD.*
† Some participants did not respond to this question.
‡ Injection(s) performed not less than 6 mo prior to entry into this study.

TABLE 2 Physical Therapists' Diagnoses of Specific Pathologies Thought to Give Rise to Symptoms of Lateral Hip Pain

Physical Therapists Diagnoses*	Number (%)
Trochanteric bursitis	24 (60)
Muscle/tendon involvement	36 (90)
Type of involvement	
Weakness	32 (80)
Tendinosis	9 (23)
Tendon tear (partial or complete)	2 (5)
Muscle/tendon implicated	
GMed only	15 (38)
GMin only	4 (10)
Both GMed and GMin	16 (40)
Unable to differentiate	1 (3)
Other relevant diagnoses	
Osteoarthritis	10 (25)
Definite diagnosis	5 (13)
Indecisive diagnosis	5 (13)
Coexisting lumbar spine dysfunction	8 (20)

Abbreviations: GMed, gluteus medius; GMin, gluteus minimus.
** More than 1 diagnosis was possible for each of the symptomatic hips (n = 40).*

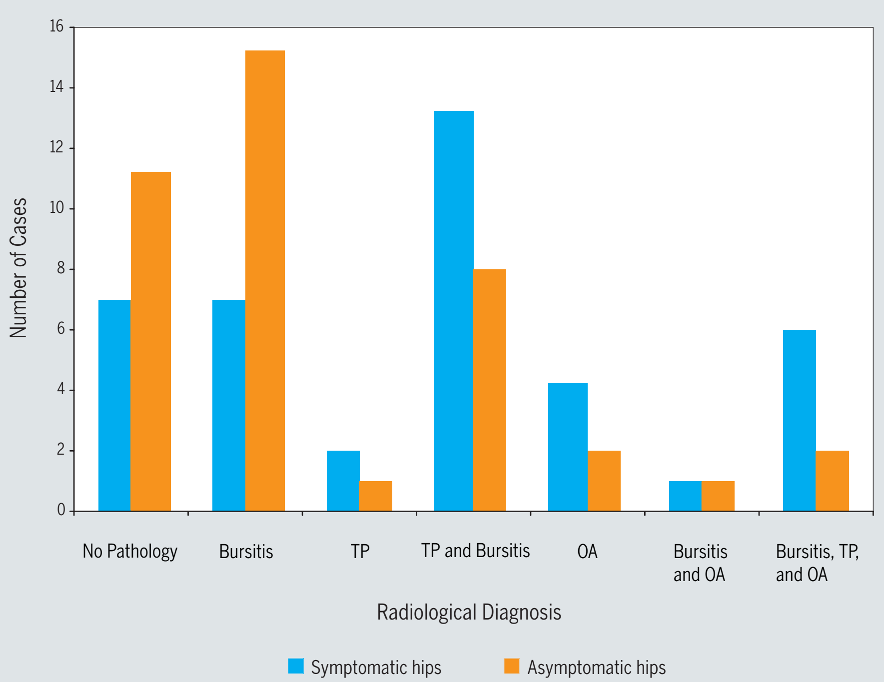

FIGURE 2. Radiological diagnoses for combinations of gluteal tendon pathology (TP), bursitis, osteoarthritis (OA), and no pathology (n = 80 hips).

a radiological diagnosis of osteoarthritis (1 had moderate changes, the other severe).

Based on the total number of responses whereby a test was ranked as 1, 2, or 3, it became apparent that, in general, 4 tests were considered most provocative in reproducing symptoms of LHP. Palpation was the clinical test most often ranked in the top 3 (n = 32), and to a lesser extent, the Patrick-Faber test (n = 16), Ober's test/modified Ober's test (n = 11), and resisted hip abduction (n = 11) also reproduced pain. **TABLE 2** summarizes the specific diagnoses reached by the physical therapists following their examination. Of note is the large number of participants who were considered to have gluteal muscle or tendon involvement. However, while muscle weakness was frequently diagnosed there were very few reports of tendinosis or tears.

Radiological Diagnosis

Of the 80 individual hips studied, 40 were clinically symptomatic. However, based on radiological diagnoses, 62 (symptomatic hips, 33; asymptomatic hips, 29) were reported to have some type of pathology. Three of the 40 participants had no pathology affecting either hip. In this sample, isolated cases of pathology were rare and it was typical for more than 1 anatomical structure to be involved. Of the symptomatic hips, the largest subgroup was that with both gluteal tendon pathology and bursitis, while for the asymptomatic hips it was bursitis alone (**FIGURE 2**). The prevalence of bursitis was almost the same for the symptomatic and asymptomatic hips. However, tendon pathology and osteoarthritis were reported more frequently in the symptomatic hips (**TABLE 3**).

Tendon Pathology Tendon pathology, predominantly affecting GMed, was diagnosed in 40% of hips and was more prevalent in symptomatic than asymptomatic hips (**TABLE 3**). As shown in **TABLE 3**, the radiological outcomes highlight the difficulties encountered in reaching firm diagnoses for types of tendon pathology. In 25 of 32 (78%) cases where abnormal signal was viewed in the tendon(s) (**FIGURE 3**), the radiologists were unable to distinguish between tendinosis and a partial tendon tear. In instances where a definite diagnosis was reached, the diagnosis was

TABLE 3 Radiological Diagnoses of Pathology, Symptomatic Versus Asymptomatic Hips*

Radiological Diagnosis	Symptomatic Hips (n = 40)	Asymptomatic Hips (n = 40)
Tendon pathology	21 (53)	11 (28)
Tendons implicated		
GMed	18 (86)	10 (91)
GMin	1 (5)	0 (0)
Both GMed and GMin	2 (9)	1 (9)
Type of tendon pathology		
Complete tendon tear	0 (0)	0 (0)
Partial tendon tear	1 (5)	0 (0)
Unable to differentiate†	15 (71)	10 (91)
Tendinosis	5 (24)	1 (9)
Bursitis	27 (68)	26 (65)
Bursae implicated‡		
Trochanteric	9 (33)	12 (46)
Deep to the tendon of GMed	2 (7)	2 (8)
Deep to the tendon of GMin	1 (3)	0 (0)
Trochanteric and deep to the tendon of GMed	14 (52)	11 (42)
Deep to the tendons of both GMed and GMin	0 (0)	1 (4)
Bursae in all 3 locations	1 (4)	0 (0)
Osteoarthritis	11 (28)	5 (13)
Graded severity§		
Mild	3 (27)	5 (13)
Moderate	6 (55)	0 (0)
Severe	2 (18)	0 (0)

Abbreviations: GMed, gluteus medius; GMin, gluteus minimus.
* *Data are number (%) of cases.*
† *Unable to differentiate between a partial tendon tear and tendinosis.*
‡ *Most cases of bursitis were graded as mild, with only 7 (8.8%) reported as moderate (6/7 were the symptomatic hips), and none as severe.*
§ *Gradings based on observations by the radiologists.*

usually tendinosis.

Bursitis Five of the 40 participants had no radiological evidence of bursitis in either hip, and 18 had bursitis affecting both their symptomatic and asymptomatic hips. In total, 53 hips had signs of bursitis. As shown in **TABLE 3**, trochanteric bursitis, whether diagnosed singly or in combination with other pathologies (**FIGURE 3**), predominated. The bursa deep to GMed was the next most commonly affected, while the bursa deep to GMin was very rarely implicated (**TABLE 3**). When considering the 22 hips diagnosed with only bursitis, the largest proportion were asymptomatic hips (**FIGURE 2**) and the majority of abnormalities affected the trochanteric bursa (13 of 22, 59%). In contrast, of the 21 hips diagnosed with pathology of both the bursae and gluteal tendons, the largest proportion presented with bursitis affecting both the trochanteric and subgluteus medius bursae simultaneously (12 of 21, 57%).

Osteoarthritis Osteoarthritis was reported in 20% of hips and was more prevalent in symptomatic compared to asymptomatic hips (**TABLE 3**). Three participants were found to have osteoarthritic changes in both hips. Osteoarthritis was diagnosed in isolation but was also seen in conjunction with bursitis as well as with both tendon pathology and bursitis (**FIGURE 2**). Of those with osteoarthritis and bursitis, the trochanteric bursa was implicated in 1 case, and, in the other, the subgluteus medius bursa was affected. Both the trochanteric and subgluteus medius bursae were involved in 5 hips with osteoarthritis, tendon pathology, and bursitis, while the trochanteric bursa was solely implicated in the remaining 3 hips.

Other In addition to those pathologies already described, a radiological diagnosis of hip joint effusion was the only other example of a consistently identified pathology affecting the hip region. Effusion was diagnosed in 24 of the 80 (30%) hips and 8 participants had an effusion on both sides. Hip joint effusion was the sole radiological diagnosis in 4 hips (2 symptomatic and 2 asymptomatic), but in the remainder of participants it was viewed in conjunction with various combinations of tendon pathology, bursitis, and osteoarthritis.

Gluteal Muscle Atrophy Gluteal muscle atrophy (**FIGURES 3** and **4**) was visually identified in 16 of 40 (40%) participants. In 1 case no asymmetry was noted between sides, as generalized wasting of all the glutei was evident in both hips. In the remaining 15 cases, atrophy was more pronounced in 1 hip than the other, affecting the symptomatic hip in all but 1 instance. The muscle most frequently atrophied was GMin (13 of 15, 87%) (**FIGURE 4**). GMed was affected in a third of hips (5 of 15 [**FIGURE 3**]) but gluteus maximus was rarely implicated (1 of 15). Four participants had atrophy of 2 muscles concurrently, in 3 instances GMed and GMin were involved, and in 1 case gluteus maximus and GMin were affected.

Retrospective evaluation revealed that of the 15 hips with significant atrophy, all but 1 had been diagnosed radiologically with tendon pathology (9) and/or bursitis (14) and/or OA (4). With respect to tendon pathology, 4 out of 5 hips with atrophy of GMed had pathology of the GMed tendon and just over half of the hips (7 of 13) with atrophy of GMin also showed signs indicative of GMed tendon pathology.

Interobserver Agreement

Diagnosis by consensus was required

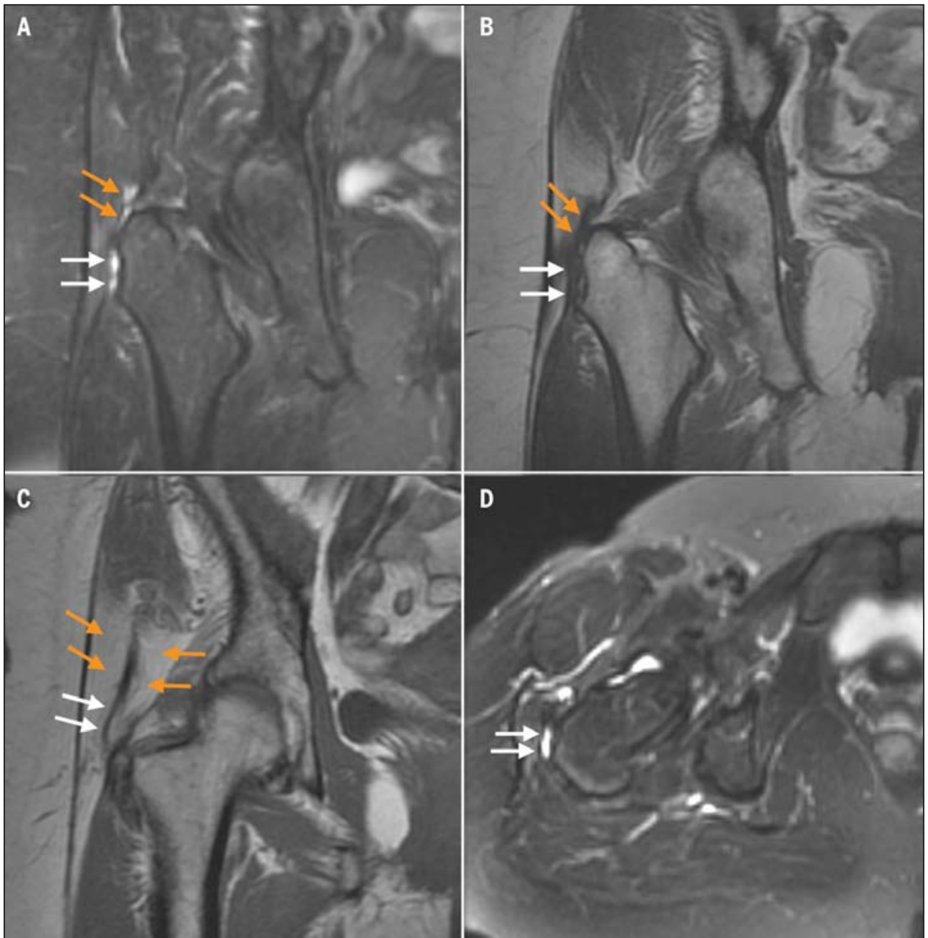

FIGURE 3. Magnetic resonance images showing gluteal tendon pathology and trochanteric bursitis. (A) On this T2 coronal image, high signal is viewed both superior (orange arrows) and lateral (white arrows) to the greater trochanter, indicating gluteus medius tendon pathology and trochanteric bursitis, respectively. (B) On the corresponding T1 image, these regions of pathology are represented by areas of low signal. (C) Further anteriorly, thinning of the gluteus medius tendon is evident (white arrows) accompanied by muscle atrophy (orange arrows). (D) The area of high signal intensity lateral to the trochanter on this axial T2 fat saturated image (white arrows) corresponds to that viewed in image A.

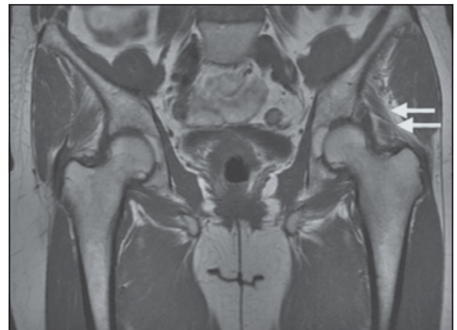

FIGURE 4. Coronal T1 image demonstrating atrophy of both the left and right gluteus minimus muscles, with changes more advanced on the left side (arrows).

for 26 out of 80 (32.5%) individual hips, and for 3 out of 40 (7.5%) cases when the hips from each patient were paired together to view for signs of gluteal muscle atrophy. When the independent interpretations for the 3 radiologists were analyzed, the degree of interobserver agreement was moderate for diagnoses of bursitis (κ = 0.45), slight for tendon pathology (κ = 0.02) and osteoarthritis (κ = 0.08), and substantial for muscle atrophy (κ = 0.61).

Accuracy of the Clinical Tests

As described previously, the results of the radiological diagnoses revealed that tendon pathology and bursitis rarely occurred in isolation. Thus, the 2 outcome groups analyzed were (1) symptomatic hips diagnosed radiologically with tendon pathology (with or without bursitis) (n = 15), compared to (2) hips with no pathology (n = 7). To avoid confounding the results, symptomatic hips with a radiological diagnosis of osteoarthritis (n = 11) were not included in the analysis.[11] Hips with isolated bursitis (n = 7) were also excluded.

Nine of the 26 clinical variables included in the analysis met the set level of significance for the chi-squared test, and/or were deemed to have a useful likelihood value for predicting gluteal tendon pathology (**TABLE 4**). Of the 9 variables, 5 were related to reproduction of pain complaint, 3 to reduced muscle strength, and 1 to reduced range of hip movement. Eight tests had a +LR greater than 2.0, and 3 had a –LR less than 0.50. Most of the associated 95% confidence intervals were wide, and all confidence intervals for the +LRs contained the null value of 1, as did all but 3 of the –LR 95% confidence intervals. In general, the tests were specific for a diagnosis of tendon pathology, but showed poor sensitivity.

Agreement Between Physical Therapists and Radiologists

In general, agreement between the radiologists and physical therapists was low. The strength of agreement for diagnoses of bursitis was classified as poor (κ = −0.04), and for gluteal tendon pathology (κ = 0.17) and osteoarthritis (κ = 0.21) it was fair.

DISCUSSION

As determined from this cross-sectional study, and in line with previous imaging studies,[11,16,22,25,46,87] females in their sixth decade of life seem to be most predisposed to develop unilateral LHP. Findings derived from the self-report questionnaire reaffirm the chronic nature of this condition, in that symptoms were often experienced for many months or years, tended to be recurrent, and in some cases were resistant to treatment by corticosteroid injection. While the immediate area around the greater trochanter was the primary site

TABLE 4 Variables from the Physical Examination That Are Useful Predictors of Tendon Pathology (Symptomatic Hips)

Test	Sensitivity (95% CI)	Specificity (95% CI)	Chi-Squared	+LR (95% CI)	–LR (95% CI)
Decreased range, passive hip IR	0.43 (0.19, 0.70)	0.86 (0.42, 0.99)	0.34*	3.00 (0.44, 20.31)†	0.67 (0.40, 1.10)
Pain, active hip IR	0.31 (0.10, 0.61)	0.86 (0.42, 0.99)	0.61*	2.15 (0.29, 15.75)†	0.81 (0.54, 1.22)
Pain, passive hip abduction	0.59 (0.33, 0.82)‡	0.93 (0.49, 1.00)‡	0.02*§	8.31 (0.56, 123.88)†	0.44 (0.24, 0.81)†
Pain, passive hip IR	0.53 (0.27, 0.78)	0.86 (0.42, 0.99)	0.17*	3.73 (0.57, 24.35)†	0.54 (0.30, 0.98)
Pain, resisted test GMin	0.47 (0.22, 0.73)	0.86 (0.42, 0.99)	0.19*	3.27 (0.49, 21.70)†	0.62 (0.37, 1.05)
Pain, resisted tests of both GMed and GMin	0.47 (0.22, 0.73)	0.86 (0.42, 0.99)	0.19*	3.27 (0.49, 21.70)†	0.62 (0.37, 1.05)
Decreased strength, both GMed and GMin	0.80 (0.51, 0.95)	0.71 (0.30, 0.95)	0.05*	2.80 (0.85, 9.28)†	0.28 (0.09, 0.86)†
Decreased strength, GMin	0.80 (0.51, 0.95)	0.57 (0.20, 0.88)	0.15	1.87 (0.76, 4.55)	0.35 (0.10, 1.19)†
Positive Trendelenburg test	0.23 (0.05, 0.57)	0.94 (0.53, 1.00)	0.49*	3.64 (0.20, 65.86)†	0.82 (0.59, 1.15)

Abbreviations: CI, confidence interval; +LR, positive likelihood ratio; –LR, negative likelihood ratio; IR, internal rotation; GMin, gluteus minimus; GMed, gluteus medius.
* *Fisher exact test used to compute* P *value.*
† *Useful likelihood ratios (+LR, >2.0; –LR, <0.50).*
‡ *0 in 1 of the cells in 2-by-2 table, so 0.5 was added to each cell in order to calculate likelihood ratios.*
§*Significant chi-square values (*P*<.05).*

of pain, the composite pain drawings highlight that symptoms were not always localized to this region. Pain referred to the lateral or anterior thigh, buttock, or groin could be attributed to pathology of the gluteal tendons and bursae[5,10,33,76,78] or to osteoarthritis of the hip.[4,42] Yet, these pain patterns are also very similar to those described for pain referral from structures of the lumbar spine and sacroiliac joints.[32,56,65,82] Although the assessing physical therapists were asked to rule out the lumbosacral area as a potential cause of symptoms, referral from structures in this region can not be completely discounted.

Radiological Diagnosis of Lateral Hip Pain

Due to the array of pathologies implicated in the report of LHP, differential diagnosis of this clinical presentation appears complex. In keeping with other imaging investigations,[11,22,25,87] GMed tendon pathology was associated with symptoms in over half of patients presenting with pain in the vicinity of the greater trochanter. Although attention was directed to the spectrum of tendon disorders with the intention of determining the prevalence of tendinosis and partial and complete tears, a conclusive diagnosis of pathology type was reached in only 22% of hips. In the remaining cases, the radiologists were unable to differentiate between tendinosis and a partial tear. This finding is in agreement with other evidence suggesting that categorical differentiation of these 2 entities is unlikely to be straightforward. For example, changes in tendon morphology may be similar in both conditions,[11,16,29,46,88] as may be alterations in signal intensity.[11,29,88] Although some objective guidelines now exist for diagnosing gluteal tendon tears,[25] the difficulties encountered in the present study demonstrate the need for more information regarding comparative imaging appearances of gluteal tendinosis and partial tears.

The importance of differentiating gluteal tendinosis from a partial or complete tear is unknown, but if comparison can be made to other regions of the lower limb, the ability to distinguish between these pathologies does appear to be valuable. An example of this is evident in relation to the treatment of Achilles and patellar tendinosis, whereby tailored exercise programs have been shown to be effective.[52,91] Conceptually, it is possible that these types of interventions could also be successful in rehabilitating patients with gluteal tendinosis. However, while treatments such as surgical repair[14,36,41,42] and injection of corticosteroid[30,33,75,76,79,87] have been advocated in the management of LHP, the effectiveness of either exercise or physical therapy intervention has only been intimated.[16,51] Given the dearth of information regarding optimal treatment strategies for gluteal tendinosis or tears, there is a need for further research in this field.

Although not formally examined, it appears that the presence of bursitis may be indirectly associated with a diagnosis of gluteal tendon or intra-articular pathology. The occurrence of soft tissue changes in the region of the hip has been addressed recently by Heller,[35] who suggests that signs of bursitis could be an important early indicator of joint instability and that tendon pathology may be the instigating event in the development of osteoarthritis of the hip. However, it is also relevant to note that, in our study, anomalies of the bursae were observed in similar proportions of symptomatic and asymptomatic hips. Bursal distention had to be apparent on imaging in order to reach a diagnosis of bursitis; but, unfortunately, these observations could not be quantified. Therefore, abnormalities of the bursae in symptomatic and asymptomatic hips were reported as similar, yet the mean volume of fluid within these bursae may have differed.[69]

The high incidence of false-positive

results ascertained by radiological examination, particularly for bursitis, is an important issue to consider. While MRI is an excellent tool for viewing tissues in the vicinity of the hip, the findings related to asymptomatic pathology indicate a potential problem associated with the use of this modality as a reference standard. Unfortunately, in this instance we are unable to offer a definitive answer as to the meaning of pathology detected in asymptomatic hips. It could be, for example, that the tissues in question were abnormal but did not cause symptoms of LHP. In the case of asymptomatic gluteal tendon pathology, these results could reinforce the notion that imaging findings and clinical symptoms do not always correlate, corroborating with reports of asymptomatic tendon pathology affecting various other peripheral joints.[23,31,77] Alternatively, the tissues in the region of the greater trochanter could have been normal, but were incorrectly interpreted as abnormal in appearance.

It is also important that the outcomes relating to radiological reliability are integrated into both the interpretation of the MRI diagnoses and the diagnostic utility of the clinical tests. Due to the wide variability in kappa values for the radiological readings, it appears that a consensus model may be necessary in the diagnosis of pathologies implicated in LHP. The analysis of the reliability data indicates that of all diagnostic categories, agreement was best for determining the presence of gluteal muscle atrophy. This finding may relate to the fact that both hips from each participant were viewed simultaneously when examining this component (allowing comparison between sides), whereas all other diagnoses were reliant on information derived from a single hip viewed in isolation. Other factors, such as the varied experience of the 3 radiologists and the knowledge that they were involved in a clinical trial, may also have contributed to the variations in interobserver reliability and to the generally poor concordance for diagnoses of bursitis, tendon pathology, and osteoarthritis. Cvitanic et al[25] are the only other authors to have reported on radiological reliability in relation to pathology in the vicinity of the greater trochanter. While not directly comparable, their values for interobserver agreement are generally higher than reported in the present study. These differences could relate to differences in diagnostic criteria. They may also be attributed in part to the method used to determine reliability, whereby interobserver agreement was calculated based on 2 readings (compared to the 3 used in the present study), meaning the kappa values were likely to have been higher regardless.[24]

Muscle atrophy, or reduction in muscle mass, normally occurs with aging, a process commonly referred to as sarcopenia.[38] However, atrophy may also occur as a consequence of a variety of other events, including denervation, disuse,[55] and specific musculoskeletal conditions such as tendon tears and osteoarthritis of related joints.[25,38,58] Atrophy is often accompanied by fatty infiltration,[58,69] but the underlying pathophysiological mechanisms that lead to these changes are not well understood.[58] All prior accounts of gluteal muscle atrophy have been referred to in the context of GMed tendon pathology, typically tendon tears.[16,25,47,88] In the present study, atrophic changes were relatively common and almost exclusively confined to symptomatic hips. Contrasting with the finding that GMed was implicated in most cases of tendon pathology, GMin was the muscle most frequently atrophied. In all instances, atrophy occurred in conjunction with tendon pathology, bursitis, and/or osteoarthritis; but from the data collected we were unable to determine whether atrophic changes existed before, or occurred as a consequence of, the onset of LHP. While this factor has not been explored extensively, it has been proposed that muscle atrophy may indirectly represent the presence of a tendon tear.[25,88] If so, we might have underestimated the prevalence of GMin tendon pathology. However, due to its insertion into the hip joint capsule,[8,68] it is possible that, similar to the rotator cuff muscles of the shoulder, GMin has an important role with respect to joint stability and proprioception. If this were the case, then pain caused by pathology in the region of the hip joint could lead to changes in joint motion and gait, thereby affecting the ability of GMin to function effectively, possibly resulting in atrophy.

Physical Therapy Diagnoses

With respect to the physical therapy diagnosis, a large proportion of clinicians appeared comfortable detecting gluteal muscle weakness, yet few committed to a diagnosis of tendinosis or tendon tear. In contrast, a relatively large percentage of participants were diagnosed with trochanteric bursitis, which perhaps indicates that physical therapists consider this pathology to be a primary cause of LHP. This premise may have contributed in part to the poor consensus evident between the physical therapy and radiological diagnoses of LHP. However, it is also important to appreciate that the association between diagnosis, pathology, and pain is likely to be complex, indicating that in order to improve the understanding of this problem, further research of both clinical and imaging assessment is required.

Palpation has been advocated as an important diagnostic test for LHP, particularly with respect to putative trochanteric bursitis.[5,20,26,50,71,76] True to this supposition, in the present study, palpation in and around the greater trochanter was undoubtedly deemed the most provocative clinical test by the physical therapists. In addition, pain with palpation was elicited in all symptomatic hips that were later radiologically diagnosed with gluteal tendon pathology and associated bursitis. However, because all of these participants tested positive to palpation, no data were available for negative responses, meaning that it was not possible to calculate sensitivity, specificity, and LRs. Further investigation is required to ascertain whether these outcomes would

hold if examined in a larger sample. As based on clinical response, it appears that reproduction of pain with palpation may potentially be valuable as an indicator of underlying pathology.

Of the remaining 3 tests considered most provocative in the assessment of LHP (pain with the Patrick Faber test, the Ober's/modified Ober's test, and resisted hip abduction), pain with resisted hip abduction was the only one that resulted in a potentially useful LR. However, due to the imprecision in the point estimate of the LR, it is difficult to draw any conclusions regarding the utility of this clinical test. Nonetheless, these findings serve as a reminder that it is important to consider the biological rationale for the use of such tests when assessing patients with LHP. For example, Ober's test was originally conceived to assess hip abductor muscle contracture,[64] but it has been suggested that pain reproduction[15,53] or reduced range of movement[15] with this test is diagnostic of trochanteric bursitis. Yet the means by which pain is produced in the hip region while performing the Ober's or modified Ober's tests is not known and, as discussed above, it appears that trochanteric bursitis rarely occurs in isolation and may purely be a marker for other pathology. Similarly, debate exists regarding the purported application of the Patrick-Faber test, as it has been suggested as an assessment tool for detecting both hip[18,59,73] and sacroiliac[12,83] joint dysfunction. While several authors have recommended that it be included in the clinical assessment of LHP,[30,33,78] response to the Patrick-Faber test in this group is largely unknown.[17,59] More information is needed before we can ascertain whether tests such as these are likely to assist clinicians in diagnosing LHP.

Accuracy of the Clinical Tests

Nine of the 26 variables examined met the set level of significance for the chi-squared test and/or were deemed to have a useful LR. However, as a consequence of the small sample size, the 95% confidence intervals associated with the LRs were wide and most contained the null value. Unfortunately, this precludes inferences regarding the diagnostic accuracy of these tests in the target population. For example, based on Jaeschke's[39] guidelines, given the range of the confidence intervals, we cannot exclude +LRs of 1.0 (which would be considered clinically worthless) nor +LRs greater than 10.0 (which would be clinically informative) for most of the tests included in this analysis. In addition, because the confidence intervals for the +LRs overlapped, as did those for the –LRs, there is no basis to conclude that any 1 of these 9 clinical tests performed any better or poorer than the other tests that were examined.

Limitations

This pragmatic study has limitations that require consideration. Physical therapists do not base their diagnoses solely on the outcome of a single test, but assimilate information gained from the patient's history and numerous tests performed as part of the physical examination. In this study, outcomes of the test variables were considered in isolation, but it is likely that valuable information would be gleaned from analyzing a variety of findings in combination. This could be achieved by using logistic regression, which would allow identification of specific variables that could be used to develop a clinical prediction rule[86] for classifying patients with LHP. However, because of the sample size and number of predictor variables, logistic regression would not have been feasible for these data.[21]

The order in which tests were performed in the physical examination was not randomized or monitored, and this may have introduced bias. A further factor to consider with regard to the clinical examination is the way in which some test outcomes were assessed. While a goniometer was used, as per usual practice, for measures of joint motion, other movements, such as those performed with the Ober's and Trendelenburg's tests, were not directly quantified. In addition, measures of muscle strength were graded using the nominal scale suggested by Kendall et al.[45] However, a handheld dynamometer may have reduced intertester variability therefore providing more accurate results. Additionally, because of the study design and limited number of cases in any 1 clinical setting, reliability of the clinical tests was not examined, but is recommended for future investigations of LHP. Without knowledge of reliability of the clinical measures, the validity of these tests cannot be accurately judged. This, together with the imprecision of the radiological outcomes, further adds to the notion that no firm conclusions can be made regarding the diagnostic utility of the clinical tests examined in this study.

Gluteal tendon pathology was the focus of this study and, therefore, of the 40 participants recruited, those with radiological diagnoses of concomitant osteoarthritis or isolated bursitis were not included in the analysis relating to the validity of the clinical tests. By excluding these participants, it is acknowledged that this does not reflect all of the combinations of pathologies that may manifest in patients with LHP and, therefore, influences the validity of the results. In addition, as discussed previously, excluding these participants also resulted in a small sample size, meaning that it was difficult to draw definitive conclusions regarding the accuracy of tests used in the assessment of gluteal tendon pathology.

To date, MRI has been consistently used as a reference standard for investigating LHP.[11,16,22,25,46,51,62] But, although pathology was detected on imaging, we cannot assume that the pain experienced by each participant definitely emanated from the structures found to be abnormal. Similarly, in cases where multiple pathologies were diagnosed, we were unable to precisely determine which tissues were responsible for pain generation. It is also recognized that the high rate of false positive diagnoses, particularly for bursitis, and the variability in radiological agreement cast some uncertainty on the validity of MRI as a reference standard. Hence, as previously discussed,

these factors need to be considered when interpreting the data relating to the outcomes of the clinical tests. Although not feasible in this study, more conclusive evidence could have resulted from corroborating imaging findings with other methods, such as surgical observation or symptom relief following guided corticosteroid injections.[19,25,42]

CONCLUSIONS

Diagnosis of LHP is challenging, with GMed tendon pathology, bursitis, osteoarthritis, and gluteal muscle atrophy all being implicated on MRI. Interestingly, with the exception of muscle atrophy, these various pathologies were identified in both symptomatic and asymptomatic limbs. However, while bursitis was equally prevalent in symptomatic and asymptomatic hips, GMed tendon pathology and osteoarthritis were more frequently observed on the symptomatic side, as was atrophy of the GMin muscle. Consideration is required of the false positive MRI diagnoses, as, together with the variability detected in the strength of radiological agreement, they demonstrate some problems associated with the use of this modality as a reference standard for delineating pathology in the region of the greater trochanter.

Little agreement was evident with regard to the physical therapy and radiological diagnoses of pathology, and, although physical therapists commonly diagnosed trochanteric bursitis, tendon pathology was rarely reported. The imprecision of the point estimates of the LRs alongside the limitations associated with the MRI diagnoses precludes conclusions regarding the diagnostic accuracy of the tests analyzed from the physical examination. To guide future studies, further investigation is recommended in a larger sample that includes a control group of individuals with no history of LHP. To obtain accurate data pertaining to clinical test outcomes, more information is required of both the normal and abnormal imaging appearance of structures involved in the pathogenesis of LHP, as well as the reliability of clinical tests used in the assessment of this problem. ◉

KEY POINTS

FINDINGS: Gluteus medius tendon pathology, bursitis, osteoarthritis, and gluteal muscle atrophy are all implicated in the cause of lateral hip pain. Further refinement is needed before magnetic resonance imaging can be considered a valid diagnostic reference standard, consequently no definite conclusions could be made regarding the accuracy of clinical tests utilized in the examination of individuals with lateral hip pain.

IMPLICATION: The findings highlight the need for further research into the imaging diagnosis of patients with lateral hip pain and the clinical tests used to assess this problem.

CAUTION: This study could have benefited from a larger number of subjects and inclusion of a control group of subjects with no history of lateral hip pain.

ACKNOWLEDGEMENTS: *The authors thank the University of Otago Research Grant, the New Zealand Society of Physiotherapists Scholarship Trust Fund, and the Department of Anatomy and Structural Biology, University of Otago for funding assistance. Thanks also to all of the collaborating clinicians and physical therapists, and the staff at the Magnetic Resonance Unit, Dunedin Hospital.*

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APPENDIX A

A SUMMARY OF QUESTIONS INCLUDED IN THE SELF-REPORT QUESTIONNAIRE

- What is your age?
- What is your height and weight?
- How long have you had this episode of hip pain?
- Can you identify a specific incident that caused your current hip pain?
- Compared to when your pain first started, is it now gone, better, the same, or worse?
- Is your current hip pain constant (24 hours a day, 7 days a week) or intermittent (some periods without pain)?
- How would you describe your pain (ache, sharp, other)?
- Does your pain feel deep or superficial (close to the surface)?
- Has the pain that you feel in your hip ever spread down the outside of your leg?
- What type of activities cause your current pain to increase?
- Can you do anything to help reduce your current pain when it is present? If so, what?
- Have you had similar hip pain before? If yes, did it affect the same hip, and how long did you have your last episode of pain for?
- How much exercise do you regularly do (currently, or until very recently)?
- What sort of exercise and/or sports do you normally do?
- Have you ever suffered an injury to either of your legs? If yes, please describe.
- Do you use a walking aid (indoors or outdoors)? If yes, what do you use?
- Have you suffered an episode of lower back pain in the last 2 years?
- Do you have lower back pain at the moment? If yes, how long have you had this episode of back pain for?
- Have you ever had a steroid injection into your painful hip? If yes, how many injections have you had, and how long ago was your last injection?

APPENDIX B

CLINICAL TESTS INCLUDED IN THE PHYSICAL EXAMINATION

Observational Analysis of Gait (Without the Use of an Aid)

The pattern of gait was recorded as either normal, Trendelenburg, antalgic, or other. The patient was also asked to ascend and descend stairs, to determine whether or not these activities reproduced his/her complaint of lateral hip pain.

Trendelenburg's Test

Performed in standing, as described by Hardcastle and Nade,[34] with a negative (normal) response recorded if the subject was able to elevate his/her pelvis on the nonstance side (either maximal or submaximal elevation) and hold this position for at least 30 seconds. All other responses were considered positive (abnormal).[66]

Active and Passive Ranges of Hip Joint Movement

Assessed as described by Norkin and White,[61] and guidelines regarding expected range of movement were derived from Magee.[53] The subjects were positioned in supine to assess flexion, abduction, and adduction, and in sitting to assess internal and external rotation. The physical therapists were asked to record whether range was full[53] and, if not, measurements of the range of movement of both hips were taken using a goniometer. The subject was also asked if any of the movements reproduced his/her pain.

The Patrick-Faber Test

Performed with the subject positioned in supine. The lateral malleolus of the limb being tested was placed on the opposite thigh, just superior to the patella. The physical therapist placed 1 hand on the medial aspect of the knee being tested, and 1 hand on the opposite anterior superior iliac spine. A simultaneous downwards pressure was slowly applied to both points, lowering the knee towards the table.[17] A positive test was recorded if either range of movement was limited (the knee of the side being assessed was not able to be lowered so that it was level with the thigh of the contralateral side) and/or the patient's pain was reproduced.[53,67]

Limb Length (Both True and Apparent)

Measured using a tape measure, with the subject supine. The distal anatomical landmark for both measurements was the lateral malleolus of the fibula (immediately below its inferior tip).[53] The proximal point of measurement for true limb length was immediately below the anterior superior iliac spine,[7] and for apparent limb length was the inferior margin of the umbilicus.[67] Measurements for both limbs were recorded by the physical therapist, and, at a later date, the difference in length between sides was calculated.

Resisted Muscle Tests of the Hip Joint Flexors, Extensors, Adductors, Abductors, and Internal and External Rotators

Tested isometrically using the positions, procedures, and gradings described by Kendall et al.[45] Any response less than grade 5 was considered a reduction in muscle strength, and reproduction of pain during testing was recorded. Specific instructions were given to the physical therapists regarding the assessment of hip abductor strength: if strength was rated between grade 3 and 5, GMed and GMin were tested individually.[45] In the statistical analysis, the outcomes from testing GMed and GMin (muscle strength and pain response) were examined both independently and together.

Palpation of the Area Over and Around the Greater Trochanter of the Femur

Performed with the patient positioned in side lying,[50] with comparison made to the greater trochanter on the asymptomatic side, as well as both anterior superior iliac spines. If pain was reproduced with palpation, the physical therapist marked or shaded on the body chart provided the area that the subject reported was symptomatic.

Ober's Test

Assessed in side lying, with the limb of interest in the uppermost position. The physical therapist stood behind the patient and stabilized the pelvis by placing 1 hand just below the iliac crest. With the knee in 90° of flexion, the physical therapist abducted and extended the uppermost limb until the thigh was in line with the trunk. While continuing to support the limb, the thigh was allowed to lower into adduction towards the plinth until the end point was reached. The end point of this movement was attained when adduction of the hip joint ceased and/or when the pelvis started to tilt laterally (downwards).[45] The physical therapist recorded the final position of the limb (whether it was abducted, horizontal with the trunk, or adducted), and also whether or not pain was reproduced with this test. The test was considered positive if range of movement was restricted (the thigh remained abducted),[63,90] and/or pain complaint was reproduced during testing.[15,45,90]

The Modified Ober's Test

Assessed in the same manner as Ober's test, except the knee was maintained in extension.[45]

Flexion/Adduction

Assessed with the subject in a supine position, as described by Maitland.[54] Pain response was recorded.

APPENDIX C

TEST VARIABLES INCLUDED IN THE STATISTICAL ANALYSIS FOR OUTCOMES RELATING TO GLUTEAL TENDON PATHOLOGY

Test Variables	Outcome Parameters
Hip joint internal rotation (variables 1-6)	Active movement: range, pain
	Passive movement: range, pain
	Resisted muscle test: strength, pain
Hip joint abduction (variables 7-10)	Active movement: range, pain
	Passive movement: range, pain
Resisted test of hip joint abduction (variables 11-18)	GMed: strength, pain
	GMin: strength, pain
	Either GMed or GMin: strength, pain
	Both GMed and GMin: strength, pain
Trendelenburg's test (variable 19)	Elevation of pelvis[66]
Patrick-Faber test (variables 20-21)	Range, pain
Palpation (variable 22)	Pain
Ober's test (variables 23-24)	Range, pain
Modified Ober's test (variables 25-26)	Range, pain

Abbreviations: GMed, gluteus medius; GMin, gluteus minimus.