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Does Femoroacetabular Impingement Syndrome Affect Self-Reported Burden in Football Players With Hip and Groin Pain?

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Background: It is unknown if football players with femoroacetabular impingement (FAI) syndrome report worse burden than those with other causes of hip/groin pain, and to what extent this is mediated by cartilage defects and labral tears.

Hypothesis: Football players with FAI syndrome would report worse burden than other symptomatic players, with the effect partially mediated by cartilage defects and/or labral tears.

Study Design: Cross-sectional study.

Level of Evidence: Level 4.

Methods: Football (soccer and Australian football) players (n = 165; 35 women) with hip/groin pain (≥6 months and positive flexion–adduction–internal rotation test) were recruited. Participants completed 2 patient-reported outcome measures (PROMs; the International Hip Outcome Tool–33 [iHOT-33] and Copenhagen Hip and Groin Outcome Score [HAGOS]) and underwent hip radiographs and magnetic resonance imaging (MRI). FAI syndrome was determined to be present when cam and/or pincer morphology were present. Cartilage defects and labral tears were graded as present or absent using MRI. Linear regression models investigated relationships between FAI syndrome (dichotomous independent variable) and PROM scores (dependent variables). Mediation analyses investigated the effect of cartilage defects and labral tears on these relationships.

Results: FAI syndrome was not related to PROM scores (unadjusted b values ranged from −4.693 (P = 0.23) to 0.337 (P = 0.93)) and cartilage defects and/or labral tears did not mediate its effect (P = 0.22-0.97).

Conclusion: Football players with FAI syndrome did not report worse burden than those with other causes of hip/groin pain. Cartilage defects and/or labral tears did not explain the effect of FAI syndrome on reported burden.

Clinical Relevance: FAI syndrome, cartilage defects, and labral tears were prevalent but unrelated to reported burden in symptomatic football players.

Keywords: cam morphology; magnetic resonance imaging; patient-reported outcomes

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Hip and/or groin (hip/groin) injuries are common in football players, accounting for 10% to 19% of all time-loss injuries.[33,40,61,64] Up to 53% of subelite players can complain of hip/groin pain per season,[8] and those with prolonged symptoms (>6 weeks) report worse burden than players with shorter symptom duration.[55] To aid with diagnosis and treatment planning, classification of hip-related pain into the following conditions was recently recommended:[44] (1) femoroacetabular impingement (FAI) syndrome (defined by the presence of cam and/or pincer morphology), (2) acetabular dysplasia and/or hip instability, and (3) other conditions without distinct bony morphology, including labral, chondral, and/or ligamentum teres conditions. FAI syndrome can be a cause hip/groin pain in football players[16,43] and has been associated with features of early hip osteoarthritis (OA; ie, cartilage defects and labral tears) in patients undertaking hip arthroscopy.[21,22] Cartilage defects and labral tears might represent a causal pathway for hip/groin pain and symptoms in FAI syndrome.[12,14,44] Quantifying the extent that cartilage defects and labral tears mediate self-reported hip/groin burden could improve understanding of the pathogenesis of FAI syndrome.

FAI syndrome is burdensome in patients seeking surgery, reducing sports participation and quality of life (QOL).[9,35,54] It is unknown whether people with FAI syndrome who do not seek surgery report worse burden than those with other causes of hip/groin pain. Football players require considerable hip function and range of motion during sport performance. As players with large cam morphology (alpha angle ≥78°) are more likely to complain of hip/groin pain than those without,[58] it is possible that relationships between FAI syndrome and reported burden may exist in symptomatic football players. Understanding the effect of FAI syndrome, cartilage defects, and labral tears on reported burden may assist with discerning the importance of these findings in young athletic adults and prioritizing treatment approaches.

Therefore, the primary aim of this study was to investigate the relationship between FAI syndrome presence and patient-reported burden in football players with hip/groin pain and a positive flexion–adduction–internal rotation (FADIR) test, using the International Hip Outcome Tool–33 (iHOT-33)[32] and Copenhagen Hip and Groin Outcome Score (HAGOS).[53] Our secondary aim was to investigate the extent that cartilage defects and labral tears mediated the effect of FAI syndrome on patient-reported outcome measure (PROM) scores.

METHODS

Study Design

This cross-sectional study investigated 18- to 50-year-old subelite football (soccer and Australian football) players with hip/groin pain. Data were collected as part of the larger baseline assessment for the FAI and hip osteoarthritis cohort (FORCe) study,[6,16,19] an ongoing prospective study investigating change in hip joint structure and symptoms over time. Ethical approval was obtained from the La Trobe University Human Ethics Committee (HEC015-019) and the University of Queensland Human Ethics Committee (2015000916). Written informed consent was obtained before data being collected. This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[60]

Participants

Football players with hip/groin pain who were participating in structured, subelite (nonprofessional) competitions in greater Melbourne and Brisbane, Australia, were recruited. For inclusion, participants needed to (1) complete at least 2 football sessions (training/matches) per week; (2) report more than 6 months of gradual onset, activity-related hip (anterior/lateral/posterior) and/or groin pain (average pain ≥3 and ≤8 on a numerical pain rating scale during football); and (3) have a positive FADIR pain provocation test. Exclusion criteria for football players with hip/groin pain are provided in Table 1. Briefly, football players with hip/groin pain were excluded if they had (1) radiographic hip OA defined by a Kellgren and Lawrence (KL) score[23] of ≥2, (2) undergone hip or pelvic surgery, (3) acetabular dysplasia defined by a lateral-center-edge angle (LCEA) of <20° in the investigated hip,[29] or (4) reported a history of significant hip condition (eg, hip fracture, congenital dislocation of the hip).

Procedures

Football players were recruited through print, electronic, and social media advertisements to football clubs and leagues and direct advertisements to and within sports medicine and physiotherapy clinics. After screening to confirm eligibility, participants attended La Trobe University or University of Queensland for testing between August 2015 and August 2018. Participant characteristics (age, sex, height, mass, football code, and duration of symptoms) were recorded. Radiographs and magnetic resonance imaging (MRI) scans were undertaken at radiology clinics in Melbourne (Imaging @ Olympic Park) and Brisbane (Q-Scan), Australia.

Patient-Reported Outcome Measures

Participants completed the iHOT-33 and HAGOS in hard-copy format or via Checkware (CheckWare, AS), an online data capture and storage platform. The iHOT-33 and HAGOS are self-reported questionnaires recommended for assessing young-to middle-aged adults with hip/groin pain.[20,51,56]

The iHOT-33 consists of 33 items scored on a visual analogue scale from 0 (worst possible score) to 100 (best possible score) and measures hip-related QOL in the most symptomatic hip in the preceding month.[32] The iHOT-33 total score (iHOT-Total) was calculated as the sum of all item scores divided by the total number of items answered. Scores (from 0 to 100) were also calculated for the following 4 subscales: (1) symptoms and functional limitations (iHOT-Symptoms); (2) sport and recreational activities (iHOT-Sport); (3) job-related concerns (iHOT-Job); and (4) social, emotional, and lifestyle concerns (iHOT-Social), by summing the subscale item scores and

Table 1. Exclusion criteria for football players with hip/groin pain[a]

Exclusion criteria
• Self-reported history of significant hip or groin condition, specifically ○ Trauma ○ Septic or rheumatoid arthritis ○ Congenital dislocation of the hip ○ Legg-Calvé-Perthes disease ○ Subluxations and dislocation ○ Slipped capital femoral epiphysis ○ Osteochondritis dissecans ○ Fracture ○ Bursitis ○ Previous hip or pelvic surgery • Kellgren and Lawrence grade ≥2 on anteroposterior pelvis radiograph • Any lumbar spine or other lower limb musculoskeletal injury/complaint in the previous 3 months (eg, patellofemoral pain, sprained ankle) that resulted in the inability to bear weight fully or undertake testing procedures • Acetabular dysplasia defined by lateral-center-edge angle <20° • Received an intra-articular hip injection of any type within the previous 3 months • Unable to understand written and spoken English • Unable to undertake hip/pelvis radiograph or magnetic resonance imaging

[a]One investigator analyzed hips for the presence of radiographic hip osteoarthritis (OA) with the Kellgren and Lawrence (KL) classification, with OA defined as KL grade of ≥2.[23] Substantial intra-rater agreement was found for KL grading (κ = 0.87).[16]

dividing by the number of subscale items answered. The iHOT-33 scores are reliable (intraclass correlation coefficient (ICC) values ranging from 0.78 to 0.88; [95% confidence intervals (CI) 0.60, 0.93]), with standard error of measurement (SEM) values ranging from 6.0 to 9.5 [95% CIs 4.6, 12.4].[51]

The HAGOS measures hip-related QOL at a per-person level and was developed and validated in active adults, including soccer players.[53] The 6 HAGOS subscale scores range from 0 (worst possible score) to 100 (best possible score) and explore the following dimensions of hip/groin burden: symptoms (HAGOS-Symptoms), pain (HAGOS-Pain), physical function in activities of daily living (HAGOS-ADL), physical function during sport and recreational activities (HAGOS-Sport), participation in physical activities (HAGOS-PA), and hip- and/or groin-related quality of life (HAGOS-QOL). The HAGOS subscale scores are reliable (ICCs range from 0.82 to 0.91 [95% CI 0.68, 0.95]) with SEM values ranging from 6.4 to 12.2 [95% CI 5.0, 16.2].[53]

Radiographs

Participants underwent a supine anteroposterior pelvis and Dunn 45° radiograph of each hip according to standardized protocols.[6] One blinded assessor determined the presence of bony hip morphology (cam and pincer morphology) with quantitative methods,[1] as detailed in Appendix A (available in the online version of this article). Briefly, a point set was placed on predetermined locations on the surface of the femur and acetabulum with statistical shape modeling software (ASM toolkit, Manchester University). The alpha angle and LCEA were then calculated using MATLAB software v7.1.0 (MathWorks Inc). Moderate-to-good intra- (ICC alpha angle Dunn = 0.93; LCEA = 0.94) and interrater reliability (ICC alpha angle Dunn = 0.93; LCEA = 0.63) were demonstrated for bony hip morphology measures.[16]

Cam Morphology

The Dunn 45° radiograph was used to quantify the extent of femoral head-neck asphericity,[21,39] as it best visualizes the anterosuperior head-neck region[30,50] where asphericity is most often observed.[30,42] Cam morphology was determined to be present if an alpha angle of ≥60° on the Dunn 45° radiograph was recorded.[1,30]

Pincer Morphology

The LCEA was measured using the anteroposterior pelvis radiograph and determined the presence of pincer morphology and acetabular dysplasia.[2,30] An LCEA of ≥40° and <20° defined the presence of pincer morphology and acetabular dysplasia, respectively.[2,30] Football players with an LCEA of less than 20° were excluded from this study.[29]

FAI Syndrome

FAI syndrome was defined as the presence of hip/groin pain, a positive FADIR test, and cam and/or pincer morphology on radiographs.[1,2,34]

MRI Acquisition and Assessment

Football players underwent an unenhanced 3.0 tesla MRI (Phillips Ingenia). Each participant was positioned in supine, with positioning aids used to maintain each hip in internal rotation and neutral abduction/adduction. A 32-channel torso coil was placed over the hips and pelvis, with right and left hips imaged independently. The MRI protocol included 3 sequences: coronal proton density (PD) spectral attenuated inversion recovery (SPAIR), sagittal PD SPAIR, and oblique PD SPAIR.

All MRI scans were evaluated by a single experienced and trained musculoskeletal radiologist, who was blinded to bony hip morphology and PROM scores. The Scoring Hip Osteoarthritis with MRI (SHOMRI)[28] was used to evaluate cartilage defects and labral tears, key features of early hip OA.[27,28,48] Cartilage defects were assessed in 6 femoral and 4 acetabular subregions and graded from 0 to 2 (0 = no defect, 1 = partial defect, or 2 = full thickness defect). Labral tears were assessed in 4 acetabular subregions and graded from 0 to 5 (0 = normal or normal variant, 1 = abnormal signal or fraying, 2 = simple tear, 3 = labrocartilage separation, 4 = complex tear, or 5 = maceration). For our analyses, a dichotomous (present/absent) "cartilage defect and/or labral tear" variable was used. This variable was considered present when a (1) partial or full thickness (grade 1 or 2) cartilage defect and/or (2) simple (grade 2) labral tear or higher, was identified in at least 1 subregion. Intraobserver agreement for cartilage defect and labral tear grading (dichotomous scoring) had prevalence-adjusted bias-adjusted kappa values of 0.76 (κ 0.66) and 0.80 (κ 0.77), respectively.[19]

Data Management

Each participant's most symptomatic hip was defined on the iHOT-33 (by answering the introductory iHOT-33 question *which (hip) gives you the most trouble?*) and used for analyses. Six participants (3 with FAI syndrome and 3 without) did not have useable iHOT-33 scores and another 6 participants (3 with FAI syndrome and 3 without) did not complete the HAGOS; they were removed from the respective analyses.

Statistical Analysis

Data were assessed for normality using boxplots and Shapiro-Wilk analyses. Continuous demographic data were summarized using means and standard deviations or medians and interquartile range (IQR) values, as appropriate. Linear regression models were used for each study aim. Before interpreting results, models were assessed for violations of assumptions. Residual scatter plots were used to assess linearity and homoscedasticity, and variance inflation factor statistics >10 indicated problematic multicollinearity. Normality of regression model residuals were assessed using residual scatter plots and Shapiro-Wilk analyses.

Primary Aim: FAI Syndrome (Linear Relationships, Dichotomous Variable)

Linear regression models were used to assess the relationships between FAI syndrome presence (dichotomous independent variable) and PROM scores (dependent variable—score of 0-100). Relationships were analyzed unadjusted and adjusted for the covariates of age, sex, and body mass index (BMI) and pseudo R^2 values quantified the strength of modelled relationships. For adjusted (multivariable) linear regression models, interaction effects between FAI syndrome and covariates were examined by adding interaction terms individually to each model. Interaction terms were removed if not significant. As PROM scores are anchored by values of 0 and 100, they may not always be optimally modeled using linear regression. Arcsin transformation of the dependent variables (PROM scores) can be used to stabilize variance and minimize bias in models.[31] Sensitivity analyses using models with arcsin-transformed PROM scores are described in Appendix B (available online).

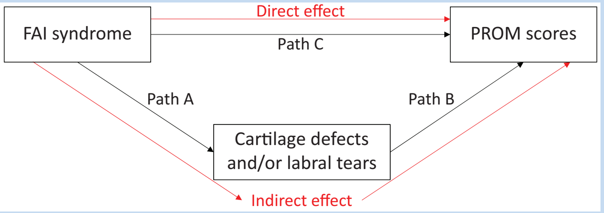

Figure 1. Model of the potential mediating effect of cartilage defects and/or labral tears on the relationship between femoroacetabular impingement (FAI) syndrome presence and patient-reported outcome measure (PROM) scores.

Secondary Aim: Mediation Analyses

Cartilage defects and labral tears may be sequalae of FAI syndrome, representing a possible causal pathway between FAI syndrome and reported hip/groin burden. Mediation analyses were used to assess if the relationships between FAI syndrome presence and PROM scores were mediated by the presence of cartilage defects and/or labral tears (dichotomous mediator variable). Figure 1 describes the direct and indirect causal pathways defined for the mediation analyses. For mediation to occur, cartilage defects and/or labral tears must be related to FAI syndrome presence (path A) and PROM scores (path B).[57] Sensitivity analyses controlled for the effects of the covariates of age, sex, and BMI during mediation analyses (causal pathways described in Appendix C1, available online). If including covariates did not alter statistical significance of the indirect effect, the results of the simplified mediation analysis were retained. Secondary sensitivity analyses assessed if the direct and indirect effects of FAI syndrome presence on PROM scores were moderated by sex (causal pathways described in Appendix C2, available online). Post hoc sensitivity analyses investigated cartilage defect presence as the mediator variable, to assess for the potential wash out of mediation effects by combining 2 variables (cartilage defects and labral tears).

Statistical analyses were completed using SPSS version 26 (IBM Corp) and the general analyses for linear models and advanced mediation models modules in Jamovi version 1.6.16.0 (The jamovi project). Level of significance was set at 0.05.

RESULTS

Participant Demographic Characteristics and Recruitment

A summary of participant recruitment is provided in Figure 2. Of the 539 football players with hip/groin pain screened, 165 players (35 women, 130 men) fulfilled the eligibility criteria and were included in this study. Demographic data and PROM scores are summarized in Tables 2 and 3, respectively. FAI syndrome was identified in 114 (69%) players (pincer type = 4 [0 women]; mixed type = 10 [1 woman]; cam type = 100 [8 women]). Cartilage defects and/or labral tears were identified in 129 (78%, 24 female) players (players with FAI syndrome = 95

Table 2. Demographic characteristics of football players with hip/groin pain[a]

	Total Cohort (n = 165); Median [IQR] or Count (%)
Female sex	35 (21)
Age, y	26 [7]
Body mass index, kg/m^2	24.1 [3.4]
Symptom duration, mo	24 [33]
Soccer player	77 (47)
FAI syndrome	114 (69)
Cartilage defect (≥grade 1)	83 (50)
Labral tear (≥grade 2)	115 (70)
Cartilage defect and/or labral tear	129 (78)
KL grade 0	157 (95)

FAI, femoroacetabular impingement; IQR, interquartile range; KL, Kellgren and Lawrence score.
[a]Reported proportions of FAI syndrome and intra-articular findings are for participants' included hip only.

[83%]; players without FAI syndrome = 34 [66%]). Seventeen football players (10% of cohort) had neither FAI syndrome nor any cartilage defects or labral tears.

Primary Study Aim: FAI Syndrome (Linear Relationships, Dichotomous Variable)

Tables 4 and 5 present the unadjusted and adjusted relationships between FAI syndrome and iHOT-33 and HAGOS scores, respectively. FAI syndrome was not related to PROM scores in any models (unadjusted *b* values ranged from −4.693 ([95% CI 12.621, 3.090], $P = 0.24$) to 0.34 ([95% CI −6.915, 7.588], $P = 0.93$)). Pseudo R^2 values for unadjusted linear models ranged from 0.017 to <0.001. Sensitivity analyses using arcsin-transformed dependent variables confirmed the findings of the untransformed linear models (Appendix B, available online).

Secondary Study Aim: Mediation Analyses

Cartilage defects and/or labral tears did not mediate the effect of FAI syndrome on PROM scores (unadjusted indirect effect estimates ranged from −0.167 ([95% CI −1.181, 0.847], $P = 0.75$) to 0.825 ([95% CI −0.898, 2.548], $P = 0.35$)). Results of mediation analyses are presented in Table 6. Sensitivity analyses confirmed that relationships were not moderated by sex. Sensitivity analyses investigating cartilage defects as the mediator variable confirmed the results of the main mediation analysis (Appendix D, available online).

DISCUSSION

In our study of subelite football players with hip/groin pain and a positive FADIR test, football players with FAI syndrome did not report worse burden than those with other causes of hip/groin pain. Cartilage defects and/or labral tears were not associated with lower PROM scores (ie, worse hip/groin burden) and did not mediate the effect of FAI syndrome on reported burden.

Symptomatic football players classified as having FAI syndrome did not describe worse hip/groin burden than those without, adding to the diagnostic challenge for clinicians.[44,45] The diagnostic utility of hip joint physical tests is limited, with clinical tests lacking specificity and acting as screening tools to rule out intra-articular conditions.[41,45,47] MRI identified a high prevalence of cartilage defects and labral tears in our football players with hip/groin pain; however, they were not associated with worse reported burden when compared to players without these findings. The immediate clinical value of diagnosing FAI syndrome, cartilage defects, and labral tears is unclear, considering their absent relationship with reported burden. Prospective studies are needed to investigate if these imaging-based diagnoses can identify those who develop worse hip/groin pain, function, and QOL over time. Classifying FAI syndrome using contemporary threshold values for cam or pincer morphology explained less than 1.7% of the variance in PROM scores in our football players with hip/groin pain. Other physical features might contribute to reported burden in hip/groin pain in football players, including other bony and soft tissue hip morphological features,[19] physical impairments,[11] and/or biomechanics.[26] As the iHOT-33 and HAGOS are self-reported measures that quantify patients' perceptions of their hip/groin burden, scores may also be influenced by nonphysical (eg, psychological, social, contextual) factors.[10,65] Nonphysical factors might explain more of the variance in

Table 3. iHOT-33 and HAGOS scores for football players with hip/groin pain

	Total Cohort (n = 165); Median [IQR]	FAI Syndrome (n = 114); Median [IQR]	Non-FAI Syndrome (n = 51); Median [IQR]
iHOT-Total[a]	63 [23]	62 [23]	66 [20]
iHOT-Symptoms[a]	70 [23]	69 [24]	72 [20]
iHOT-Sport[a]	45 [27]	46 [31]	44 [18]
iHOT-Job[b]	72 [34]	72 [38]	71 [28]
iHOT-Social[a]	63 [32]	62 [32]	65 [31]
HAGOS-Symptoms[a]	61 [14]	61 [14]	59 [23]
HAGOS-Pain[a]	75 [18]	75 [18]	75 [20]
HAGOS-ADL[a]	80 [20]	80 [20]	80 [25]
HAGOS-Sport[a]	66 [25]	63 [25]	66 [26]
HAGOS-PA[c]	63 [38]	63 [38]	63 [28]
HAGOS-QOL[a]	60 [20]	60 [25]	60 [16]

ADL, activities of daily living; FAI, femoroacetabular impingement; HAGOS, Copenhagen Hip and Groin Outcome Score; iHOT-33, International Hip Outcome Tool–33; IQR, interquartile range; PA, participation in physical activity; QOL, quality of life.
[a]Sample size variation: n = 159 (FAI syndrome n = 111, non-FAI syndrome n = 48).
[b]Sample size variation: n = 145 (FAI syndrome n = 101, non-FAI syndrome n = 44).
[c]Sample size variation: n = 158 (FAI syndrome n = 110, non-FAI syndrome n = 48).

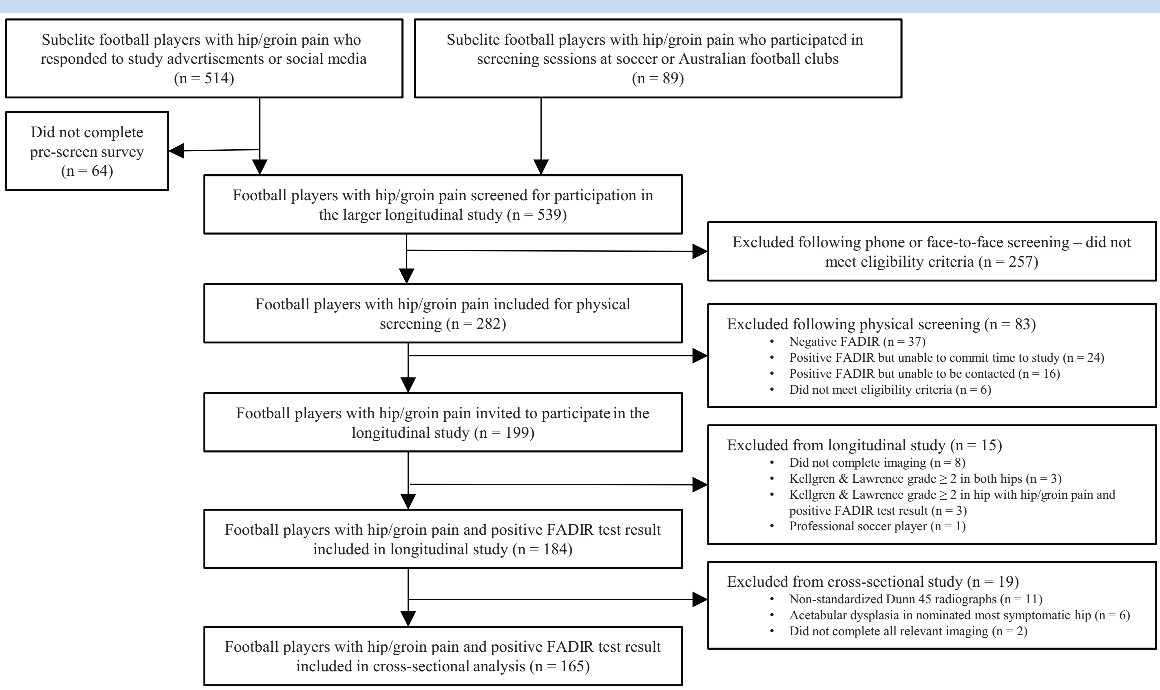

Figure 2. Participant flow for football players with hip/groin pain. FADIR, flexion–adduction–internal rotation test.

Table 4. Relationships between FAI syndrome presence and iHOT-33 scores[a]

N = 159		iHOT-Total		iHOT-Symptoms		iHOT-Sport		iHOT-Job[b]		iHOT-Social	
Model		Unadjusted $R^2 = 0.001$	Adjusted $R^2 = 0.065$ ($P = 0.03$)	Unadjusted $R^2 < 0.001$	Adjusted $R^2 = 0.071$ ($P = 0.02$)	Unadjusted $R^2 < 0.001$	Adjusted $R^2 = 0.059$ ($P = 0.05$)	Unadjusted $R^2 = 0.010$	Adjusted $R^2 = 0.035$ ($P = 0.29$)	Unadjusted $R^2 = 0.004$	Adjusted $R^2 = 0.051$ ($P = 0.09$)
FAI syndrome	*b* Value (95% CI) *P* value	−1.428 (−7.315, 4.459) $P = 0.63$	−2.385 (−8.932, 4.162) $P = 0.47$	−0.975 (−7.000, 5.051) $P = 0.75$	−2.630 (−9.307, 4.048) $P = 0.44$	0.337 (−6.915, 7.588) $P = 0.93$	1.438 (−6.647, 9.523) $P = 0.73$	−4.693 (−12.475, 3.090) $P = 0.23$	−3.880 (−12.621, 4.861) $P = 0.38$	−3.047 (−10.381, 4.286) $P = 0.41$	−4.606 (−12.833, 3.622) $P = 0.27$

R^2 indicates pseudo R^2 values. FAI, femoroacetabular impingement; iHOT-33, International Hip Outcome Tool–33.
[a]Adjusted means multivariable model estimates adjusted for age, sex, and body mass index.
[b]Indicates n = 145.

Table 5. Relationships between FAI syndrome presence and HAGOS scores[a]

N = 159		HAGOS-Symptoms		HAGOS-Pain		HAGOS-ADL		HAGOS-Sport		HAGOS-PA[b]		HAGOS-QOL	
Model		Unadjusted $R^2 = 0.002$	Adjusted $R^2 = 0.050$ ($P = 0.11$)	Unadjusted $R^2 < 0.001$	Adjusted $R^2 = 0.086$ ($P = 0.06$)	Unadjusted $R^2 = 0.002$	Adjusted $R^2 = 0.033$ ($P = 0.26$)	Unadjusted $R^2 = 0.003$	Adjusted $R^2 = 0.026$ ($P = 0.40$)	Unadjusted $R^2 = 0.01$	Adjusted $R^2 = 0.020$ ($P = 0.54$)	Unadjusted $R^2 = 0.02$	Adjusted $R^2 = 0.055$ ($P = 0.07$)
FAI syndrome	*b* Value (95% CI) *P* value	−1.345 (−6.248, 3.558) $P = 0.59$	−3.605 (−9.042, 1.832) $P = 0.19$	0.106 (−4.525, 4.736) $P = 0.96$	−2.919 (−7.945, 2.107) $P = 0.25$	−1.484 (−7.059, 4.092) $P = 0.60$	−2.245 (−8.474, 3.984) $P = 0.48$	−2.245 (−8.483, 3.992) $P = 0.48$	−2.185 (−9.187, 4.816) $P = 0.54$	−3.996 (−12.832, 4.839) $P = 0.37$	−3.920 (−13.869, 6.029) $P = 0.44$	−4.488 (−9.949, 0.974) $P = 0.11$	−4.519 (−10.598, 1.560) $P = 0.14$

R^2 indicates pseudo R^2 values. ADL, activities of daily living; FAI, femoroacetabular impingement; HAGOS, Copenhagen Hip and Groin Outcome Score; PA, participation in physical activity; QOL, quality of life.
[a]Adjusted means multivariable model estimates adjusted for age, sex, and body mass index.
[b]Indicates n = 158.

Table 6. Results of mediation analyses investigating proposed causal pathways between FAI syndrome and PROM scores[a]

	Total Effect		Direct Effect		Indirect Effect		
	Effect Estimate (95% CI)	*P*	Effect estimate (95% CI)	*P*	Effect Estimate (95% CI)	*P*	Proportion Mediated
iHOT-Total	–1.428 (–7.251, 4.395)	0.63	–1.869 (–7.773, 4.034)	0.54	0.442 (–0.743, 1.627)	0.47	N/A
iHOT-Symptoms	–0.975 (–6.935, 4.986)	0.75	–1.366 (–7.412, 4.679)	0.66	0.392 (–0.808, 1.591)	0.52	N/A
iHOT-Sport	0.337 (–6.836, 7.510)	0.93	–0.374 (–7.637, 6.888)	0.92	0.711 (–0.792, 2.214)	0.35	N/A
iHOT-Job[b]	–4.693 (–12.382, 2.997)	0.23	–4.724 (–12.561, 3.112)	0.24	0.032 (–1.607, 1.671)	0.97	N/A
iHOT-Social	–3.047 (–10.301, 4.207)	0.41	–3.325 (–10.689, 4.039)	0.38	0.277 (–1.151, 1.706)	0.70	N/A
HAGOS-Symptoms	–1.345 (–6.195, 3.505)	0.59	–1.186 (–6.099, 3.727)	0.64	–0.159 (–1.052, 0.734)	0.73	N/A
HAGOS-Pain	0.106 (–4.475, 4.686)	0.96	0.008 (–4.633, 4.649)	0.99	0.098 (–0.740, 0.936)	0.82	N/A
HAGOS-ADL	–1.484 (–6.999, 4.031)	0.60	–1.316 (–6.903, 4.270)	0.64	–0.167 (–1.181, 0.847)	0.75	N/A
HAGOS-Sport	–2.245 (–8.415, 3.925)	0.48	–2.298 (–8.550, 3.954)	0.47	0.053 (–1.071, 1.177)	0.93	N/A
HAGOS-PA[c]	–3.996 (–12.735, 4.743)	0.37	–4.821 (–13.644, 4.001)	0.28	0.825 (–0.898, 2.548)	0.35	N/A
HAGOS-QOL	–4.488 (–9.890, 0.915)	0.10	–5.196 (–10.636, 0.244)	0.06	0.708 (–0.440, 1.857)	0.23	N/A

ADL, activities of daily living; FAI, femoroacetabular impingement; HAGOS, Copenhagen Hip and Groin Outcome Score; iHOT-33, International Hip Outcome Tool–33; PA, participation in physical activity; PROM, patient-reported outcome measure; QOL, quality of life.

[a]N/A indicates that the effect of FAI syndrome on PROM scores was not mediated by cartilage defects and/or labral tears (indirect causal pathway was not statistically significant, $P > 0.05$).

[b]Sample size variation: n = 145.

[c]Sample size variation: n = 158.

reported burden than imaging findings alone and warrant further investigation. These factors may also influence the success of treatments that address imaging findings (cam morphology, cartilage defects, and/or labral tears),[52] indicating that better understanding of the mechanisms of these treatments is needed.

Football players with cam morphology, cartilage defects, and/or labral tears did not report worse burden than symptomatic football players with a positive FADIR test and without these imaging features. Our findings are consistent with those of van Klij et al[58] who reported that cam morphology was not related to HAGOS scores in a sample of academy football players, including some (n = 9) who reported hip/groin pain. By investigating a large cohort of football players with hip/groin pain (n = 165) and avoiding dichotomizing continuous PROM scores, we undertook a more robust assessment of the relationship between bony hip morphology and reported burden in symptomatic players. Cam morphology was also found unrelated to reported burden in other symptomatic populations, including middle-aged adults with self-reported hip OA[25] and patients undergoing hip arthroscopy.[63] Combined with others, our results suggest that people with FAI syndrome (with an alpha angle ≥60°) do not report worse burden than people with other causes of hip/groin pain. Furthermore, we found that cartilage defects and/or labral tears did not explain the effect of FAI syndrome on reported burden, primarily because of their presence being unrelated to PROM scores. This is consistent with findings from middle-aged and older adults[28,48] and patients undertaking hip arthroscopy.[63] While a structural relationship between cam morphology and cartilage defects and labral tears is evident,[17,21] our findings suggest that other mechanisms may contribute more meaningfully to pain and symptoms in football players with FAI syndrome. MRI is frequently used to aid diagnosis in patients with FAI syndrome,[15] and although the presence of cartilage defects may affect treatment outcomes after hip arthroscopy,[24,36] cartilage defects and labral tears in active football players should be interpreted with caution considering their unclear relationship with reported burden and high prevalence in asymptomatic athletes.[3,18]

While our study had many methodological strengths, several limitations should be considered. First, extra-articular causes of hip/groin pain likely coexisted in our football players and contributed to self-reported burden, including lumbar and groin pain entities.[62] All participants reported long-standing hip/groin pain and had a positive FADIR test; however, the low specificity[45,46] of the FADIR test means that the proportion of football players with hip-related pain is unknown. To aid the challenging diagnostic process in hip/groin pain,[44] we aimed to discern the relationship between imaging-based classifications and reported burden in a typical hip/groin pain population where various sources of nociception may have existed. Second, although the radiographic views used have demonstrated good sensitivity and specificity[7,37] and are recommended to quantify femoral and acetabular morphology in the clinical setting,[5,44] they do not provide a 3-dimensional understanding of femoral and acetabular anatomy that can be achieved with computed tomography and MRI. Threshold angles for defining anterosuperior cam morphology (as visualized with the Dunn 45° radiograph) might also be higher than current recommendations.[30,59] We also acknowledge that other bony morphologies such as acetabular retroversion, femoral version, and/or femoral neck-shaft angle may coexist, potentially contributing to mechanical impingement and influencing self-reported burden in FAI syndrome.[4] Finally, cartilage defects and labral tears may be more accurately assessed with contrast-enhanced MRI,[49] but this procedure has increased patient risk.[13] We used high-resolution, unenhanced 3T MRI, which has demonstrated similar accuracy to contrast-enhanced MRI for assessing identifying cartilage defects and labral tears.[38] As grading of hip MRIs was completed by 1 trained musculoskeletal radiologist, cartilage defects and labral tears may be over- or underreported (misclassification bias); potentially affecting the investigated relationships. The relationship between cartilage defect or labral tear severity and self-reported burden was not investigated; however, moderate interrater reliability may limit semiquantitative MRI scoring methods.[5,27,28,48]

CONCLUSION

Football players with FAI syndrome did not report worse hip/groin pain burden than those with other causes of hip/groin pain. Cartilage defects and labral tears did not mediate the effect of FAI syndrome on PROM scores. Defining the presence of FAI syndrome, cartilage defects, and/or labral tears did not explain reported burden in football players with hip/groin pain, raising questions about the immediate usefulness of these clinical classifications.

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