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Hylonome

Original Article

Is hip range of motion and strength impaired in people with hip chondrolabral pathology?

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Abstract

Objective: The aims of this study were to: i) to compare physical impairments in people with chondrolabral pathology identified at hip arthroscopy 12-24 months previously to age-matched healthy people; and ii) to understand whether sex has any influence on impairments. **Methods:** 84 patients (42 female; age=36±10) 12-24 months post hip arthroscopy and 60 controls (41 female; age=36±10) were included. Measurements of active hip ROM and strength were assessed. Two-way analyses of co-variance examined the effect of sex and chondrolabral pathology on hip ROM and strength. **Results:** Patients exhibited less hip internal rotation (IR) ROM (p=0.001) and more extension (p=0.014) ROM; and less hip adduction (p<0.001), extension (p=0.001), flexion (p<0.001), ER (p=0.044) and IR (p<0.001) strength when compared to controls. For abduction strength, a significant interaction was found between the presence of chondrolabral pathology and sex (p=0.035). **Conclusions:** People with hip chondrolabral pathology have differences in hip ROM and strength when compared to controls. Rehabilitation programs should focus on addressing these specific physical impairments in order to enhance outcomes. This information may be of great value to both researchers and clinicians alike in determining interventions to improve outcomes in people with early hip OA.

Keywords: Hip Arthroscopy, Muscle Strength, Joint Range of Motion, Acetabular Labrum, Osteoarthritis

Introduction

Hip-related symptoms are associated with substantial morbidity in young adults[1,2], with arthroscopy increasingly used to diagnose and treat intra-articular hip pathology[1]. Various hip pathologies, including acetabular labral pathology and femoroacetabular impingement (FAI)[3,4], are treated arthroscopically with good results reported at up to 10 years follow up[1]. However, less favourable outcomes following hip arthroscopy are reported for patients with radiographic osteoarthritis (OA)[5,6] or chondropathy seen at surgery[7]. Since chondral and labral pathology are frequently observed in hip arthroscopy patients, commonly co-exist[7,8], and outcomes in those patients with chondropathy are poorer[9], there is a need to identify whether modifiable features are associated with this condition. Features such as reduced muscle strength are associated with OA disease progression at the knee[10,11]. If people with hip chondrolabral pathology exhibit physical impairments compared to healthy controls, then such impairments may be important targets for improving outcome and potentially minimizing the onset or progression of hip OA.

Physical impairments, such as altered hip range of motion (ROM) or strength (particularly in flexion, abduction and adduction) have been described in people with advanced hip OA[12,13]. Specifically, compared to healthy counterparts, people with hip OA have less hip ROM in all directions[12] as well as reduced flexion, abduction and adduction strength[12,13]. In those with advanced hip OA, lower hip ROM and strength have been shown to be associated with poorer pain and function outcomes[14,15], while a recent report found that an exercise intervention, targeted to address physical impairments, reduced the risk of total hip arthroplasty (THA) by 44% compared to an education control group over six years follow-up[16]. It is possible that similar physical impairments also

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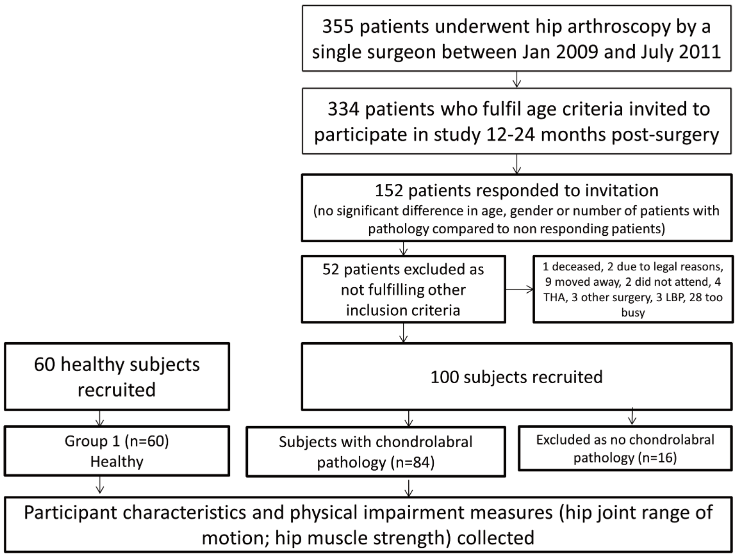

Figure 1. Flow-chart of recruitment of participants into study.

exist in people with hip chondrolabral pathology who have undergone hip arthroscopy, even at a time when full recovery is expected (i.e. 12-24 months post-arthroscopy). A consistency of impairments, between those with hip chondrolabral pathology (OA in its earliest detectable stages) and those reported for people with established hip OA, could indicate that such impairments may play a role in the progression of symptoms and structural disease. This potential link is possibly due to reduced hip ROM and strength resulting in abnormal hip joint loading patterns and increased shearing within articular cartilage. Thus, it is possible that such physical impairments may contribute to the onset of hip OA[17]. Furthermore, as differences in hip muscle strength exist between sexes in healthy people[18], physical impairments are likely to vary between men and women. However, no studies have examined the relationship between the presence of chondrolabral pathology, sex and physical impairments in a hip arthroscopy population.

The aim of the current study was twofold: first, to determine if physical impairments (i.e. deficits in hip ROM and strength) are evident in people with chondrolabral pathology (defined as damage to the acetabular labrum, hip chondral surfaces or both) identified at hip arthroscopy 12-24 months previously, when compared to age-matched healthy people; and, second: to understand whether sex has any influence on observed impairments.

Materials and methods

Study design

This cross-sectional study was conducted in a community setting, and was carried out according to the Helsinki Declaration. Approval was obtained from the University of Melbourne Human Research Ethics Committee (HREC number 1033063), and the University of Queensland Medical Research Ethics Committee (MREC number 2012000708). All participants provided written informed consent at the commencement of the study.

Participants

Consecutive patients who had undergone hip arthroscopic surgery between January 2009 and July 2011 by a single surgeon (MGP) were invited by letter to participate. Invitations were sent when patients were between 12 and 24 months post-surgery (Figure 1). Inclusion criteria were: (i) being aged between 18 and 60 years; and (ii) having undergone hip arthroscopic surgery 12-24 months previously for hip chondrolabral pathology. Healthy participants were also recruited from the community via advertisements in the local media and posters. Participants were excluded if they could not speak or read English, could not walk without assistance, or had current low back pain or lower limb injury. Healthy participants were also excluded if they had any history of hip surgery, or had experienced hip pain in the past six months. Eighty-four hip arthroscopy patients and 60 healthy age-matched people were included in this study (Figure 1).

Hip arthroscopy patients were included according to the presence of chondropathy, labral pathology or both. All hip arthroscopy patients underwent surgery because of hip pain regardless of the severity of chondrolabral pathology. Chondropathy was defined as chondral pathology ≥ Outerbridge grade I identified at the time of arthroscopy, which required surgical intervention. The Outerbridge grading system of chondral injury was defined as follows: Grade I represented softening and swelling of the articular cartilage; Grade II represented fragmenting and fissuring of articular cartilage in an area less than 15 mm; Grade III represented fragmenting and fissuring of articular cartilage greater than 15 mm; and Grade IV represented erosion of articular cartilage to the subchondral bone[19]. Surgical intervention included chondral debridement or microfracture as deemed appropriate by the surgeon[9]. Labral pathology was defined as labral pathology at the time of surgery requiring surgical intervention (labral de-

Baseline characteristic	Healthy Group women (n=41) Mean (SD)	Healthy Group men (n=19) Mean (SD)	Chondrolabral Group women (n=42) Mean (SD)	Chondrolabral Group men (n=42) Mean (SD)	Significant difference (p)
Age	37(10)	33(10)	39(11)	33(12)	<0.001**
Height (m)	1.66(0.08)	1.80(0.05)	1.68(0.07)	1.81(0.06)	<0.001**
Weight (kg)	64(9)	78(12)	72(12)	84(9)	<0.001***
BMI (kg/m²)	23.2(3.4)	24.1(3.4)	26.6(7.8)	25.6(3.1)	0.001*
Waist girth (cm)	69(7)	80(10)	77(13)	84(8)	<0.001***
Time since surgery (months)	N/A	N/A	16(3)	18(4)	0.032*
Physical activity (hours/week)	4 (2)	5(2)	4 (3)	5(4)	0.685

m= metres; kg= kilograms; BMI= body mass index; cm = centimetres; N/A= not applicable; * significant difference between groups (chondrolabral pathology); **significant difference between groups (gender); ***significant difference between groups (chondrolabral pathology and gender).

Table 1. Participant baseline characteristics.

bridement or repair)[9]. Participants were partitioned into two groups: (1) healthy participants, herein referred to as the 'healthy group' (n=60); and (2) hip arthroscopy patients, herein referred to as the 'chondrolabral group' (n=84) (Figure 1). Hip arthroscopy patients may have also had concomitant hip morphological abnormalities such as FAI or hip dysplasia, but this did not determine their inclusion in the study. All hip arthroscopy patients were offered post-operative rehabilitation with a physiotherapist of their own choice.

Procedures

Hip arthroscopy was performed by a fellowship trained high volume hip arthroscopist (MGP), using a standardised surgical technique[20]. The surgery was performed in the lateral decubitus position with the limb in hip abduction and slight flexion. Traction was applied in the direction of the femoral neck using a padded boot with a bolster situated between the legs. Entry to the central and peripheral compartments of the hip was performed with a 70° arthroscope via a viewing mid-trochanteric portal, and an instrument anterior trochanteric portal. Intra-articular pathology, including the presence of chondropathy, was systematically assessed and documented[20]. All data collection for the present study took place in a private physiotherapy clinic between 12 and 24 months post-surgery. The investigator collecting data (JLK) was not blinded to participants' allocation to the control or hip arthroscopy groups. Demographic measures collected included age, sex, height, weight and waist girth, while body mass index (BMI) was calculated. In addition, the following variables were also recorded: time since surgery, presence of chondropathy and labral pathology at the time of surgery, the surgical intervention, and weekly hours of physical activity.

Dependent variables

All participants underwent standardized testing of hip joint ROM and hip muscle strength, using previously described methods[18,21]. Briefly, active ROM measures included hip flexion, extension, external rotation (ER) and internal rotation (IR) (ER and IR ROM measured at 90° of hip flexion) using a Plurimeter V gravity inclinometer (Dr Rippstein, Switzerland). Hip flexion ROM was measured in supine. Hip extension ROM was measured in prone. Hip ER and IR ROM were measured in sitting. Active ROM was measured as this reflects ROM required in functional activity. Hip muscle strength (isometric peak torque normalized for body weight (NPT) (Nm/kg)) was assessed using a Commander Power Track II hand-held dynamometer (J-tech Medical, Salt Lake City, Utah, USA). Strength measures collected included hip abduction, adduction, extension, flexion, ER and IR[18]. Hip abduction and adduction strength were measured in supine. Hip extension, ER and IR strength were measured in prone. Hip flexion strength was measured in sitting. Measures of hip strength[18] and ROM have previously been shown to be reliable. Intra-class correlation coefficients (ICC) for strength ranged from ICC 0.80 to 0.96[18], while those for ROM ranged from 0.75 to 0.96[22].

Independent variables

Independent variables evaluated were group (i.e., healthy group; chondrolabral group) and sex.

Data collection and statistical analysis

All statistical analyses were performed using SPSS Version 20.0 software (SPSS Inc., Chicago IL USA). Between-group differences in participant baseline characteristics were compared using independent t-tests. Two-way (group and sex) analysis of co-variance (ANCOVA) tests were used to determine whether differences existed in compare hip ROM and strength, with age, height and weight included as co-variates. Significance was set at $p<0.05$ *a priori* for all tests. Mean differences (MD) between groups (along with 99% confidence intervals) were also calculated.

Results

The control and chondrolabral groups were matched for age and height (Table 1). Men were significantly taller and younger

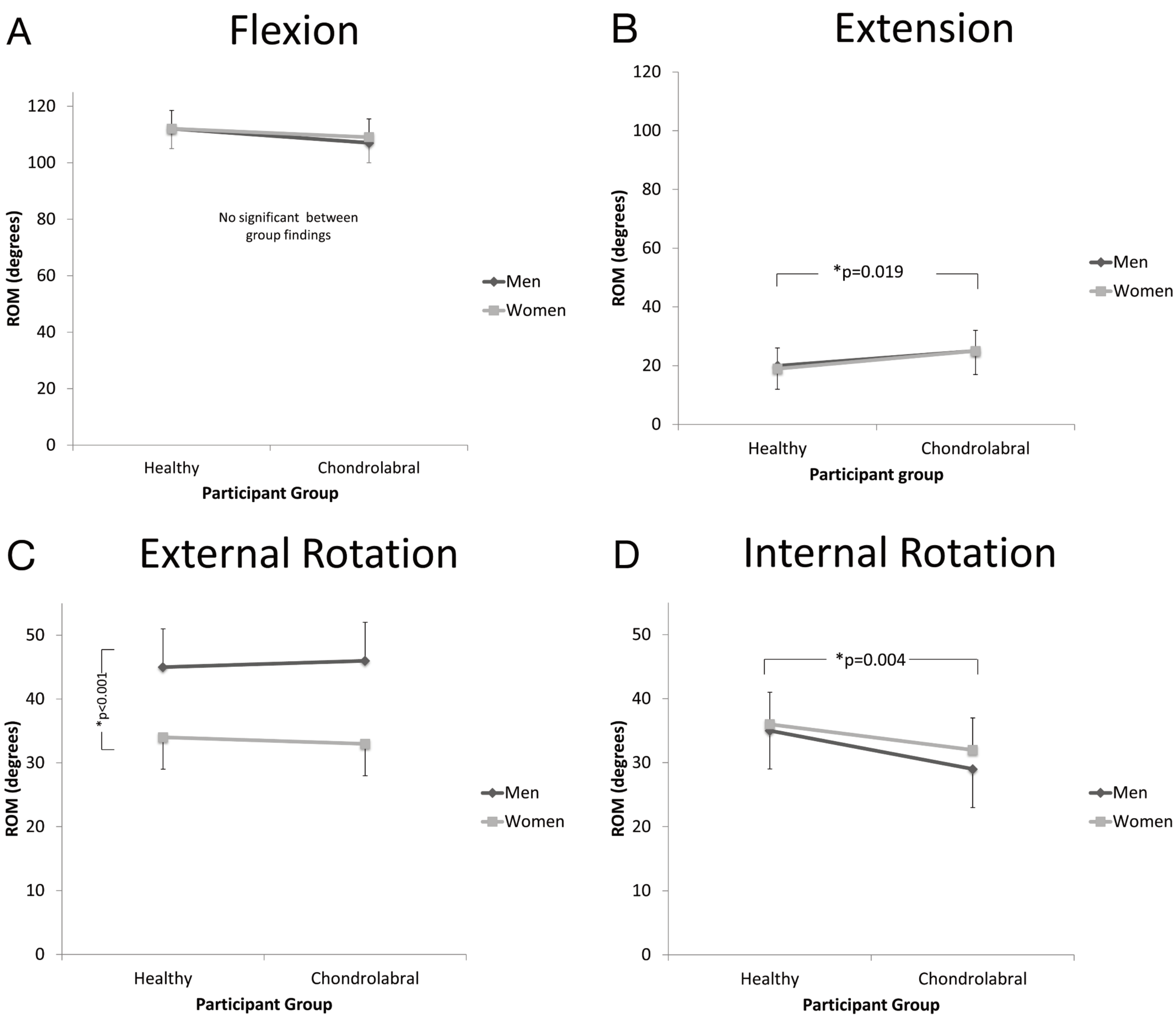

Figure 2. A: Results of two-way ANCOVA analysis for hip flexion range of motion. B: Results of two-way ANCOVA analysis for hip extension range of motion. C: Results of two-way ANCOVA analysis for hip external rotation range of motion. D: Results of two-way ANCOVA analysis for hip internal rotation range of motion. ROM= range of motion.

than women. The chondrolabral group and men were significantly heavier (p<0.001) and had a larger waist girth (p<0.001) than the healthy group and women. Finally, BMI was significantly (p=0.001) greater for the chondrolabral group compared to the healthy group. The proportion of women in the healthy group was significantly greater than the chondrolabral group.

Between-group differences in hip ROM and strength were found. Significant main effects for group were observed for extension ROM (p=0.043) (Figure 2B) and IR ROM (p=0.001) (Figure 2D). The chondrolabral group had significantly less IR ROM compared to the healthy group (p=0.004; mean difference: MD=5° (95% confidence interval: 2 to 8)) (Figure 2D); and significantly greater hip extension ROM compared to the healthy group (p=0.019; MD=5° (1 to 9)). With regards to hip muscle strength, the chondrolabral group had significantly lower strength in adduction (p<0.001; MD=0.27 $Nm.kg^{-1}$ (0.14 to 0.41)) (Figure 3B), extension (p=0.001; MD=0.25 $Nm.kg^{-1}$ (0.10 to 0.41)) (Figure 4A), flexion (p<0.001; MD= 0.31 $Nm.kg^{-1}$ (0.19 to 0.42)) (Figure 4B), and ER (p=0.044; MD=0.09 $Nm.kg^{-1}$ (0.00 to 0.17)) (Figure 5A) compared to the healthy group.

Several dependent variables displayed a significant main effect for sex. Women exhibited less ER ROM (p<0.001; MD=12° (7 to 16)) (Figure 2C) and lower strength in abduction (p=0.001; MD=0.46 $Nm.kg^{-1}$ (0.27 to 0.65)) (Figure 3A), adduction

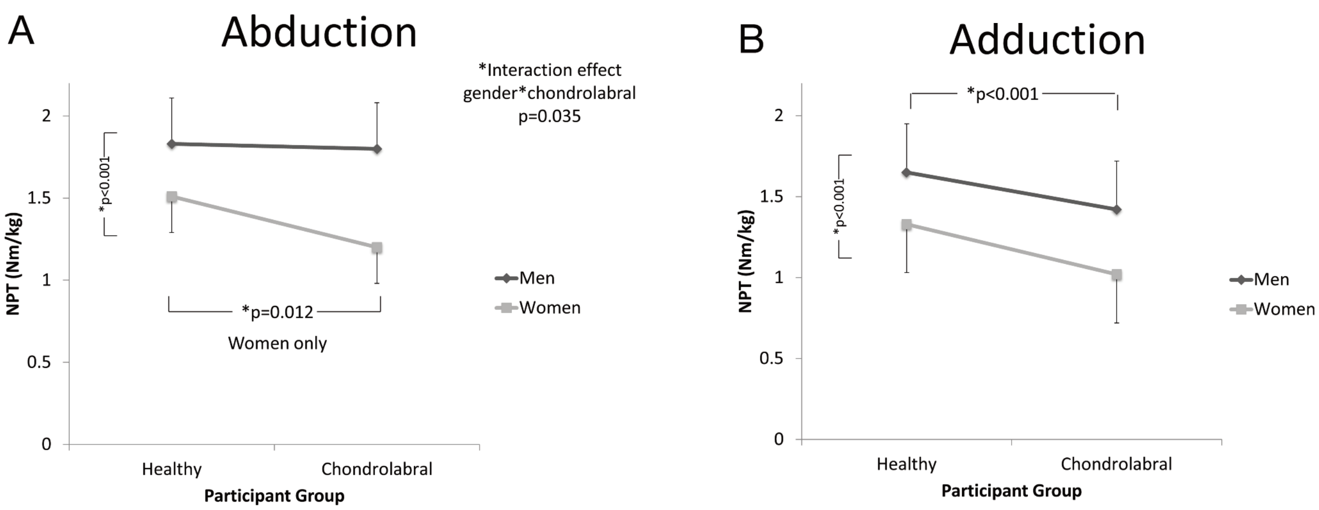

Figure 3. A: Results of two-way ANCOVA analysis for hip abduction muscle strength. B: Results of two-way ANCOVA analysis for hip adduction muscle strength. NPT= hip muscle strength measured as normalized peak torque; N= Newton; m= metre; kg= kilogram.

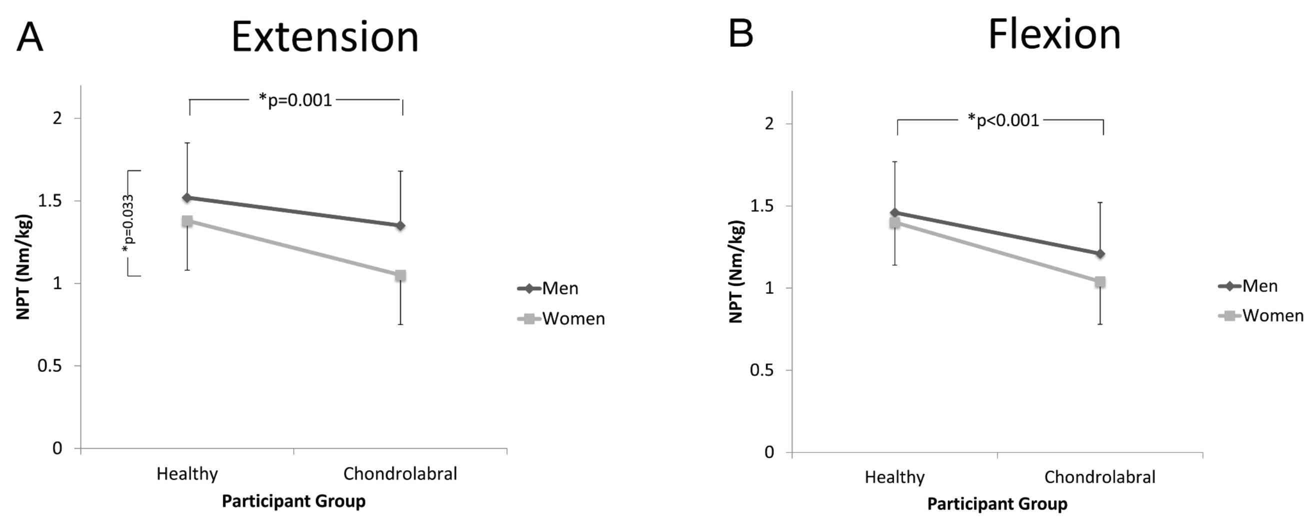

Figure 4. A: Results of two-way ANCOVA analysis for hip extension muscle strength. B: Results of two-way ANCOVA analysis for hip flexion muscle strength. NPT= hip muscle strength measured as normalized peak torque; N= Newton; m= metre; kg= kilogram.

(p<0.001; MD=0.36 Nm.kg^{-1} (0.18 to 0.54)) (Figure 3B); extension (p=0.033; MD=0.23 Nm.kg^{-1} (0.03 to 0.43) (Figure 4A), ER (p<0.001; MD=0.27 Nm.kg^{-1} (0.15 to 0.38)) (Figure 5A) and IR (p<0.001; MD=0.17 Nm.kg^{-1} (0.08 to 0.25)) (Figure 5B).

An interaction between group and sex was seen for hip abduction strength (p=0.035). No other significant interactions were found.

Discussion

Impairments in hip ROM and muscle strength were observed in patients with chondrolabral pathology, 12-24 months post-surgery. Overall, our findings indicate similar impairments in ROM and strength to those observed in people with advanced hip OA[12,13]. We also observed some sex specific findings for hip ER ROM as well as hip abduction, adduction, extension, ER and IR strength.

Hip IR ROM was significantly reduced in patients with chondrolabral pathology compared to healthy people. If we consider that hip OA may be a continuum from morphological variation such as FAI or dysplasia to painful chondrolabral pathology through to end-stage disease, our finding of reduced hip IR ROM in those with chondrolabral pathology is consistent with what has been previously reported across the spec-

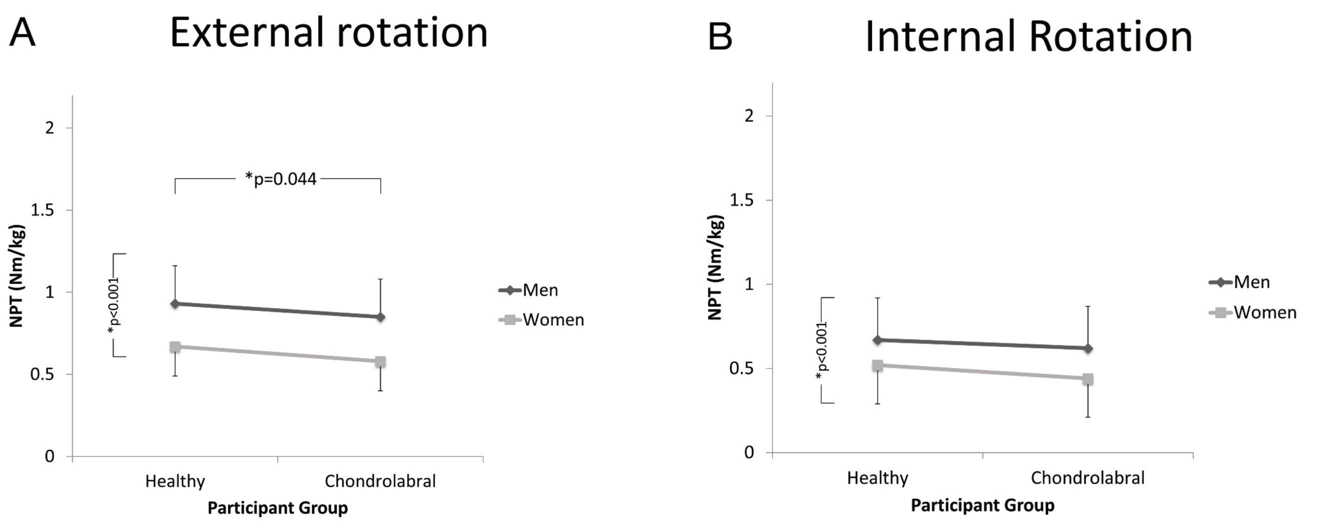

Figure 5. A: Results of two-way ANCOVA analysis for hip external rotation muscle strength. B: Results of two-way ANCOVA analysis for hip internal rotation muscle strength. NPT= hip muscle strength measured as normalized peak torque; N= Newton; m= metre; kg= kilogram.

trum of pathologies, including painful cam-type FAI[23], early radiographic hip OA[24,25] and advanced hip OA[12,26]. Therefore, while reduced hip IR ROM may be an early sign of hip OA[27], it may also reflect the presence of FAI and concomitant pathology in the hip arthroscopy group. Longitudinal studies are required to substantiate this hypothesis. We also found hip ER ROM to be reduced in women regardless of whether chondrolabral pathology was present or not. This finding may reflect the sex-based differences in acetabular version, where men have less acetabular anteversion and thus greater hip ER ROM than women[28]. Based on this premise, women would be expected to have greater IR ROM than men, but such a result was not observed in the present study. It is possible that the presence of intra-articular pathology may have reduced hip IR ROM in the women in our study, thus mitigating any sex effect on hip IR ROM.

Interestingly, we found that people with chondrolabral pathology had significantly greater hip extension ROM compared to healthy controls. Lewis et al. used a musculoskeletal model and reported that increased hip extension ROM resulted in increased anterior hip force[29]. The authors suggested that increased anterior hip force in hip extension may be a possible cause of hip pain and associated anterior acetabular labral pathology in susceptible adults[29]. In addition, Lewis et al. reported that reduced gluteus maximus activation in hip extension results in a further increase in anterior hip joint force[29]. In healthy adults, walking with greater hip extension was found to increase the anterior hip joint force[30], while gluteus maximus provides the greatest modulating action to anterior hip contact force and anterior hip contact impulse during gait[31]. Taken together, these findings suggest that the patients in this study are placing the anterior hip joint structures, including the acetabular labrum and chondral surfaces, at risk, due to increased range of hip extension. As the chondrolabral group also have reduced hip extension muscle strength, the normal function of gluteus maximus may be compromised, creating further adverse anterior hip joint force. Due to the cross-sectional design of this study, it is unclear whether a causal relationship exists between increased hip extension ROM and the presence of chondrolabral pathology. In addition, it is unknown whether greater hip extension ROM is associated with increased hip-related symptoms in this patient group. Nevertheless, minimising hip extension ROM and/or improving gluteus maximus strength in patients with chondrolabral disease may be an important target in reducing the structural and symptomatic progression of hip degenerative disease.

Patients with chondrolabral pathology had significantly reduced hip muscle strength in flexion, extension, adduction, abduction (women only) and ER when compared to healthy people. Thus, hip muscle weakness appears to be a feature of those with early degenerative hip disease. This result is consistent with previous studies that have reported hip strength deficits to be associated with advanced hip OA[13,32]. Casartelli et al.[33] also found hip strength to be reduced in people with symptomatic FAI, the majority of whom may have had concomitant chondrolabral pathology[1,7]. If so, then the findings of Casartelli et al.[33] together with those from the current study suggest that impairments in hip muscle strength are more likely to be present once the degenerative process has commenced (painful FAI and chondrolabral pathology).

It is important to understand the possible consequences of reduced hip muscle strength in people with chondrolabral pathology, as this impairment may affect the progression of degenerative hip joint disease[34,35]. It is unclear whether lower muscle strength is a consequence of pain inhibition, alterations in muscle activation, muscle atrophy, or a combination of all of these factors. Previously, altered gluteal muscle activation has been reported in people with unilateral hip OA[34,36]. Furthermore, hip abductor and extensor atrophy has been shown to be present in people with advanced hip OA[37]. Possible causes of the alterations in hip muscle strength seen when chondropathy is present warrants further investigation, as hip muscle strength has the potential to lead to abnormal intra-articular hip joint loads[29], which may result in increased pain[29], remodelling of articular cartilage and subchondral bone[38,39], and ultimately OA[38,39]. Therefore, interventions that improve hip muscle strength may have the potential to restore normal hip joint loading patterns, and possibly minimise further hip joint degeneration. Strengthening interventions have been demonstrated to improve symptoms and function in advanced hip OA[40,41] and also reduce the risk of a THA[16]. Consequently, interventions targeting strength deficits in people with chondrolabral pathology following hip arthroscopy may improve symptoms and function, and possibly alter the progression of hip degenerative change.

Interestingly, we found that an interaction existed between group and sex for hip abduction strength. Women with chondrolabral pathology had lower hip abductor strength compared to healthy women; however a similar effect was not seen in men. An interaction effect was also not observed for any other impairment measures. The reason for this effect is unclear, although there are several explanations that may have contributed to this result. For example, it may be a consequence of muscle inhibition. A reduction in gluteal muscle activation in functional activities involving hip abduction has been reported in people with induced hip pain and effusion[42]. Therefore, women with chondropathy may present with greater pain-associated inhibition of the hip abductors. In addition, the extent of the inhibition may be compounded in women due to the mechanical disadvantage of the female pelvis[43], and the reported sex-based differences in hip muscle strength[44].Women have a greater normalized bi-trochanteric width than men[45], which may alter the lines of action of the hip abductors in the frontal plane and adversely affect their ability to generate an abductor moment. Studies have also demonstrated that women have lower hip abduction torque than men when normalized for body weight[46]. While the reason for this finding is unclear and requires further research, it would appear that women with chondrolabral pathology require targeted interventions to strengthen the hip abductor complex as a priority.

Rehabilitation is commonly recommended following hip arthroscopy[47,48]. The duration of previously reported rehabilitation protocols vary from 16 weeks to 24 weeks[47,48]. Patients in this study were offered post-operative rehabilitation with a physiotherapist of their own choice which was not standardised. While we cannot comment on the pre-operative status or how much change has occurred in the post-operative period, the current study does provide evidence that impairments in hip strength and ROM exist post-operatively for at least 12-24 months. Therefore, it is possible that extended duration of rehabilitation programs may be needed, especially for female patients with chondrolabral pathology who demonstrated the greatest impairments. Given the large economic and societal burden associated with hip OA, future studies examining the effects of targeted rehabilitation programs on symptoms associated with early hip OA in both sexs are warranted.

Our study has some limitations. We did not examine the change in physical impairments in people over time. However, we chose to record data 12-24 months post arthroscopy, as recovery from surgery is generally assumed be complete at this time point. There were a greater proportion of women in the healthy group. However, as our analysis was conducted examining the effect of sex and reported significant effects for sex, this imbalance in sex proportion is unlikely to have changed the outcomes reported. Patients were included based on the presence of chondrolabral pathology, not abnormal hip morphology such as FAI or hip dysplasia. Pre-operative radiographs were not available for this study to determine hip morphology. Patients were not allocated to additional groups based on morphology as the aim of this study was to determine the impact of chondrolabral pathology on impairments, regardless of the underlying cause of the chondrolabral pathology present in the hip arthroscopy group. As morphology may lead to variations in physical impairments, it is possible this may have influenced our results. Further longitudinal studies with large sample sizes could enable comparisons between multiple groups based on morphology, in addition to sex and chondrolabral pathology, to evaluate this potential relationship further. Finally, the difference in body mass between healthy subjects and hip arthroscopy patients may have resulted in participants with lower body mass (healthy group) appearing to be stronger than those with higher body mass (chondrolabral group) when peak torque measures were normalised for body weight. The normalising of torque measures for body weight is important, as heavier participants should be able to generate higher peak torques than lighter participants, and so greater normalised peak torque measures are likely to reflect real differences in strength.

In conclusion, the current study identified that people with chondrolabral pathology had lower hip IR ROM, greater hip extension ROM; and greater adduction, extension, flexion and internal rotation strength than healthy controls. In addition, women exhibited greater impairments than men. Since the impairments are consistent with those observed in people with established hip OA, targeting these impairments in people with hip chondrolabral pathology may have long term implications for the progression of hip-related symptoms or disease.

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Contributions

Joanne Kemp contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and the final approval of the submitted version.

Anthony Schache contributed to the conception and design of the study, analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and the final approval of the submitted version.

Michael Makdissi contributed to the conception and design of the study, *analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and the final approval of the submitted version.*

Michael Pritchard contributed to the acquisition of data, analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and the final approval of the submitted version.

Kevin Sims contributed to the analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and the final approval of the submitted version.

Kay Crossley contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and the final approval of the submitted version.

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