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Persons With Chronic Hip Joint Pain Exhibit Reduced Hip Muscle Strength

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 that leads 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, a better understanding of the factors proposed to be associated with CHJP, in particular hip muscle performance, is needed.

STUDY DESIGN: Controlled laboratory cross-sectional study.

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 that in asymptomatic controls.

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

METHODS: Thirty-five participants with CHJP and 35 matched controls (18 to 40 years of age) participated. Using handheld dynamometry, strength of the hip external rotators and internal rotators was assessed with the hip flexed to 90° and 0°. To assess external rotator and internal rotator strength, the hip was placed at the end range of external rotation and internal rotation, respectively. Strength of the hip abductors 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-sample *t* tests were used to compare strength values between (1) the involved limb in participants with CHJP and the corresponding limb in the matched controls, and (2) the uninvolved limb in participants with unilateral CHJP and the corresponding limb in the matched controls.

RESULTS: Compared to controls, participants with CHJP demonstrated weakness of 16% to 28% ($P<.01$) in all muscle groups tested in the involved hip. The uninvolved hip of 22 subjects with unilateral CHJP demonstrated weakness of 18% and 16% ($P<.05$) in the external rotators (0°) and abductors, respectively, when compared to the corresponding limb of the matched controls.

CONCLUSION: The results of the present study 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. *J Orthop Sports Phys Ther 2014;44(11):890-898. Epub 9 October 2014. doi:10.2519/jospt.2014.5268*

KEY WORDS: *abductor, dynamometry, external rotator, femoroacetabular impingement, internal rotator*

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, and the martial arts.[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, lead-

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ing 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, is important in controlling internal rotation of the hip.[45] Hip internal rotator strength is important for the control of hip external rotation. The muscles responsible for controlling hip external rotation include the anterior fibers of the gluteus minimus and medius, tensor fascia 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 tensor fascia 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 FAI and found weakness in the hip external rotators and abductors, but not in the internal rotators, when compared to asymptomatic controls. In a recent systematic review, Loureiro et al[34] concluded that persons with hip OA exhibited 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 CHJP.

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 differed from that in 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

The participants were a subset of participants from a prospective cohort study that assessed the proposed risk factors for CHJP. The participants, aged 18 to 40 years, were recruited from Washington University School of Medicine's orthopaedic, physical medicine and rehabilitation, and physical therapy clinics from a 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, and 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 magnetic resonance imaging, (3) known pregnancy, (4) neurological involvement that influenced coordination or balance, and (5) a BMI greater than 30 kg/m^2. Three exclusion criteria—contraindication to magnetic resonance imaging, 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 matched 1 to 1 with participants with CHJP by sex, age (within 5 years), BMI (within 5 kg/m^2), and limb side. The involved limb or, in the case of bilateral CHJP, the most symptomatic limb of each participant was matched to the corresponding limb of the matched control. The participants in 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 participation in the study.

Examination procedures and data collection were performed by a licensed physical therapist certified in orthopaedic physical therapy, with 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, Salt Lake City, UT) handheld dynamometer was used to assess hip strength. Prior to the study, the dynamometer was factory calibrated and reported to be accurate within 1%. Handheld dynamometry is a relatively inexpensive method to quantify muscle strength and 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,[46] Hip Outcome Score,[38] and the modified Harris Hip Score.[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 the tests among participants and to reduce the likelihood of fatigue, the strength tests were performed in a standardized order, alternately to the left and right limbs. Given that 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°, internal rotators with hip flexed to 90°, external rotators with hip in neutral flexion/extension, internal rotators with hip in neutral flexion/extension, and abductors with the hip abducted 15°. Break tests[29,31] were performed using the dynamometer to determine maximum muscle force in Newtons. A submaximal 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 to 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 numeric pain rating scale (0, no pain; 10, worst pain imaginable) was used to document the participant's pain intensity during testing. Moment-arm length of the external force provided for external and internal rotators corresponded to the distance between the knee joint line and 4 cm proximal to the malleolus on the medial and lateral sides, respectively. For hip abductor strength testing, the distance between the superior greater trochanter and 4 cm proximal to the lateral malleolus was used.

FIGURE 1. Hip external rotation (A) and internal rotation (B) with the hip flexed to 90°.

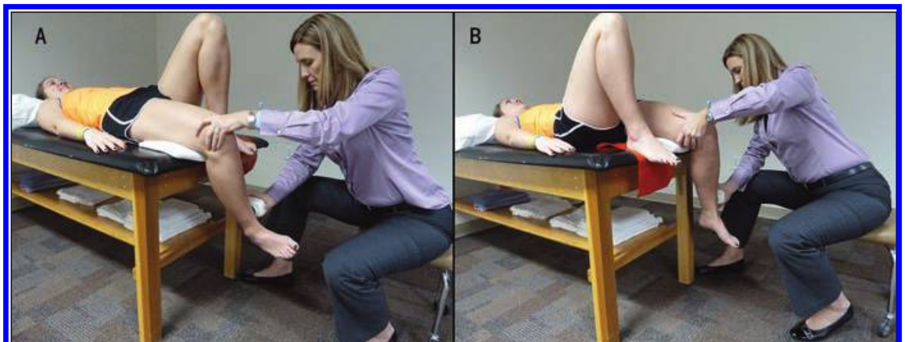

FIGURE 2. Hip external rotation (A) and internal rotation (B) with the hip in neutral flexion/extension.

For strength assessments of the hip external and internal rotators with the hip flexed to 90°, participants were positioned in sitting, with a towel placed under 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 external rotators with the hip flexed to 90°, the hip was placed in end-range external rotation, as described by Kendall et al,[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. Counterstabilization 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 the internal rotators with the hip flexed to 90°; 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 strength assessments of the hip external and internal rotators with the hip in neutral flexion/extension, the testing technique was the same as that for hip external and internal rotators with the hip flexed to 90°, except that participants were positioned in supine, with the tested limb's knee flexed to 90° over the table edge and the nontested limb flexed so the foot could rest on the table (**FIGURE 2**). A towel was

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 for Strength Testing*

Variable	$ICC_{3,3}$[†]	SEM
External rotators 90°[‡]	0.89 (0.44, 0.98)	0.39
Internal rotators 90°[‡]	0.86 (0.25, 0.97)	0.64
External rotators 0°[§]	0.97 (0.84, 0.99)	0.22
Internal rotators 0°[§]	0.90 (0.52, 0.98)	0.33
Abductors[‖]	0.94 (0.67, 0.99)	0.47

Abbreviations: ICC, intraclass correlation coefficient; SEM, standard error of measurement.
**Muscle torque (Nm) was normalized by body weight (N) × height (m) × 100.*
[†]Values in parentheses are 95% confidence interval.
[‡]Hip flexed to 90°.
[§]Hip in neutral flexion/extension.
[‖]Hip abducted to 15°.

placed underneath the distal thigh to position the hip in 0° of extension.

For the hip abduction strength assessments, participants were positioned in sidelying, with the nontested limb in approximately 45° of hip flexion and 90° of 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. Counterstabilization 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 3 maximal trials were averaged and multiplied by the associated moment arm in meters to determine the average torque. To create a body size–independent measurement, the average torque was normalized by body weight and height in meters: normalized torque = [torque/(body weight × height) × 100].[5] Test-retest reliability using the described procedures above was performed in 8 asymptomatic participants. The testing was completed by the examiner who performed the strength testing for this study. Both strength tests and moment-arm measurements were completed on 2 separate testing sessions 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 errors of measurement (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 device to determine range of motion of the hip external and internal rotation with the hip flexed to 90° and in neutral flexion/extension. 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 an alpha of .05 using 2-tailed tests.

The Kolmogorov-Smirnov test was used to confirm normal distribution of the data, and the Levene test was used to confirm equality of variance. For group comparisons, independent-sample *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 less than .05 was considered significant.

RESULTS

Demographic characteristics and hip range-of-motion 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 in high-level activities such as jogging, tennis, and skiing at least 1 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, 0.4-13 years) and moderate functional limitations as measured by patient-reported outcome measures (**TABLE 3**). Magnetic resonance imaging measures of bony morphology were available for 33 of the 35 participants with

TABLE 2 Demographic Characteristics and Hip Range of Motion*

Variable	CHJP (n = 35)	Control (n = 35)	*P* Value†
Demographics			
Sex, n			
Female	28	28	
Male	7	7	
Limb side, n			
Right	19	19	
Left	16	16	
Age, y	28.2 ± 5.0	28.0 ± 5.7	.84
BMI, kg/m^2	24.1 ± 2.8	24.1 ± 2.6	.99
UCLA‡	9 (3-10)	10 (4-10)	.30§
Hip ROM			
ER ROM 90°, deg‖	40 ± 10	39 ± 7	.23
IR ROM 90°, deg‖	39 ± 7	39 ± 6	1.00
ER ROM 0°, deg¶	42 ± 8	40 ± 10	.30
IR ROM 0°, deg¶	32 ± 10	31 ± 9	.96

Abbreviations: BMI, body mass index; CHJP, chronic hip joint pain; ER, external rotation; IR, internal rotation; ROM, range of motion; UCLA, University of California Los Angeles activity score.
**Values are mean ± SD unless otherwise indicated.*
†Independent-sample t tests were used unless otherwise indicated.
‡Values are median (range). Participants were 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.
§Mann-Whitney U test was performed. One control participant did not complete the UCLA.
‖Hip flexed to 90°.
¶Hip in neutral flexion/extension.

CHJP. Eight had an alpha angle of 60° or greater, consistent with cam FAI[44]; 1 had a lateral center-edge angle of 20° or less, consistent with structural instability[18,26]; 2 had a lateral center-edge angle of 40° or greater, 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% to 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 the uninvolved hip, with deficits of 18% and 16% in the hip external rotators with the hip in neutral flexion/extension and the abductors, 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 1 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 the 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 that participants with unilateral CHJP also demonstrated weakness in the external rotators with the hip in neutral flexion/extension and the abductors of the 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. The observed weakness, therefore, might have been the result of disuse atrophy, reduced activation, or muscle inhibition due to pain during testing or to 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 1 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 external rotators with the hip flexed to 90°, internal rotators with hip flexed to 90°, and abductors in people with FAI and asymptomatic control participants. Comparing our investigation to that of Casartelli et al,[8] both reported strength deficits in the external rotators with hip flexed to 90°, internal rotators with hip flexed to 90°, and abductors; however, the significance of these deficits varied. Casartelli et al[8] and the current study found a strength deficit in the external rotators with the hip flexed to 90° of 18% and 16%, respectively. The hip abductors were 11% to 22% deficient in the painful participants across both studies. We found a 28% deficit in the internal rotators with hip flexed to 90° in participants with CHJP, compared to a 14% (P = .076) deficit in participants with FAI in the Casartelli et al[8] study. The greater deficit in internal rotators with hip flexed to 90° 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[8] 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 exist between our study and that of Casartelli et al.[8] First, all symptomatic participants in the Casartelli et al[8] 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 only those with FAI. An a posteriori analysis of our data found no differences in muscle strength between participants with CHJP, those with 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, due to the small sample size of the present study, no definitive conclusions can be made. Second, all symptomatic participants in the Casartelli et al[8] study were scheduled to undergo a surgical intervention. Our participants were not considered surgical candidates at the time of testing, which suggests 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.[8] The symptomatic participants in the Casartelli et al[8] study reported mean pain ratings ranging from 18 to 27 mm on a visual analog scale (0-100), and our participants reported a range of 1 to 6 on the verbal numeric pain rating scale (0-10). Interestingly, the percentages of strength deficits in our symptomatic participants were similar to those reported in surgical candidates. Due to our exclusion criteria, our participants were slightly younger, with a mean age of 28 years versus 32 years for those in the Casartelli et al[8] 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.

TABLE 3 DESCRIPTIVE DATA REPORTING PAIN AND PATIENT-REPORTED OUTCOME MEASURES IN PARTICIPANTS WITH CHRONIC HIP JOINT PAIN*

Variable	CHJP (n = 35)
Pain duration, y†	3.5 (0.4-13)
Average pain‡	3.0 (1-8)
Worst pain‡	6.0 (2-10)
HOOS-pain§	77.2 ± 13.6
HOOS-symptoms§	72.7 ± 17.3
HOOS-ADL§	91.3 ± 9.7
HOOS-sport§	75.0 ± 19.5
HOOS-QoL§	60.3 ± 21.6
HOS-ADL§	88.6 ± 9.8
HOS-sport§	76.8 ± 18.9
mHHS§	80.2 ± 11.4

Abbreviations: ADL, activities of daily living; CHJP, chronic hip joint pain; HOOS, Hip disability and Osteoarthritis Outcome Score; HOS, Hip Outcome Score; mHHS, modified Harris Hip Score; QoL, quality of life.
**Values are mean ± SD unless otherwise indicated.*
†Value is mean (range).
‡Values are median (range). Pain rated by the participant using a verbal numeric pain rating scale: 0, no pain; 10, worst pain imaginable.
§Patient-reported outcome measures where 100 is no disability.

TABLE 4 GROUP COMPARISONS BETWEEN PARTICIPANTS WITH CHRONIC HIP JOINT PAIN AND ASYMPTOMATIC CONTROLS*

	CHJP (n = 35)	Control (n = 35)	Mean Difference†	Difference, %	*P* Value
ER 90°‡	3.58 ± 0.80	4.24 ± 1.06	–0.66 (–1.11, –0.21)	16	<.01
IR 90°‡	3.57 ± 1.09	4.96 ± 1.63	–1.39 (–2.05, –0.72)	28	<.01
ER 0°§	2.84 ± 0.80	3.65 ± 0.89	–0.81 (–1.22, –0.41)	22	<.01
IR 0°§	2.38 ± 0.71	3.01 ± 0.81	–0.63 (–0.99, –0.26)	21	<.01
Abductors‖	6.98 ± 2.05	8.95 ± 1.78	–1.97 (–2.88, –1.05)	22	<.01

Abbreviations: CHJP, chronic hip joint pain; ER, external rotators; IR, internal rotators.
**Muscle torque (Nm) was normalized by body weight (N) × height (m) × 100. Values are mean ± SD unless otherwise indicated.*
†Values in parentheses are 95% confidence interval.
‡Hip flexed to 90°.
§Hip in neutral flexion/extension.
‖Hip abducted to 15°.

Finally, Casartelli et al[8] 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 the 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 had weaker hip external rotators with the hip in neutral flexion/extension and abductors compared to their asymptomatic counterparts, 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 those 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 strength assessment of the hip abductors. 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.

TABLE 5 Group Comparisons Between the Uninvolved Hip of Participants With Unilateral Chronic Hip Joint Pain and the Matched Hip of Asymptomatic Controls*

	CHJP (n = 22)	Control (n = 22)	Mean Difference†	Difference, %	*P* Value
ER 90°‡	4.01 ± 0.79	4.48 ± 1.12	–0.47 (–1.06, 0.12)	10	.12
IR 90°‡	4.28 ± 1.34	5.09 ± 1.60	–0.81 (–1.71, 0.84)	16	.07
ER 0°§	3.12 ± 0.88	3.79 ± 1.14	–0.67 (–1.29, –0.06)	18	.03
IR 0°§	2.71 ± 0.78	3.11 ± 0.96	–0.40 (–0.93, 0.13)	13	.14
Abductors‖	7.71 ± 1.69	9.16 ± 2.61	–1.45 (–2.78, –0.11)	16	.04

Abbreviations: CHJP, chronic hip joint pain; ER, external rotators; IR, internal rotators.
**Muscle torque (Nm) was normalized by body weight (N) × height (m) × 100. Values are mean ± SD unless otherwise indicated.*
†Values in parentheses are 95% confidence interval.
‡Hip flexed to 90°.
§Hip in neutral flexion/extension.
‖Hip abducted to 15°.

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 the 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 nonsurgical 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.

The present study is not without limitations. Due to the cross-sectional design, we could not establish a temporal relationship between muscle weakness and CHJP. Future work to assess muscle morphology may provide insight to the mechanism underlying muscle weakness in people with CHJP. Handheld 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 might 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 because Kendall et al[29] recommend the end-range position to assess the strength of muscles that cross a single joint. 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, but did not attempt to differentiate specific pathology. We cannot confirm a clinical diagnosis of a labral tear, chondral lesion, or other pathology. Additionally, recent studies have reported labral tears[48,50] and bony abnormalities[19,27,28] in asymptomatic individuals, suggesting that pathology may not always correspond to pain complaints or functional ability. 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 with the hip in neutral flexion/extension and the abductors in the uninvolved hip of people with CHJP, indicating that the uninvolved hip should also be considered in rehabilitation. ◉

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.

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