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Correlation of Hip Passive Range of Motion with Lower Limbs Injuries in Iranian Professional Soccer Players

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Abstract

Introduction: This study aimed to evaluate the association between hip passive range of motion (ROM) and lower limb injuries in Iranian professional soccer players. **Material and Methods**: This prospective cohort study was conducted on 266 male professional soccer players (mean age: 24.91 years) playing in Iran Soccer Premium League during seasons 2017-2018 and 2018-2019. Hip joint passive ROM at baseline was evaluated in all athletes. Then, athletes were followed for two consecutive playing seasons and lower limb injuries, which caused missing at least one competitive match, was recorded. The association between hip ROM and the incidence of lower limb injuries was analyzed. **Results**: The most common lower limb injuries were ankle and foot injuries (12.4%), groin pain (11.5%), and muscle strain (10.9%), respectively. Non-injured athletes had a significantly higher left abduction and bilateral internal rotation (IR) ROM than normal ROM. Right side injury was associated with significantly higher contralateral flexion and external rotation (ER) and left side injury was associated with a significantly higher contralateral extension, abduction, and IR. Restricted hip IR was associated with a higher incidence of groin pain (OR=2.06), ACL injury (OR=2.56), and knee injuries (OR=4.18). A significant correlation was observed between decreased hip ER with muscle strain (OR=1.89) and knee injuries (OR=4.25). The higher knee and ACL injuries were also associated with reduced hip abduction (OR=4.76 and 9.01, respectively). There was no association between ankle and foot injuries and hip passive ROM. **Conclusions**: This study indicated that hip passive ROM could be used to identify soccer players at higher risk of lower limb injuries. Hip rotational ROM and abduction limitation were significantly associated with incidence of several common soccer injuries, including groin pain, muscle strain, and ACL/knee injuries. Hip rotational ROM and abduction limitation can be used as a screening tool in professional male soccer players.

Keywords: Hip Range of Motion; Lower limb Injuries;Professional Soccer Player

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Introduction

Soccer is one of the most popular sports worldwide [1]. According to previous studies, soccer has a higher injury rate that its percentage compared to other competitive sports has been estimated approximately 15 to 35 injuries per 1000 hours [2, 3]. Due to high loads of running, directional changes, explosive movements, repeated kicking, and body contact, injuries of lower limb are accounted about 85% injuries in professional soccer player. Injuries to muscles and tendons are most often involved with sprains, strains, and contusions which are the most common types [4, 5].

The injuries of lower limb are considered as a major concern in professional athletes since they usually cause reduced player optimal function, financial cost, long-term absence, and health-related problems [6]. Hence, it is important to precisely identify and assess risk factors and predictors of lower limb injuries in professional soccer players. Several screening tools such as balance index score and muscle strength assessment have been described with conflicting findings to identify players at an increased risk of injuries and to prescribe individualized preventive measures [7, 8].

One of predisposing anthropomorphic factors of the lower limb injuries is restricted hip range of motion (ROM) in professional athletes. Several previous studies have described its association with non-contact injuries of the anterior cruciate ligament (ACL), adductor strain, and groin pain [1, 9-13]. Despite the importance of hip ROM in lower limb kinematics and its effect on sport-related injuries, there are limited investigations on prevention or therapeutic protocols focusing on hip ROM [14, 15]. Few prospective studies evaluated association of hip ROM with sports-related lower limb injuries according to a systematic review that there was very limited evidence on this topic prospectively and only significant finding regarding hip ROM was its association with groin pain in two retrospective high-quality studies [16]. Furthermore, most of the studies concerning this topic have focused only on a small portion of lower limb injuries. Due to these shortcomings, we conducted a 2-year prospective cohort study to evaluate the association between hip passive ROM and lower limb injuries in Iranian professional soccer players. With this study, we aimed to evaluate the role of hip ROM as a predisposing risk factor in male professional soccer players and to assess its association with all type of lower limb injuries.

Material and Methods

Study design and subjects

This was a prospective cohort study approved by the ethics committee of the Iran University of Medical Sciences (IUMS) with code: IR.IUMS.FMD.REC.1397.053. Informed consent was obtained from all athletes. 300 male professional soccer players, playing in the Iran Soccer Premium League during 2017-2018 and 2018-2019 seasons, were enrolled in initial evaluation. The exclusion criteria were history of ACL tear, history of ankle sprain within the last 1 year, history of muscle strain or groin pain in the last 6 months, player's exit from Iran Soccer Premium League (to either lower domestic league or abroad), and lack of player or team physician cooperation to record injuries. Then, 34 athletes met the exclusion criteria (16 due to history of ankle injuries, 3 due to the history of ACL tear, 2 due to injuries of other knee ligaments, 4 due to muscle strain, 3 due to groin pain, and 8 players due to leaving the premium League). Therefore, the study was carried out with 266 athletes.

Measurements

Hip joint passive ROM at baseline was evaluated at the start of first season by a sports medicine specialist using a digital goniometer (mobee® med) with a mean of three measurements recorded, according to the method describe in Tainaka *et al.* study [13]. Mobee med is a software-based measurement method which provides a measurement accuracy of ±1 degree. Validity and reliability of digital goniometer has been confirmed in various studies [17, 18]. For hip flexion evaluation, the athlete was placed in the supine position. The examiner placed his hip in maximum flexion and the angle between the center line of the femur and the examination bed was recorded. Hip extension was evaluated in prone position and the angle between the center line of the femur and the examination bed was recorded after placing the hip joint in maximum extension. Hip adduction and abduction were checked in the supine position and hip extended. The examiner, one hand on the athlete's ankle, the other on the anterior superior iliac spine (ASIS), move the tested limb towards and away from the central line to evaluate the hip adduction and abduction, respectively. The endpoint was reached when passive motion in any of two directions was started to move the pelvis. The angel between the line perpendicular to the center of the line linking the bilateral ASIS and central line of the femur was reported. Hip Internal and external rotation were evaluated in supine position with hip in neutral rotational and flexed position. The examiner, holding knee joint with one hand and foot with the other, placed the knee and hip in 90° flexion. Then, the hip was internally and externally rotated with one hand on foot and femur was immobilized with the other hand, and then hip rotation was recorded using the tibial axis. All measures were reported as normal or decreased. Based on previous reports, normal hip passive ROM values were considered: 129±9° for flexion, 20±11° for extension, 46±8° for abduction, 24±11° for adduction, 32±8° for internal rotation (IR), and 38±8° for external rotation (ER) [19, 20].

The repeatability and reproducibility of goniometric evaluation were measured using Intra-class correlation coefficient (ICC). The ICC was calculated according to the test results of 5 players for each of the six measured ROM and for the right and left foot separately. The ICC of goniometry was measured to be ≥0.90 for either hip movement (Table 1).

Athletes were followed for two consecutive playing seasons. Then, lower limb injuries, including groin pain, ACL injury, knee injuries, muscle strain, and ankle and foot injuries, which caused at least one competitive match absent at any time during the subsequent two playing seasons, were reported.

During the playing season, lower limb injuries were recorded daily by the team physicians, according to an injury checklist published by the Fédération Internationale de Football Association (FIFA) [*i.e.*, pre-competition medical assessment (PCMA)]. We recorded these injuries weekly by contacting team physicians. During the Pre-Participation Evaluations (PPE), the incidence of lower limb injuries was asked

Table 1. The assessment of hip ROM Repeatability. [*Intra-class correlation coefficient* (Upper bound-lower bound)]

Hip Movements	Right side	Left side
Flexion	0.91 (0.88-0.98)	0.92 (0.89-0.99)
Extension	0.90 (0.88-0.97)	0.90 (0.87-0.96)
Abduction	0.94 (0.86-0.98)	0.94 (0.89-0.98)
Adduction	0.93 (0.87-0.97)	0.96 (0.90-0.99)
Internal rotation	0.92 (0.89-0.99)	0.93 (0.86-0.94)
External rotation	0.94 (0.93-0.95)	0.91 (0.90-0.98)

Table 2. Mean (SD) of demographic of injured and non-injured athlete

Variables	Non-injured (n=185)	Injured (n=81)	*P*-value
Age (year)	24.9 (4.1)	25.0 (5.1)	0.430
Weight (Kg)	74.1 (4.4)	74.1 (4.2)	0.280
Body mass index (Kg/m2)	23.9 (1.5)	23.8 (1.6)	0.310

from all players and the final report was made. No treatment or specific preventive measures regarding hip joint ROM were given to any athletes enrolled in this study (Figure 1).

Statistical analysis

The association between hip ROM and incidence of lower limb injuries was analyzed using SPSS software V20, SPSS Inc., Chicago, IL, USA. The data were analyzed by descriptive statistics (frequency, mean, percent, and standard deviation) and Chi-Square test was utilized for statistical comparison. The significant level was considered to be less than 0.05.

Results

Of 266 athletes (mean age of 24.91±4.38 years and mean body mass index (BMI) of 23.5±1.5 kg/m2), 81 demonstrated at least one lower limb injury during the study. No significant difference was observed between non-injured and injured athletes (*i.e.*, athlete with ≥1 injury event) regarding age, weight, and BMI (Table 2).

The non-injured athletes had a significantly higher left abduction (58.89±11.02° vs. 54.57±11.26°; *P*=0.004) and bilateral IR ROM (right hip: 45.82±8.31° *vs*. 43.05±9.44°; *P*=0.020; left hip: 44.68±11.26° *vs*. 40.3±11.45°; *P*=0.004) than normal (Table 3).
Ankle and foot injuries were the most frequently reported lower limb injuries with an incidence of 12.4% followed by groin pain and muscle strain with an incidence of 11.5% and 10.9%, respectively. ACL tear was the least common lower limb injury with an incidence of 2.6% (Table 4).

According findings shown in Table 5, only reduced right IR was significantly associated with groin pain in soccer players with an incidence of 18.3% compared to 9.8% (odds ratio (OR)=2.06, and *P*=0.04).

Table 3. Mean (SD) of hip joint passive range of motion in injured and non-injured athletes

Hip Movements	Non-injured (n=185)	Injured (n=81)	*P*-value
Flexion (°)			
Right	115.54 (11.38)	112.78 (11.11)	0.070
Left	118.6 (11.35)	115.78 (21.51)	0.160
Extension (°)			
Right	5.4 (3.12)	5.98 (3.63)	0.500
Left	3.58 (1.72)	3.74 (1.89)	0.750
Abduction (°)			
Right	65.56 (9.21)	63.50 (9.32)	0.096
Left	58.89 (11.02)	54.57 (11.26)	0.004
Adduction (°)			
Right	12.38 (6.60)	13.21 (5.95)	0.330
Left	17.42 (7.04)	19.20 (6.88)	0.060
Internal rotation (°)			
Right	45.82 (8.31)	43.05 (9.44)	0.020
Left	44.68 (11.26)	40.3 (11.45)	0.004
External rotation (°)			
Right	50 (10.53)	51.02 (11.25)	0.480
Left	51.31 (9.48)	52.86 (15.41)	0.400

Table 4. Mean (SD) of comparison of hip joint passive range of motion in injured athlete based on injury side

Hip Movements	Right hip	Left hip	*P*-value
Flexion (°)			
Right limb	114.69 (11.59)	118.77 (9.11)	0.001
Left limb	112.78 (11.12)	115.78 (21.51)	0.250
Extension (°)			
Right limb	5.63 (3.36)	3.69 (1.63)	<0.001
Left limb	3.62 (5.98)	1.89 (3.74)	0.030
Abduction (°)			
Right limb	63.28 (9.43)	57.29 (10.36)	<0.001
Left limb	63.51 (9.32)	54.57 (11.26)	<0.001
Adduction (°)			
Right limb	12.96 (6.63)	17.32 (6.73)	0.710
Left limb	13.21 (5.95)	19.20 (6.88)	<0.001
Internal rotation (°)			
Right limb	44.26 (8.76)	43.78 (12.85)	0.890
Left limb	43.05 (9.44)	40.3 (11.45)	0.030
External rotation (°)			
Right limb	50.3 (10.62)	50.46 (10.75)	0.010
Left limb	51.03 (11.25)	52.86 (15.41)	0.270

Reduced right ER and normal left adduction were significantly associated with the occurrence of muscle strain with OR=1.89; *P*=0.05 and OR=0.37; *P*=0.02, respectively (an incidence of 16.9% and 13.3% compared to 9.7% and 5.4%, respectively) (Table 6).

Left ACL injury was observed in 15.4% of athletes with reduced left hip abduction and 7% of athletes with reduced left

Table 5. The comparison between Hip ROM and occurrence of groin pain

Hip ROM	Right side				Left side			
	Non-injured	Injured	OR (95%CI)	*P*-value	Non-injured	Injured	OR (95%CI)	*P*-value
Flexion, *n* (%)								
Normal	33 (89.2)	4 (10.8)	1	0.51	59 (88.1)	8 (11.9)	1	0.41
Decreased	200 (87.3)	29 (12.7)	1.19 (0.39-3.62)		179 (89.9)	20 (10.1)	1.82 (0.34-1.96)	
Extension, *n* (%)								
Normal	17 (81)	4 (19)	1	0.25	9 (81.8)	2 (18.2)	1	0.32
Decreased	216 (88.2)	29 (11.8)	0.57 (0.18-1.83)		229 (89.8)	26 (10.2)	0.51 (0.1-2.49)	
Abduction, *n* (%)								
Normal	233 (87.6)	33 (12.4)	-	-	227 (89.7)	26 (10.3)	1	0.41
Decreased	0 (0)	0 (0)	-		11 (84.6)	2 (15.4)	1.58 (0.33-7.55)	
Adduction, *n* (%)								
Normal	22 (88)	3 (12)	1	0.62	88 (89.8)	10 (10.2)	1	0.53
Decreased	211 (87.6)	30 (12.4)	1.04 (0.29-3.69)		150 (89.3)	18 (10.7)	1.05 (0.46-3.38)	
Internal rotation, *n* (%)								
Normal	166 (90.2)	18 (9.8)	1	0.04	144 (91.1)	14 (8.9)	1	0.19
Decreased	67 (81.7)	15 (18.3)	2.06 (1.0-4.33)		94 (87)	14 (13)	1.53 (0.69-3.35)	
External rotation, *n* (%)								
Normal	111 (89.5)	13 (10.5)	-	0.24	126 (90)	14 (10)	1	0.46
Decreased	122 (85.9)	20 (14.1)	1.4 (0.66-2.94)		112 (88.9)	14 (11.1)	1.12 (0.51-3.46)	

Table 6. The comparison between Hip ROM and occurrence of muscle strain

Hip ROM	Right side				Left side			
	Non-injured	Injured	OR (95% CI)	*P*-value	Non-injured	Injured	OR (95% CI)	*P*-value
Flexion, n (%)								
Normal	31 (83.8)	6 (16.2)	1	0.38	64 (95.5)	3 (4.5)	1	0.14
Decreased	199 (86.9)	30 (13.1)	0.77 (0.30-2.02)		180 (90.5)	19 (9.5)	2.25 (0.64-7.86)	
Extension, n (%)								
Normal	18 (85.7)	3 (14.3)	1	0.41	11 (100)	0 (0)	1	0.38
Decreased	212 (86.5)	33 (13.5)	0.93 (0.26-3.34)		233 (91.4)	22 (8.6)	0.95 (0.92-0.98)	
Abduction, n (%)								
Normal	230 (86.5)	36 (13.5)	-	-	232 (91.7)	21 (8.3)	1	0.71
Decreased	0 (0)	0 (0)	-		12 (92.3)	1 (7.7)	0.92 (0.11-7.43)	
Adduction, n (%)								
Normal	22 (88)	3 (12)	1	0.55	85 (86.7)	13 (13.3)	1	0.02
Decreased	208 (86.3)	33 (13.7)	1.16 (0.33-4.10)		159 (94.6)	9 (5.4)	0.37 (0.15-0.90)	
Internal rotation, n (%)								
Normal	159 (86.4)	25 (13.6)	1	0.57	146 (92.4)	12 (7.6)	1	0.39
Decreased	71 (86.6)	11 (13.4)	0.98 (0.46-2.11)		98 (90.7)	10 (9.3)	1.24 (0.51-2.98)	
External rotation, n (%)								
Normal	112 (90.3)	12 (9.7)	1	0.05	129 (92.1)	11 (7.9)	1	0.48
Decreased	118 (83.1)	24 (16.9)	1.89 (0.9-3.97)		115 (91.3)	11 (8.7)	1.12 (0.46-2.07)	

hip IR, whereas its incidence was 2% and 0% in athletes with normal left abduction and IR ROM, respectively, and this difference was significant with OR=9.01; *P*=0.04 and OR=2.56; *P*=0.002, respectively (Table 7).

We observed a significant correlation between the occurrence of left knee injury with restricted left abduction (OR=4.76; *P*=0.04), IR (OR=4.18; *P*=0.005), and ER (OR=4.25; *P*=0.007), with an occurrence rate of 23.1%, 12%, and 11.1% compared to 5.9%, 3.2%, and 2.9% in athlete with normal ROM, respectively (Table 8).

There was no significant association between hip passive ROM and ankle and foot injuries in the present study (Table 9).

Table 7. The comparison between Hip ROM and occurrence of ACL injury

Hip ROM	Right side				Left side			
	Non-injured	Injured	OR (95% CI)	*P*-value	Non-injured	Injured	OR (95% CI)	*P*-value
Flexion, *n* (%)								
Normal	37 (100)	0 (0)	1	0.34	67 (100)	0 (0)	1	0.12
Decreased	222 (96.9)	7 (3.1)	0.85 (0.81-0.90)		192 (96.5)	7 (3.5)	0.74 (0.69-0.79)	
Extension, *n* (%)								
Normal	21 (100)	0 (0)	1	0.55	11 (100)	0 (0)	1	0.74
Decreased	238 (97.1)	7 (2.9)	0.91 (0.88-0.95)		248 (97.3)	7 (2.7)	0.95 (0.93-0.98)	
Abduction, *n* (%)								
Normal	259 (97.4)	7 (2.6)	-	-	248 (98)	5 (2)	1	0.04
Decreased	0 (0)	0 (0)	-		11 (84.6)	2 (15.4)	9.01 (1.57-51.7)	
Adduction, *n* (%)								
Normal	25 (100)	0 (0)	1	0.49	95 (96.9)	3 (3.1)	1	0.51
Decreased	234 (97.1)	7 (2.9)	0.90 (0.86-0.94)		164 (97.6)	4 (2.4)	0.77 (0.16-3.52)	
Internal rotation, *n* (%)								
Normal	177 (96.2)	7 (3.8)	1	0.07	158 (100)	0 (0)	1	0.002
Decreased	82 (100)	0 (0)	0.68 (0.62-0.74)		101 (93.5)	7 (6.5)	2.56 (1.22-3.0)	
External rotation, *n* (%)								
Normal	119 (96)	5 (4)	1	0.17	138 (98.6)	2 (1.4)	1	0.18
Decreased	140 (98.6)	2 (1.4)	0.34 (0.06-1.78)		121 (96)	5 (4)	2.85 (0.54-14.96)	

Table 8. Comparison between Hip ROM and occurrence of Knee injury

Hip ROM	Right side				Left side			
	Non-injured	Injured	OR (95% CI)	*P*-value	Non-injured	Injured	OR (95% CI)	*P*-value
Flexion, *n* (%)								
Normal	36 (97.3)	1 (2.7)	1	0.15	64 (95.5)	3 (4.5)	1	0.29
Decreased	208 (90.8)	21 (9.2)	3.63 (0.47-27.87)		184 (92.5)	15 (7.5)	1.73 (0.48-6.20)	
Extension, *n* (%)								
Normal	20 (95.2)	1 (4.8)	1	0.46	11 (100)	0 (0)	1	0.45
Decreased	224 (91.4)	21 (8.6)	1.87 (0.24-14.67)		237 (92.9)	18 (7.1)	0.95 (0.93-0.98)	
Abduction, *n* (%)								
Normal	244 (91.7)	22 (8.3)	-	-	238 (94.1)	15 (5.9)	1	0.04
Decreased	0 (0)	0 (0)	-		10 (76.9)	3 (23.1)	4.76 (1.18-19.14)	
Adduction, *n* (%)								
Normal	22 (88)	3 (12)	1	0.34	90 (91.8)	8 (8.2)	1	0.35
Decreased	222 (92.1)	19 (7.9)	0.62 (0.17-2.28)		158 (94)	10 (6)	0.71 (0.27-1.86)	
Internal rotation, *n* (%)								
Normal	167 (90.8)	17 (9.2)	1	0.27	153 (96.8)	5 (3.2)	1	0.005
Decreased	77 (93.9)	5 (6.1)	0.63 (0.22-1.79)		95 (88)	13 (12)	4.18 (1.44-12.11)	
External rotation, *n* (%)								
Normal	115 (92.7)	9 (7.3)	1	0.37	136 (97.1)	4 (2.9)	1	0.007
Decreased	129 (90.8)	13 (9.2)	0.34 (1.28-3.12)		112 (88.9)	14 (11.1)	4.25 (1.36-12.27)	

Discussion

Although hip ROM evaluation is a fundamental part of clinical assessment to determine therapeutic method and to return person for playing in professional soccer players, there is conflicting evidence of restrained ROM as a predisposing risk factor for injuries of lower limb [15, 19]. The study aimed to evaluate hip passive ROM in athletes playing in the Iran Soccer Premium League and whether its restriction could be associated with a higher incidence of lower limb injuries.

We demonstrated that non-injured athletes had a significantly higher left abduction and bilateral IR ROM than normal. Right side injuries were associated with lower ipsilateral flexion and left side injuries were related to lower ipsilateral extension, abduction, and IR. According to the findings of the present study, except for ankle and foot injuries, higher incidence of common lower limb injuries, i.e., groin pain, muscle strain, ACL tear, and knee injuries, was associated with reduced hip passive ROM. As was demonstrated, reduced passive IR was associated with a higher incidence of groin pain (OR=2.06), ACL injury (OR=2.56), and knee injuries (OR=4.18). A significant correlation was observed

Table 9. The comparison between Hip ROM and occurrence of ankle and foot injury

Hip ROM	Right side				Left side			
	Non-injured	Injured	OR (95%CI)	*P*-value	Non-injured	Injured	OR (95%CI)	*P*-value
Flexion, *n* (%)								
Normal	32 (86.5)	5 (13.5)	1	0.49	60 (89.6)	7 (10.4)	1	0.37
Decreased	201 (87.8)	28 (12.2)	0.89 (0.32-2.47)		173 (86.9)	26 (13.1)	1.28 (0.53-3.12)	
Extension, n (%)								
Normal	18 (85.7)	3 (14.3)	1	0.49	10 (90.9)	1 (9.1)	1	0.59
Decreased	215 (87.8)	30 (12.2)	0.83 (0.23-3.01)		223 (87.5)	32 (12.5)	1.43 (0.17-11.58)	
Abduction, n (%)								
Normal	233 (87.6)	33 (12.4)	-	-	221 (87.4)	32 (12.6)	1	0.51
Decreased	-	-	-		12 (92.3)	1 (7.7)	0.57 (0.04-1.57)	
Adduction, n (%)								
Normal	20 (80)	5 (20)	1	0.18	83 (84.7)	15 (15.3)	1	0.18
Decreased	213 (88.4)	28 (11.6)	0.52 (0.18-1.51)		150 (89.3)	18 (10.7)	0.66 (0.31-1.38)	
Internal rotation, n (%)								
Normal	165 (89.7)	19 (10.3)	1	0.09	140 (88.6)	18 (11.4)	1	0.33
Decreased	68 (82.9)	14 (17.1)	1.78 (0.84-3.76)		93 (86.1)	15 (13.9)	1.25 (0.60-2.61)	
External rotation, n (%)								
Normal	105 (84.7)	19 (15.3)	1	0.12	120 (85.7)	20 (14.3)	1	0.21
Decreased	128 (90.1)	14 (9.9)	0.60 (0.28-1.26)		133 (89.7)	13 (10.3)	0.69 (0.32-1.15)	

between decreased hip ER with muscle strain (OR=1.89) and knee injuries (OR=4.25). Higher knee and ACL injuries were also associated with reduced hip abduction (OR=4.76 and 9.01, respectively). It should be noted that most common lower limb injuries in the present study were ankle and foot injuries (12.4%), groin pain (11.5%), and muscle strain (10.9%), respectively.

In the present study, the groin pain was associated with right hip IR limitation. Individuals with reduced right ER were 2.06 times more likely to face right groin pain. In a systematic review of 11 studies by Tak *et al.* in 2017 [9], a pre-season total hip rotation (ER+IR with hip and knee flexed to 90°) of <85° had a strong association with the incidence of groin pain in professional athletes. Kloskowsk *et al.* in a meta-analysis [16] reported that among ROM measurements, strong evidence was observed between total hip ER (sum of both hip ER) with sport-related groin pain (SRGP). They suggested that increasing hip IR and ER should be considered during athletes' rehabilitation suffering from SRGP. According to Mosler *et al.* [19], hip ER could be utilized to differentiate players without and with SRGP. Also, the data indicated that athletes with SRGP had a lower hip ROM by 3.6 cm (1.3-5.8 cm) evaluated by the bent knee fall out (BKFO), a combined movement of hip flexion, abduction and ER. Verrall *et al.* [12] followed 29 elite Australian football players for 2 consecutive seasons for the occurrence of chronic groin injury (CGI) and reported that total hip ROM (sum of total hip ER and IR) was associated with groin injury and its restriction precede groin injury development (83.13° compared to 103.18° with a rate ratio (IR) of 0.90, and a p-value of 0.03). In Nevin *et al.* study of 36 Gaelic football players [21], patients with longstanding groin injury had a significantly lower BKFO, hip IR, and ER, bilaterally (all with $P<0.05$). On the contrary, Mosler *et al.* [22] reported that among male professional soccer players, aged 18≥ years in the Qatar Stars League, none of the hip ROMs were significantly associated with the risk of SRGP and suggested that there was a little indication to include ROM measures in pre-season screening. Cheng *et al.* [23] conducted a 5-year cohort study on 94 female soccer players and reported that hip ROMs values at baseline were not predictive of lower limb injuries occurrence. This difference with the present study could be interpreted based on different study populations. Although both studies were conducted among professional soccer players, Cheng *et al.* [23]enrolled adolescent female athletes with a mean age of 14.6±1.8 years, but the participants of present study were male players with mean ages of 24.91±4.38 years.

The ration for the association of hip joint restriction and CGI and groin pain has been described in several studies. It is hypothesized that in athletes with a restricted hip joint ROM, greater stress is implied across the superior pubic ramus, and pubic symphysis surrounding soft tissues lead to increased force in this vulnerable area, thereby increasing likelihood of development of CGI [24-26]. Furthermore, for the absorption of adequate load during activities requiring direction change, sufficient hip ROM is fundamental, thus, reduced hip ROM could be a vital factor for SRGP [27]. Additionally, another suggested mechanism for SRGP is Femoroacetabular impingement (FAI) which could be manifested through reduced hip IR [28]. Kapron *et al.* [29] suggested that soccer players with reduced hip IR and groin pain should be evaluated for underlying Cam FAI abnormalities.

In the present study, decreased left hip passive IR and abduction were associated with ACL injuries among soccer player as reduced left ER and abduction preceded left ACL injury with 2.56 and 9.01 times more likelihood, respectively. In Tainaka *et al*. study [13], only limited hip IR and ER were significantly related to the development of ACL injury with an OR for a 10° increase=0.18 and 0.23, for hip IR and ER, respectively, both with a *P*-value of <0.01. IR and ER were 35.0±9.1° and 45.7±6.1° in the participants with non-contact ACL injury compared to 50.2±7.2° and 56.3±6.8° in the control group, respectively. In Vandenberg study of 50 athletes [11], patients with an injured ACL have a lower IR compared to the control group (23.4±7.6° compared to 30.4±10.4° with *P*<0.01). They suggested that a 10° increase of hip IR could led to a decreased risk of ACL injury with an OR of 0.419. In Gomes *et al*. study [10], strong association was reported between the restricted hip rotational ROM and incidence of non-contact ACL injury (either IR, ER or sum of ER+IR). According to a systematic review carried by Boutris *et al*. [30], a significant association was found between hip rotational restriction and ACL injuries (>10° of IR loss or >20° of ER or IR+ER loss). Bedi *et al*. [31] reported that in 224 NFL players, the hip IR reduction was correlated with a statistically significant increased risk of ACL injury in the ipsilateral or contralateral knee (OR=0.95, *P*<0.01).

It has been demonstrated that non-contact ACL injuries are associated with the valgus positioning of the knee joint. The rotational ROM of hip joint is considered as a buffer to decrease loading stress on the knee joint in this position. The restriction of hip ROM may impose strong rotational force on the knee joint, causing the increased strain of the ACL accompanying with the risk of ACL fatigue failure, thereby resulting in a higher rate of ACL tear [11, 13, 30, 32]. In line with this potential mechanism of ACL injury, several cadaveric studies have demonstrated that peak ACL strain was inversely related to internal rotation of the femur [33].

Our finding demonstrated a significant relationship between limited right hip ER with muscle injuries with an OR of 1.89. Ibrahim *et al*. [1] reported that pre-season hip total rotational ROM (IR+ER) in professional soccer players with an adductor strain during play season was lower compared to normal participants (44.7° compared to 53.7° with *P*-value=0.03). According to Bradley *et al*. study [34], soccer players with lower pre-season ROM of knee and hip flexors had a statistically higher risk of strain injuries to hip flexors muscle groups during a competitive season.

Conclusions

Our study showed that hip passive ROM could be used to identify soccer players at high risk of lower limb injuries. Hip rotational ROM and abduction limitation were significantly associated with the incidence of several common soccer injuries, including groin pain, muscle strain, and ACL/knee injuries. Hip rotational ROM and abduction limitation can be used as a screening tool in professional male soccer players

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