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Gender-Dependent Differences in Hip Range of Motion and Impingement Testing in Asymptomatic College Freshman Athletes

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Abstract

Background—Athletic activity is a proposed factor in the development and progression of intraarticular hip pathology. Early diagnosis and preventive treatments in "at risk" athletes is needed.

Objectives—Primary: To report hip range of motion (ROM) and prevalence of positive impingement testing in asymptomatic college freshman athletes; Secondary: To determine if an association exists between hip ROM and a positive flexion-adduction-internal rotation (FADIR) test.

Design—Cross-sectional study

Setting—Collegiate athletic campus

Participants—Four hundred thirty (299 males, 131 females) freshman athletes reporting no current or previous hip pain.

Methods—During the athletes' preseason medical screening, trained examiners performed a hip-specific exam to obtain data for hip ROM and impingement testing.

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Main Outcome Measurements—Bilateral passive ROM measures included hip flexion, and hip internal and external rotation with the hip flexed 0° and 90°

Results—Mean age of males was 18.5 ± 0.8 and females 18.3 ± 0.6 years old (p=.003). Males demonstrated less hip ROM than females in flexion (115.8 ± 11.2° vs. 122.0 ± 10.5°, p<.001), internal rotation in 90° flexion (26.9 ± 9.8° vs. 34.7 ± 10.7°, p<.001) and 0° flexion (29 .0 ± 9.8° vs. 38.9 ± 10.1°, p<.001), and external rotation in 90° flexion (44.7 ± 10.9° vs. 49.7 ± 10.4°, p<.001), but not for external rotation in 0° flexion (39.8 ± 11.1° vs. 37.6 ±11. 5°, p=.06). Pain with FADIR test on the right and left hip were reported in 11.9% and 14.5% of athletes, respectively. Gender and a positive FADIR were not related (males 12.2%, females 15.3%, p=.36).

Conclusions—In asymptomatic college freshman athletes, males generally demonstrated less hip ROM than females. Additionally, a positive FADIR was more prevalent than previously reported in healthy young adults. Pre-season screenings utilizing this baseline data in conjunction with other examination findings may allow identification of athletes at future risk for hip pain and/or injury.

Keywords

range of motion; impingement test; hip; athlete

Introduction

Athletic activity is a proposed factor in the development and progression of hip disorders, such as femoroacetabular impingement, labral tears and chondral lesions.[1–6] Pre-season screening may allow early identification of those at higher injury risk and enable training regime modifications to minimize injury risk. While normal hip ROM ranges have been described for the general population,[7–10] few studies have reported on hip ROM in asymptomatic athletes.[11–13] Hip ROM limitation may result in abnormal stresses to hip structures during athletic activities, particularly activities requiring large joint excursions. To better understand why some athletes may develop hip pain, we need to improve our understanding of normal hip ROM in young, asymptomatic athletes.

Additionally, the prevalence of a positive hip flexion-adduction-internal rotation test (FADIR), a common provocative test,[14] in athletes participating in various sports has not been determined. Provocative tests are commonly used to identify pathology but may have potential to screen for injury risk factors. The FADIR is often performed to assist in diagnosing hip joint pathology, as this test position stresses a large portion of the acetabulum[15] and labrum.[16] The FADIR has high sensitivity for detecting pain and hip joint pathology in symptomatic individuals,[14,17] but low specificity.[17,18] The FADIR may be a useful screening test to identify individuals at risk for future hip pain, but the prevalence of a positive test in asymptomatic individuals is not well known. At least one study reported positive provocative testing in asymptomatic athletes,[19] but findings were specific to female soccer players. If the FADIR can be a useful screening tool, the prevalence of a positive test in asymptomatic athletes needs to be assessed.

The primary purpose of this study was to report hip ROM and prevalence of a positive FADIR in asymptomatic college freshman athletes. We hypothesized males would demonstrate decreased hip ROM compared to females and the prevalence of positive FADIR tests would be low. The secondary purpose was to determine if an association exists between hip ROM and a positive FADIR. Because the FADIR is most commonly associated with femoroacetabular impingement, we hypothesized athletes with a positive FADIR would demonstrate reduced hip ROM in flexion and internal rotation with the hip flexed to 90°.

Methods

During 2008–2012 Washington University in St. Louis preseason medical screenings, freshman Division III varsity athletes were recruited for a hip specific screening exam. Athletes were required to participate in these medical screenings prior to any sports participation, including practices, at the University. Only data from athletes reporting no current or history of hip pain were included in this analysis. This study was approved by the Washington University School of Medicine's Human Research Protection Office and all athletes signed an informed consent statement prior to participating. Parental consent and athlete assent was required for athletes under 18 years old.

Examiner training

Given the large number of athletes to be screened at each session, multiple examiners were needed. Thirty-five examiners, including 12 orthopaedic physical therapists, 8 physical medicine and rehabilitation physicians and 15 student physical therapists, completed training to participate in the study. All students had passed their required ROM measurement course at Washington University in St. Louis Program in Physical Therapy. Training included review of a procedure manual and participation in a training session led by the principle investigator (MHH), a therapist with 13 years of clinical experience and 10 years of teaching experience. Prior to participating in data collection, each examiner was required to demonstrate proper testing procedures for each ROM measurement and for the FADIR test. If an examiner did not demonstrate proper testing procedures, additional training was provided. Using these training methods, our research team has reported good reliability in hip ROM measurement and excellent agreement (96%) for the FADIR test, among examiners from different medical disciplines.[20] As imaging to determine specific pathology or bony morphology would be cost-prohibitive, we were unable to determine the validity of the FADIR test.

Athlete testing

After informed consent was obtained, athletes completed questionnaires to provide demographic information and musculoskeletal pain history, and were assigned to a testing station. Athletes' leg dominance was determined by asking which leg was their preferred kicking leg. Height and weight were self-reported. Supine hip ROM, FADIR and prone hip ROM were performed sequentially. Supine hip ROM and FADIR were performed during all screenings (2008–2012) and prone hip ROM was performed from 2009–2012. To minimize athlete burden and disruption of medical screenings, each test item was performed once.

Two examiners participated in testing each athlete. Hip ROM was measured using a standard 12.5 inch goniometer. Measurement of hip ROM using a goniometer has been shown to have good intra- and inter-rater reliability.[21–24] For each measure, the first examiner passively moved the hip through full ROM to demonstrate the movement to the athlete. This examiner determined the end of passive joint ROM, preventing compensatory motion at adjacent joints through stabilization and monitoring. Once the first examiner determined the final position, the second examiner held the athlete's limb while the first examiner completed the measurement. All tests were performed with the contralateral hip/knee extended.

Supine hip flexion (Flexion)—The examiner flexed the hip to the end of passive motion, with his/her opposite hand under the lumbar spine to prevent posterior pelvic tilt during the motion. The end of hip flexion was determined to be when the hip could not be flexed without posterior pelvic tilting, and was defined as the angle formed by the bisection of the pelvis and thigh.

Supine hip internal and external rotation, hip flexed to 90° (IR90, ER90)—The examiner flexed the hip and knee to approximately 90° and internall y rotated the hip to the end of passive motion, while visually monitoring for compensatory lateral pelvic tilt. The end of hip rotation was determined to be when the hip could not be rotated without lateral pelvic tilting, and was defined as the angle formed between a line parallel to the trunk and the bisection of the tibia. Similar methods were used for ER90, however the hip was externally rotated.

Prone hip internal rotation and external rotation with hip in neutral flexion/ extension (IR0, ER0)—The testing technique for IR0 and ER0 was the same as for IR90 and ER90, except the athlete was prone with the tested limb's knee flexed to 90°. During testing, the examiner prevented compensatory pelvic rotation and excessive motion at the tibiofemoral joint, movements that have been shown to contribute to inflated hip rotation ROM values.[25] Rotation ROM was defined as the angle formed between a line perpendicular to the testing surface and the bisection of the tibia.

FADIR test—We focused on this provocative test because it has been shown to be sensitive for intra-articular, nonarthritic hip joint pain[14,26] and is the most commonly reported physical examination test to assess symptoms in young adult hip pain. The examiner flexed the hip to 90°, internally rotated and adducted the hip to its end motion and applied overpressure.[27] The examiner asked the athlete to report any pain in the hip region during testing. Although classically, the FADIR is considered a positive test if it elicits groin pain[27] many observational studies of individuals with symptomatic hip impingement or labral pathology report groin, lateral hip and buttock pain as the most common locations of pain.[28–32] Additionally, buttock pain, followed by thigh and groin pain, are the most commonly reported pain locations in individuals that obtain relief from therapeutic hip joint injections.[33] Therefore, during our testing, if pain was reported and was determined not to be muscle soreness or stretching, the test was recorded as positive and pain location was recorded as either groin (anteriorly along the inguinal crease between the pubis and ASIS), buttock (posteriorly between the iliac crest to the gluteal fold), or lateral hip (laterally between the iliac crest and superior greater trochanter).

Data Analysis

Data are presented as mean values ± standard deviations for continuous variables and counts (percent of specified group) for categorical variables. Between gender differences were assessed using Wilcoxon's two-sample test for age and body mass index (BMI), and a chi-square test for lower limb dominance. Because ROM and FADIR testing were measured on both limbs of each athlete, Generalized Estimating Equation (GEE) models with an exchangeable correlation was used for analyses of these variables to account for the dependence of measurements from each limb within each athlete. GEE models were used to determine if the association between FADIR and ROM is similar for limbs of males compared to females. For these models, ROM was the dependent variable, and independent variables included FADIR impingement (presence/absence), gender, and the interaction between FADIR and gender. When the interaction was not significant, it was dropped from the model and the main effects of impingement and gender were examined. Except where noted, additional GEE models were used to compare the prevalence of impingement for (a) limbs of athletes that do versus do not play each sport, (b) limbs of males compared to females, and (c) dominant compared to the non-dominant legs. We also used GEE models to assess BMI by the presence/absence of impingement on the measured limb.

The possibility that the association between ROM and the presence of impingement may differ depending on the magnitude of the ROM measurement was explored using several data-dependent methods that include GEEs to compare the prevalence of impingement across ROM quartiles, visual inspection of prevalence across ROM deciles, and graphical diagnostics such as cumulative frequency plots. For all analyses, a p-value $< .05$ was considered significant.

Results

From a total of 520 athletes, 431 reported no current or previous hip pain. Data from one female athlete was omitted due to the absence of FADIR data for either limb, leaving a total of 430 athletes for analysis (299 males, 131 females). Demographic characteristics are provided in Table 1. On average, males were 2.6 months older and had significantly higher BMI than females. Gender and leg dominance were not related.

Males demonstrated statistically significant decreased hip flexion, IR90, ER90 and IR0 ROM compared to females. No significant difference in hip ER0 ROM was noted between males and females (Table 2).

Three hundred and fifty-four (82.3%) athletes had a negative FADIR for both hips, 39 (9.1%) had a positive FADIR unilaterally, and 37 (8.6%) bilaterally. A positive FADIR was recorded on the right and left hip in 11.9% and 14.5% of athletes, respectively. The prevalence of a positive FADIR was not associated with sport type (Table 3). The presence of a positive FADIR was similar for males and females. Pain location reported with the FADIR was similar for males and females (p=.69), with groin pain noted in 60.2% of limbs tested, lateral hip pain in 38.0%, and buttock pain in 1.8% (Table 4). For those athletes with a positive test bilaterally, 19 reported bilateral groin pain, 11 bilateral lateral thigh pain and 1 bilateral buttock pain; all other athletes reported pain in different locations in each hip.

Hip ER0 ROM was significantly associated with a positive FADIR (p=.01, supplementary material), where limbs with a positive FADIR demonstrated greater hip ER0 (42.6°± 13.3) compared to those with a negative FADIR (38.6°± 10.8). No other ROM measurement was significantly different for limbs with and without a positive FADIR. This lack of significance prompted further exploratory analyses to determine if the association between ROM and FADIR differed depending on the magnitude of the ROM measurement (i.e., is there a threshold ROM value(s) discriminating between limbs with a positive and negative FADIR?). Across ROM measurements, we found no consistent pattern for such a threshold(s). Due to the lack of a consistent pattern of findings and the inflation of Type 1 error rates due to multiple testing, these exploratory data are not reported. The presence of a positive FADIR was not associated with leg dominance (p=.09) or BMI (p=.41).

No significant difference in ROM was found due to the interaction between FADIR and gender; meaning that ROM differences for male and female limbs did not depend on the presence/absence of a positive FADIR. However, there was a trend (p=.051) for ER90, where a positive FADIR was associated with ROM in females but not males. ER90 was similar for male limbs with a positive (43.6° ± 11.5°) and negative (44.9° ± 10.8°) FADIR, but female limbs with a positive FADIR had increased ER90 (53.8° ± 9.5°) co mpared to female limbs with a negative FADIR (48.9° ± 10.4°).

Discussion

As hypothesized, in this population of asymptomatic college athletes, males generally had significantly less hip ROM than females. The prevalence of a positive FADIR was higher than expected and was not related to athlete's gender, sport played, leg dominance or BMI. Athletes with a positive FADIR demonstrated greater ER0 ROM than those with a negative FADIR. To our knowledge, this is the largest sample of individuals without hip pain for which standardized methods and measurements for hip ROM and FADIR testing have been utilized and recorded. This study improves our understanding of hip ROM and the prevalence of positive FADIR testing in asymptomatic athletes. It is unknown whether an asymptomatic athlete with positive clinical findings will later become symptomatic. However, pre-season screenings utilizing this baseline data in conjunction with other examination findings, may allow identification of athletes at risk for hip pain and/or injury.

We found only one other study reporting ROM and FADIR in a large cohort. Laborie et al[34] reported on hip ROM and positive FADIR prevalence in a large, similarly aged adult population, some of whom had current hip pain. It is interesting to draw comparisons between their cohort, which included the general population, and ours, which specifically included collegiate athletes. In both studies, males had less hip flexion and internal rotation ROM than females. ROM differences may be related to gender-specific differences in osseous morphology and/or muscle or ligamentous stiffness. Developmental hip dysplasia is more common in females,[35] which may result in larger ROM excursions. Large Cam deformities of the femoral neck are more prevalent in males,[36,37] which may contribute to hip ROM limitations.[28,38]Imaging was cost-prohibitive and is not available for our sample, so we cannot draw conclusions regarding bony structure based on our data alone. Previous studies have found that males generally have decreased joint laxity[39,40] and increased muscle stiffness[41] compared to females. Our athletes demonstrated similar hip flexion ROM but less prone internal and external rotation ROM than the general population, which may suggest hip rotation ROM is related to activity participation. Siebenrock et al[3] reported male athletes have reduced hip internal rotation compared to non-athletic males and preliminary data suggests participation in impact activities may affect bony structures.[1–6] Differences in reported hip rotation ROM measures may relate to differences in study methodology rather than true ROM differences between populations. In the current study, during hip rotation ROM measurement we specifically prevented excessive tibiofemoral joint motion, as excessive movement at the knee can contribute to inflated ROM values.[25] Further studies are needed to clarify whether young athletes have significant hip rotation ROM differences compared to the general population.

Interestingly, the prevalence of a positive FADIR in our asymptomatic athletes was higher than that reported for the general population. Laborie et al[34] reported a positive FADIR in at least one hip in 4.8% and 7.3% of females and males, respectively. The prevalence was higher in our study, with 15.3% of female limbs and 12.2% of male limbs demonstrating a positive FADIR. It is surprising Laborie et al found fewer positive tests because they did not exclude those with hip pain. Athletes may be more likely to have a positive FADIR given their activity level. Our reported prevalence of a positive FADIR was similar to that found by Prather et al,[19] who reported on prevalence in athletes across multiple age groups, including grade school/middle school (16%), high school (19%) and professional (21%).

Previous studies have reported associations between hip ROM and a positive FADIR. Laborie et al[34] reported a positive FADIR was associated with decreased hip flexion in males and females, and decreased IR0 in males. We were surprised to find athletes with a positive FADIR demonstrated greater ER0 ROM than those with a negative FADIR, and that a trend existed for greater ER90 in females with a positive FADIR. The differences in our findings may relate to more standardized ROM measurements and the exclusion of individuals with current or a history of hip pain. Nevertheless, repetitive external rotation with axial loading during sporting activities has been proposed to contribute to atraumatic instability and subsequent hip injury.[42] Hip ER ROM may be important to assess in future screenings. Prather et al[19] noted that decreased hip flexion ROM in professional soccer players and increased hip flexion ROM in grade school and middle school soccer players was associated with a positive provocative test. However, provocative tests included the FADIR test, Patrick’s test and resistive straight leg raise.

Though the FADIR is a common provocative test performed to assist in diagnosing hip joint pathology, the location of pain produced during testing is not often reported. We felt it important to clearly define the location of symptoms produced and to utilize the same locations where patients with hip joint pathology typically report pain (e.g. the groin, lateral hip, and buttock).[29–33,43,44] As our athletes did not have hip pain, we defined a positive FADIR as eliciting pain in any of these regions. Reports of a stretching sensation or pain elsewhere, such as the lumbar spine, were not considered positive. Among limbs with a positive FADIR, 60.2% of athletes reported pain in the groin, 38.0% in the lateral hip and 1.8% in the buttock. With our current data, we cannot make links between pain location, presence of hip pathology, or future injury risk. We plan to follow these freshman athletes through their collegiate careers to determine if relationships between these variables exist.

This study has several limitations. Multiple examiners were required to complete data collection for this study, which may have increased the variability within ROM measurements. Previous reports have shown good inter- and intra-rater reliability for hip ROM measurements taken by physicians and physical therapists.[20–24] Additionally, each examiner was trained in testing procedures and required to correctly demonstrate each test prior to participation in the data collection process. We believe our training methods, including specific techniques to prevent motion at the pelvis and knee joint help to reduce variability among our examiners. We used the FADIR, a test traditionally used to identify pathology, as a potential screening test. This test has high sensitivity in identifying hip joint pathology in symptomatic individuals.[17] We did not have imaging to confirm the presence or absence of pathology in our athletes. It is possible athletes with a positive FADIR have pathology that was not severe enough to cause pain or restrict activities. Athletes may have been hesitant to report pain for fear a report of symptoms may result in reduced playing time. There is also limited generalizability of our results due to testing a young, athletic population; however this sample is representative of those likely to have pain related to femoroacetabular impingement.[45] Our sample included predominantly Caucasian athletes so ethnic differences may not have been detected. Similarly, with a variety of sports represented in this study, many of which included small numbers of athletes, sport-specific differences may not have been detected. A preliminary study reported hip ROM changes in collegiate male baseball players over the course of sports season.[46] As we were limited by the demographics of the incoming athletes and the timing of preseason screenings at our University, future studies should incorporate more diverse populations.

Conclusion

Our data suggest males generally have less hip ROM than females and the prevalence of a positive FADIR is higher in the young asymptomatic athlete than previously reported in the general population. Pre-season screenings may assist in identifying athletes at risk for developing hip disorders though future studies are needed to determine specific risk factors.

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Table 1

Demographic Characteristics.

Characteristic	Males (n=299)	Females (n=131)
Age (years) *	18.5 ± 0.8	18.3 ± 0.6
BMI (kg/m^2) **	25.3 ± 4.6	21.9 ± 2.9
Lower Limb Dominance ***		
Right	253 (84.6%)	108 (82.4%)
Left	29 (9.7%)	13 (9.9%)
Reported Unknown/Missing	17 (5.7%)	10 (7.6%)
Race		
Caucasian	255 (85.2%)	108 (82.4%)
African American	12 (4.0%)	7 (5.3%)
Asian	15 (5.0%)	7 (5.3%)
Other	3 (1.0%)	1 (0.8%)
>1 race	9 (3.0%)	7 (5.3%)
Reported Unknown/Missing	5 (1.7%)	1 (0.8%)
Ethnicity		
Hispanic or Latino	8 (2.7%)	6 (4.6%)
Not Hispanic or Latino	240 (80.3%)	104 (79.4%)
Reported Unknown/Missing	51 (17.1%)	21 (16.0%)
Primary Sport		
Baseball/Softball	18 (6.0%)	8 (6.1%)
Basketball	30 (10.0%)	24 (18.3%)
Cross Country/ Running/Track	58 (19.4%)	32 (24.4%)
Football	147 (49.2%)	0 (0.0%)
Soccer	24 (8.0%)	24 (18.3%)
Swimming	15 (5.0%)	16 (12.2%)
Volleyball	0 (0.0%)	10 (7.6%)
Other	7 (2.3%)	17 (13.0%)

* P=.003 by Wilcoxon's test.

** P<.001 by Wilcoxon's test.

*** P=.74 by chi-square test.

Table 2

Range of motion (ROM) comparisons between males and females.

Hip ROM	Gender	# limbs	Mean ± SD	Mean Difference*	p-value‡
Flexion	Male	598	115.8 ± 11.2	− 6.2 (−7.8, −4.6)	<.001
	Female	262	122.0 ± 10.5		
IR90	Male	598	26.9 ± 9.8	− 7.8 (−9.3, −6.3)	<.001
	Female	262	34.7 ± 10.7		
ER90	Male	598	44.7 ± 10.9	− 5.0 (−6.5, −3.4)	<.001
	Female	262	49.7 ± 10.4		
IR0†	Male	510	29.0 ± 9.8	− 9.9 (−11.5, −8.4)	<.001
	Female	226	38.9 ± 10.1		
ER0†	Male	509	39.8 ± 11.1	2.1 (0.4, 3.9)	.06
	Female	226	37.6 ± 11.5		

IR90 = Hip internal rotation ROM with hip at 90° flexion
ER90 = Hip external rotation ROM with hip at 90° flexion
IR0 = Hip internal rotation ROM with hip at 0° extension
ER0 = Hip internal rotation ROM with hip at 0° extension

*Calculated by subtracting female limbs from male limbs. Values in parentheses are 95% confidence interval.

†Fewer participants due to testing only performed in years 2009–2012.

‡P-value compares ROM for limbs of males versus females by GEE.

Table 3

Prevalence of positive FADIR test by gender and sport.

Sport	By Gender*		By Participation in Sport†		
	Male	Female	Plays the Sport	Does Not Play the Sport	p-value‡
Baseball, Softball	8/36 (22.2%)	4/16 (25.0%)	12/52 (23.1%)	101/807 (12.5%)	.11
Basketball	7/60 (11.7%)	12/48 (25.0%)	19/108 (17.6%)	94/751 (12.5%)	.27
Cross Country, Running, Track	10/115 (8.7%)	10/64 (15.6%)	20/179 (11.2%)	93/680 (13.7%)	.54
Football	40/294 (13.6%)	0/0 (0.0%)	40/294 (13.6%)	73/565 (12.9%)	.85
Soccer	3/48 (6.2%)	8/48 (16.7%)	11/96 (11.5%)	102/763 (13.4%)	.68
Swimming	5/30 (16.7%)	3/32 (9.4%)	8/62 (12.9%)	105/797 (13.2%)	.95
Volleyball	0/0 (0.0%)	0/20 (0.0%)	0/20 (0.0%)	113/839 (13.5%)	.09§
Other	0/14 (0.0%)	3/34 (8.8%)	3/48 (6.2%)	110/811 (13.6%)	.27

*Separately for males and females, values expressed as the number of limbs with positive FADIR test in the sport / the total number of limbs in the sport (percent). Impingement data not available for one limb of one male athlete.

†Separately for athletes that do and do not play the sport, values expressed as the number of limbs with positive FADIR test / the total number of limbs (percent). Impingement data not available for one limb of one male athlete.

‡For males and females combined, p-value compares the proportion of limbs with a positive FADIR test for athletes that do play the sport compared to athletes that do not play the sport by GEE, except where noted.

§Due to small prevalence which prevented GEE modeling, p-value by Fisher's exact test.

Table 4

Prevalence of positive FADIR and location of pain during FADIR testing by gender.

		By Gender		
	Total	**Male**	**Female**	**p-value**
Positive limbs	113/859 (13.2%)	73/597 (12.2%)	40/262 (15.3%)	.36*
Pain location for positive limbs:				.69†
Groin	68/113 (60.2%)	46/73 (63.0%)	22/40 (55.0%)	
Lateral Hip	43/113 (38.0%)	27/73 (37.0%)	16/40 (40.0%)	
Buttock	2/113 (1.8%)	0/73 (0.0%)	2/40 (5.0%)	

Values expressed as the number of positive limbs / the total number of limbs (percent).

*P-value compares the proportion of limbs with a positive FADIR test for males compared to females by GEE. Impingement data not available for one limb of one male athlete.

†For limbs with a positive FADIR test, p-value compares the proportion of limbs with pain in each location for males compared to females by GEE. Due to small prevalence, 2 limbs with pain in the buttock were excluded from this analysis. Impingement data not available for one limb of one male athlete.