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Does hip muscle strength and functional performance differ between football players with and without hip dysplasia?

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ABSTRACT

Objective: To compare hip muscle strength and functional performance in football players with and without hip dysplasia and investigate if the relationships were modified by sex.
Design: Cross-sectional study.
Methods: This study compared football players with hip dysplasia (HD group) and without hip dysplasia (control group). Hip muscle strength (Nm/kg) and functional task performance were assessed in both groups. Linear regression with generalized estimating equations were used to assess differences between groups. Sex was assessed as a potential effect modifier.
Results: 101 football players were included (HD group, n = 50, control group, n = 51). There was no difference in hip muscle strength or functional performance between the HD group and the control group. Results ranged from hip extension strength (Estimate −0.13.95%CI: 0.29 to 0.02, P = 0.087) to hip external rotation strength (Estimate 0.00.95%CI: 0.05 to 0.05, P = 0.918). No relationships were modified by sex or age.
Conclusions: Similar levels of hip muscle strength and functional performance were found in active football players with and without hip dysplasia. These findings differ from other studies. This may be due to our cohort having less advanced hip dysplasia than the surgical populations that have been previously investigated, or due to a beneficial effect of football participation on muscle strength and functional performance in people with hip dysplasia.

1. Introduction

Hip dysplasia is a common cause of hip-related pain (Reiman et al., 2020) but is often misdiagnosed (Nunley et al., 2011). Characterized by a shallow or poorly orientated acetabulum (Harris et al., 2021), hip dysplasia is often associated with physical impairments (e.g., reduced hip strength) (O'Brien et al., 2022), hip and groin pain (O'Brien et al., 2023) and a two-fold greater odds of progression to hip osteoarthritis than people without hip dysplasia (Casartelli et al., 2021; Saberi Hosnijeh et al., 2017). In athletic populations, research investigating hip dysplasia is scarce, with current literature focusing on people with hip dysplasia undergoing surgical treatments (O'Brien et al., 2022; Jacobsen et al., 2021; Parilla et al., 2022).

Football players commonly report hip and groin pain, with approximately half (40-53%) experiencing pain during a competition season (Esteve et al., 2020; Langhout et al., 2019). The prevalence of hip

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dysplasia in these athletes is difficult to establish due to variable diagnostic criteria. Recently proposed assessment guidelines for hip dysplasia encourage a lateral-centre-edge angle (LCEA) of <25° to be considered for diagnosis (Bali et al., 2020; McClincy et al., 2019; Wilkin et al., 2017). In a cohort of women soccer players, hip dysplasia was identified in 16% when using an LCEA <20° cutoff, but this increased to 66% when an LCEA of <25° was used (Kapron et al., 2015). Hip dysplasia may be more common in football players than previously thought, though little is known about the extent of modifiable physical impairments (e.g., reduced hip strength) and the natural history of those with this joint condition.

Hip and groin pain that is commonly experienced in both football players and people with hip dysplasia, could suggest that football players with hip dysplasia have particularly poor outcomes. Conversely, the muscle force generation and control required to play football may provide strength and stability to improve outcomes for this group. Muscle strength and functional performance in football players with or without hip dysplasia could also be influenced by factors such as sex. Women exhibit different physical impairments when experiencing hip-related pain (King et al., 2019) and are four-times more likely to present for treatment for hip dysplasia compared to men (Sankar et al., 2017). Understanding relationships between physical impairments and demographic characteristics may improve treatment selection and outcomes in those with hip dysplasia.

The primary aim of this study was to compare hip muscle strength and functional performance between football players with hip dysplasia and football players without hip dysplasia. The secondary aim was to investigate if the relationships were modified by sex.

2. Methods

2.1. Study design

This observational cross-sectional study used baseline data from participants in the Femoroacetabular impingement and hip OsteoaRthritis Cohort (FORCe) study (Crossley et al., 2018a). This is a longitudinal cohort study evaluating symptoms and hip joint structural change over two years in football (soccer and Australian football) players. The FORCe study had 184 symptomatic football players, and 55 control football players, at baseline.

For this present study, symptomatic football players with radiographic verified hip dysplasia (LCEA <25 °) (Clohisy et al., 2008) formed the hip dysplasia (HD) group, and control football players without radiographic hip dysplasia (LCEA between 25 ° and 40 °) formed the control group. Hips with an LCEA of above 40° were excluded as this could represent acetabular overcoverage (Mascarenhas et al., 2021). Both limbs could be included in the study if the above criteria were met bilaterally. Ethical approvals were obtained from the La Trobe University Human Ethics Committee (HEC015-019 and HEC016-045) and the University of Queensland Human Ethics Committee (20150000916 and 2016001694). We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2008).

2.2. Participants

All football players were undertaking at least two football sessions (training/matches) per week in structured, sub-elite (non-professional) competitions in Melbourne and Brisbane, Australia, between August 2015 and October 2018. Eligibility criteria for participants are described in detail in Table 1. Participants were recruited through print, electronic, and social media advertisements to football clubs and leagues, and direct advertisement to sports medicine and physiotherapy clinics.

Demographic and anthropometric data including sex, age, height, and body mass were recorded at the beginning of the testing session. Each participant completed the International Hip Outcome Tool 33 (iHOT-33) (Mohtadi et al., 2012) and the Copenhagen Hip and Groin Outcome Score (HAGOS) (Thorborg et al., 2011). The iHOT-33 was completed for the most symptomatic hip only, whilst the HAGOS is completed at a per-person level.

Table 1
Participant inclusion and exclusion criteria.

Inclusion criteria		Exclusion criteria	
Women or men aged 18-50 years old		Unable to understand English	
Playing or training at least two sessions per week of football (soccer or Australian Football)		Kellgren & Lawrence grade ≥2 (defined as definite presence of OA, with minimal severity) on anteroposterior radiograph Lumbar spine or lower limb injury/complaint in the previous 3 months (e.g., hamstring injury, ankle sprain etc.) resulting in inability to weight bear or undertake testing	
Football players with hip/groin pain	Control players	Football players with hip/groin pain	Control players
At least 6-month history of insidious onset hip and/or groin pain	Negative FADIR bilaterally	Planned lower-limb surgery	Self-reported history of hip/groin pain
LCEA <25°	LCEA 25° – 40°	LCEA >25°	LCEA <25° or >40°
Average hip/groin pain >3 and < 8 on an 11-point NPRS[a] with football-specific movements (squatting, kicking, or cutting/change of direction), with or without symptoms, including clicking, giving way, locking, or catching		Previous hip surgery	Previous lower limb surgery
Positive FADIR in at least one hip		Other diagnosis of a significant hip condition, i.e. o Trauma, o Rheumatoid arthritis, o Perthes disease, o subluxation, o Slipped upper femoral epiphysis, o Osteochondritis dissecans, o Bursitis or tendinitis. Intra articular hip injection in the past 3 months	Self-reported significant hip or groin condition, i.e. o Trauma, o Rheumatoid arthritis, o Perthes disease, o subluxation, o Slipped upper femoral epiphysis, o Osteochondritis dissecans, o Bursitis or tendinitis.

FADIR - Flexion-adduction-internal rotation test; LCEA – Lateral-centre-edge angle; NPRS – numerical pain rating scale. [a]Use of the NRPS in symptomatic football payers is a deviation from the original study protocol (Crossley et al., 2018b).

2.3. Acetabular morphology

All participants underwent a supine anteroposterior (AP) pelvis radiograph taken with standardised protocols (Crossley et al., 2018a). A physiotherapist (J.H.), with 10 years of experience and training in the methodology and who was blinded to hip classification, analysed bony hip morphology using quantitative methods (Agricola et al., 2013). A point set was transposed over the radiological image of the femur and acetabulum to identify predetermined anatomical locations, using statistical shape modelling software (active shape model toolkit; The University of Manchester, Manchester, UK). The LCEA was then calculated using MATLAB Version 7.1.0 (The MathWorkds, Inc, Natick, MA). The LCEA on the AP pelvic radiograph describes the superolateral coverage of the femoral head by the acetabulum (see APPENDIX A). Moderate-to-good intra- (ICC = 0.94) and interrater reliability (ICC = 0.63) were demonstrated for LCEA measures (Heerey et al., 2021). The LCEA was analysed using continuous and threshold values, with an LCEA of less than 25° used to define hip dysplasia (Clohisy et al., 2008; Mosler et al., 2016).

2.4. Strength

Isometric muscle strength was assessed using hand-held dynamometry for hip flexion, extension, abduction, adduction, internal and external rotation planes via a "make test" protocol (Crossley et al., 2018a). In addition, the participants performed hip abduction and hip adduction eccentric strength "break" tests (Crossley et al., 2018a). The JTECH medical Commander muscle tester™ (Midvale, United States of America) was used to assess strength in standardised positions based on previously used methods (Crossley et al., 2018a). All participants performed one sub-maximal familiarisation test for each hip muscle group, followed by 3 maximum voluntary contractions. Intra-rater reliability for hip muscle strength testing protocol has been established in the FORCe cohort with intraclass correlation coefficient (ICC) ranging from 0.74 to 0.96[28].

2.5. Functional task performance

Functional performance tasks included the single leg hop for distance (Kemp et al., 2013a), side bridge endurance test (Kemp et al., 2013a) and single leg rise test (Culvenor et al., 2016/07). All functional performance tasks were standardised (Crossley et al., 2018a), reliable (Kemp et al., 2016; Mosler et al., 2020; Woon et al., 2021), and relevant for this population (Mosler et al., 2020). Participants performed functional performance tasks on each limb with a 5-min rest to ensure recovery between tests. A detailed description of the tasks has been published (Crossley et al., 2018a).

Single-leg hop for distance (HFD) (Kemp et al., 2013b): participants were instructed to place their hands behind their back and stand on one leg behind a line. They were then instructed to hop forward, as far as they could and land, maintaining their landing position (without stumbling or putting their contralateral foot on the ground) for 3 s (s). The distance (cm) was recorded from the start line to the heel of their landing leg. One practice attempt was performed, with continual repetitions completed until three successful trials were obtained for each limb.

Side bridge (SB) endurance (Kemp et al., 2013b): with the testing side down, participants started in side-lying with their opposite hand on their chest, hip and knees extended, and feet together. Participants applied force through the forearm and foot on the testing side to lift their pelvis from the floor. Participants were asked to maintain this position for as long as possible. The time(s) was recorded with a stopwatch from the moment the lateral hip left the ground until when the lateral hip touched the ground. One trial only was completed per side.

Single leg rise test (Culvenor et al., 2016): participants started in a seated position with the hip and knee of the testing leg at 90° flexion and their heel placed on a line 10 cm from the edge of the plinth. The contralateral leg was placed in 45° of knee flexion in the starting position with participants instructed to keep their contralateral foot off the ground during the test. With arms crossed over their chest, participants were asked to move from sitting to standing (and return to sitting) in time with a metronome at a speed of 45 counts per minute, with a single leg rise being completed over two counts i.e. one count up/one count down. A warning was given if the contralateral foot touched the ground or descent was inadequately controlled. If three warnings were given, the test was stopped. Participants stopped at 50 repetitions or when they were no longer able to continue, and the total number of repetitions were recorded.

2.6. Data analysis

Peak strength (N) was converted to a mass normalized torque (Nm/kg) by multiplying peak strength by the lever arm (perpendicular distance from the centre of rotation to the position of the dynamometer) and dividing it by the participants mass. Continuous demographic data were summarized using medians and interquartile range [IQR] values. All statistical analyses were performed in R (R, R foundation for Statistical computing) with $\alpha = 0.05$ for all analyses. Linear regression with generalized estimating equations (GEE) were used to determine if strength and functional performance differed between the HD Group and Control group. Interaction terms (muscle strength ~ group + sex + group*sex or functional performance task ~ group + sex + group*sex) were added individually to each model to assess if sex was a possible effect modifier. Data was to be stratified if there was evidence of an interaction ($P < 0.05$). Interaction terms were removed if not significant ($P > 0.05$) and all analyses were controlled for age and sex, due to their potential influence on the relationship between the groups and the dependent variable (hip muscle strength or functional performance task) (Bonello et al., 2023; Roughead et al., 2022).

3. Results

3.1. Participant demographic characteristics and recruitment

A total of 101 football players were included in this study. The HD group consisted of 50 football players (26% female), with 59 hips included (Fig. 1). The control group consisted of 51 people (27% female) with 87 hips included (Fig. 2). Detailed characteristics of both groups are presented in Table 2.

3.2. Comparison of hip muscle strength between HD group and controls

There was no difference in hip muscle strength between the HD group and the Control group. Results ranged from hip extension strength (Estimate −0.13.95%CI: 0.29 to 0.02, P = 0.087) to hip external rotation strength (Estimate 0.00.95%CI: 0.05 to 0.05, P = 0.918) (Table 3). No relationships were modified by sex.

3.3. Comparison of functional performance task between HD group and controls

There was no difference in functional performance task between the HD group and the Control group. Results ranged from one-leg-rise test (Estimate 2.13.95%CI: 2.95 to 7.21, P = 0.410) to the side bridge test (Estimate −2.47.95%CI: 15.02 to 10.06, P = 0.698) (Table 3). No relationships were modified by sex.

4. Discussion

We aimed to compare hip muscle strength and functional performance between football players with and without hip dysplasia, and to examine whether these relationships were modified by sex. The results of this study showed no differences between football players with and without hip dysplasia, regardless of sex.

Previous studies examining outcomes in people with hip dysplasia have investigated people before and/or after orthopaedic surgery, with no known studies of active football players with hip dysplasia. Prior reports of people with hip dysplasia being weaker than controls appear to report on a more debilitated group of hip dysplasia participants than our study. Jacobsen (2021) found 13-34% lower hip strength in adults with hip dysplasia compared to a healthy group (Jacobsen et al., 2021). Compared to our athletic hip dysplasia group, the Jacobsen (2021) patients reported approximately 30% worse pain, function and sports and

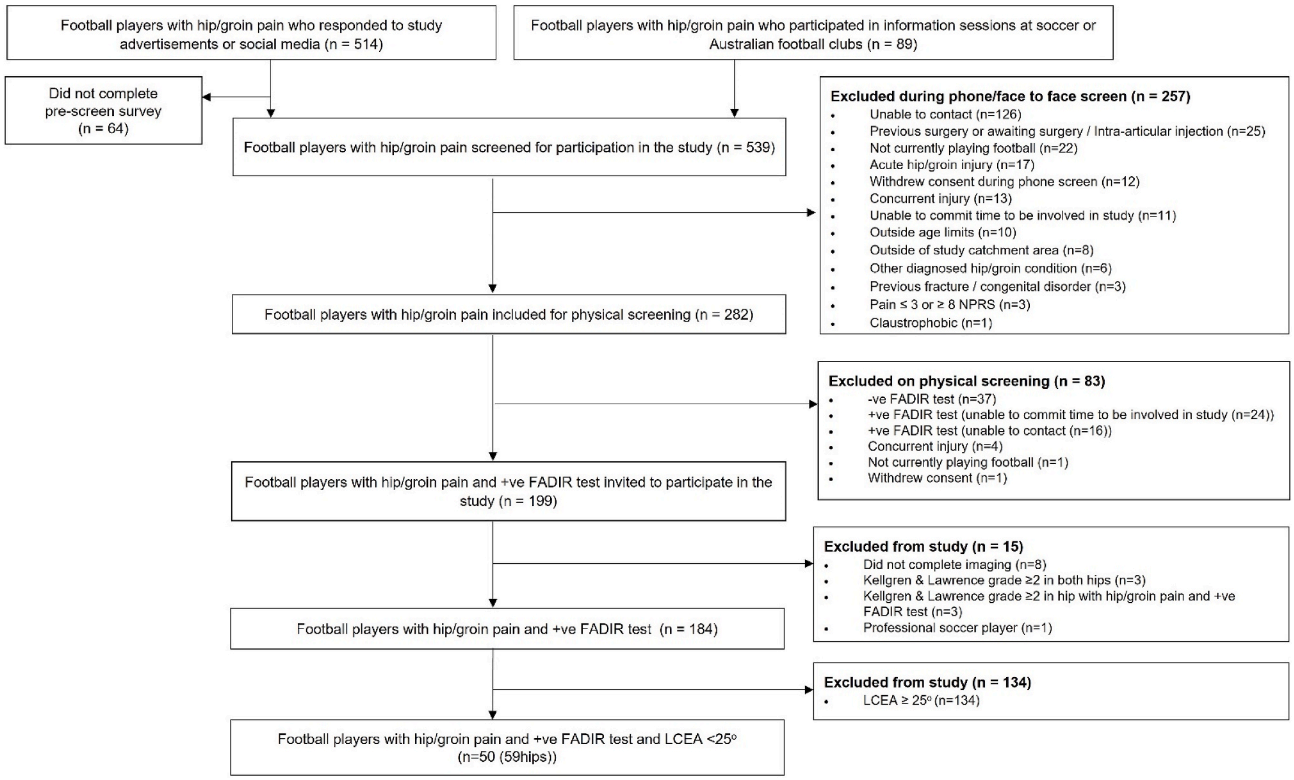

Fig. 1. Flowchart of Hip Dysplasia group
Abbreviations: FADIR, Flexion adduction internal rotation; LCEA, Lateral-centre-edge angle.

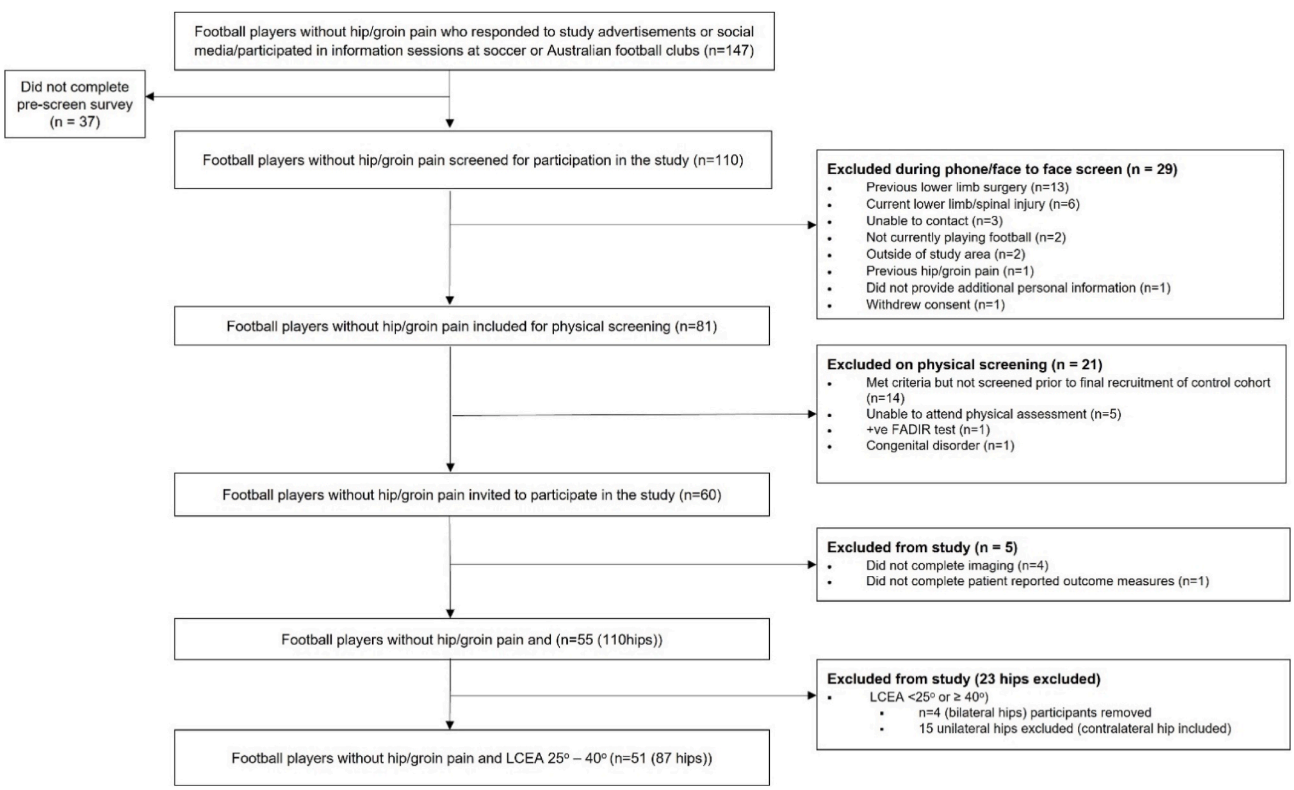

Fig. 2. Flowchart of control group
Abbreviations: FADIR, Flexion adduction internal rotation; LCEA, Lateral-centre-edge angle.

Table 2
Demographic characteristics and PROMs of the HD group and Control group.

	Hip Dysplasia (n = 50)[a]	Controls (n = 51)[a]
Female sex (%)	n = 13 (26)	n = 14 (27)
Age, y	25 [23, 27]	26 [24, 31]
Height, m	1.77 ± 0.09	1.78 ± 1.00
Body mass, kg	77.8 [68.9, 82.9]	80 [68.2, 88.6]
Body mass index, kg/m^2	24.0 [22.9, 25.8]	24.3 [22.4, 26.8]
Football code, n (%) soccer	27 (54)	27 (53.0)
Lateral centre edge angle[b],°	22.4 [20.5, 23.9]	31.6 [29.3, 34.4]
Symptom duration, months	24 [18, 48]	NA
Training/competition (per week), %		
2 to 3 sessions	83	81
≥4 session	17	19
Labral tear, n (%) hips [b]	43 (73)	57 (66)
Cartilage defect, n (%) hips [b]	28 (48)	42 (48)
HAGOS Symptoms	62.5 [53.6–68.75]	100 [92.3–100]
HAGOS Pain	77.5 [67.5–85.6]	100 [100-100]
HAGOS Function	85 [80-95]	100 [100-100]
HAGOS Sport	71.9 [58–81.3]	100 [100-100]
HAGOS Physical Activity	75 [50–87.5]	100 [100-100]
HAGOS Quality of life	62.5 [55-70]	100 [100-100]
iHOT Symptoms	81.4 [77.0–86.7]	98.5 [96.8–100]
iHOT Sport	65.2 [36–66.7]	99.5 [97.0–100]
iHOT Job	82.8 [73.4–85.5]	99.3 [97.3–100]
iHOT Social	77.1 [68.9–84.8]	99.6 [97.5–100]
iHOT Total	79.3 [67.8–81.3]	98.7 [97.5–99.9]

Values are presented as n (%), or median [interquartile range], or mean ± standard deviation.
Abbreviations: PROMs, Patient Reported Outcome Measures; HD, Hip Dysplasia; HAGOS, Copenhagen Hip and Groin Outcome Score; iHOT, International Hip Outcome Tool-33; NA, not applicable.
[a] data are presented per person unless otherwise specified.
[b] data are presented per hip for all 59 HD hips/87 Control group hips.

Table 3
Differences in hip muscle strength and functional performance tasks between HD group and Control group.

	HD Mean (95% CI)	Control Mean (95% CI)	Effect Estimate (95% CI)	P
Isometric Hip Abduction (Nm/kg)	1.34 (1.28–1.4)	1.37 (1.23–1.45)	0.03 (−0.07 to 0.13)	0.579
Isometric Hip Adduction (Nm/kg)	1.34 (1.25–1.43)	1.37 (1.27–1.47)	0.04 (−0.1 to 0.17)	0.597
Eccentric Hip Abduction (Nm/kg)	1.59 (1.48–1.69)	1.62 (1.5–1.73)	0.03 (−0.13 to 0.18)	0.714
Eccentric Hip Adduction	1.73 (1.60–1.86)	1.86 (1.73–1.99)	0.13 (−0.05 to 0.32)	0.158
External Rotation (Nm/kg)	0.53 (0.49–0.56)	0.53 (0.48–0.57)	0.00 (−0.05 to 0.06)	0.918
Internal Rotation (Nm/kg)	0.48 (0.44–0.51)	0.48 (0.44–0.52)	0.01 (−0.05 to 0.06)	0.768
Flexion (Nm/kg)	1.00 (0.93–1.09)	0.96 (0.88–1.05)	−0.04 (−0.16 to 0.07)	0.457
Extension (Nm/kg)	1.56 (1.46–1.67)	1.43 (1.32–1.54)	−0.13 (−0.29 to 0.02)	0.087
Hop For Distance (cm)	135 (128.4–140.8)	136 (129.63–141.85)	1.15 (−7.47 to 9.76)	0.794
One leg rise (reps)	24 (20.6–27.3)	26.1 (22.26–29.92)	2.13 (−2.95 to 7.21)	0.411
Side bridge (s)	89 (80.77–97.73)	86.7 (77.23–96.14)	−2.48 (−15.02 to 10.06)	0.698

Abbreviations: HD, Hip Dysplasia; CI, confidence interval; Nm/kg, newton metres per kilogram; cm, centimetres; s, seconds.

recreation ability (Jacobsen et al., 2021). Similarly, Wang (2022) found reduced hip flexion strength, reduced hip abduction strength, and poorer dynamic balance in adults with hip dysplasia compared to controls (Wang et al., 2022). Again, the Wang (2022) cohort had 15% to 32% poorer scores in their pain, function and sport and recreation ability compared to our hip dysplasia group (Wang et al., 2022). The contrast between our hip dysplasia group and those in other studies may explain the discrepant findings.

Our cohort of football players may represent a group with less severe, or less advanced, hip dysplasia. Severity of hip dysplasia is difficult to objectively ascertain as there is no consensus on how to grade this. Traditionally, severity of hip dysplasia was based solely on the LCEA, but recent notions now dispute this (Bali et al., 2020; McClincy et al., 2019; Wilkin et al., 2017). With a higher risk of osteoarthritis in those with hip dysplasia (Casartelli et al., 2021; Wyles et al., 2017), perhaps advancement of disease progression could be characterized by articular joint changes and proximity to osteoarthritis. It is possible that our cohort of football players with hip dysplasia, but no radiographic osteoarthritis, achieve better outcomes as they are less advanced from a disease progression perspective and hence still able to participate in sport such as football.

Alternatively, it is possible that their participation in football promotes their higher level of physical function. The level or type of physical activity may influence the physical hip function, perhaps more so than acetabular morphology or the presence of pain. This could call into question the role that pain and acetabular morphology has in people with hip pain (Heerey et al., 2018; Mose et al., 2019). Perhaps it is when physical activity levels reduce, and sport cannot continue, that physical impairments (i.e., strength deficits and decreased functional performance) become evident. This could support interventions targeting physical activity and sport participation in people with hip dysplasia to maintain physical performance, but this needs to be confirmed with prospective longitudinal studies.

4.1. Limitations

The cross-sectional nature of this study prevents our ability to infer causation. Our study may also have been underpowered to explore sex as an effect modifier. Prospective longitudinal studies with a larger sample size would help establish the natural history of hip dysplasia in football players, including change in symptoms, physical impairments, and participation in physical activity. Future studies would also benefit from international agreement regarding the diagnosis of hip dysplasia. Our HD group consisted of football players with hip and/or groin pain, a positive FADIR test and a LCEA <25° based on AP radiograph, however, debate still exists about many of these criteria. This includes whether the AP pelvis radiographs should be performed in supine versus standing (Flintham et al., 2021), whether a LCEA of 25° or 20° should be used (McClincy et al., 2019), whether additional radiographs should be included (Herfkens et al., 2022) and the appropriateness of the FADIR test as a diagnostic test (O'Brien et al., 2022; Bali et al., 2020). Any discrepancies with future consensus on hip dysplasia diagnosis could limit the applicability of our findings. Given the current lack of research in football players with hip dysplasia, we believe this study provides valuable findings that can be explored further in future studies.

5. Conclusion

We found similar levels of hip muscle strength and functional performance in active football players with and without hip dysplasia. Our findings differ from previous research, which may be explained by less disease severity and/or the high level of physical capacity in our participants with hip dysplasia. Another explanation could be that participation in football maintains or improves physical function for adults with hip dysplasia. Prospective longitudinal studies are required but these findings provide interesting early insights into these under researched athletes.

Ethics approval

Ethical approvals were obtained from the La Trobe University Human Ethics Committee (HEC015-019) and The University of Queensland Human Ethics Committee (20150000916).

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Declaration of competing interest

No authors have a any financial or personal relationships with other people or organisations that could inappropriately influence this study.

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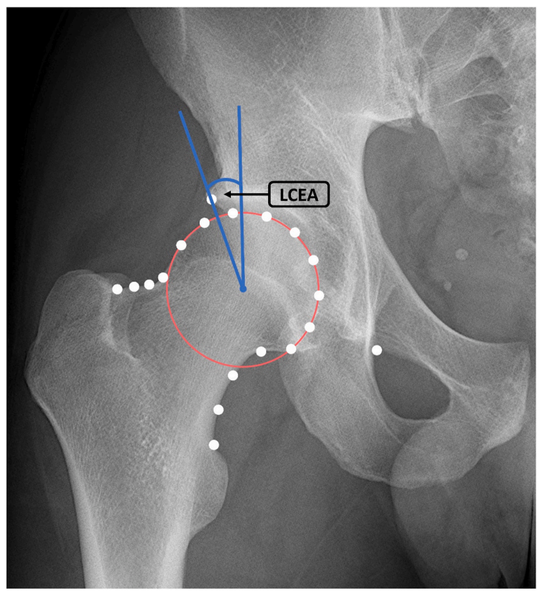
Appendices.

APPENDIX A



The LCEA (anteroposterior pelvis view) was determined by a vertical line originating from the centre of the femoral head and a corresponding line from the centre of the femoral head to the most lateral weight-bearing portion of the acetabular sulcus. The vertical line was drawn perpendicular to a horizontal line connecting the 2 superolateral points of both obturator foramen to correct for potential pelvic malposition. The white points on the images represent the manual point set that is placed on predetermined locations on the surfaces of the femur and acetabulum.

Abbreviation: LCEA, lateral centre-edge angle.

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