Clinical Biomechanics 84 (2021) 105348

Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

Association between severity of hip chondrolabral injuries, dynamic hip muscle strength and quality of life: A cross-sectional study in patients with femoroacetabular impingement syndrome scheduled for hip arthroscopy

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ARTICLE INFO

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Keywords:
Arthroscopy
Rehabilitation
Muscle strength
Isokinetics
Quality of life
Cartilage

ABSTRACT

Background: We assessed the association between: the severity of hip chondral or labral pathology with dynamic hip muscle strength or quality of life in patients with femoroacetabular impingement syndrome scheduled for hip arthroscopy. We also assessed the association between dynamic hip muscle strength with quality of life.

Methods: Eighty-three participants with femoroacetabular impingement syndrome scheduled for hip arthroscopy were included. We measured dynamic hip abduction and adduction muscle strength with an isokinetic dynamometer (Nm/kg), and quality of life with the iHoT-33 questionnaire. The severity of hip chondrolabral pathologies was scored using the modified Beck classification. Linear regression analyses were conducted to assess the association between severity of hip chondral or labral pathology with dynamic hip muscle strength and quality of life.

Findings: The regression analyses showed no association between the (i) severity of hip chondral (adjusted r^2: 0.14) or labral (adjusted r^2: 0.08) pathology and quality of life ($P > 0.05$), (ii) between the severity of hip chondral or labral pathology and dynamic hip abduction and adduction muscle strength ($P > 0.05$). Significant correlation was observed for quality of life and hip abduction (adjusted r^2:0.29; $P < 0.001$) or adduction (adjusted r^2: 0.32; $P < 0.001$) muscle strength.

Interpretation: The severity of hip chondral or labral pathologies were not associated with quality of life or dynamic hip muscle strength in participants with femoroacetabular impingement syndrome. Greater dynamic hip abduction and adduction muscle strength were associated with better quality of life in participants with femoroacetabular impingement syndrome scheduled for hip arthroscopy.

1. Introduction

Femoroacetabular impingement (FAI) syndrome is defined as a motion related disorder of the hip, presenting a symptomatic premature contact between the proximal femur and acetabulum findings (Griffin et al., 2016). Patients with FAI syndrome present by a triad of symptoms, clinical signs and image findings (Griffin et al., 2016). The early contact between proximal femur and acetabulum is typically caused by the irregular shape of the femur (cam morphology) and/or acetabulum (pincer morphology), resulting in deterioration of the acetabular labrum, hip chondropathy and hip osteoarthritis (Khan et al., 2016; Kowalczuk et al., 2015). Hip arthroscopy is one of the most commonly used interventions to address FAI syndrome and chondrolabral pathologies, with 50.000 procedures in the U.S. per year and a rise of 727% in England between 2002 and 2013 (Palmer et al., 2019).

Patients with FAI syndrome present a prevalence of 72% of hip chondropathy or severe labral tears at hip arthroscopy (Kemp et al., 2012; Nepple et al., 2011). Individuals with severe hip chondropathy have poorer quality of life when compared to individuals with mild chondropathy one to two years after hip arthroscopy (Filbay et al.,

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https://doi.org/10.1016/j.clinbiomech.2021.105348
Received 12 November 2020; Accepted 30 March 2021
Available online 2 April 2021

2016). However, there is a paucity of evidence about the association between the severity of hip chondrolabral pathologies and quality of life in patients scheduled for hip surgery. The severity of hip chondrolabral injuries presented very weak association to quality of life before hip arthroscopy in military individuals with FAI syndrome (Freke et al., 2019a). It is unclear whether this lack of association is also present in a non-military population with lower levels of physical activity.

Patients with chondrolabral injuries presented hip muscle strength impairments after hip arthroscopy (Kemp et al., 2014a). Also, individuals with hip labral injuries presented lower hip muscle strength compared to controls (Mendis et al., 2014). The severity of hip chondrolabral injuries was previously associated with male sex and increasing age (Ishøi et al., 2019; Nakashima et al., 2019). The association between the severity of hip chondrolabral injuries and hip muscle strength is poorly understood.

Hip muscle strength is associated with quality of life or functional performance before and after hip arthroscopy (Freke et al., 2018; Kemp et al., 2016a, 2016b). For example, one study reported greater hip adduction strength to be associated with better dynamic postural control in patients scheduled for hip arthroscopy (Freke et al., 2018). Another study reported hip muscle strength impairments to be associated with lower level of quality of life after hip arthroscopy in patients with chondrolabral injuries (Kemp et al., 2016a). Greater hip abduction and adduction strength were, respectively, associated with better functional performance and higher quality of life in patients with hip chondrolabral pathology 1–2 years after hip arthroscopy (Kemp et al., 2016a, 2016b). Despite the influence of hip muscle strength in functional outcomes prior to surgery and in quality of life outcomes after surgery few studies investigated the association of hip muscle strength in the quality of life before hip arthroscopy (Freke et al., 2019b).

A recent study using handheld dynamometry demonstrated that lower isometric hip muscle strength was associated with poorer quality of life in individuals with hip chondrolabral pathology scheduled for arthroscopy (Freke et al., 2019a). Although handheld dynamometry is easy to apply in clinical setting, it does not assess the dynamic function of hip muscles. The isokinetic dynamometry is widely accepted as the reference standard for assessing hip muscle performance under dynamic conditions (de Castro et al., 2020). Since FAI syndrome is a motion related disorder (Griffin et al., 2016), a dynamic evaluation might better determine strength deficits related to FAI syndrome.

Understanding the association between the severity of hip chondrolabral injuries or hip muscle dynamic strength with quality of life in patients scheduled for hip arthroscopy will help designing or optimizing rehabilitation programs for patients with FAI syndrome. This study aimed to explore the association between: (i) severity of hip chondrolabral pathology and quality of life; (ii) severity of hip chondrolabral pathology and dynamic hip muscle strength and (iii) dynamic hip muscle strength and quality of life.

2. Methods

2.1. Study design

This was a cross-sectional study conducted at the Labclin Neuromusculoskeletal Rehabilitation and Clinical Biomechanics Laboratory in Florianópolis, Brazil. This study was approved by the local ethical committee with the protocol number of CAAE 96023618.0.0000.0118 (Brazil). All individuals provided written informed consent before participating in the study.

2.2. Participants

Individuals with hip pain were assessed by one experienced hip surgeon between January and November 2019. The surgeon has already performed approximately 2000 hip arthroscopies throughout his 15 years of practice. Patients were elected for surgery if they presented an Alpha angle >55° (cam morphology) and/or lateral center edge angle >39° (pincer morphology); hip pain; positive FADIR test, and no improvement of symptoms after conservative treatment.

All scans were performed using the GE LightSpeed VCT 64-slice CT scanner (General Eletric Healthcare, USA) or Canon Aquilion Lightning 80-slice CT (Canon medical System). Positioning of participants in the scanner was standardized with the legs in neutral abduction/adduction, 15° internally rotated foot and with the patellae pointing upwards. The pelvis was scanned from the anterior superior iliac spines to the lesser trochanters, with 1-mm collimation. Coronal and 3D reformats were then performed with a workstation. Using these images, acetabular version was then measured in the axial plane, after correction for pelvic tilt in the sagittal plane, at the superior (8 mm below the subchondral surface of acetabulum) and at the equator of the femoral head (Dandachli et al., 2011). Measurements of acetabular version on cross-sectional imaging were more reliable than to those obtained in radiographs and when correction for pelvic tilt was done (Dandachli et al., 2009). The acetabular coverage was measured according to the centre-edge method of Wiberg (Mascarenhas et al., 2020). The head-neck offset was measured as follows: a line bisecting the longitudinal axis of the femoral neck is drawn (using the narrowest portion of the neck); then, parallel lines tangent to the anterior border of the femoral head and neck are drawn. The perpendicular distance between these two lines was the anterior "offset". In this same image, the alpha angle was measured between the axis of the femoral neck and a line connecting the center of the femoral head and the point at which the femoral head bone first exceeds a circular template covering the femoral head (Nötzli et al., 2002). An alpha angle of 55° was used as threshold. Increasing the threshold will increase specificity, but that would decrease sensitivity. In addition, it is important to consider that some patients above that cut-off remained asymptomatic (Mascarenhas et al., 2018). The femoral neck version angle was obtained after the fusion of the axial images of the femoral neck and femoral condyles.

The FADIR test was performed in the supine position with passive movement of the thigh into full flexion, adduction, and internal rotation. The FADIR test presents high sensitivity and low specificity and can be used to rule out patients with FAI syndrome when the results are negative (Pålsson et al., 2020; Reiman et al., 2015). The Warwick agreement (Griffin et al., 2016) recommends the FADIR test as part of the diagnosis of individuals with FAI syndrome despite its psychometric limitations .

Inclusion criteria were: scheduled hip arthroscopy; FAI syndrome identified by the surgeon; and, being aged between 18 and 60 years. Participants were excluded if they only could walk with assistance; had undergone another hip surgery in the last two years; presented a previous history of Perthes disease, hip dysplasia (center edge angle <25°) (Beck et al., 2005), or any kind of neurological sequel. If patients underwent bilateral surgery, the most affected side, as informed by the patient through the iHOT-33, was used in the analysis.

2.3. Procedures

Between one and four weeks before surgery, quality of life, hip abduction and adduction muscle strength, body height and body mass were assessed in a clinical setting. During the surgical procedure images were recorded for the determination of the severity of hip chondral and labral pathology. The surgeon, who was blind to the muscle strength and quality of life results, performed the analyses of images. The same surgeon (RPC) operated all surgical procedures.

2.4. Outcome measures

The primary outcome measures were dynamic hip muscle strength, severity of hip chondrolabral pathology and quality of life.

2.4.1. Dynamic hip muscle strength

We used a HUMAC NORM Isokinetic Extremity System (Computer Sports Medicine Inc. Stoughton, MA) to measure abductor and adductor concentric muscle strength (Fig. 1). Isokinetic testing of hip muscle strength in patients with FAI syndrome is reliable and represents the dynamic function of hip muscles (Mayne et al., 2017). Tests were performed in the standing position as previously described (Claiborne et al., 2009). We adopted a range of motion of 30°, starting with hip neutral position and ending at 30° of hip abduction (Fig. 1). The dynamometer axis of rotation was aligned perpendicular to the projection of the hip joint center of rotation. The moving arm of the dynamometer was fixed two fingers above the lateral femoral epicondyle. We weighted participants' lower limbs and used gravitational corrections to account for the effect of the lower limb and dynamometer arm weight on torque measurements. Before the test, all participants were oriented to perform five repetitions as a warm-up, and three submaximal to maximal effort repetitions as a familiarization. Following 30 s as a rest, the participants performed three maximal effort repetitions and received verbal encouragement from the researcher during the test procedure. All tests were performed bilaterally and at a pre-set angular velocity of 30°*/sec*. We extracted the peak torque from the isokinetic waveforms as a measure of muscle strength. Peak torque was normalized by body mass (unit Nm/kg).

Fig. 1. Isokinetic hip abduction and adduction strength assessment.

2.4.2. Severity of hip chondral and labral pathology

We used a Stryker SDC Classic Digital Capture System with the Stryker 1288 HD Camera System (Striker™, Kalamazoo, MI) to record the images for determination of chondral and labral pathology. The severity of chondral pathology on the acetabulum was assessed using the modified Beck classification (Beck et al., 2005), which presents proper inter-observer reliability (Nepple et al., 2012). Chondral pathology was graded in five degrees: normal (0); malacia (1); debonding (2); cleavage (3) and defect (4). Labral pathology were also graded in five degrees: (0) normal; (1) degeneration; (2) full thickness tear; (3) detachment and (4) ossification (Beck et al., 2005). The severity of chondral pathology on the head of the femur was not assessed.

2.4.3. Quality of life

Quality of life data was assessed by the International Hip Outcome Tool (iHOT-33) (Portuguese version). This questionnaire uses a visual analog scale to evaluate the quality of life of patients with hip pathology (Mohtadi et al., 2012) and presents a minimum score of zero (worst possible outcome) and a maximum score of 100 (best possible outcome). The Patient-Reported Outcome Measure (PROM) has appropriate psychometric properties in the hip arthroscopy population and presents a minimal important change value of 10 points (Kemp et al., 2013).

2.5. Statistical analysis

All statistical analyses were conducted using the software R (R Core Team., 2016). We used ordinary least squares (OLS) regression models using the lm function from stats package in R (R Core Team., 2016). The OLS models were used to regress: (i) quality of life (dependent variable) on severity of hip chondral or labral pathology (independent variable); (ii) quality of life (dependent variable) on dynamic hip abduction and adduction muscle strength (independent variables); and (iii) dynamic hip abduction or adduction muscle strength (dependent variables) on severity of hip chondral and labral pathology (independent variables). We used body mass and age as covariate for the regression models. For those analyses, alpha was set at 0.05.

For all regression analyses, severity of hip chondral pathology was considered an ordinal variable with 5 levels (normal = 0; malacia = 1; debonding = 2; cleavage = 3 and defect = 4); severity of hip labral pathology was considered an ordinal variable with 5 levels (normal = 0; degeneration = 1; full thickness tear = 2; detachment = 3; and ossification = 4), quality of life was considered a continuous variable (with scores ranging from 0 to 100); and dynamic hip abductor and adductor muscle strength were considered as continuous variable.

We conducted separated OLS regression models for dynamic hip abductor muscle strength, dynamic hip adduction muscle strength, severity of hip chondral pathology, and severity of hip labral pathology. The data from the following regression analyses did not meet assumption for homoscedasticity: (1) dynamic hip abduction muscle strength on severity of hip labral pathology; (2) quality of life on severity of hip labral pathology; (3) quality of life on dynamic hip muscle adduction strength; (4) quality of life on dynamic hip abduction muscle strength. Therefore, for those analyses we used robust linear regression using the lmrob function from WRS2 package (Field and Wilcox, 2017).

3. Results

Ninety-two patients were evaluated and 83 patients (48% women and 52% men) fulfilled all inclusion criteria. Participants characteristics are described in Table 1.

There was no correlation between any grade of the severity of chondral (adjusted $r^2 = 0.20$, $P > 0.05$) or labral pathology (adjusted $r^2 = 0.15$, $P > 0.05$) and quality of life (Table 2).

Severity of chondral (adjusted $r^2 = 0.16$, $P > 0.05$) and labral

Table 1
Patients demographic and clinical.

Characteristics	Descriptive statistics (mean and standard deviation; or n and percentage)
Age (years)	39 (9.92)
Females, n (%)	40 (48.2%)
Body mass (kg)	74.5 (14.54)
Height (cm)	170 (0.99)
BMI (kg/m^2)	25.2 (3.38)
Bilateral Surgery, n (%)	41 (49%)
iHOT-33	36.3 (18.41)
Chondral injury	**n, (%)**
Grade 0	7 (8.4%)
Grade 1	35 (42.2%)
Grade 2	11 (13.3%)
Grade 3	17 (20.5%)
Grade 4	13 (15.7%)
Labral injury	**n, (%)**
Grade 0	2 (2.6%)
Grade 1	43 (55.1%)
Grade 2	5 (6.4%)
Grade 3	27 (34.6%)
Grade 4	1 (1.3%)
Hip abduction peak torque (Nm/kg)	1.69 (0.40)
Hip adduction peak torque (Nm/kg)	1.07 (0.47)

iHOT-33 scores range between 0 and 100 with 0 representing the worst possible outcome. Chondral and labral injuries were assessed using the Beck classification. Scores can range between 0 and 4 with 0 representing no chondral or labral injury.

pathology (adjusted $r^2 = 0.19$, $P > 0.05$) were not associated to dynamic hip abduction muscle strength (Table 2). Severity of chondral (adjusted $r^2 = 0.23$, $P > 0.05$) and labral pathology (adjusted $r^2 = 0.19$, $P > 0.05$)

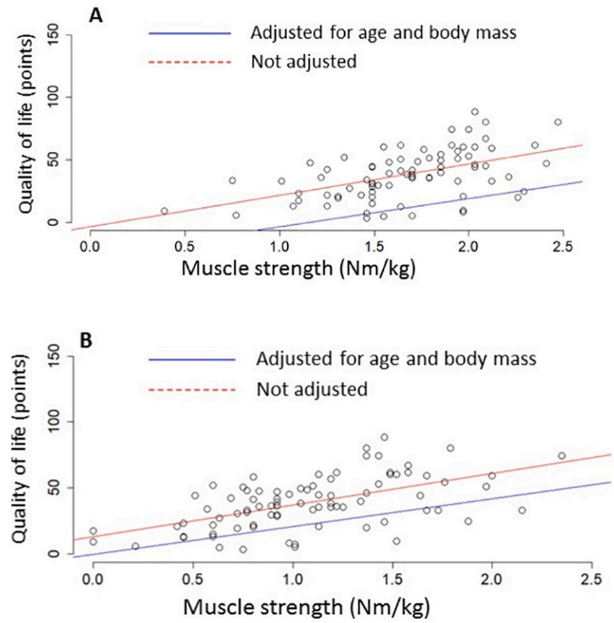

Fig. 2. A. Association between quality of life and dynamic hip abduction muscle strength; B. Association between quality of life and dynamic hip adduction muscle strength. Quality of life scores range between 0 and 100 with 0 representing the worst possible outcome.

Table 2
Regression linear models for association between quality of life, dynamic hip abduction or adduction muscle strength, and severity of hip chondral or labral pathologies.

Dependent variable	Predictor	Regression coefficient (SE)	t-value	*P*-value	r^2	Adjusted r^2
Quality of life	Chondral pathology			0.0063	0.205	0.143
	Grade 1	−6.89(8.13)	−0.84	0.39903		
	Grade 2	10.87(7.15)	1.52	0.13266		
	Grade 3	−6.56(4.99)	−1.31	0.19254		
	Grade 4	−5.38(4.97)	−1.08	0.28304		
	Labral pathology			0.0865	0.153	0.086
	Grade 1	10.35(9.60)	1.20	0.23280		
	Grade 2	12.46(9.29)	1.50	0.13716		
	Grade 3	3.30(4.51)	0.68	0.49442		
	Grade 4	1.73(6.65)	0.26	0.79483		
	Hip abduction strength	22(4.60)	4.89	**< 0.01**	**0.320**	**0.294**
	Hip adduction strength	21(4.16)	5.06	**< 0.01**	**0.351**	**0.327**
Hip abduction strength	Chondral pathology			0.6923	0.038	−0.024
	Grade 1	0.12(0.70)	0.70	0.480		
	Grade 2	−0.01(0.15)	−0.10	0.913		
	Grade 3	0.04(0.11)	0.41	0.682		
	Grade 4	−0.10(0.11)	−0.98	0.326		
	Labral pathology			0.1859	0.077	0.017
	Grade 1	0.51 (0.10)	4.95	0.0176		
	Grade 2	−0.13(0.13)	−1.05	0.2959		
	Grade 3	0.29(0.07)	3.75	0.0003		
	Grade 4	0.11(0.12)	0.86	0.3907		
Hip adduction strength	Chondral pathology			0.2958	0.074	0.014
	Grade 1	0.22(0.19)	1.13	0.259		
	Grade 2	0.21(0.18)	1.16	0.246		
	Grade 3	0.09(0.12)	0.73	0.461		
	Grade 4	−0.15(0.12)	−1.19	0.273		
	Labral pathology			0.8398	0.025	−0.037
	Grade 1	0.48(0.37)	1.30	0.198		
	Grade 2	0.06(0.33)	0.19	0.848		
	Grade 3	0.24(0.19)	1.23	0.221		
	Grade 4	0.12(0.17)	0.69	0.493		

Chondral and labral pathologies were assessed using the Beck classification. Scores can range between 0 and 4 with 0 representing no chondral or labral pathology. SE, standard error. Bold values highlight significant association between variables.

were not associated to dynamic hip adduction muscle strength (Table 2).

Dynamic hip abduction and adduction muscle strength were positively associated to quality of life (Table 2 and Fig. 2). Greater dynamic hip abduction muscle strength was associated with better quality of life (adjusted $r^2 = 0.29$, $P < 0.001$), indicating that for every additional 1 Nm/kg of hip abduction peak torque we can expect an average increase of 22 points in the iHOT-33. Greater dynamic hip adduction muscle strength was also associated with better quality of life (adjusted $r^2 = 0.32$, $P < 0.001$); for this case, every increase of 1 Nm/kg at the hip adduction peak torque we can expect an average increase of 21 points in the iHOT-33 (Table 2).

4. Discussion

The main findings of the current study were that the severity of hip chondral and labral injuries was not associated with quality of life or with dynamic hip muscle strength, and that greater dynamic hip muscle strength was associated with better quality of life in participants with FAI syndrome scheduled for hip arthroscopy. The results from our study represent preliminary evidence that dynamic hip muscle strength is an important outcome to be assessed and targeted when managing those patients. Dynamic hip muscle strength may help improving clinical outcomes, particularly, the quality of life of patients with chondral and labral injuries. Duo to the cross-sectional design of our study, future longitudinal studies are warranted to support dynamic strength as a treatment target for this population.

Our study demonstrated that the severity of hip chondral and labral injuries was not associated to quality of life before hip arthroscopy. Previous studies suggested that patients with severe chondral pathology experienced worse functional levels, satisfaction, pain, and quality of life scores when compared to patients with moderate chondral injuries 18–24 months after hip arthroscopy (Chahla et al., 2019; Filbay et al., 2016; Kemp et al., 2014b). A previous study (Freke et al., 2019b) indicated that severe chondral injury and larger labral tears explained 22% of the variability of PROMs before hip arthroscopy. Their participants were predominantly military. Our participants were not exposed to physical activity levels and mechanical loads such as the military personnel. Hence, our findings have larger external validity to individuals with FAI syndrome presenting a severe clinical condition, since our subjects were scheduled to hip arthroscopy.

Our findings demonstrated that higher values of dynamic hip abduction and adduction muscle strength are associated to better quality of life. These results agree with a previous study demonstrating that patients presenting FAI syndrome and poor quality of life presented significantly less hip muscle strength (Freke et al., 2019a). Our study is the first to associate hip muscle strength and quality of life in the FAI syndrome population using the reference standard for assessing dynamic muscle strength with isokinetic dynamometry. Our regression model indicated that increasing 27% of dynamic hip abduction strength is associated to achieving the minimal important change in quality of life - 10 points at iHot-33 (Kemp et al., 2013). These findings bring into question if patients with FAI syndrome could beneficiate from a rehabilitation process based on specific hip muscle strengthening before arthroscopy. A recent study indicated that a pre rehabilitation intervention did not improve PROM scores in patients with FAI syndrome after hip arthroscopy (Grant et al., 2017). However, this was a small pilot study and exercise prescription was not individualized, making it difficult load progression and hip muscle strength adaptations.

Our study suggests hip abduction and adduction muscle strength are not associated to the severity of hip chondral and labral injuries. These findings raise questions about the association between the hip muscle strength and the structural damage of the hip. Participants with chondrolabral pathologies present hip muscle strength impairments (Kemp et al., 2014a), but the severity of these injuries were not associated with hip muscle strength in our study. The association between hip chondral or labral injuries and hip muscle strength impairments is often explained by the onset of hip degeneration process and subsequent instability and pain which leads to impaired hip neuromuscular control (Dwyer et al., 2013; Herzog et al., 2003). However, several asymptomatic individuals present cam and pincer morphology, labral tears, and chondral damage (Frank et al., 2015; Tresch et al., 2017). It's unclear if hip chondrolabral injuries are a normal process of aging and a non-pathological feature of FAI syndrome or a sign of a pre-symptomatic hip that may develop symptomatic osteoarthritis (Register et al., 2012). Hip muscles are responsible to provide stability and diminish shearing forces at the hip joint just like the passive structures of the hip (Gottschalk et al., 1989; Retchford et al., 2013). This could explain why the severity of hip chondral or labral pathology were not associated with hip muscle strength as the hip muscle strength itself could assist the impaired function of hip passive structures. These findings combined with our data suggests that maybe impairments in hip related quality of life could be better explained by hip muscle strength impairments itself instead of hip chondral and labral pathologies or their severity.

Understanding that hip structure abnormalities and image findings may not influence PROMs in the FAI syndrome population before surgery is important in the rehabilitation process. Symptom severity on patients with FAI syndrome seems to be more related to cognitive processes than the size of labral tears before hip arthroscopy (Jacobs et al., 2017). Patients presenting hip pathology may exhibit significant pain catastrophizing, anxiety, and depression (Hampton et al., 2019). Psychological impairments such as depression and anxiety before hip arthroscopy were related to worse outcomes after surgery in the FAI syndrome population (Cheng et al., 2019). As the magnitude of structural damage was not associated with quality of life in our study, future research may focus in patient education as part of the rehabilitation process to help control fear and anxiety, especially for those patients with substantial chondrolabral pathologies.

This study has limitations. We only analyzed the influence of acetabular structural injuries but did not analyze femoral structural injuries. We consider this not to be an important limitation, given that most chondrolabral injuries in participants with FAI syndrome are located at the acetabulum (Kaya et al., 2016). In addition, some subjects underwent bilateral surgery, and it is unclear how that could affect their hip muscle strength. Given the cross-sectional nature of the study, we cannot indicate causal effects between the variables analyzed. Future research should use prospective cohort design to confirm whether there is a causal effect between the severity of hip chondral or labral injuries and hip muscle strength and quality of life following hip surgery.

5. Conclusions

Our findings suggest that the severity of hip chondral or labral injuries were not associated with quality of life, dynamic hip abduction or adduction muscle strength in participants with FAI syndrome scheduled for hip arthroscopy. Dynamic hip abduction and adduction muscle strength were associated with quality of life in a group of participants who were scheduled for hip arthroscopy for managing FAI syndrome.

Declaration of Competing Interest

The authors confirm that they have no financial or involvement with any commercial organization that has a direct financial interest in any matter included in this manuscript.

Acknowledgements

D.C.R is funded by the Sir Charles Hercus Health Research Fellowship (18/111) – Health Research Council of New Zealand. The authors thank Dr. Daniel Sandrini de Castro for his assistance with the measures of scans.

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