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Persons with Chronic Hip Joint Pain Exhibit Reduced Hip Muscle Strength

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Abstract

STUDY DESIGN—Controlled Laboratory Cross-Sectional Study

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Statement of Institutional Review Board approval
This study was approved by the Human Research Protection Office of Washington University School of Medicine. All subjects read and signed an informed consent statement before participating in the study.

Statement of Financial Interest
The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article.

OBJECTIVES—To assess strength differences of the hip rotator and abductor muscle groups in young adults with chronic hip joint pain (CHJP) and asymptomatic controls. A secondary objective was to determine if strength in the uninvolved hip of those with unilateral CHJP differs from asymptomatic controls.

BACKGROUND—Little is known about the relationship between hip muscle strength and CHJP in young adults.

METHODS—35 participants with CHJP and 35 matched controls (18 to 40 years of age) participated. Using hand-held dynamometry, strength of the hip external rotators (ERs) and internal rotators (IRs) was assessed with the hip flexed to 90° (ERs90°, IRs90°) and 0° (ERs0°, IRs0°). To assess ER and IR strength, the hip was placed at the end-range of external rotation and internal rotation, respectively. Strength of the hip abductors (ABDs) was assessed in sidelying, with the hip in 15° of abduction. Break tests were performed to determine maximum muscle force and the average torque was calculated using the corresponding moment arm. Independent samples t-tests were used to compare strength values between the 1) involved limb in participants with CHJP and corresponding limb in the matched controls and 2) the uninvolved limb in participants with unilateral CHJP and corresponding limb in the matched controls.

RESULTS—Compared to controls, participants with CHJP demonstrated weakness of 16–28%, (P<0.01) in all muscle groups tested in the involved hip. The uninvolved hip of 22 subjects with unilateral CHJP demonstrated weakness of 18% and 16% (P<0.05) in the ERs0° and ABDs, respectively when compared to the corresponding limb of the matched controls.

CONCLUSION—Our results demonstrate that persons with CHJP have weakness in the hip rotator and hip abductor muscles. Weakness also was found in the uninvolved hip of persons with CHJP.

Keywords

Femoroacetabular impingement; dynamometry; external rotator; internal rotator; abductor

Introduction

Chronic hip joint pain (CHJP), also referred to as prearthritic hip disease[11] or intra-articular hip disease,[23] is a major cause of hip dysfunction in young adults leading to significant activity limitations.[6, 10] Diagnoses associated with CHJP include femoroacetabular impingement (FAI),[17] structural instability,[52] acetabular labral tears[36] and chondral lesions.[42] Often individuals with CHJP have limitations in sitting and standing, thus restricting their ability to work or complete everyday tasks.[6, 10] Without proper management, conditions associated with CHJP may progress to hip osteoarthritis (OA).[16, 20, 41] To improve treatment of CHJP and potentially prevent or delay the onset of hip OA, there is a need to better understand the factors proposed to be associated with CHJP, in particular hip muscle performance.

The hip muscles are important to hip joint stability.[45, 49] They provide dynamic and passive resistance to external forces that may contribute to excessive motion, particularly in a joint that may be compromised by injury to the acetabular labrum or capsuloligamentous structures. One proposed mechanism of injury in persons with CHJP is repetitive hip rotation with axial loading, common in activities such as golf, soccer, martial arts, etc.[47, 52]

Repetitive hip internal rotation may contribute to increased compressive forces in the anterior hip joint, leading to mechanical impingement and subsequent injury to the acetabular labrum and articular cartilage.[25] Repetitive external rotation may result in an accumulation of tensile stresses to the capsuloligamentous structures and acetabular labrum, leading to injury and potentially microinstability of the hip.[47, 52] Adequate strength of the hip external rotators, including the gluteus maximus, posterior fibers of the gluteus medius and minimus, piriformis, quadratus femoris, obturator internus and externus, the gemelli, sartorius and the long head of the biceps femoris are important in controlling internal rotation of the hip.[45] Hip internal rotator strength is important for the control of hip external rotation. Muscles responsible for controlling hip external rotation include the anterior fibers of the gluteus minimus and medius, tensor fasciae latae, adductors (longus, brevis and posterior head of the magnus) and the pectineus. [45] Excessive hip adduction during weight-bearing activities also has been implicated in CHJP.[4] The hip abductors, gluteus medius, gluteus minimus and the tensor fasciae latae, provide stability of the pelvis on the hip during single limb weight-bearing activities, such as walking and stair ambulation.[2]

Despite the importance of hip rotator and abductor performance in providing hip stability, the evidence specific to hip muscle strength in patients with CHJP is limited. Casartelli et al[8] assessed hip muscle strength in young adults with symptomatic femoroacetabular impingement and found weakness in the hip external rotators and abductors, but not the internal rotators when compared to asymptomatic controls. In a recent systematic review, Loureiro et al[34] concluded that persons with hip OA exhibit weakness in the hip abductors compared to asymptomatic controls. None of the studies reviewed however, compared hip rotator strength in people with hip OA to asymptomatic controls, suggesting that hip rotator performance may be overlooked in people with hip joint pathology. There is a need to understand the relationship between hip muscle performance and chronic hip joint pain.

The primary purpose of the current study was to determine strength differences of the hip rotator and abductor muscles in young adults with CHJP compared to asymptomatic controls matched by sex, age, body mass index (BMI) and limb. The secondary purpose was to determine if strength in the uninvolved hip of those with unilateral CHJP differs from asymptomatic controls. We hypothesized that participants with CHJP would exhibit weakness in the hip rotator and abductor muscles in their involved limb compared to pain-free matched controls. We also hypothesized that participants with unilateral CHJP would exhibit no strength deficits in their uninvolved hip when compared to pain-free individuals.

METHODS

Participants

Participants were a subset of participants from a prospective cohort study to assess proposed risk factors for CHJP. Participants, aged 18–40 years, were recruited from Washington University School of Medicine’s Orthopaedic, Physical Medicine and Rehabilitation, and Physical Therapy clinics, Research Participant Registry and through public announcements.

Participants with CHJP reported deep hip joint or anterior groin pain lasting longer than 3 months that was reproducible with the Flexion-Adduction-Internal Rotation impingement test, also known as the FADIR or FAIR test.[35] Control participants reported no history of hip pain or current lower extremity pain. Exclusion criteria for both groups included: 1) previous hip surgery or fracture, 2) contraindication to MRI, 3) known pregnancy, 4) neurological involvement that influenced coordination or balance and 5) a BMI greater than 30. Three exclusion criteria, contraindication to MRI, neurological involvement and BMI, were necessary for other testing procedures used in the parent study. Additionally, participants were excluded if screening tests for differential diagnosis were positive indicating possible lumbar spine radiculopathy.

Control participants were recruited to match 1:1 with participants with CHJP by sex, age (within five years), BMI (within five kg/m^2) and limb side. The involved limb or in the case of bilateral pain, the most symptomatic limb of each participant with CHJP was matched to the corresponding limb in the matched control. The participants for this study were the first 35 matched pairs enrolled in the parent study. Thirteen of 35 participants with CHJP reported bilateral pain. The study was approved by Washington University's Human Research Protection Office and all participants signed an informed consent statement prior to participating in the study.

Examination procedures and data collection were performed by a licensed physical therapist who was certified in orthopaedic physical therapy and had 16 years of clinical and research experience. A research assistant was present to assist with the examination and document strength measures. After consent was obtained, the examiner completed a subjective history and performed the screening tests to confirm the presence or absence of CHJP.

Instrumentation

The *microFET3* (Hoggan Health Industries, West Jordan, UT) handheld dynamometer was used to assess hip strength. Prior to the study, the dynamometer was factory calibrated and was reported to be accurate within 1%. Handheld dynamometry is a relatively inexpensive method to quantify muscle strength that may be used conveniently in the clinical setting. Handheld dynamometry to assess hip strength has been shown to be a reliable and valid instrument when compared to isokinetic devices. [3, 22]

Procedure

All participants completed questionnaires for demographic information and the University of California Los Angeles Activity Score (UCLA)[1] to estimate activity level. Participants with CHJP also completed hip-specific patient-reported outcome measures including the Hip Disability and Osteoarthritis Outcome Score (HOOS),[46] Hip Outcome Score (HOS),[38] and the Modified Harris Hip Score (MHHS).[7] After questionnaire completion, the participants completed a 5 minute warm-up using a stationary bike with light resistance or walking at a comfortable pace on a treadmill. After the warm-up, the examiner placed marks 4 cm proximal to the inferior pole of the medial and lateral malleoli to designate dynamometer placement.

To ensure systematic performance of tests among participants and reduce the likelihood of fatigue, the strength tests were performed in a standardized order alternating left and right limbs. Given that the hip muscle moment arms and actions have been reported to change as a function of hip flexion angle,[12, 13] hip internal rotation and external rotation strength was assessed at 90° and 0°. Strength tests were performed in the following order for all participants: external rotators with hip flexed to 90°(ERs90°), internal rotators with hip flexed to 90°(IRs90°), external rotators with hip in neutral flexion/extension (ERs0°), internal rotators with hip neutral flexion/extension (IRs0°) and abductors with the hip abducted 15° (ABDs). Break tests[29, 31] were performed using the dynamometer to determine maximum muscle force in Newtons (N). A sub-maximal practice trial was performed to familiarize the participant with the procedures, followed by 3 maximal tests with a 15 second rest between each trial. [24, 53]

To perform the break tests, the examiner first positioned the participant's limb in the testing position. The examiner then placed the dynamometer on the appropriate location and provided resistance to the limb. The examiner started with light resistance and then gradually over 2–3 seconds, increased resistance until the participant could no longer maintain the initial limb position. Verbal encouragement was provided by the examiner during the test. The examiner monitored the limb for compensatory movements during testing. If compensatory movements were noted, the participant was instructed in correct performance and the trial was repeated. Three maximal trials were performed. If there was a difference greater than 10% among the recorded values, the trial was discarded and an additional trial was performed. A verbal numerical pain rating scale (NPRS) (0 = no pain, 10 = worse pain imaginable) was used to document the participant's pain intensity during testing. Moment arm length of the external force provided for ERs and IRs corresponded to the distance between the knee joint line and 4 cm proximal to the malleolus on the medial and lateral side respectively. For hip abductor strength testing the distance between the superior greater trochanter and 4 cm proximal to the lateral malleolus was used.

For hip ERs90° and IRs90° strength assessments, participants were positioned in sitting with the hip and knee flexed to 90°. A towel was placed underneath the distal thigh to maintain the hip position. Participants were allowed to place their hands on the testing surface for balance, however they were not allowed to grip the sides of the table. To test the ERs90°, the hip was placed in end-range external rotation as described by Kendall[29] and the participant was encouraged to hold this position (FIGURE 1). The examiner placed the dynamometer on the previously placed mark on the medial aspect of the shank. Counter-stabilization was provided by the examiner at the distal thigh to prevent undesired motion, such as hip flexion, abduction or adduction. Similar methods were used for IRs90°, however the hip was placed in end-range internal rotation[29] and the examiner placed the dynamometer on the lateral aspect of the shank.

For the hip ERs0° and IRs0° strength assessments, the hip was placed in neutral flexion/extension. The testing technique was the same as that for ERs90° and IRs90°, except that participants were positioned in supine with the tested limb's knee flexed to 90° over the table edge and the non-tested limb flexed so the foot could rest on the table (FIGURE 2). A towel was placed underneath the distal thigh to position the hip in 0° extension.

For the hip abduction strength assessments, participants were positioned in sidelying with the non-tested limb in approximately 45° hip flexion and 90° knee flexion. To test the abductors, the hip was placed in 15° of abduction, 0° of flexion and 0° of rotation (FIGURE 3). The examiner placed the dynamometer on the previously placed mark on the lateral aspect of the shank. Counter-stabilization was provided by the examiner at the pelvis to prevent undesired motion, such as pelvic rotation or lateral tilt.

For each strength variable, forces from the 3 maximal trials were averaged and multiplied by the associated moment arm in meters to determine the average torque (T). To create a body-size independent measurement, torque was normalized by body weight (BW) and height (HT) in meters: $T_{norm}=(T/(BW\times HT))\times 100$.[5] Test-retest reliability using the described procedures above was performed in 8 asymptomatic participants. The testing was completed by the same examiner who performed the strength testing for this study. Both strength tests and moment arm measurements were completed on 2 separate testing sessions that were at least 1 week, but no more than 2 weeks apart. The examiner was blinded to the strength and moment arm values from the first session while completing the procedures during the second session. Test-retest reliability and standard of measurements (SEMs) for the calculated torque values are provided in TABLE 1.

As we tested the hip rotator muscles at the end of hip rotation range of motion, the position of hip rotation used during strength testing may be important when assessing hip rotator muscle strength.[9] We therefore measured hip joint range of motion to determine if differences existed between the groups. We used the inclinometer function of the *microFET3* (Hoggan Health Industries, West Jordan, UT) device to determine range of motion of the hip external and internal rotation with the hip flexed to 90° (ER ROM90°; IR ROM90°) and in neutral flexion/extension (ER ROM0°; IR ROM0°). For each range of motion test, we used the average of 3 measurements.

Data Analysis

A priori sample size calculations performed for the parent study estimated a target enrollment of 80 participants. Projected scenarios based on preliminary data (unpublished) and published literature[24, 39] indicated that a sample size of 40 per group would afford statistical power of at least 0.80 to detect clinically meaningful differences in the primary outcomes of muscle strength with effect sizes of at least 0.64 at alpha of 0.05 using two-tailed tests.

The Kolmogorov-Smirnov test was used to confirm normal distribution of the data and Levene's test was used to confirm equality of variance. For group comparisons, independent t-tests were used for continuous variables and Mann-Whitney U tests were used for ordinal data. The primary analysis compared strength differences between the involved hip of participants with CHJP and the corresponding hip of the matched control participants. The secondary analysis compared strength differences between the uninvolved hip of participants with unilateral CHJP and the corresponding hip of the matched control participants. A P value < 0.05 was considered significant.

RESULTS

Demographic characteristics and hip ROM values for both groups are summarized in TABLE 2. As a result of matching, there were no significant differences between participants with CHJP and controls in sex, limb side, age and BMI. According to the UCLA[1], both groups reported participating high level activities such as jogging, tennis, and skiing, at least one time per week. No differences were found in hip range of motion between groups (TABLE 2).

Participants with CHJP reported a mean duration of symptoms of 3.5 years (range, 0.4 to 13 years) and moderate functional limitations as measured by patient-reported outcome measures (TABLE 3). MRI measures of bony morphology were available for 33 of the 35 participants with CHJP. Eight had an alpha angle ≥ 60° consistent with cam FAI,[44] 1 had a lateral center edge angle ≤ 20° consistent with structural instability,[18, 26] 2 had a lateral center edge angle ≥ 40° consistent with pincer FAI[54] and 22 had no signs of bony abnormalities.

Compared to the control group, participants with CHJP demonstrated significant weakness (deficits ranging from 16–28%) in all muscle groups tested in the involved hip (TABLE 4). Compared to the control subjects, the participants with unilateral CHJP (N=22) demonstrated significant weakness in their uninvolved hip (deficits ranging from 16–18%) for the ERs0 and ABDs, respectively (TABLE 5).

Twenty-seven participants with CHJP reported hip joint pain, ranging from 1/10 to 6/10, during the performance of at least one strength test on the involved limb. In 19 of these participants, the reported pain was 2/10 or less. No pain in the tested limb was reported when testing the limbs of the control participants or the uninvolved limbs of participants with CHJP. Two participants with unilateral CHJP reported pain, rated less than 2/10, in their involved hip while testing the hip abductors of the uninvolved limb.

DISCUSSION

As hypothesized, participants with CHJP exhibited significant weakness of the hip abductors and rotators compared to pain-free controls. We found significant differences in all muscle groups tested in the involved limb. Surprisingly, we found participants with unilateral CHJP also demonstrated weakness in the ERs0° and ABDs of their uninvolved hip, raising questions about the cause and effect relationship between muscle weakness and CHJP. Based on the study design however, we are unable to determine the cause of the muscle weakness in people with CHJP. To be enrolled in our study, people had to report pain duration greater than 3 months. Weakness, therefore may have been the result of disuse atrophy, reduced activation, or potentially, muscle inhibition due to pain during testing or increased intra-articular fluid, induced by injury.[15] Our findings do suggest however that muscle weakness may be a factor to consider in persons with CHJP.

Our report is one of only 2 studies to assess the strength of hip musculature in persons with CHJP. Casartelli et al[8] used methods similar to ours to compare strength of the ERs90°, IRs90° and ABDs in people with FAI and asymptomatic control participants. Comparing our investigation to the Casartelli et al. study, both reported strength deficits in the ERs90°, IRs90° and ABDs, however the significance of these deficits varied. Both Casartelli et al. and current study found a strength deficit in the ERs90° of 18% and 16%, respectively. The hip abductors were 11–22% deficient in the painful participants across both studies. We found a 28% deficit in the IRs90° in participants with CHJP compared to a 14% (P=0.076) deficit in participants with FAI in the Casartelli et al. study. The greater deficit in IRs90° found in our study may be related to differences in testing methods. We used a break test with the hip placed in end-range internal rotation. Casartelli et al. used a make test with the hip in neutral hip rotation. The position of end-range of internal rotation with the hip flexed to 90° is often painful in patients with CHJP, therefore the greater difference in our study may be related to pain during the testing procedures.

Additional differences existed between our study and that of Casartelli et al. First, all symptomatic participants in the Casartelli et al. study had a clinical diagnosis of FAI. The symptomatic participants in our study had varied bony morphology. Ten had imaging findings consistent with FAI, 1 with structural instability and 22 with no bony abnormalities. To increase the generalizability of our results, we chose to include individuals with pain consistent with CHJP and not limit to only those with FAI. An a-posteriori analysis of our data found no differences in muscle strength between those participants with CHJP and bony morphology consistent with FAI and those with CHJP and no bony abnormalities. These findings suggest that bony abnormalities may not explain hip muscle strength deficits, however we cannot be definitive based on our small sample. Second, all symptomatic participants in the Casartelli et al. study were scheduled to undergo a surgical intervention. Our participants were not considered surgical candidates at the time of testing, which might suggest a lower pain severity in our symptomatic participants.

Although a direct comparison cannot be made, pain levels during testing appear to be similar between our study and that of Casartelli et al. The symptomatic participants in the Casartelli et al. study reported mean pain ratings of 18–27/100 mm using a visual analog scale and our participants reported a range 1–6/10 on the verbal numerical pain rating scale. Interestingly, the percentages of strength deficits in our symptomatic participants were similar to those reported for the surgical candidates. Due to our exclusion criteria, our subjects were slightly younger (mean age of 28 versus 32 years) than those in the Casartelli et al. study. Our study also included a greater percentage of female participants (80% compared to 64%). Participants in both studies were involved in recreational physical activities. Age, sex and activity level may be factors to consider in future studies.

Finally, Casartelli et al. also reported weakness in the hip adductors and hip flexors in patients with FAI. We limited the number of strength tests to avoid participant fatigue and pain provocation. We were particularly interested in hip rotator performance in different hip positions and therefore chose not to assess the hip adductor and flexor muscles in our participants. The hip adductor and flexor muscle groups, as well as the hip extensors will be considered in the future. Despite minor differences between studies, the results of the current investigation add to previous evidence[8] indicating that hip muscle weakness exists among patients with CHJP. Future work to assess the relationship among bony structure, muscle strength and function will improve our understanding of CHJP.

We also compared muscle performance of the uninvolved hip in people with unilateral CHJP to their matched asymptomatic control. The participants with unilateral CHJP were weaker in the hip ERs0° and ABDs compared to asymptomatic counterpart, suggesting that weakness may also exist on the uninvolved side. This finding is interesting as it suggests that weakness may be related to factors other than pain inhibition, given that none of the symptomatic participants reported pain in the tested hip. Similar weakness in the involved and uninvolved limbs may be suggestive of a pain-induced reduction in overall activity participation, resulting in disuse muscle atrophy or reduced muscle activation in both limbs. Based on the UCLA scores however, our symptomatic participants reported participating in relatively high level activities, similar to that reported by our asymptomatic control participants. The UCLA does not however differentiate activities that produce varying loads on the hip joint. Methods to better define activity profiles and categorize activities based on hip joint loading will improve our understanding of CHJP.

Weakness in the uninvolved hip may be due to insufficient pelvic stability provided by the weaker, painful contralateral hip during hip abductor strength assessment. Additional external stabilization of the pelvis may produce different results in measures of strength for the uninvolved hip. Concurrent use of electromyography to assess muscle activation bilaterally during strength tests may provide additional information about muscle activity necessary to provide stability.[55] Deficits in the uninvolved limb also may be related to central nervous system involvement,[21] a topic for future investigation. Finally, weakness may also be present prior to pain onset and a potential contributor to symptoms.[33, 43] Due to the cross sectional nature of our study, we cannot comment on the temporal relationship between muscle weakness and pain onset. Our findings suggest, however, that strengthening the uninvolved hip should be considered as part of the rehabilitation process. Future investigations of muscle strength should include comparison to asymptomatic control participants and the uninvolved hip for a more thorough understanding of muscle function and its relationship to CHJP.

We tested the hip rotators and abductors because of their proposed role in providing hip stability and limiting excessive joint motion in the frontal and transverse planes during weight-bearing activities. Little is known about the relationship between hip muscle performance and movement impairments among people with CHJP. Few studies have reported on the biomechanical analysis of young adults with CHJP, however some authors suggest that movement impairments, such as reduced or excessive joint motion, may be associated with multiple factors. Compared to asymptomatic controls, persons with FAI demonstrate limited frontal hip and sagittal pelvis motion during gait[30] and limited sagittal plane pelvis motion during a deep squat.[32] Conversely, in a case study by Austin et al, [4] higher level activities such as running, single-leg squat and drop vertical jump maneuver were assessed in a patient with a labral tear. The authors described a movement pattern of excessive hip adduction and internal rotation that may be associated with hip joint pain, suggesting that movement impairments may also be influenced by hip muscle performance. Given our findings related to hip muscle strength and previous work related to kinematic assessment and imaging findings, there is a need for investigations to simultaneously assess multiple factors proposed to be associated with CHJP, including muscle strength, movement patterns, and bony abnormalities.

Based on our results, we are unable to recommend a specific treatment approach. However, a case series reported by Yazbek et al[56] supports the use of hip muscle strengthening as a component of non-surgical treatment in patients with CHJP. Another case series by Emara et al, [14] however reported improvements in pain and function with conservative care that included only activity modification and stretching. Clinical trials are needed to assess the effectiveness of muscle strengthening in patients with CHJP.

Our study is not without limitations. Due to the cross-sectional design, we cannot establish a temporal relationship between muscle weakness and CHJP. Future work to assess muscle morphology may provide insight to mechanism underlying muscle weakness in people with CHJP. Hand-held dynamometry may be influenced by examiner strength.[51] One examiner performed all tests and excellent test-retest reliability was established prior to completing the study. The examiner was not blinded to participant group which may have led to experimental bias, however break tests were performed and the examiner was able to overcome the resistance of all participants to determine each participant's maximal force production. We used the end-range rotation position to assess internal and external rotation strength instead of positioning the hip in a neutral rotation position. We chose this position as Kendall recommends the end-range position to assess the strength of muscles that cross a single joint.[29] Pilot work completed during the design of this study found no differences in muscle strength between persons with CHJP and asymptomatic controls when the hip was tested in a neutral position.

The participants in our CHJP group may be viewed as being relatively heterogeneous. Our primary inclusion criteria were the participant's report of pain in the anterior groin or deep hip joint and a positive FADIR test. In studies using diagnostic injection for pain relief, the FADIR test has been shown to be a sensitive test for pain[37] and pathology[40], but not specific.[37, 40] In fact, many of the signs and symptoms used clinically to identify the intra-articular source of symptoms have been shown to be limited.[37] Given the limitations associated with clinical testing, we included tests to differentiate symptoms from other sources such as lumbar spine radiculopathy and extra-articular structures, however did not attempt to differentiate specific pathology. We cannot confirm a clinical diagnosis of a labral tear, chondral lesion or other pathology. We believe our results will be generalizable to a broader group of patients typically seen in outpatient clinics.

CONCLUSION

Our results demonstrate that persons with CHJP exhibit weakness of the hip rotator and hip abductor muscle groups. This weakness may result in reduced hip joint stability or impaired movement patterns, a topic for future research. Interestingly, weakness was also found in the external rotators when the hip was in neutral flexion/extension and the abductors in the uninvolved hip of people with CHJP, indicating the uninvolved hip should also be considered in rehabilitation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Amstutz HC, Thomas BJ, Jinnah R, Kim W, Grogan T, Yale C. Treatment of primary osteoarthritis of the hip. A comparison of total joint and surface replacement arthroplasty. J Bone Joint Surg Am. 1984; 66:228–241. [PubMed: 6693450]
2. Anderson FC, Pandy MG. Individual muscle contributions to support in normal walking. Gait Posture. 2003; 17:159–169. [PubMed: 12633777]
3. Arnold CM, Warkentin KD, Chilibeck PD, Magnus CR. The reliability and validity of handheld dynamometry for the measurement of lower-extremity muscle strength in older adults. J Strength Cond Res. 2010; 24:815–824. [PubMed: 19661831]
4. Austin AB, Souza RB, Meyer JL, Powers CM. Identification of abnormal hip motion associated with acetabular labral pathology. J Orthop Sports Phys Ther. 2008; 38:558–565. [PubMed: 18758045]
5. Bazett-Jones DM, Cobb SC, Joshi MN, Cashin SE, Earl JE. Normalizing Hip Muscle Strength: Establishing Body-Size-Independent Measurements. Arch Phys Med Rehabil. 2011; 92:76–82. [PubMed: 21187208]
6. Burnett RS, Rocca GJD, Prather H, Curry M, Maloney WJ, Clohisy JC. Clinical Presentation of Patients with Tears of the Acetabular Labrum. J Bone Joint Surg Am. 2006; 88:1448–1457. [PubMed: 16818969]
7. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 2-year follow-up. Arthroscopy. 2000; 16:578–587. [PubMed: 10976117]
8. Casartelli NC, Maffiuletti NA, Item-Glatthorn JF, et al. Hip muscle weakness in patients with symptomatic femoroacetabular impingement. Osteo Cart. 2011; 19:816–821.
9. Cibulka MT, Strube MJ, Meier D, et al. Symmetrical and asymmetrical hip rotation and its relationship to hip rotator muscle strength. Clin Biomech. 2010; 25:56–62.
10. Clohisy JC, Baca G, Beaule PE, et al. Descriptive epidemiology of femoroacetabular impingement: a North American cohort of patients undergoing surgery. Am J Sports Med. 2013; 41:1348–1356. [PubMed: 23669751]
11. Clohisy JC, Keeney JA, Schoenecker PL. Preliminary assessment and treatment guidelines for hip disorders in young adults. Clin Orthop. 2005; 441:168–179. [PubMed: 16331000]
12. Delp SL, Hess WE, Hungerford DS, Jones LC. Variation of rotation moment arms with hip flexion. J Biomech. 1999; 32:493–501. [PubMed: 10327003]
13. Dostal WF, Soderberg GL, Andrews JG. Actions of hip muscles. Phys Ther. 1986; 66:351–361. [PubMed: 3952148]
14. Emara K, Samir W, Motasem el H, Ghafar KA. Conservative treatment for mild femoroacetabular impingement. J Orthop Surg (Hong Kong). 2011; 19:41–45. [PubMed: 21519074]
15. Freeman S, Mascia A, McGill S. Arthrogenic neuromusculature inhibition: A foundational investigation of existence in the hip joint. Clin Biomech. 2013; 28:171–177.
16. Ganz R, Leunig M, Leunig-Ganz K, Harris W. The Etiology of Osteoarthritis of the Hip. Clin Orthop Relat Res. 2008; 466:264–272. [PubMed: 18196405]

17. Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement - A cause for osteoarthritis of the hip. Clin Orthop Relat Res. 2003; 417:112–120. [PubMed: 14646708]
18. Gosvig KK, Jacobsen S, Sonne-Holm S, Palm H, Troelsen A. Prevalence of malformations of the hip joint and their relationship to sex, groin pain, and risk of osteoarthritis: a population-based survey. J Bone Joint Surg Am. 2010; 92:1162–1169. [PubMed: 20439662]
19. Hack K, Di Primio G, Rakhra K, Beaule PE. Prevalence of Cam-Type Femoroacetabular Impingement Morphology in Asymptomatic Volunteers. J Bone Joint Surg Am. 2010; 92:2436–2444. [PubMed: 20962194]
20. Harris-Hayes M, Royer NK. Relationship of acetabular dysplasia and femoroacetabular impingement to hip osteoarthritis: a focused review. Pm R. 2011; 3:1055–1067. [PubMed: 22108232]
21. Heales LJ, Lim EC, Hodges PW, Vicenzino B. Sensory and motor deficits exist on the non-injured side of patients with unilateral tendon pain and disability--implications for central nervous system involvement: a systematic review with meta-analysis. Br J Sports Med. 2013
22. Hebert LJ, Maltais DB, Lepage C, Saulnier J, Crete M, Perron M. Isometric muscle strength in youth assessed by hand-held dynamometry: a feasibility, reliability, and validity study. Pediatr Phys Ther. 2011; 23:289–299. [PubMed: 21829128]
23. Hunt D, Prather H, Harris Hayes M, Clohisy JC. Clinical outcomes analysis of conservative and surgical treatment of patients with clinical indications of prearthritic, intra-articular hip disorders. Pm R. 2012; 4:479–487. [PubMed: 22595328]
24. Ireland ML, Willson JD, Ballantyne BT, Davis IM. Hip strength in females with and without patellofemoral pain. J Orthop Sports Phys Ther. 2003; 33:671–676. [PubMed: 14669962]
25. Ito K, Leunig M, Ganz R. Histopathologic features of the acetabular labrum in femoroacetabular impingement. Clin Orthop Relat Res. 2004:262–271. [PubMed: 15577497]
26. Jacobsen S, Sonne-Holm S, Soballe K, Gebuhr P, Lund B. Hip dysplasia and osteoarthrosis: a survey of 4151 subjects from the Osteoarthrosis Substudy of the Copenhagen City Heart Study. Acta Orthopaedica. 2005; 76:149–158. [PubMed: 16097538]
27. Jung KA, Restrepo C, Hellman M, AbdelSalam H, Morrison W, Parvizi J. The prevalence of cam-type femoroacetabular deformity in asymptomatic adults. J Bone Joint Surg Br. 2011; 93:1303–1307. [PubMed: 21969426]
28. Kang ACL, Gooding AJ, Coates MH, Goh TD, Armour P, Rietveld J. Computed Tomography Assessment of Hip Joints in Asymptomatic Individuals in Relation to Femoroacetabular Impingement. Am J Sports Med. 2010; 38:1160–1165. [PubMed: 20228244]
29. Kendall, FP.; McCreary, EK.; Provance, PG.; Rodgers, MM.; Romani, WA. Muscles: testing and function with posture and pain. Baltimore: Lippincott Williams & Wilkins; 2005.
30. Kennedy MJ, Lamontagne M, Beaule PE. Femoroacetabular impingement alters hip and pelvic biomechanics during gait Walking biomechanics of FAI. Gait Posture. 2009; 30:41– 44. [PubMed: 19307121]
31. Krause DA, Schlagel SJ, Stember BM, Zoetewey JE, Hollman JH. Influence of lever arm and stabilization on measures of hip abduction and adduction torque obtained by hand- held dynamometry. Arch Phys Med Rehabil. 2007; 88:37–42. [PubMed: 17207673]
32. Lamontagne M, Kennedy MJ, Beaule PE. The effect of cam FAI on hip and pelvic motion during maximum squat. Clin Orthop Relat Res. 2009; 467:645–650. [PubMed: 19034598]
33. Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. Med Sci Sports Exerc. 2004; 36:926– 934. [PubMed: 15179160]
34. Loureiro A, Mills PM, Barrett RS. Muscle weakness in hip osteoarthritis: a systematic review. Arthritis Care Res (Hoboken). 2013; 65:340–352. [PubMed: 22833493]
35. MacDonald Steven JGD, Ganz R. Clinical examination of the symptomatic young adult hip. Semin Arthroplasty. 1997; 8:3–9.
36. Martin RL, Enseki KR, Draovitch P, Trapuzzano T, Philippon MJ. Acetabular labral tears of the hip: examination and diagnostic challenges. J Orthop Sports Phys Ther. 2006; 36:503–515. [PubMed: 16881467]

37. Martin RL, Irrgang JJ, Sekiya JK. The diagnostic accuracy of a clinical examination in determining intra-articular hip pain for potential hip arthroscopy candidates. Arthroscopy. 2008; 24:1013–1018. [PubMed: 18760208]
38. Martin RL, Kelly BT, Philippon MJ. Evidence of validity for the hip outcome score. Arthroscopy. 2006; 22:1304–1311. [PubMed: 17157729]
39. Martin RL, Philippon MJ. Evidence of reliability and responsiveness for the hip outcome score. Arthroscopy. 2008; 24:676–682. [PubMed: 18514111]
40. Maslowski E, Sullivan W, Forster HJ, et al. The diagnostic validity of hip provocation maneuvers to detect intra-articular hip pathology. Pm R. 2010; 2:174–181. [PubMed: 20359681]
41. McCarthy JC, Noble PC, Schuck MR, Wright J, Lee J. The Otto E. Aufranc Award: The role of labral lesions to development of early degenerative hip disease. Clin Orthop Relat Res. 2001; 393:25–37. [PubMed: 11764355]
42. Mintz DN, Hooper T, Connell D, Buly R, Padgett DE, Potter HG. Magnetic resonance imaging of the hip: detection of labral and chondral abnormalities using noncontrast imaging. Arthroscopy. 2005; 21:385–393. [PubMed: 15800516]
43. Nadler SF, Malanga GA, DePrince M, Stitik TP, Feinberg JH. The relationship between lower extremity injury, low back pain, and hip muscle strength in male and female collegiate athletes. Clin J Sport Med. 2000; 10:89–97. [PubMed: 10798789]
44. Nepple JJ, Prather H, Trousdale RT, et al. Clinical diagnosis of femoroacetabular impingement. J Am Acad Orthop Surg. 2013; 21 (Suppl 1):S16–19. [PubMed: 23818186]
45. Neumann DA. Kinesiology of the hip: a focus on muscular actions. J Orthop Sports Phys Ther. 2010; 40:82–94. [PubMed: 20118525]
46. Nilsdotter AK, Lohmander LS, Klassbo M, Roos EM. Hip disability and osteoarthritis outcome score (HOOS)--validity and responsiveness in total hip replacement. BMC Musculoskelet Disord. 2003; 4:10. [PubMed: 12777182]
47. Philippon MJ. The role of arthroscopic thermal capsulorrhaphy in the hip. Clin Sports Med. 2001:817–829. [PubMed: 11675889]
48. Register B, Pennock AT, Ho CP, Strickland CD, Lawand A, Philippon MJ. Prevalence of Abnormal Hip Findings in Asymptomatic Participants: A Prospective, Blinded Study. Am J Sports Med. 2012; 40:2720–2724. [PubMed: 23104610]
49. Retchford TH, Crossley KM, Grimaldi A, Kemp JL, Cowan SM. Can local muscles augment stability in the hip? A narrative literature review. J Musculoskelet Neuronal Interact. 2013; 13:1–12. [PubMed: 23445909]
50. Schmitz MR, Campbell SE, Fajardo RS, Kadrmas WR. Identification of acetabular labral pathological changes in asymptomatic volunteers using optimized, noncontrast 1.5-T magnetic resonance imaging. Am J Sports Med. 2012; 40:1337–1341. [PubMed: 22422932]
51. Scott DA, Bond EQ, Sisto SA, Nadler SF. The intra- and interrater reliability of hip muscle strength assessments using a handheld versus a portable dynamometer anchoring station. Arch Phys Med Rehabil. 2004; 85:598–603. [PubMed: 15083436]
52. Shindle MK, Ranawat AS, Kelly BT. Diagnosis and management of traumatic and atraumatic hip instability in the athletic patient. Clin Sports Med. 2006; 25:309–326. [PubMed: 16638494]
53. Snyder KR, Earl JE, O’Connor KM, Ebersole KT. Resistance training is accompanied by increases in hip strength and changes in lower extremity biomechanics during running. Clin Biomech. 2009; 24:26–34.
54. Tannast M, Siebenrock KA, Anderson SE. Femoroacetabular Impingement: Radiographic Diagnosis--What the Radiologist Should Know. Am J Roentgenol. 2007; 188:1540–1552. [PubMed: 17515374]
55. Widler KS, Glatthorn JF, Bizzini M, et al. Assessment of hip abductor muscle strength. A validity and reliability study. J Bone Joint Surg Am. 2009; 91:2666–2672. [PubMed: 19884441]
56. Yazbek PM, Ovanessian V, Martin RL, Fukuda TY. Nonsurgical treatment of acetabular labrum tears: a case series. J Orthop Sports Phys Ther. 2011; 41:346–353. [PubMed: 21335929]

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Key Points

FINDINGS

Persons with CHJP exhibit weakness of the hip abductor and rotator muscle groups compared to pain-free controls. Among those with unilateral CHJP, the external rotators and abductors of the uninvolved hip also were weaker compared to matched controls.

IMPLICATIONS

Our findings suggest that muscle weakness may be an important factor to consider in patients with CHJP.

CAUTION

Due to the cross-sectional design of this study, we are unable to determine the temporal relationship between muscle weakness and CHJP. Future studies are needed to assess the effectiveness of muscle strengthening in patients with CHJP.

Figure 1.
Hip external rotation (ERs90°) and internal rotation (IRs90°) with hip flexed to 90°.

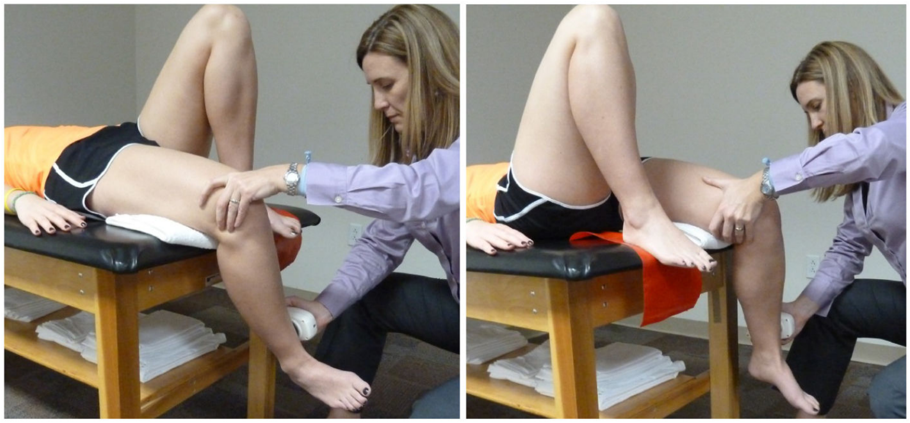

Figure 2.
Hip external rotation (ERs0°) and internal rotation (IRs0°) with hip in neutral flexion/extension.

Figure 3.
Hip abduction with the hip in neutral flexion/extension and neutral internal rotation/external rotation.

Table 1

Test-retest reliability and standard error of measurement (SEM) for strength testing. Muscle torque (Nm) was normalized by body weight (N) X height (m) X 100.

Variable	ICC (3,3)	SEM
ERs90°	0.89 (0.44, 0.98)	0.39
IRs90°	0.86 (0.25, 0.97)	0.64
ERs0°	0.97 (0.84, 0.99)	0.22
IRs0°	0.90 (0.52, 0.98)	0.33
ABDs	0.94 (0.67, 0.99)	0.47

Abbreviations: ICC, intraclass correlation coefficient; SEM, standard error of measurement

ERs90° = external rotators with hip flexed 90°

IRs90° = internal rotators with hip flexed 90°

ERs0° = external rotators with hip in neutral flexion/extension 0°

IRs0° = internal rotators hip in neutral flexion/extension 0°

ABDs = abductors with the hip abducted 15°

Table 2

Demographic characteristics and hip range of motion.

Variable	CHJP N=35	Control N=35	*P* Value
Demographics			
Sex	28F:7M	28F:7M	
Limb side	19R:16L	19R:16L	
Age, years[*]	28.2±5.0	28.0±5.7	0.84[†]
BMI, kg/m^2[*]	24.1±2.8	24.1±2.6	0.99[†]
UCLA[‡,/]	9 (3–10)	10 (4–10)	0.30[§]
Hip ROM			
ER ROM90°, deg[*]	40±10	39±7	0.23[†]
IR ROM90°, deg[*]	39±7	39±6	1.00[†]
ER ROM0°, deg[*]	42±8	40±10	0.30[†]
IR ROM0°, deg[*]	32±10	31±9	0.96[†]

Abbreviations: CHJP, chronic hip joint pain; BMI, body mass index; UCLA, University of California Los Angeles Activity Score; ROM, range of motion; ER ROM90°, external rotation ROM with hip flexed to 90°; IR ROM90°, internal rotation ROM with hip flexed to 90°; ER ROM0°, external rotation ROM with hip in neutral flexion/extension 0°; IR ROM0°, internal rotation ROM with hip in neutral flexion/extension 0°; deg, degrees

[*] Values are mean ± SD.

[†] Independent sample t-tests were used.

[‡] UCLA: participants are asked to rate their activity level over the previous 6 months. 1=wholly inactive, dependent on others; 10= regularly participates in impact sports such as jogging, tennis, skiing, acrobatics, ballet, heavy labor, or backpacking.

[/] Values are median (range)

[§] Mann-Whitney U Test was performed. One control participant did not complete UCLA.

Table 3

Descriptive data reporting pain and patient-reported outcome measures in participants with chronic hip joint pain.

Variable	CHJP N=35
Pain duration, years*	3.5 (0.4–13)
Avg pain†	3.0 (1–8)
Worst pain†	6.0 (2–10)
HOOSPain‡	77.2 ± 13.6
HOOSSymptoms‡	72.7 ± 17.3
HOOSADL‡	91.3 ± 9.7
HOOSSport‡	75.0 ± 19.5
HOOSQOL‡	60.3 ± 21.6
HOSADL‡	88.6 ± 9.8
HOSSport‡	76.8 ± 18.9
MHHS‡	80.2 ± 11.4

Abbreviations: CHJP, chronic hip joint pain; Avg, average; HOOS, Hip Disability and Osteoarthritis Outcome Score; HOS, Hip Outcome Score; MHHS, Modified Harris Hip Score; ADL, function in activities of daily living; Sport, function in sports and recreation; QOL, quality of life

*Value is mean (range).

†Pain rated by the participant using a verbal numerical pain rating scale. 0=no pain; 10=worst pain imaginable. Values are median (range)

‡Patient-reported outcome measures with 100=no disability. Values are means ± SD.

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Table 4

Group comparisons between participants with chronic hip joint pain and asymptomatic controls. Muscle torque is normalized by body weight X height X 100.

	CHJP N=35	Control N=35	Mean difference†	% difference	*P* Value
ERs90° *	3.58 ± 0.80	4.24 ± 1.06	−0.66 (−1.11, −0.21)	16%	<0.01
IRs90° *	3.57 ± 1.09	4.96 ± 1.63	−1.39 (−2.05, −0.72)	28%	<0.01
ERs0° *	2.84 ± 0.80	3.65 ± 0.89	−0.81 (−1.22, −0.41)	22%	<0.01
IRs0° *	2.38 ± 0.71	3.01 ± 0.81	−0.63 (−0.99, −0.26)	21%	<0.01
ABDs *	6.98 ± 2.05	8.95 ± 1.78	−1.97 (−2.88, −1.05)	22%	<0.01

Abbreviations: CHJP, chronic hip joint pain

ERs90° = external rotators with hip flexed 90°

IRs90° = internal rotators with hip flexed 90°

ERs0° = external rotators with hip in neutral flexion/extension 0°

IRs0° = internal rotators hip in neutral flexion/extension 0°

ABDs = abductors with the hip abducted 15°

* Values are means ± SD.

† Values in parentheses are 95% confidence interval.

Table 5

Group comparisons between the uninvolved hip of participants with unilateral CHJP and the matched hip of asymptomatic controls. Muscle torque is normalized by body weight X height X 100.

	CHJP N=22	Control N=22	Mean difference†	% difference	*P* Value
ERs90°*	4.01 ± 0.79	4.48 ± 1.12	−0.47 (−1.06, 0.12)	10%	0.12
IRs90°*	4.28 ± 1.34	5.09 ± 1.60	−0.81 (−1.71, 0.84)	16%	0.07
ERs0°*	3.12 ± 0.88	3.79 ± 1.14	−0.67 (−1.29, −0.06)	18%	0.03
IRs0°*	2.71 ± 0.78	3.11 ± 0.96	−0.40 (−0.93, 0.13)	13%	0.14
ABDs*	7.71 ± 1.69	9.16 ± 2.61	−1.45 (−2.78, −0.11)	16%	0.04

Abbreviations: CHJP, chronic hip joint pain

ERs90° = external rotators with hip flexed 90°

IRs90° = internal rotators with hip flexed 90°

ERs0° = external rotators with hip in neutral flexion/extension 0°

IRs0° = internal rotators hip in neutral flexion/extension 0°

ABDs = abductors with the hip abducted 15°

* Values are means ± SD.

† Values in parentheses are 95% confidence interval.