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Original Research

A new clinical test for measurement of lower limb specific range of motion in football players: Design, reliability and reference findings in non-injured players and those with long-standing adductor-related groin pain

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ABSTRACT

Objective: The association between groin pain and range of motion is poorly understood. The aim of this study was to develop a test to measure sport specific range of motion (SSROM) of the lower limb, to evaluate its reliability and describe findings in non-injured (NI) and injured football players.
Design: Case-controlled.
Setting: 6 Dutch elite clubs, 6 amateur clubs and a sports medicine practice.
Participants: 103 NI elite and 83 NI amateurs and 57 football players with unilateral adductor-related groin pain.
Main outcome measures: Sport specific hip extension, adduction, abduction, internal and external rotation of both legs were examined with inclinometers. Test-retest reliability (ICC), standard error of measurement (SEM) and minimal detectable change (MDC) were calculated. Non-injured players were compared with the injured group.
Results: Intra and inter tester ICCs were acceptable and ranged from 0.90 to 0.98 and 0.50–0.88. SEM ranged from 1.3 to 9.2° and MDC from 3.7 to 25.6° for single directions and total SSROM. Both non-injured elite and amateur players had very similar total SSROM in non-dominant and dominant legs (188–190, SD ± 25). Injured players had significant ($p < 0.05$) total SSROM deficits with 187(SD ± 31)° on the healthy and 135(SD ± 29)° on the injured side.
Conclusion: The SSROM test shows acceptable reliability. Loss of SSROM is found on the injured side in football players with unilateral adductor-related groin pain. Whether this is the cause or effect of groin pain cannot be stated due to the study design. Whether restoration of SSROM in injured players leads to improved outcomes should be investigated in new studies.

1. Introduction

Groin injuries account for 4–19% of football injuries (Hawkins & Fuller, 1999; Walden, Hagglund, & Ekstrand, 2015). Two recent systematic reviews of prospective studies on risk factors for groin injury included 9 studies where hip ROM was examined. In 3

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studies hip ROM deficits conferred a higher risk of groin injury and no increased risk was found in 6 studies (Ryan, DeBurca, & Mc Creesh, 2014; Whittaker, Small, Maffey, & Emery, 2015). Another recent systematic review pooled data on studies examining whether hip ROM differentiated between athletes with and without groin pain (Mosler, Agricola, Weir, Holmich, & Crossley, 2015). A reduced hip internal rotation and bent knee fall out was found in athletes with current groin pain but hip external rotation was similar.

These conflicting results may have several explanations; different age groups (youth and adults) as well as different levels (elite or amateur) and type of sports (football (soccer), Gaelic or Australian Rules football, rugby and ice hockey) were studied. Additionally ROM was assessed in different postures (i.e. supine or prone) but also the movement excursions that were taken into the analyses differed (rotations of the injured versus the non-injured leg or total rotation of one leg versus that of both legs). Many different definitions of groin pain were used in these studies. This may contribute to the inconsistency of findings in reviews reporting on ROM as a risk factor (Dallinga, Benjaminse, & Lemmink, 2012; Mosler et al., 2015; Ryan et al., 2014; Whittaker et al., 2015).

Adductor-related groin pain is the most common groin injury in football (Hölmich, Thorborg, Dehlendorff, Krogsgaard, & Gluud, 2013; Serner et al., 2015). Due to the inconsistency in findings between clinical examination and imaging findings in athletes with groin pain, a clinical classification was proposed (Hölmich, 2007). This was modified and embraced by the recent Doha agreement on terminology and definitions of groin pain in athletes (Weir et al., 2015).

Hip ROM is usually assessed in hip flexion or with the hip in a neutral position and targets one joint or muscle in isolation (Nussbaumer et al., 2010; van Trijffel, van de Pol, Oostendorp, & Lucas, 2010) while sporting actions like kicking are multi-segmental movements (Shan & Westerhoff, 2005). Conceptual ideas why reduced hip ROM may lead to overloading of the anterior groin structures were presented long ago (Williams, 1978). A cadaver study (Birmingham, Kelly, Jacobs, McGrady, & Wang, 2012) showed that the presence of a cam deformity, an aspherical appearance of the femoral head that is associated with reduced hip ROM (Audenaert, Peeters, Vigneron, Baelde, & Pattyn, 2012), leads to increased shear forces of the pubic symphysis. A conceptual model relating reduced ROM to groin pain and physical demands in sporting activities that has been tested in vivo is currently lacking. The debate on the association between ROM and groin pain may therefore continue (Hegedus, Stern, Reiman, Tarara, & Wright, 2013).

Football players with long-standing adductor-related groin pain (LARGP) often complain about their inability to kick a ball with maximal power (Holmich, 2013) and kicking is the most frequent injury mechanism (Serner et al., 2015). A maximal kick is usually performed using the instep kick as this is the most powerful kick in football (Shan & Westerhoff, 2005). Five phases (preparation, back swing, leg cocking, acceleration and follow through) have been described for the instep kick (Brophy, Backus, Pansy, Lyman, & Williams, 2007). These phases involve a sequential wind up followed by a proximal-to-distal wind off (Naito, Fukui, & Maruyama, 2010; Shan & Westerhoff, 2005). During back swing and leg cocking, potential energy is stored to be converted into kinetic energy to accelerate body segments. The end of the backswing is known as the tension arc. This tension arc consists of maximal kicking hip extension, a large knee flexion, contralateral trunk rotation and horizontal arm abduction (Naito et al., 2010). A kinematic study on differences between submaximal and maximal kicking shows that segmental ROM is larger in maximal kicking than in submaximal kicking (Langhout, Tak, van der Westen, & Lenssen, 2016). This also applies to the involved central body segments.

To explore the relationship between ROM of the lower limb and LARGP, accounting for the biomechanical concept of kicking, a new way of testing may be beneficial to gain further understanding in this area. In the current study, a measurement of sport specific ROM of the lower limb is proposed. The first objective of this study was to develop a new measurement method for football specific ROM in footballers. The second objective was to examine the intra- and inter-observer reliability of this test and establish reference values in the non-injured and injured population. The third objective was to evaluate differences between non-injured footballers and those with unilateral LARGP. The hypothesis tested is that footballers with unilateral LARGP show reduced ROM in the tension arc position of the instep kick.

2. Methods

2.1. Participants

All participating footballers signed informed consent and the local medical ethics committee approved this study. This study was performed in accordance with the 1964 Declaration of Helsinki.

2.1.1. Non-injured players

Professional footballers from 6 clubs of the Dutch professional premier football league (Eredivisie) were invited to participate. Amateur football players from the 1st team of 6 3rd and 4th division clubs were also invited. Inclusion and exclusion criteria (Table 1) were checked by interview and standardized physical examination by three experienced physical therapists working fulltime in outpatient clinics and athlete care to streamline the assessments.

Thorborg et al. showed that footballers have hip and groin symptoms to some extent, even when not deemed to be injured. Those with a time loss injury (Fuller et al., 2006) in the previous season show substantially more ongoing symptoms than those without (Tak et al., 2015; Thorborg, Branci, Stensbirk, Jensen, & Hölmich, 2014). Therefore players with more than one week out of play in the previous 12 months due to groin injury were excluded in the non-injured groups. The pain as provoked by testing should exacerbate the athletes' recognizable pain (Weir et al., 2015). Palpation and resistance provocation testing for LARGP are reliable (Holmich, Holmich, & Bjerg, 2004). All players were tested on location at their football clubs.

2.1.2. Injured players

Players suffering unilateral LARGP were recruited from and tested at our outpatient primary healthcare clinics. They were referred by other physiotherapists, sports physicians or self-referral.

2.2. Test technique

All test positions mimic the full body backswing during kicking (Shan & Westerhoff, 2005). ROM of hip extension is examined as this facilitates pre-stretch and motion-dependent moments that both assist in developing hip velocity (Bober, Putnam, & Woodworth, 1987; Putnam, 1993). As football players need to adapt body positions to varying football situations, the tension arc includes more degrees of freedom than isolated hip extension. The available biological workspace of the tension arc shows multi-dimensional ROM, which allows variability during different kicking situations (Egan, Verheul, & Savelsbergh, 2007). From the transition of the backswing to leg cocking, Coriolis forces accelerate hip external rotation and abduction to create momentum (Naito

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Table 1
Inclusion and exclusion criteria the football players.

Inclusion	Exclusion
Non-injured players Amateur • Age between 18 and 45 years • Minimal playing load of two times and maximal load of four times per week (training and match) Elite • Age >18 years. • Participation in training and match >5 days per week	• Back, hip or groin injury in the last 12 months resulting in >1 week out of play (training and match) or • Complaints of groin pain in daily life or sports at the time of examination • Tenderness on palpation of the adductor origin at the symphysis pubis (Hölmich, 2007; Weir et al., 2015) or • Groin pain on resisted hip adduction (Hölmich, 2007; Weir et al., 2015).
Injured football players • Age 18–45 • Groin pain >8 weeks • Not able to play unrestrictedly due to groin symptoms • Tenderness on palpation of proximal insertion of Adductor Longus origin on injured side (Hölmich, 2007; Weir et al., 2015) and • Pain on resisted adduction testing in supine (Hölmich, 2007; Weir et al., 2015) • Minimal playing load of two times per week (training and match)	• Groin pain <8 weeks • Football players with bilateral groin pain. • High impact acute onset of injury (Weir et al., 2015).

et al., 2010). Therefore, test positions also consist of abduction-adduction and external-internal rotation ROM. During the tension arc, knee flexion influences hip ROM because of bi-articular muscles and fascia and can reach up to 100° (Langhout et al., 2016). All tests were performed with the knee in 90 degrees of flexion to take this into account and to standardize the test procedure.

Before data collection a 30 cm metal semi-rigid ruler was attached to the lower and upper leg with Velcro straps. A magnetic digital inclinometer (Wixey, Seattle, US) was fixed at the middle of the ruler. All measurements in each direction were performed twice for reliability assessment. The leg was moved and the inclinometer measurement button was locked when marked resistance restricted further movement. The inclinometer was then loosened from the ruler and values were recorded by an assistant. This procedure was identical in test 1–3. Observers (RL and IT) were blinded for the side of dominance, injured side and for the readings of values. As a consequence of the assessments being performed on location at the clubs the observers were not blinded for the level of play of the players. The testing time was around 10 min per player.

2.2.1. Test 1: the extension test

Player position: The body position at the end of the back swing was mimicked. Body position was derived from biomechanical studies on football kicking (Tak, Weir, & Langhout, 2012). See Table 2 for the segment positions.

The extension measurement was performed in prone lying with the non-kicking leg supported in 45° hip and knee flexion (Fig. 1a) mimicking the stance leg position while kicking.

The ruler was placed in the midline of the back of the thigh. The upper body was lifted 10° in extension from the Iliac crest and pushed into further extension and rotation by a 20-degree wedge cushion (Michel Koene, Grou, Netherlands, Fig. 1b) to recreate the trunk rotation during the kick. The lower side of the cushion was placed at the umbilical level and the higher side supported the contralateral shoulder. The inclinometer was calibrated to 0° for extension in the resting position. The knee was held at 90 degrees of flexion throughout the testing procedure. A maximum extension position of the leg was created while the buttock was fixed downwards with the ispilateral forearm without restriction of anterior pelvic tilt.

2.2.2. Test 2: the adduction/abduction test

Player position: The player was positioned in side lying. A post was used for pelvic fixation at the L5 level to prevent the body shifting backwards on the table. The ipsilateral knee was strapped to the table. Then the upper body was turned into full extension and rotation. In this position the hip was fully extended with 90 degrees of knee flexion. Adduction (Fig. 2) and abduction (Fig. 3) were measured with the inclinometer placed halfway along the lateral side in the midline of the upper leg.

2.2.3. Test 3: the internal/external rotation test

Player position: In the same position as the abduction and adduction test the leg was supported by a standard 18 cm roll (Enraf Nonius, Delft, The Netherlands) directly above the medial femoral condyle. With the hip in maximal extension and the knee in 90° flexion on the roll, a maximal internal (Fig. 4) and external rotation (Fig. 5) of the hip was performed. Inclinometers were placed halfway on the lateral side in the midline of the lower leg.

2.3. Pain

Pain felt by the non-injured players while testing was determined to be the cut-off point to further increase tension. Instructions were given to express pain verbally. No attempt was made to score the pain using an NRS scale. Two days after testing the club physical therapists of the elite players were asked to check for pain and/or time lost to play due to the testing procedure by a standardized direct mail. This mail requested that we be informed if any player had felt pain that they attributed to the testing procedure. No thresholds for pain levels or pain measure scales were used. The same was asked to the club staff of the amateurs. Injured players were asked whether this was the case at their next visit after the testing procedure.

Table 2
Segmental characteristics of the leg-cocking phase for the lower extremity of the kick side and the upper extremity of the non-kick side (Tak et al., 2012).

Kick side	Non-kick side
• Pelvis: anterior rotation • Hip: from 30° to 0° extension and 25° abduction and decreasing external rotation • Knee: to a minimum of 90° flexion • Ankle: submaximal plantar flexion	• Arm: from extension to horizontal flexion • Shoulder: from retraction to protraction • Trunk: from extension rotation towards flexion and rotation of the kick side • Stance leg: foot makes ground contact while hip and knee flex.

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Fig. 1. a: Extension test. Note the replication of the stance leg position to be placed in hip and knee flexion. b: Extension test. The knee position is 90° of flexion. Full hip extension with anterior pelvic tilt allowance is measured.

2.4. Reliability testing

The reliability of the measurement protocol was tested in a subgroup of 20 professional football players who were randomly tested. Each player was tested by two observers on two occasions on the same day. The order of the observers was determined randomly using a coin toss. As the observers were blinded to their previous recorded values they could not be aware of the values measured in the previous test. The order in which the tests were performed were extension, adduction, abduction, external and internal rotation and was not changed between the series.

2.5. Statistical analysis

All parameters were tested for normal distribution using the Kolmogorov–Smirnov test. Normally distributed data ($p > 0.05$) were analysed parametrically and presented as mean (±standard deviation) and not normally distributed variables as median (inter quartile range). Mann-Whitney *U* test and Wilcoxon signed rank test were used for non-parametric analyses. Group differences for subject characteristics were tested using a *t*-test for independent samples. For the analysis of ROM either the Mann–Whitney U for differences between injured and non-injured subjects was used, or the Wilcoxon signed rank test for comparisons between legs in subjects was used. Intra and inter observer reliability (ICC) was assessed by a two way mixed single measures (model 2.1) procedure and absolute agreement for all directions separately and for the total ROM scores. Standard error of measurements (SEM) and minimal detectable change (MDC) were obtained. The rating of Landis and Koch (1977) for ICCs was followed where ICCs<0.00 = poor, 0.0–0.20 = slight, 0.21–0.40 = fair, 0.41–0.60 = moderate, 0.61–0.80 = substantial and 0.81–1.00 = almost perfect agreement.

Fig. 2. Adduction.

Fig. 3. Abduction.

Cut off values for the percentage of asymmetry between legs were determined to discriminate between non-injured and injured footballers using a Receiver Operator Characteristics (ROC) curve analysis. The ROC curve ideally identifies the threshold for a test score while keeping the greatest sensitivity and specificity (van der Roer, Ostelo, Bekkering, van Tulder, & de Vet, 2006). Data were processed using SPSS 20 (IBM, Chicago, US). The α-level for statistical significance was set at 0.05.

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Fig. 4. Internal rotation.

Fig. 5. External rotation.

3. Results

All tests for the non-injured players were performed between August and October 2011. The data collection of injured players was from August 2011 until October 2012. A flowchart for the inclusion and exclusion process can be found in Fig. 6. Of the 57 injured players there were 4 elites and 53 amateurs. The characteristics of all subjects are presented in Table 3. No significant differences between groups were found ($p > 0.10$).

The results for interobserver and intraobserver reliability testing are shown in Table 4. ICCs for intraobserver reliability range from 0.90 to 0.98. The SEM for single directions ranges from 1.3 to 2.4° with an MDC of 3.7–6.6°. The SEM for total ROM is 5.9° with a MDC of 16.4°. Between observers the ICCs range from 0.50 to 0.88. SEM for single directions is 2.9–6.9° with MDC ranging from 7.9 to 19.0°. For total ROM the SEM and MDC were respectively 9.2° and 25.6°.

The single directions and total ROM scores for the three groups of football players are shown in Table 5. Except for a 2° abduction difference in elites and a 1° adduction difference in amateurs no significant differences between the non-dominant and dominant leg of non-injured footballers were found. Between elite and amateur footballers no significant differences in ROM were found, except for extension which was found to be larger in the elites (Elite; D 35(8)°, ND 35(9)°, Amateur; D 30(10)°, ND 29(10)°, $p < 0.01$).

In injured players the ROM of the injured leg was significantly lower in all directions compared to the non-injured leg (all $p < 0.01$) and larger than the MDC for adduction, abduction, internal and external rotation. The ROC curve analysis showed the area under the curve varied from 0.88 to 0.98, indicating that the ROC curve presented suitable accuracy to correctly distinguish between healthy and injured subjects. The ROC curve revealed that, in terms of sensitivity and specificity, the optimal cut-off point for the total ROM would be at 17% asymmetry between legs (then sensitivity and specificity is respectively 0.91 and 0.94).

3.1. Pain

Marked end range stiffness noted by the observer was obtained before pain occurred in all but one healthy and injured players. Evaluation of the elite and amateur players two days after testing revealed no physical complaints or time lost to play due to the testing procedure. None of the injured football players reported aggravation of their groin pain after testing. As such we consider the test protocol to be safe.

4. Discussion

A new, reliable and safe sport specific test for ROM of the lower limb in football players was introduced and analysed in this study. The test has clinically acceptable reliability and reference values are presented for amateur and professional players. The hypothesis that footballers with unilateral LARGP show loss of sport specific ROM on the injured side was tested and confirmed. From a biomechanical point of view it seems that this ROM deficit may be of importance.

Agreement testing revealed almost perfect values for intraobserver measurements of separate and total ROM scores ($p < 0.05$). Interobserver reliability testing shows moderate agreement for adduction and internal rotation, substantial agreement for external rotation and almost perfect agreement for extension and abduction as well as total ROM. This suggests that the test is acceptable for use in clinical practice. These intraobserver ICCs are comparable to previous work that studied ROM testing with the assistance of an inclinometer (Herrington, Rivett, & Munro, 2006; Malliaras, Hogan, Nawrocki, Crossley, & Schache, 2009) but the interobserver ICCs for adduction and internal rotation are somehow lower than in these studies. This may be the result of testing all through the end of range of motion and across multiple joints eventually being a more complex method. As football players perform through range we chose to test through

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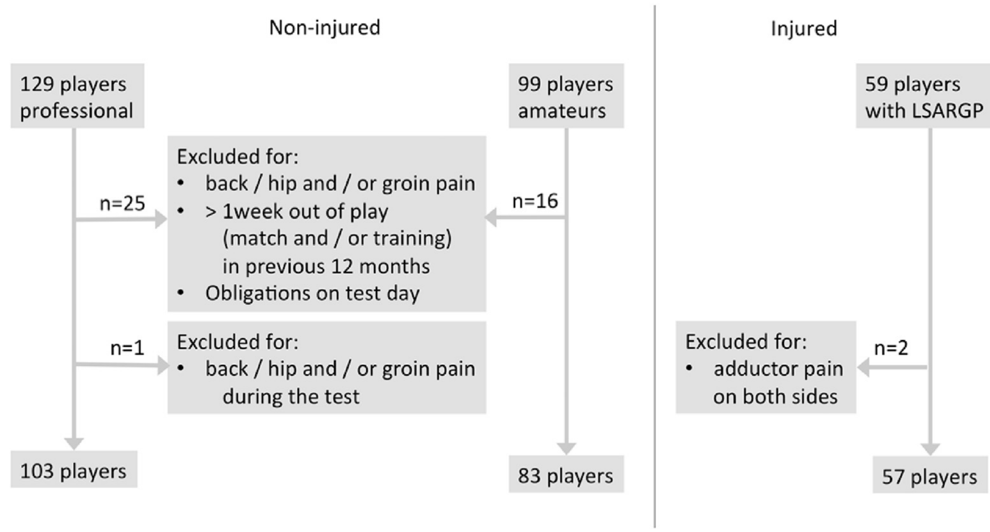

Fig. 6. Inclusion and exclusion process of non-injured and injured players.

Table 3
Subject characteristics of healthy elite, healthy amateur and injured football players are displayed as mean (±SD).

	Elite non-injured players	Amateur non-injured players	Injured players with LARGP
n	103	83	57
Age (yr)	23 (4.1)	24 (5.5)	26 (7.0)
Height (cm)	182 (7)	182 (6)	180 (7)
Weight (kg)	76.3 (7.5)	76.3 (7.7)	73 (7.3)
BMI (kg/m^2)	23.1 (1.6)	23.0 (1.7)	22.3 (1.7)
Dominance (% right-left)	71–29	81–19	84–16
Frequency sport (x/week)	≥5	2–4	2-4 (53/57) ≥5 (4/57)
Injured side (% dominant)	–	–	70
Time out of play (weeks)	–	–	15 (2–27)

Table 4
The ICC values of intra and inter observer reliability for specific directions and total ROM, SEM and MDC.

	Intra observer ICC	SEM (degrees)	MDC (degrees)	Inter observer ICC	SEM (degrees)	MDC (degrees)
Extension	0.92	2.4	6.6	0.88	2.9	7.9
Adduction	0.96	1.3	3.7	0.57	4.3	11.8
Abduction	0.90	1.9	5.4	0.81	3.9	10.7
Internal rotation	0.98	2.0	5.5	0.50	6.9	19.0
External rotation	0.95	2.3	6.3	0.63	5.6	15.4
Total ROM	0.92	5.9	16.4	0.88	9.2	25.6

Table 5
Reference values of sport specific hip ROM of the non-injured and injured footballers in degrees (mean ± SD).

	ROM elite non dominant	ROM elite dominant	ROM amateur non dominant	ROM amateur dominant	ROM non-injured side	ROM injured side
Extension	35 (9)*	35 (8)*	29 (10)*	30 (10)*	26 (11)	21 (11)^
Adduction	18 (6)	19 (6)	22 (6)**	23 (7)**	23 (6)	11 (6)^
Abduction	41 (7)**	39 (7)**	40 (7)	39 (7)	40 (8)	28 (9)^
Internal rotation	31 (12)	30 (12)	31 (12)	30 (11)	34 (11)	21 (12)^
External rotation	66 (9)	65 (11)	66 (17)	66 (17)	64 (20)	55 (22)^
Total ROM	191 (25)	188 (25)	188 (25)	188 (25)	187 (31)	136 (29)^

* = Significant difference of dominant and non-dominant legs between amateurs and elite.
** = Significant difference between non-dominant and dominant leg in elite or amateur players.
^ = Significant difference between injured side and non-injured side in injured players.

maximum range until marked stiffness was observed. It seems that this stiffness within one observer is experienced quite similarly but between observers lower agreement is obtained. Testing with pressure quantification may help improve the reliability (Nussbaumer et al., 2010) but this requires high tech testing devices. The SEM is small for intraobserver measurements. It is substantially larger for interobserver measurements but still clinically acceptable. Relative left-right differences (as expressed in percentage) therefore are preferred for use in individual players. The differences between injured and non-injured sides exceed the

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MDC for adduction abduction, internal and external rotation.

In both elite and amateur healthy players no clinically relevant side-to-side difference was found. The statistically significant differences found for adduction and abduction, were 1° and 2°. These do not exceed the SEM and only represent a very small proportion of the ROM values obtained, thus were deemed by us clinically irrelevant. The absence of side-to-side difference in non-injured players can only be compared to studies that measure classic rotational hip joint ROM (Brophy et al., 2009; Manning & Hudson, 2009; Verrall et al., 2007) as previous studies of sport specific flexibility have not been performed. These studies on rotational hip joint ROM also found no side-to-side differences.

Comparing elite and amateur players there was a small statistically significant difference between extension of non-injured amateurs and elite football players of 6° that does exceed the SEM. This may be associated with clinical findings of increased lordosis as a result of hip flexor stiffness of the lower back of elite football players (Wodecki, Guigui, Hanotel, Cardinne, & Deburge, 2002) existing as a functional adaptation.

In the players with LARGP a large and clinically relevant decrease was found on the injured side. No previous studies have examined sport specific ROM but two previous cross sectional studies report on internal and external rotation (IR and ER), both assessed in neutral (0°) hip extension. One found IR and ER of both legs were restricted in adult Gaelic football players with groin pain when compared to those without (Nevin & Delahunt, 2014). The majority (14/18 injured players) reported unilateral and the remaining 4 reported bilateral long-standing adductor related groin pain. The other study, performed in a group of young elite Australian football/soccer players found no differences (Malliaras et al., 2009). In this study 8/10 injured players reported bilateral pain and only 2 reported unilateral groin pain. The majority (9/10 players) had adductor related pain. The inclusion criteria in these studies differed. The sum of (dominant and non-dominant) IR and ER (hips flexed) has been reported to be lower in adult professional Australian football players with groin pain when compared with those without (Verrall et al., 2005). In a study comparing athletes with sportsman's hernia (Rambani & Hackney, 2015) with those without, a decreased hip IR and ER were reported on the injured side. Neither ROM data for the uninjured side nor type of sports of the participants were reported. One study performed a reliability analysis for the ROM assessment (Malliaras et al., 2009). Another study followed this same protocol but did not perform a reliability analysis (Nevin & Delahunt, 2014). Two studies assessing hip ROM in flexion (Rambani & Hackney, 2015; Verrall et al., 2005) do not report any reliability measures nor do they refer to a protocol that has been tested as such. No effect studies have been performed correlating hip ROM with changes in groin pain.

This new test was developed because hip ROM is usually measured with the hips in a flexed or neutral position. Examining one joint does not measure functional ROM according to recent insights that motion-dependent moments are important for body segment velocity (Naito et al., 2010). The total body position and adequate biological work space (Egan et al., 2007) is important in order to create moments and therefore a more functional test was warranted (Ibrahim, Murrell, & Knapman, 2007; Malliaras et al., 2009). The current study shows that in a sport specific posture the ROM deficit is located on the injured side and not on the injured side. This is a new finding when compared to previous work that, if present, the association finds both hips are restricted in those with groin pain.

With respect to treatment we think that this hip extension, rotation and ab- and adduction deficit (HERAD) may lead to compensatory muscle contractions compared to when full motion is present (Naito et al., 2010). When HERAD is detected we suggest this deficit should be improved so that speed of movement can be achieved through movement related moments instead of muscle related moments (Tak et al., 2012). This would mean that less muscle force is needed to generate speed. To prove this concept an effect study should be performed to see whether restoring ROM affects symptoms. Manual therapy in which a forceful stretch was applied to the adductors with a large hip joint motion has been shown to be an effective treatment for athletes with long standing adductor related groin pain (Weir et al., 2011). In this randomised trial no measurements of hip joint ROM were performed.

Some limitations of this study should be considered. An important limitation is the fact that the observational design cannot answer the question whether the left-right differences observed in injured players is cause or effect of groin pain. As this is the first study to evaluate lower limb ROM measured over multiple joints no comparisons can thus be made with other studies. The interobserver ICCs are clinically acceptable but they are lower than the intraobserver measurements. This decreased reliability with multiple testers should be considered when considering how to apply our results in practice. Standardization of the testing position needs attention and takes time and this may complicate use in daily clinical practice. When introducing this test to professionals in the field, emphasis should be placed on this. Media like movie fragments may be used to transfer this information. The use of pressure quantification with instrumentally assisted measurements may improve the reliability but would make the test less simple. The cohort of non-injured elite footballers was available for the test-retest assessment. We were allowed to perform these on two moments on one day but it was impossible to plan this with a larger time interval because of the tight playing schedule at that time of the season. Regarding the populations tested more work should be done. Homogeneity of groups of injured players may need attention and data should also be derived from athletes like female players. It would have been of interest to assess classical ROM findings in the injured and non-injured players but this was not performed.

5. Conclusion

This study presents a new sport specific lower limb ROM measurement that is reliable, safe and provides reference values for elite and amateur football players. Total ROM is very similar between the dominant and non-dominant legs in elites and amateurs. Players with unilateral long-standing adductor-related groin pain show marked reduction of ROM on the injured side. These preliminary data provide a basis for further research aiming to clarify whether or not restricted sport specific ROM is a risk factor for development of groin injury.

Ethical Approval

Approved by METC Noord Holland, registration M011-030.

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Conflicts of interest

The authors state that there is no conflict of interest.

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