Title

Prevalence of femoroacetabular impingement syndrome among young and middle-aged Caucasian adults

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Abstract

Objective

The purpose of the study was to determine the prevalence of femoroacetabular impingement syndrome (FAIS) in Caucasian adults 20 to 49 years of age.

Methods

Participants were Caucasian men and women aged 20-49, recruited through random digit dialing from the population of Metro Vancouver, Canada. Participants filled out a self-administered questionnaire and underwent a physical examination and x-rays of both hips. FAIS was defined as a combination of hip symptoms, physical signs of impingement, and radiological findings of cam or pincer morphology as recommended by the Warwick Agreement. All analyses were weighted to reflect the population from which the sample was drawn.

Results

Data were obtained for 500 participants. In the study population, 48.9% were males and the age distribution was 32.2%, 31.4% and 36.4% in the groups 20-29, 30-39 and 40-49 years, respectively. The physical signs of impingement correlated significantly with symptoms but there was no significant association between either symptoms or physical examination with radiographic findings. Femoroacetabular impingement syndrome on either side was found in 3.0% (95% confidence interval 1.5-4.5) of the population.

Conclusion

In this study, femoroacetabular impingement syndrome was present in 3% of Caucasians ages 20-49. Further research is needed to develop consistent criteria for assessing hip symptoms,

physical signs, and hip joint morphology, and to better understand the relationships between them.

Key terms: femoroacetabular impingement syndrome, hip pain, cam morphology, pincer morphology, flexion-adduction-internal-rotation test, epidemiology

Introduction

Femoroacetabular impingement (FAI) is considered a risk factor for hip pain and osteoarthritis (OA) [1,14,26]. In 2016, to clarify FAI-related concepts and terminology, an international panel of experts defined femoroacetabular impingement syndrome (FAIS) as a "motion-related clinical disorder of the hip with a triad of symptoms, clinical signs and imaging findings" (Warwick Agreement) [16]. Two types of imaging findings that may be associated with impingement are referred to as cam and pincer morphology. Cam morphology is a flattening of the femoral head-neck junction whereas pincer morphology is characterized by acetabular over-coverage [13,14,16]. These features, in combination with some types of movements or positions, may lead to inappropriate contact between femoral head and acetabulum, eventually causing labral and cartilage damage [13,16].

To our knowledge no study to date has provided information on the prevalence of FAIS as defined in the Warwick Agreement. A number of studies assessed the prevalence of cam and pincer morphology, although few were truly population-based, a wide variety of methods and definitions were used, and the results showed extreme variation, ranging from 5% to almost 100% [10,12,38]. In addition, there is conflicting evidence on the correlation between symptoms, physical signs and radiological measurements [21,22]. The purpose of our study was to estimate FAIS prevalence among Caucasian adults 20 to 49 years of age and investigate the relationships between the three components of FAIS (symptoms, physical signs, and imaging findings).

Methods

Participants were Caucasian men and women aged 20-49, recruited through random digit dialing (RDD) from the population of Metro Vancouver, Canada, in March-November 2012. A stratified sample of persons with and without hip pain was obtained. To this end, randomly selected individuals were screened for hip symptoms by asking the following question: "At any time in the past 12 months, have you experienced any pain, stiffness or discomfort in your groin or the front of your upper thigh?" [21,22]. Follow-up questions asked whether symptoms lasted at least 6 weeks or occurred on 3 or more occasions. Pregnant women and persons with bilateral hip replacement were excluded. Subjects without hip pain were selected randomly once a sufficient number of persons with pain had been identified. Eligible subjects who agreed to participate in the study filled out a self-administered questionnaire, underwent a standardized physical examination by a physiotherapist, and obtained x-rays of both hips.

The main symptom of FAIS has been described as pain in the groin or hip, although some variation exists in precise location and precipitating factors [16]. In the current study, we were interested in persistent or recurrent symptoms from the hip joint. In the self-administered questionnaire we repeated the screening questions about hip symptoms and obtained additional details about the location of pain/stiffness/discomfort and other variables. In particular, body mass index (BMI) was calculated based on self-reported height and weight and hip injury was assessed by asking "Have you ever had a hip injury that required you to use a walking aid (e.g., cane or crutch) for at least one week?" We also asked which hip was injured and age at the time of injury (first injury in case of multiple injuries).

As part of the physical exam, we performed the flexion-adduction-internal-rotation (FADIR) test on both hips [31,36]. Following the assessment protocol [31], the subject was in a supine position and aligned to the lateral edge of exam table. The examiner was standing on the ipsilateral side of the hip to be examined and passively flexed the hip and knee to 90°. The examiner adducted the hip to the endpoint and then internally rotated the hip, maintaining flexion and adduction components. The examiner asked the subject if they "feel pain or discomfort in the inner thigh, upper thigh or groin area". Nine physiotherapists (PTs) conducted the physical exam. Prior to the study, CR (an experienced researcher and PT) led a training session with 7 PTs and two rheumatologists, which introduced a standardized description of each test, a standardized script for asking patient questions, demonstration of each test, and practice with feedback. In a previously reported interrater reliability study, which included 4 of the 9 PTs participating in the current study, we found overall agreement of 0.76 (0.66–0.91), negative agreement of 0.79 (0.60–0.93), and positive agreement of 0.73 (0.58–0.89), indicating that the test was reliable [31].

Standardized x-rays of the pelvis with AP view and Dunn views of both hips were obtained as described in detail in previous publications [20,22,32]. For the AP pelvis view, the subject was in a weight-bearing position, with legs internally rotated 15°. For the bilateral Dunn view, the subject was supine and the hip was positioned in 45° flexion and 20° abduction while maintaining neutral rotation [34]. Cam morphology was defined as alpha angle >60° [2,22] on the Dunn view, while pincer morphology was defined as lateral centre edge (LCE) angle >40° on

the AP view [38]. All radiographic measurements were performed by a single, trained reader. In a reliability study in 49 subjects with the same reader, the intrarater intraclass correlation coefficient (ICC) was 0.97 for the alpha angle and 0.87 for the LCE angle [32]. All subjects provided informed consent and the study was approved by the University of British Columbia Clinical Research Ethics Board (No. H11-00868).

Statistical methods

All statistical analyses were performed using Proc Survey procedures in SAS (version 9.4) to account for sampling weights. Sampling weights were used to adjust for the design of the survey (stratified sampling) and non-response in terms of age, sex and hip pain status, followed by a post-stratification to reflect the age and sex distribution of the population of Metro Vancouver. Descriptive statistics included means and proportions with 95% confidence intervals. FAIS was defined as coexistence of symptoms, positive FADIR, and cam or pincer morphology in the same hip. We used a Venn diagram to visually present the relationships between these components. Associations between symptoms, physical signs and cam/pincer morphology, were analyzed in logistic regression adjusting for age, sex, and BMI. In the analysis combining both hips, each participant was treated as a cluster. In addition, we carried out the analyses separately for left and right hip.

Results

Using RDD, we obtained a sample of 858 potential subjects and were able to contact 754 (87.9%). However, 254 (33.7%) of those did not provide data: 41 were ineligible, 66 not

interested, 84 not available, 53 declined for other/unknown reasons, and 10 were excluded due to incomplete data. Data were obtained from 500 participants. Descriptive data for the study sample and weighted data reflecting the study population are given in Table 1.

In the study population, 48.9 were males, 32.2, 31.4 and 36.4 were 20-29, 30-39 and 40-49 years old, respectively, 44.9% had college/university education, 15.1% were obese (BMI >30), and 2.0% reported a hip injury in the past (Table 1). Only 1.1% reported being diagnosed with hip OA. Persistent or recurrent hip joint symptoms on either side were present in 28.1% (95% CI 22.3-33.8) of the population, 21.9% in men and 34.0% in women (Table 2).

A positive FADIR test on either side was found in 34.3% (27.6-41.1), 35.7% in men and 33.1% in women. The distribution of alpha angle was strongly skewed, while the LCE angle was symmetrically distributed. Cam morphology, defined as alpha angle >60^{o} on either side, was observed in 20.5% (14.1-26.9) of the population, 35.1% and 6.6% in men and women, respectively (Table 2). Pincer morphology (LCE angle > 40^{o}) was present in 7.6% (3.9-11.4), 9.8% in men and 5.6% in women.

FAIS on either side was found in 3.0% (1.5-4.5) of the population, 3.4% in men and 2.7% in women. In Figure 1 we show the weighted percentages of all combinations of the three components of FAIS, separately for the left and right hip, in a Venn diagram. Prevalence of FAIS was 1.9% (0.63-3.2) on the left side and 2.1% (0.80-3.5) on the right side.

After adjusting for age, sex and BMI, prevalence of cam/pincer morphology was not significantly different in persons with vs. without symptoms in the same hip (OR 0.71, 95% CI 0.38-1.34) or in persons with vs. without a positive FADIR test (OR 1.010.53-1.90) (Table 3). Hip symptoms and FADIR test were strongly and significantly correlated (OR 3.98, 2.49-6.36). When the data were analyzed separately for the left and right hip, the results were similar.

Discussion

To our knowledge, this is the first large study in a random population sample to determine the prevalence of FAIS that applied the definition proposed in the Warwick Agreement. FAIS was defined in this study as coexistence of hip symptoms (persistent or recurrent pain, stiffness or discomfort in the groin or upper thigh), positive impingement sign (FADIR test) on physical examination, and evidence of cam (alpha angle >60^{o} in the Dunn view) or pincer (LCE angle >40^{o} in the AP view) morphology in the same hip. We found FAIS in 3% of the Caucasian population of Metro Vancouver aged 20-49. Each of the individual components was present in 25-34% of the population. FADIR test was associated significantly with symptoms, but there was no significant correlation between either symptoms or FADIR and radiological evidence of cam or pincer morphology in the same hip.

Prevalence of hip symptoms in our study was higher than in previous published reports, especially among women. Most previous studies have been done in older populations [5,6,8,19,35]. Kim et al. [19] reported prevalence of 14.7% in men and 24.7% in women aged 50+ in the Framingham Osteoarthritis Study and 18.5% and 27.5%, respectively, in the

Osteoarthritis Initiative. In European studies, prevalence tended to be lower and ranged from 7.0% to 18.8% in men and 10.0% to 21.0% in women [5,6,8,35]. A population survey of adults in Canada found a prevalence of 20.0% in men and 27.0% in women [21]. In addition to population differences, different wording of the questions (e.g., inclusion of stiffness and discomfort in our study) might have influenced these findings.

In our study, prevalence of a positive clinical test (FADIR test) was higher than in previous studies, which is consistent with a relatively high frequency of hip symptoms. Physical examination plays an important role in the definition of FAIS and several impingement tests have been described in the literature [16,33,36]. For the current study, we selected the FADIR test because it has been recommended by an international panel of experts [16], is reliable [31,36,33], and commonly used by clinicians [16,30]. However, prevalence of a positive FADIR test in the general population is not well established. In a study among healthy young men and women, Laborie et al. [23] found prevalence on either side to be 7.3% in men and 4.8% in women. Czuppon et al. [7] reported higher prevalence in asymptomatic athletes, 12.2% in men and 15.3% in women.

Our findings of prevalence of cam and pincer morphology fall about in the middle of the large range reported in the literature for various populations. However, comparisons of our data with published data are limited because of a high degree of heterogeneity, as demonstrated in recent reviews [10,12,38]. For example, prevalence of cam morphology varied from 5% to 75% in a review of 30 studies by Dickenson et al. [10]. Cam morphology is usually based on alpha

angle and this extreme variation in prevalence is likely due to differences in populations, imaging method (AP, frog lateral, cross table lateral, and Dunn lateral radiographs, CT, and MR) and the cut-off value. In the aforementioned review, the cut-off value varied from 50° to 83° and none of the studies was population based [10].

For pincer morphology, prevalence depends largely on the radiological features being considered, most of which are qualitative and not highly reliable [32]. Therefore, we selected a quantitative measure (LCE angle) with good reliability and a well-established cut-off value [8]. Nonetheless, prevalence of pincer morphology based on LCE angle ≥40° varied in published studies from 5.8% to 29.7% in males and 2.0% to 35.1% in females [26,28]. Among adults, deBruin et al. [9] reported LCE angle ≥40° in 22.6% of men and 17.3% of women, whereas Diesel [11] found overall prevalence to be 10.9%. Thus our results are within the range reported by other authors. The mean alpha and LCE angles in our study were also similar to those found by others [12].

In the current study, frequency of radiographic evidence of cam or pincer morphology was not different in persons with and without hip symptoms. This is consistent with several published reports [15,18,4,29,37]. However, some studies reported a significant correlation between symptoms and alpha angle [3,27,24]. This discrepancy may be due to several factors, including the type of population being studied, non-linear nature of the relationship, dilution of effect due to measurement errors, and small sample size in many studies [22]. In a prior study, we observed a non-linear relationship between alpha angle (treated as a continuous variable) and

patient-reported outcomes [22]. On the other hand, no study so far has demonstrated a correlation between symptoms and isolated pincer morphology or high LCE angle.

The relationship between various physical maneuvers, including FADIR, with cam or pincer morphology has been studied clinically to assess the validity of these tests against imaging data [36,33]. Unfortunately, the quality of such studies has been poor and the data show extreme heterogeneity [33]. Our study, in contrast, assessed the relationship between FADIR and cam/pincer morphology in the general population. The high prevalence of a positive test and lack of a significant association with radiological measures is consistent with data suggesting that the test is sensitive but non-specific, and is likely to detect changes that may not be seen on x-ray [33,36]. In one previous population study [23], FADIR was related to pain in women but not in men and was not related to alpha angle or other measures of cam or pincer morphology, except an association with a cam “composite score” in men.

The relationship between cam and pincer morphology with age and sex has been studied by several authors, as reviewed by van Klij et al. [38]. Consistently with the literature [5,8,10,12,19,35,38], our study found cam to be more common in men while hip pain was more common in women. The effect of age on cam/pincer morphology in adults is less clear [38] but hip symptoms in the general population tend to increase with age [5].

Some methodological strengths and limitations of the study are important to mention. The sample was relatively large and the data were weighted to be representative of the general

Caucasian population of Metro Vancouver. Since ethnicity has been shown to be a risk factor for impingement, our results should not be generalized to non-Caucasian populations. Subjects underwent comprehensive assessment that included both AP and Dunn views of both hips, standardized physical examination, and a self-administered questionnaire. Inter-rater agreement of cam and pincer measurements and the FADIR test was high. Comparisons with other studies are limited because of differences in definitions and methods. Agreed upon definitions, criteria, or cut-off values for each of the three components of FAIS do not currently exist [16]. Hip symptoms and a positive FADIR test were relatively common in our sample. Our results for cam and pincer morphology were within the range observed in the literature.

In conclusion, prevalence of FAIS in this study was estimated to be 3%. We used the Warwick Agreement definition of FAIS as a triad of symptoms, physical signs, and imaging findings. Current challenges in applying this definition include the lack of agreement on the best method to measure each element of this triad and incomplete understanding of the relationships between them.

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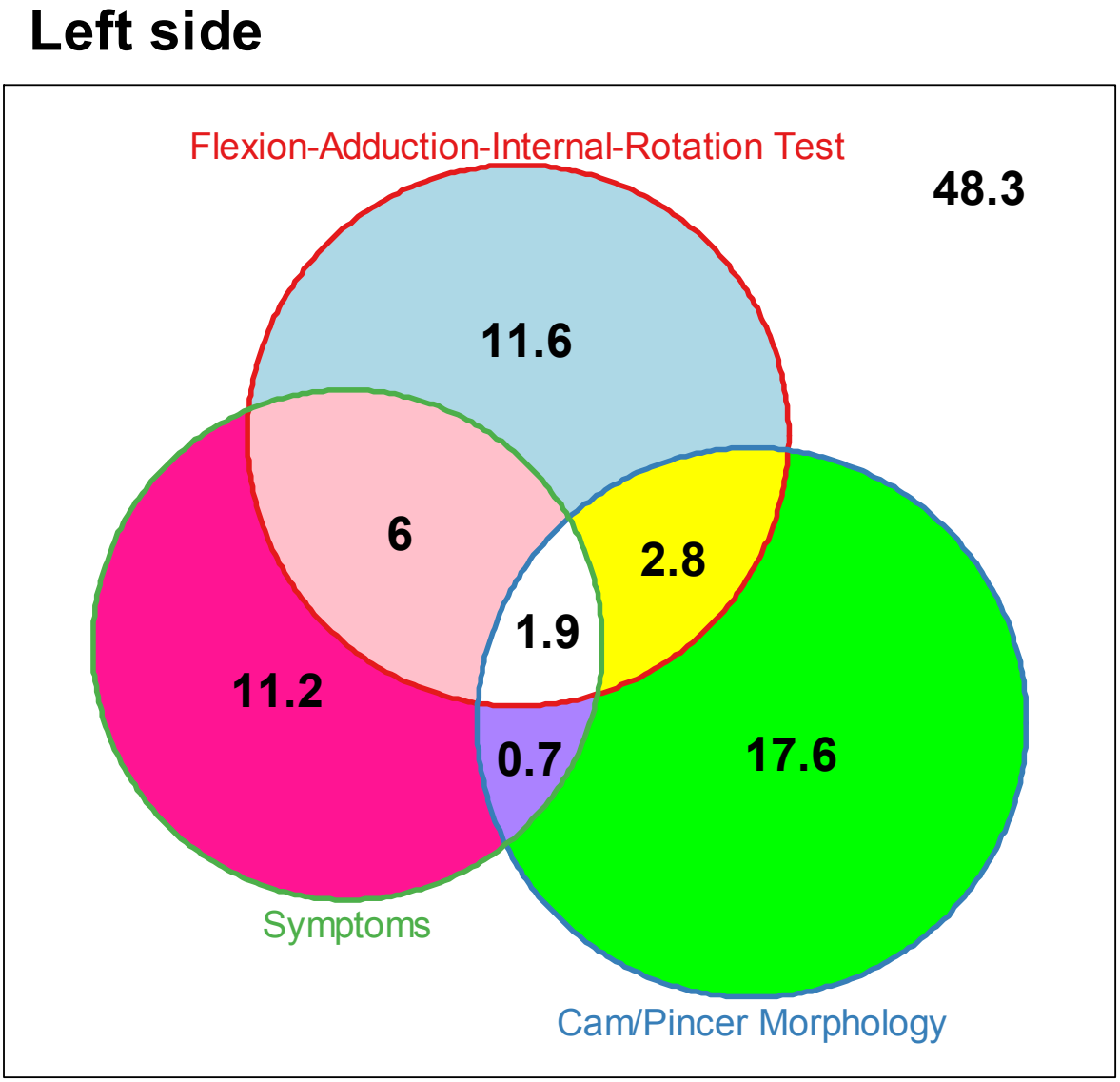
Figure 1: Overlap between hip pain, FADIR test, and cam/pincer morphology (numbers are weighted percentages).



Right side

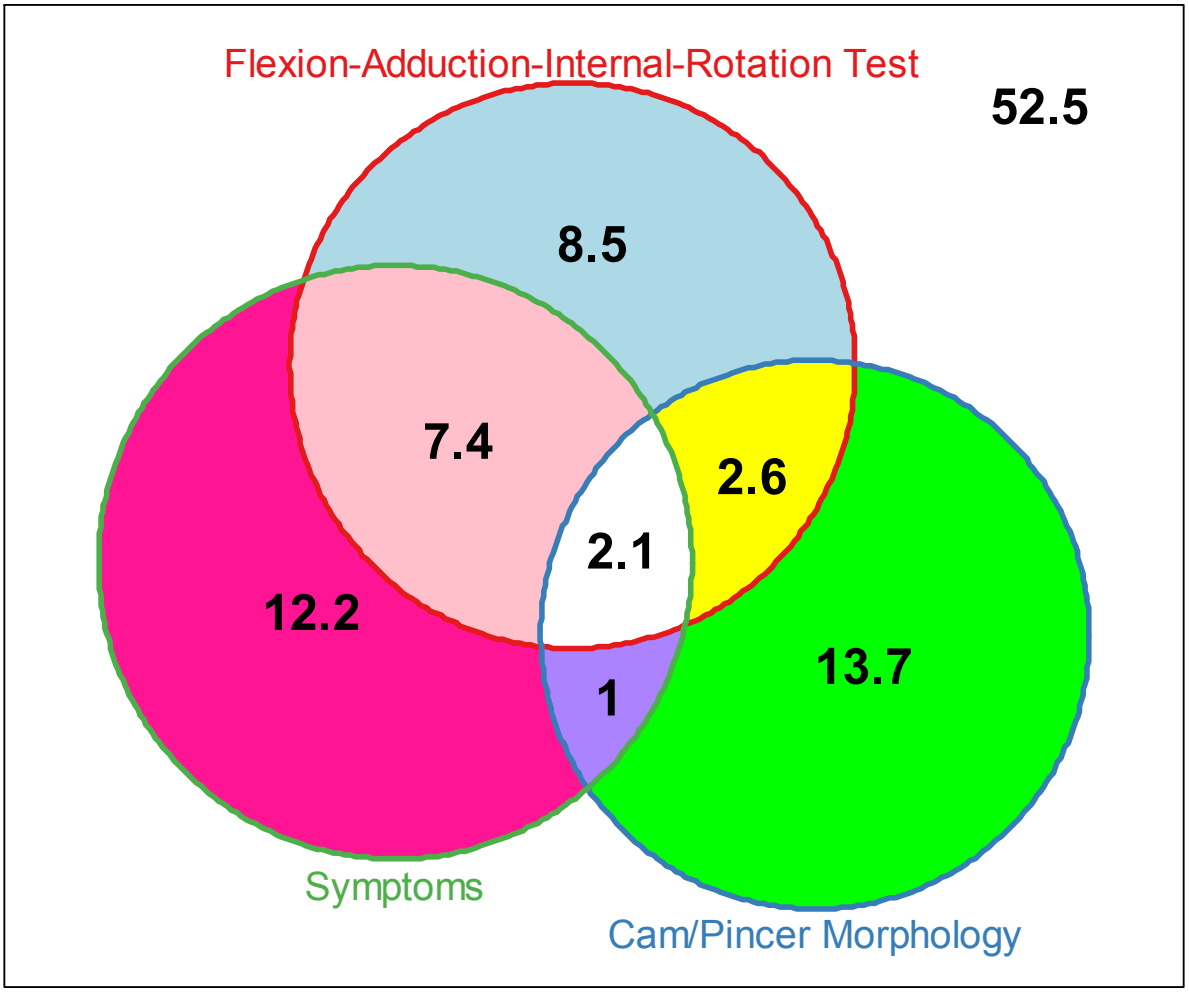


Table 1: Descriptive data for the study sample (N=500)

Variable	N (%)	Weighted % (95% CI)*
Sex		
Male	181 (36.2)	48.9 (41.6, 56.2)
Female	319 (63.8)	51.1 (43.8, 58.4)
Age		
20-29	50 (10.0)	32.2 (23.8, 40.6)
30-39	109 (21.8)	31.4 (25.1, 37.7)
40-49	341 (68.2)	36.4 (30.5, 42.3)
Education		
High school or less (0-13 grade)	101 (20.2)	27.3 (20.0, 34.6)
Vocational or some college	178 (35.6)	27.8 (21.8, 33.7)
College or university	221 (44.2)	44.9 (37.7, 52.1)
BMI		
<25	241 (48.2)	58.8 (51.9, 65.6)
25-29.9	155 (31.0)	26.1 (20.3, 31.9)
30+	104 (20.8)	15.1 (10.6, 19.6)
Hip injury		
Yes	26 (5.2)	2.0 (0.8, 3.1)
No	474 (94.8)	98.0 (96.9, 99.2)

*Weighted data adjust for oversampling of persons with pain to reflect population prevalence
BMI=body mass index.

Table 2: Sampling weighted prevalence (95% confidence intervals) of hip symptoms, positive FADIR test, cam/pincer morphology, and FAIS (in either hip)

	Male	Female	All
Any hip pain	21.9 (15.1, 28.7)	34.0 (25.4, 42.6)	28.1 (22.3, 33.8)
Positive FADIR	35.7 (25.3, 46.2)	33.1 (24.3, 41.8)	34.3 (27.6, 41.1)
Cam morphology	35.1 (23.9, 46.3)	6.6 (1.9, 11.3)	20.5 (14.1,26.9)
Pincer morphology	9.8 (3.0, 16.6)	5.6 (2.4, 8.8)	7.6 (3.9, 11.4)
Cam or pincer	39.1 (27.9, 50.3)	12.2 (6.6, 17.8)	25.3 (18.7, 31.9)
FAIS	3.4 (1.3, 5.4)	2.7 (0.5, 4.8)	3.0 (1.5, 4.5)

Cam morphology is defined as alpha angle >60^{o} and pincer as LCE angle >40^{o}

FADIR=Flexion-adduction-internal-rotation test; FAIS = Femoroacetabular impingement syndrome

Table 3. Relationships between hip symptoms, FADIR test, and cam/pincer morphology

Outcome	Comparison	Odd ratio	95% CI
Two sides combined			
FADIR test	Symptoms (+) vs. Symptoms (-)	3.98	2.49-6.36
Cam/pincer morphology	Symptoms (+) vs. Symptoms (-)	0.71	0.38-1.34
Cam/pincer morphology	FADIR (+) vs. FADIR (-)	1.01	0.53-1.90
Left side			
FADIR test	Symptoms (+) vs. Symptoms (-)	3.22	1.63-6.34
Cam/pincer morphology	Symptoms (+) vs. Symptoms (-)	0.64	0.31-1.33
Cam/pincer morphology	FADIR (+) vs. FADIR (-)	0.86	0.39-1.88
Right side			
FADIR test	Symptoms (+) vs. Symptoms (-)	5.26	2.60-10.64
Cam/pincer morphology	Symptoms (+) vs. Symptoms (-)	0.81	0.41-1.60
Cam/pincer morphology	FADIR (+) vs. FADIR (-)	1.18	0.51-2.78

Cam morphology was defined as alpha angle >60° and pincer as LCE angle >40°. Odds ratios were obtained from logistic regression adjusted for age, sex and BMI.
FADIR=Flexion-adduction-internal-rotation test