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Abnormal hip physical examination findings in asymptomatic female soccer athletes

Heidi Prather,

Department of Orthopaedic Surgery, Washington University School of Medicine, One Barnes Plaza, Suite 11300, St. Louis, MO 64110, USA

Devyani Hunt,

Department of Orthopaedic Surgery, Washington University School of Medicine, One Barnes Plaza, Suite 11300, St. Louis, MO 64110, USA

Monica Rho,

Department of Orthopaedic Surgery, Washington University School of Medicine, One Barnes Plaza, Suite 11300, St. Louis, MO 64110, USA

Ted Yemm,

Rehab One, St. Louis, MO, USA

Kathryn Fong, and

University of Buffalo, SUNY School of Medicine, Buffalo, NY, USA

Robert H. Brophy

Department of Orthopaedic Surgery, Washington University School of Medicine, One Barnes Plaza, Suite 11300, St. Louis, MO 64110, USA

Heidi Prather: pratherh@wudosis.wustl.edu

Abstract

Purpose—Examination of the hip provides information regarding risk for pre-arthritis hip disorders, knee injuries, and low back pain. The purpose of this study was to report a hip screening examination of asymptomatic female soccer athletes and to test the hypothesis that these findings vary by competition experience.

Methods—Asymptomatic females from a youth soccer club, a college, and a professional team were evaluated. Passive hip range of motion, hip abduction strength, and hip provocative tests were assessed. Data were compared for the grade/middle school, high school, college, and professional athletes.

Results—One hundred and seventy-two athletes with a mean age of 16.7 ± 5 years (range 10–30) participated. Professional athletes had less flexion (HF) for both hips ($p < 0.0001$) and less internal rotation (IR) for the preferred kicking leg ($p < 0.05$) compared to all other groups. Grade/middle school athletes had more external rotation in both hips as compared to all other groups ($p < 0.0001$). For the preferred kicking leg, collegiate athletes had less hip abduction strength as

Correspondence to: Heidi Prather, pratherh@wudosis.wustl.edu.

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compared to other groups ($p < 0.01$). Positive provocative hip tests were found in 22 % of all players and 36 % of the professionals. In professionals, a positive provocative test was associated with ipsilateral decreased HF ($p = 0.04$).

Conclusion—Asymptomatic elite female soccer athletes with the most competition experience had less bilateral hip flexion and preferred kicking leg IR than less-experienced athletes. Positive provocative hip tests were found in 22 % of athletes. Future studies are needed to show whether these findings link to risk for intra-articular hip or lumbar spine and knee disorders.

Level of evidence—III.

Keywords

Hip range of motion; Female soccer athletes; Hip deformity; Anterior cruciate tears; Low back pain

Introduction

Female participation in soccer has dramatically increased in the past 20 years. Literature regarding female athletes has focused on knee injuries, but a recent study of high school soccer injuries reported 13.3 % of all injuries sustained by girls involved the hip and thigh [40]. However, the role of underlying hip deformity such as femoroacetabular impingement (FAI) and developmental hip dysplasia (DDH) with or without acetabular labral tears plays in this incidence number is unknown. A recent study by Gerhardt et al. [11] found the incidence of FAI deformity to be quite common. Radiographic deformity was found in 72 % of male and 50 % of female professional soccer athletes. The question as to why some athletes develop symptoms and others do not remains unanswered. Studies suggest the presence of hip deformity increases the risk of symptomatic acetabular labral tears [26]. With an increased incidence of symptomatic hip acetabular labral tears being demonstrated in the athletic population [1, 9, 14, 23], health care providers need more information regarding training and prevention strategies for athletes involved in high-risk sports such as soccer with repetitive pivoting and end-range hip motion.

Information is emerging regarding the presentation and functional limitations related to intra-articular hip disorders that occur prior to the onset of osteoarthritis (pre-arthritis) which include acetabular labral tears, DDH, and FAI [3, 5, 25, 28, 29]. This group of pre-arthritis hip disorders present with similar distributions of pain and history of onset of symptoms [3, 5, 18, 25, 28, 29]. Physical examination findings are also similar in this group of disorders including positive provocative hip tests such as the anterior hip impingement, flexion abduction external rotation (FABER), and log roll [3, 5, 25, 28, 29]. Hip ROM restrictions found in athletes with symptomatic pre-arthritis hip disorders [3, 5] have also been found in athletes with ACL tears and low back pain (LBP) [12, 13, 37–39]. Additional studies are needed to define the relationships of hip bony morphology and movement with hip, lumbar spine, and knee injuries.

Further, the long-term impact of soccer on the hip has been documented [8, 31, 32, 35, 36] with elevated rates of hip osteoarthritis in ex-professional male soccer athletes [8, 31, 32, 36] and female athletes with a two- to threefold increased risk of radiologic changes

consistent with osteoarthritis of the hips [32]. The presence of hip deformity has been linked to hip osteoarthritis [15, 26]. Long-term studies are needed to determine whether the high prevalence of radiographic findings of hip deformity in soccer athletes as described by Gerhardt et al. [11] plays a part in the incidence of osteoarthritis in this population later in life.

The physical examination of the hip provides information regarding the potential for hip pain and injury as well as injuries involving the knee and lumbar spine. The purpose of this study was to describe characteristics of asymptomatic female soccer athletes and their hip screening examination to test the hypothesis that these findings vary by age and level of competition.

Materials and methods

Female soccer athletes were recruited from a youth soccer club, an NCAA Division I university team, and a women's professional team. The three senior authors (HP, DH, and RB) evaluated all subjects at the beginning of the athletes' competitive seasons. Athletes were excluded if they had an active lumbar spine, hip, or lower extremity disorder that required ongoing treatment. After obtaining informed consent, the athletes completed a questionnaire including demographic information, medical history, specific musculoskeletal injuries, and surgical history. The athletes were asked to record their on-field soccer-playing position and preferred kicking leg. The examiners were not blinded to the athletes' age, level of play, or preferred kicking leg. Every member of each team participated. The athletes were considered elite because they played at the highest level of competition available nationally for their age group.

Hip physical examinations

All hip examinations were performed by one of two physiatrists (HP, DH) with an expertise in the hip evaluation. Prior to this study, we conducted a study to assess inter-rater reliability of passive hip ROM and agreement of provocative hip tests performed by multiple examiners from multiple medical disciplines including physicians specializing in physical medicine and rehabilitation and orthopaedic surgery and physical therapists [30]. Passive hip ROM measurements were completed with the athlete in the supine position using standard goniometer methods previously determined to be reliable and valid amongst examiners of similar training [10, 16, 21, 24]. In a study of multiple examiners from multiple medical specialties, Prather et al. [30] found good-to-excellent inter-rater reliability for hip flexion with intraclass correlation coefficient (ICC) of 0.86 with a 95 % confidence interval (CI) of 0.75–0.93. The ICC for hip internal and external rotation performed in the supine positions were 0.77 (95 % CI 0.60–0.88) and 0.67 (95 % CI 0.44–0.82), respectively. These measurements were assessed in this study. The hip strength manual muscle testing with the athlete in a side lying position with the hip in neutral and extension was performed as described by Kendall using a grading scale of 0–5 with 0 being no muscle activation and 5 being full muscle strength against resistance [19]. With the patient in the side lying position, the extremity to be tested was placed in abduction by the examiner. The examiner asked the athlete to resist abduction with counter pressure by one hand of the examiner's placed just

below the knee while the examiner's opposite hand was placed on the pelvis to monitor for rotational movement. This was repeated with the athlete's hip in extension and abduction.

Hip provocative tests performed included the anterior hip impingement test and FABER/Patrick's test, and resisted active straight leg raise [17, 20]. Each test was recorded as being positive if the test provoked groin or lateral hip pain. Prior to this study, these tests were found to have high inter-rater agreement (96–98 %) between multiple examiners from multiple medical disciplines [30]. Before recruitment, this study was approved by the Washington University School of Medicine Human Studies Committee with institutional review board identification number 201109195.

Statistical analysis

Data were compared by level of competition: grade school/ middle school (GS/MS), high school (HS), collegiate (COL), and professional (PRO) levels. For continuous variables, data were compared using analysis of variance (ANOVA) with Tukey–Kramer adjusted least square means for all pair-wise between-group comparisons. Comparisons of categorical variables were performed using chi-square tests with Bonferroni adjusted p values for pair-wise between-group comparisons. The Cochran–Armitage test was used to compare dichotomous variables when the linear trend across age groups was of interest. Unless otherwise noted, data are reported as mean $\pm$ standard deviation.

Results

One hundred seventy-two female soccer athletes ranging from preadolescent (10 years) to adult (30 years) with a mean age of 16.7 ± 5 years completed the questionnaire and hip examination (Table 1). These athletes participated in 10.3 ± 6 h (range 5.1 ± 2 – 17.9 ± 5 h) of organized soccer training per week and began playing soccer at 4.9 ± 1 years of age. The majority of players, 156 (91 %), reported a right leg kicking preference.

Passive hip range of motion

Passive hip range of motion findings are summarized in Table 2. Professional athletes had significantly less hip flexion in both the preferred kicking leg ($105^\circ \pm 8^\circ$) and the support leg ($104^\circ \pm 8^\circ$) compared to the other groups. Professional athletes also demonstrated significantly decreased hip internal rotation (IR) in the kicking leg ($28^\circ \pm 7^\circ$) but not the support leg ($31^\circ \pm 8^\circ$) compared to the other groups. The GS/MS athletes demonstrated significantly more passive hip external rotation (ER) in both their kicking ($56^\circ \pm 9^\circ$) and support leg ($59^\circ \pm 11^\circ$) compared to the other groups.

Side-to-side passive hip flexion ROM differences were found in collegiate level athletes where the kicking leg had significantly ($p = 0.03$) less hip flexion ($111^\circ \pm 7^\circ$) compared to the support leg ($114^\circ \pm 7^\circ$). This side-to-side difference in hip flexion was not demonstrated in any other group. For passive hip IR, the GS/MS athletes ($p = 0.02$) and the professional athletes ($p = 0.01$) demonstrated statistically significant side-to-side differences. In both groups there was decreased hip IR in the preferred kicking leg (GS/MS $34^\circ \pm 10^\circ$, PRO $28^\circ \pm 7^\circ$) compared to the support leg (GS/MS $36^\circ \pm 12^\circ$, $p = 0.02$, PRO $31^\circ \pm 8^\circ$, $p = 0.01$). Only the GS/MS athletes demonstrated significantly ($p = 0.02$) decreased hip ER ROM in

the preferred kicking leg ($56^{\circ} \pm 9^{\circ}$) when compared to the support leg ($59^{\circ} \pm 11^{\circ}$). There were no other groups with significant side-to-side differences with hip external ROM.

There was a significant negative correlation between level of competition and passive hip flexion (preferred kicking leg $r = -0.35$, $p < 0.0001$, stance leg $r = -0.35$, $p < 0.0001$) and ER (preferred kicking leg $r = -0.52$, $p < 0.0001$, stance leg $r = -0.55$, $p < 0.0001$) in both hips with no statistically significant side-to-side differences. More experienced female soccer athletes had less flexion and ER in both hips. There was no significant association of hip IR ROM with experience.

Hip strength

For the preferred kicking leg, the collegiate athletes had significantly less hip abduction strength with the hip in neutral and in extension as compared to the GS/MS athletes (neutral $p = 0.001$, extension $p < 0.0001$) and the professional athletes (neutral $p = 0.0004$, extension $p = 0.008$). (Table 3) There were no side-to-side differences in hip abduction strength for the high school, collegiate, and professional groups. Amongst the GS/MS athletes, hip abduction in neutral was significantly weaker in the support leg compared to the kicking leg ($p = 0.002$). For either kicking leg, only one collegiate player (5 %) achieved the maximum strength value (5/5) for gluteal strength in neutral as compared to 18 (53 %) of the professional athletes ($p = 0.006$).

Provocative hip tests

A positive provocative test was present in 22 % of all asymptomatic athletes with the highest rate in GS/MS athletes (34 %) and PRO athletes (36 %). (Table 4) The PRO group had a significantly greater percentage of athletes with a provocative hip test that correlated with their non-preferred kicking leg ($p = 0.046$). The anterior impingement test was the test most commonly found to be positive in all groups. A history of popping and clicking in the region of the hip was reported by 35 % of athletes and significantly increased with level of experience ($p < 0.0001$) but was not associated with a positive provocative test (n.s.). Professionals with a positive provocative test had decreased hip flexion on that side ($p = 0.04$). The GS/MS athletes with a positive provocative test had increased hip flexion on that side ($p = 0.003$).

Discussion

The most important finding in this study was that hip physical examination findings differed by age and experience with PRO athletes having less hip flexion and internal rotation as compared to the GS/MS athletes. Further, one or more positive provocative hip tests were found in 22 % of all athletes in this study. Only the PRO athletes' percentage of positive provocative tests of 36 % was significantly higher compared to all other groups. This is the first study to describe baseline hip physical examination findings in female soccer athletes across an age span from preadolescent to adulthood. This combination of physical exam findings (passive HF and IR and a decreased HF and IR with positive provocative hip tests) is also seen in athletes with symptomatic hip labral tears or hip deformity. This subgroup of asymptomatic athletes is possibly at increased risk for intra-articular hip disorders. The

mechanistic causes that lead an asymptomatic athlete with clinical hip findings to become symptomatic remain unknown. Identifying athletes at increased risk will aid the development of targeted injury-prevention programs.

The range of “normal” reported for hip range of motion is wide and what constitutes a clinically significant change or difference has not been determined. Several factors contribute to range of motion in asymptomatic people including gender, bony changes, soft tissue restrictions, and movement impairments. Likely, all 3 contribute with varying degrees to ROM measurements unique to each individual. For now, studies rely on comparisons. Inter-rater reliability of ROM measurements can vary as described in a recent review of measures used to assess hip osteoarthritis by Dobson et al. [7] For this reason, the authors of this study (HP and DH) assessed inter-rater reliability and used the most reliable measure for this study [30]. Studies specifically comparing genders have reported women to have greater active hip internal rotation, external rotation [33], passive hip flexion [34], and internal rotation as compared to men. Compared to non-soccer-playing asymptomatic young adults [30], the professional female soccer players in this study had reduced hip flexion. A previous study comparing male and female college soccer athletes also reported decreased hip flexion in both male and female soccer athletes [2]. Data from the study presented here found professional female soccer athletes to have less hip flexion in both hips, as well as less hip IR in their preferred kicking leg when compared to elite youth and collegiate athletes. The GS/MS group also demonstrated significantly greater hip ER bilaterally when compared to the other groups. This data suggest that female soccer athletes’ hip ROM pattern may evolve over time.

Descriptions of athletes and non-athletes with FAI include reduced hip flexion and internal rotation similar to our study of asymptomatic athletes [5]. Another study comparing hip passive range of motion of senior and junior soccer athletes revealed less IR-combined flexion abduction and external rotation (FABER motion) and greater abduction compared to controls. The authors concluded that the senior athletes were developing osteoarthritis but did not comment on the explanation of reduced motion in the junior athletes. These athletes may acquire a bony deformity, soft tissue restrictions, or aberrant movement patterns as a result of training and competition over time, resulting in a reduced range of motion as compared to controls. It is unclear whether this change in ROM is unique to soccer athletes and/or allows them to excel in the sport. A longitudinal study of players and asymptomatic age-matched controls is needed to assess whether playing soccer alters the natural history of hip ROM.

In an athletic female population with documented increased risk of developing radiographic osteoarthritis of the hips and knees [35], what specifically predisposes these individuals to osteoarthritis? Data from this study suggest that passive hip ROM measurements including less hip flexion in adult athletes as compared to younger athletes likely predates the development of osteoarthritis. This may represent a population of athletes with hip deformity who are also at risk for hip osteoarthritis. Further studies that correlate the physical exam findings with imaging could help answer this question regarding the contributing factors in the development of hip osteoarthritis.

Though all of the athletes in this study reported no symptoms involving the pelvis or hips, 22 % of female athletes had at least one positive provocative hip test on examination. There were no statistically significant differences across the groups with the exception of the PRO group. The professionals had the highest percentage of positive tests at 36 % ($p = 0.046$). The professional athletes with a positive provocative hip test were also found to have reduced flexion on the ipsilateral side. Athletes in the GS/MS group with a positive provocative hip test had increased HF on the ipsilateral side. The authors of this study propose that these subgroups of athletes may be at greatest risk for developing pre-arthritis hip disorders because they had a combination of ROM findings on the same side as the positive provocative hip test. An identical combination of findings has also been described in athletes with pre-arthritis hip disorders [3–5, 25]. Philippon et al. [28] reported decreased hip rotation and a positive hip impingement test both correlated with a higher incidence of labral pathology on MRI in 20 asymptomatic elite youth hockey players. This relationship may also exist in female soccer athletes.

In the present study, there were no significant side-to-side differences found with hip abductor strength with the exception of the GS/MS group where hip abduction in neutral on the support leg was weaker than the preferred kicking leg. This varies from a previous study that found reduced hip abduction in the non-kicking leg of soccer athletes [2]. One of the limitations of this study was the use of manual muscle grading scale. Although manual muscle testing is a valid screening tool for strength deficits [6], the ceiling effect associated with higher functioning subjects may have decreased the ability to assess small differences from side to side and between subjects. Further research is needed to more precisely measure hip abduction strength and compare the dominant kicking limb to the supporting limb in this population.

Hip ROM deficits are important to assess because reduced hip ROM is linked to non-contact ACL injuries [12, 13]. Gomes et al. [13] examined the total hip IR and ER of 50 male soccer athletes with non-contact ACL injuries. Between 38 and 64 % of the athletes demonstrated significantly reduced ($p < 0.001$) hip ROM as compared to controls. Philippon et al. [27] assessed a radiographic measurement (alpha angle) [5] in soccer athletes surgically treated for ACL injuries compared to athletes with non-ACL knee injuries. Athletes with an ACL injury had a significantly higher ($p < 0.001$) alpha angle on the injured side.

In addition to the links between the hip and the knee, there is increasing evidence regarding the links between the hip and LBP. Patients treated surgically for developmental hip dysplasia (DDH), acetabular labral tears, and femoroacetabular impingement (FAI) reported LBP and buttock pain in addition to hip pain in 17, 38, and 52 % of the time, respectively [17, 21]. As a result, athletes with pre-arthritis hip disorders are at additional risk for developing LBP. Prior studies also suggest that athletes with LBP playing rotational sports have reduced lead-leg active and passive hip internal rotation [22, 37, 38] and less hip flexion and time lag [39]. The athletes in this study have similar physical examination findings and may be at additional risk of developing LBP. Recognizing this sub-group of athletes via a screening examination could lead to the development of targeted prevention programs with the goal of reduction in injuries over time.

Limitations of the present study include a relatively small sample size, particularly within our collegiate and professional groups. It is possible that with greater representation in these higher levels of experience, we may have been able to find more of a difference with passive hip IR in both hips across all levels of play and not just within the preferred kicking leg. Another potential limitation is the possibility of examiner bias as they were aware of the patient age, level, and kicking leg preference. However, it was impossible to completely blind the examiners as they evaluated each team prior to practice so they were aware of their level and general age. It is not clear that knowing the age or kicking leg preference would have biased the examiner as the effect, if any, of these variables is unknown. Finally, only 3 players reported a left leg preference, so the vast majority of athletes were right foot dominant. The use of manual muscle testing is another limitation because of the ceiling effect in detecting small differences in these active athletes. Further, manual muscle testing in general can be unreliable between examiners [7]. Another weakness is the lack of a control group for comparison. Finally, imaging is needed to confirm or disprove the potential link between the findings of ROM and positive provocative hip tests to clinical findings commonly found in patients with pre-arthritis hip disorders [3, 5, 25].

These athletes are examined longitudinally over time to determine whether our findings result from changes in individual athletes or self-selection for athletes with particular attributes. Further, we will be able to determine what findings, if any, predict future development of positive provocative tests and loss of hip ROM. Finally, tracking injury over time will help establish which findings may be predictive of injury risk.

These data are clinically relevant because they suggest that some asymptomatic soccer athletes have the same physical examination findings as athletes with symptomatic intra-articular hip disorders and/or ACL tears and LBP. If the reduced ROM findings and positive provocative tests are found prior to injury or symptom development, prevention programs and recommendations for training can be individualized for the athlete.

Conclusion

Asymptomatic elite female soccer athletes with the most competition experience have less bilateral hip flexion and preferred kicking hip IR than younger, less-experienced female soccer athletes. On average, 22 % of all female soccer athletes and 36 % of the professional athletes were found to have a positive provocative hip test on physical examination. Future studies are needed to show whether athletes with these findings are at risk for intra-articular hip disorders. Furthermore, these athletes demonstrated hip ROM restrictions that have been shown to be associated with a higher risk for ACL injuries and LBP.

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Table 1

Baseline demographics of asymptomatic female soccer athletes

	Grade school/middle school (GS/MS) (<i>n</i> = 62)	High school (HS) (<i>n</i> = 54)	Collegiate (COL) (<i>n</i> = 20)	Professional PRO (<i>n</i> = 36)	All athletes (<i>n</i> = 172)
Age (years)					
Mean	12.3 ± 1	15.9 ± 1	19.2 ± 1	24.1 ± 2	16.7 ± 5
Range	10–14	15–17	18–21	19–30	10–30
BMI (kg/m ²)	18.2 ± 2	21.0 ± 2	22.4 ± 2	22.8 ± 2	20.8 ± 3
Initial soccer-playing age (years)	4.4 ± 1	5.2 ± 2	4.8 ± 1	5.4 ± 2	4.9 ± 1
Organized soccer training (h/week)	5.1 ± 2	9.0 ± 2	16.9 ± 3	17.9 ± 5	10.3 ± 6
Preferred kicking leg (# of players)					
Right	58 (94 %)	48 (89 %)	19 (95 %)	31 (86 %)	156 (91 %)
Left	3 (5 %)	6 (11 %)	1 (11 %)	3 (8 %)	13 (8 %)
Both	1 (2 %)	0 (0 %)	0 (0 %)	2 (6 %)	3 (2 %)

Table 2

Passive hip range of motion findings and comparisons by level of experience

Leg	Groups			p value comparing groups*	
	GS/MS (n = 61)	HS (n = 54)	COL (n = 20)	PRO (n = 34)	
Passive hip flexion, mean in degrees $\pm$ SD	Preferred	115 $\pm$ 9	115 $\pm$ 9	111 $\pm$ 7	105 $\pm$ 8
					<0.0001 GS/MS versus PRO $p < 0.0001$ GS/MS versus PRO $p < 0.0001$ COL versus PRO $p = 0.05$
	Non- preferred	115 $\pm$ 8	115 $\pm$ 9	114 $\pm$ 7	104 $\pm$ 8
					<0.0001 GS/MS versus PRO, $p < 0.0001$ HS versus PRO, $p < 0.0001$ COL versus PRO, $p = 0.0006$
Passive hip internal rotation, mean in degrees $\pm$ SD	Side to side difference	-0.07 $\pm$ 6	0.04 $\pm$ 5	-3.0 $\pm$ 5	0.44 $\pm$ 6
					n.s.
	p value [†]	0.93	0.96	0.03	0.69
	Preferred	34 $\pm$ 10	35 $\pm$ 10	35 $\pm$ 9	28 $\pm$ 7
Passive hip external rotation, mean in degrees $\pm$ SD					0.006 GS/MS versus PRO, $p = 0.01$ HS versus PRO, $p = 0.01$ COL versus PRO, $p = 0.04$
	Non- preferred	36 $\pm$ 12	35 $\pm$ 10	33 $\pm$ 9	31 $\pm$ 8
					n.s.
	Side-to-side difference	-2.0 $\pm$ 7	-0.4 $\pm$ 5	2.0 $\pm$ 6	-2.6 $\pm$ 6
Passive hip external rotation, mean in degrees $\pm$ SD					0.005 [‡] GS/MS versus COL, $p = 0.04$ COL versus PRO, $p = 0.006$
	p value [†]	0.02	0.92 [‡]	0.13	0.01
	Preferred	56 $\pm$ 9	45 $\pm$ 9	44 $\pm$ 7	40 $\pm$ 8
					<0.0001 GS/MS versus HS, $p < 0.0001$ GS/MS versus COL, $p < 0.0001$ GS/MS versus PRO, $p < 0.0001$
Passive hip external rotation, mean in degrees $\pm$ SD	Non- preferred	59 $\pm$ 11	46 $\pm$ 10	45 $\pm$ 8	40 $\pm$ 9
					<0.0001 GS/MS versus HS, $p < 0.0001$ GS/MS versus COL, $p < 0.0001$ GS/MS versus PRO $p < 0.0001$ HS versus PRO, $p = 0.02$

Leg	Groups				p value comparing groups*	
	GS/MS (n = 61)	HS (n = 54)	COL (n = 20)	PRO (n = 34)		
Side-to-side difference	-2.7 ± 9	-1.4 ± 7	-1.1 ± 10	0.1 ± 6		n.s.
p value [†]	0.02	0.15	0.62	0.94		

Players who stated that they have bilateral kicking leg preference were excluded from this table

Data are mean ± standard deviation or median [interquartile range]

GS/MS grade school/middle school, HS high school, COL collegiate, PRO professional

* p value compares groups by ANOVA. When the overall model is significant ($p < 0.05$), pairwise between-group comparisons were performed by Tukey-Kramer method. Significant pairwise comparisons are reported

[†] p value compares the preferred to the non-preferred side within group by paired t test

[‡] Analysis performed using rank-transformed data

Table 3

Hip abduction strength by level of experience and comparison between groups

Variable	Side	Group				<i>p</i> value comparing groups*
		GS/MS group (<i>n</i> = 61)	HS group (<i>n</i> = 54)	COL group (<i>n</i> = 20)	PRO group (<i>n</i> = 34)	
Gluteal strength in neutral, median (IQR)	Preferred	4 [4, 5]	4 [3, 5]	4 [3, 4]	5 [4, 5]	<0.0001 [‡] GS/MS versus COL, <i>p</i> = 0.001 HS/MS versus PRO <i>p</i> = 0.02 COL versus PRO <i>p</i> = 0.0004
	Non- preferred	4 [4, 5]	4 [3, 5]	4 [4, 4]	5 [4, 5]	0.009 HS versus PRO, <i>p</i> = 0.03 COL versus PRO <i>p</i> = 0.01
	Difference	0 [0, 0]	0 [0, 0]	0 [-2, 0]	0 [0, 0]	0.002 [‡] 10-14 versus COL, <i>p</i> = 0.002
	<i>p</i> value [†]	n.s. [‡]	n.s. [‡]	n.s. [‡]	n.s. [‡]	
Gluteal strength in extension, median (IQR)	Preferred	4 [4, 5]	4 [3, 4]	3 [3, 3]	4 [3, 4+]	<0.0001 [‡] GS/MS versus COL, <i>p</i> < 0.0001 HS versus COL, <i>p</i> = 0.003 COL versus PRO, <i>p</i> = 0.008
	Non- preferred	4 [4, 5]	4 [3, 4]	3 [3, 4]	4 [3, 5]	0.007 [‡] GS/MS versus COL, <i>p</i> = 0.01 COL versus PRO, <i>p</i> = 0.03
	Difference	0 [0, 0]	0 [0, 0]	0 [-2, 0]	0 [0, 0]	0.02 [‡]
	<i>p</i> value [†]	n.s. [‡]	n.s. [‡]	n.s. [‡]	n.s. [‡]	

Data are mean ± standard deviation or median [interquartile range]

GS/MS grade school/middle school, HS high school, COL collegiate, PRO professional

* *p* value compares groups by ANOVA. When the overall model is significant (*p* < 0.05), pairwise between-group comparisons were performed by Tukey-Kramer method. Significant pairwise comparisons are reported

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$\dagger$ p value compares the preferred to the non-preferred side within group by paired t test

$\ddagger$ Analysis performed using rank-transformed data

Provocative hip test that provoke groin, lateral hip and/or posterior pelvic in soccer athletes

Table 4

Provocative test	Side	Group	GS/MS (n = 61)	HS (n = 54)	COL (n = 20)	PRO (n = 34)	p value comparing groups*
Positive ant imping test	Preferred		5 (8 %)	7 (13 %)	1 (5 %)	3 (9 %)	n.s. [†]
	Non-preferred		7 (11 %)	7 (13 %)	0	7 (21 %)	n.s. [†]
	Impingement in either		10 (16 %)	10 (19 %)	1 (5 %)	7 (21 %)	n.s. [†]
Positive Faber/Patrick's test	Preferred		9 (15 %)	4 (7 %)	1 (5 %)	0	0.08 [†]
	Non-preferred		6 (10 %)	2 (4 %)	1 (5 %)	3 (9 %)	n.s. [†]
	Impingement in either		10 (16 %)	4 (7 %)	1 (5 %)	3 (9 %)	n.s. [†]
Positive resist SLR test	Preferred		2 (3 %)	0	0	1 (3 %)	n.s. [†]
	Non-preferred		2 (3 %)	1 (2 %)	0	0	n.s. [†]
	Impingement in either		3 (5 %)	1 (2 %)	0	1 (3 %)	n.s. [†]
Any positive provocative test	Preferred		13 (21 %)	11 (20 %)	1 (5 %)	4 (12 %)	n.s.
	Non-preferred		8 (13 %)	8 (15 %)	1 (5 %)	8 (24 %)	n.s.
	Impingement in either		14 (23 %)	13 (24 %)	1 (5 %)	8 (24 %)	n.s.

Data are # of players (% of group)

GS/MS grade school/middle school, HS high school, COL collegiate, PRO professional

^{*} p value compares groups by Chi square test[†] p value by Fisher's exact test