Hip and groin pain in athletes
*Morphology, function and injury from a clinical perspective*
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CHAPTER 6

Hip range of motion is lower in professional football players with hip and groin symptoms or previous injury, independent of cam deformities

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Abstract

Background: Footballers (soccer) often have hip or groin symptoms (HGS) and previous groin injury is a risk factor for a relapse. Decreased hip range of motion (HROM) has been related to both hip and groin pain and the presence of a cam deformity. How these factors interact is unknown.

Purpose: The first aim was to study whether HGS are associated with HROM. The second aim was to study the association of the presence of a cam deformity with HROM. Additionally the influence of a cam deformity on the relationship between hip and groin symptoms and HROM was examined.

Study Design: Retrospective cross-sectional

Methods: Seasonal screening data of two professional football clubs were used. Variables for HGS were current hip or groin pain, the Hip And Groin Outcome Score (HAGOS) and previous hip and groin related time-loss injury. HROM was determined for hip internal, external and total rotation in a supine position and for the bent knee fall out test (BKFO). Cam deformity was defined by an alpha angle >60° on standardized antero-posterior pelvic and frog-leg lateral radiographs.

Results: Sixty players (mean (±standard deviation(SD)) age=23.1(±4.2) years) were included. All were non-injured at the time of screening. Current hip or groin pain was not associated with hip ROM. Hips of players in the lowest HAGOS inter quartile range (thus most affected by complaints, n=12) showed less internal rotation (23.9±8.7 vs 28.9±7.8, p=0.036) and total rotation (58.2±13.5 vs 65.6±11.8, p=0.047) than those in the highest (n=29). No such differences were found for BKFO (p=0.417). Hips of players with a previous hip and groin related time-loss injury showed less internal rotation (21.1±6.8 vs 28.3±8.9, p<0.001) and total rotation (56.0±8.2 vs 64.5±13.6, p<0.001) than those without. This was independent of presence of a cam. BKFO did not differ between groups (p=0.983). Hips with a cam deformity showed less yet non-significant IR (25.5±10.3 vs 29.0±7.1, p=0.066) and TROM (p=0.062) and higher (17.1±3.4 vs 14.2±4.6, p=0.078) yet non-significant BKFO values than hips without.

Conclusion: Decreased hip ROM in professional football players is associated with more hip and groin related symptoms and with previous injury history, independent of the presence of cam deformity.
Introduction

Hip and groin pain accounts for 11-16% of the time-loss injuries in football\(^2\). As footballers often experience hip or groin related symptoms\(^3\) time-loss injuries\(^7\) are most likely on the most severe end of the injury-spectrum. As such, hip and groin pain is probably a more significant problem in footballers than is suggested when using the time-loss injury definition\(^7\).

The severity of hip and groin symptoms can be quantified using the Hip And Groin Outcome Score (HAGOS)\(^2\), a validated patient reported outcome measure for young active individuals with hip and/or groin pain. Lower HAGOS scores have been associated with hip and groin pain in the previous football season indicating persistent increased level of symptoms in players over time\(^3\). Previous hip or groin injury has also been identified as a risk factor for re-injury\(^14,202\).

There appears to be a complex interplay between hip and groin pain and hip joint range of motion (HROM). Some studies have observed an association between restricted HROM and hip and groin pain in athletes\(^14,244\) while others have failed to find any relationship\(^60,141,263\).

Recently, growing attention has been given to the role of cam deformity. Cam deformity, the presence of an aspherical femoral head, has been demonstrated to be associated with decreased internal rotation of the hip joint\(^15,120,269\) and with hip and groin pain\(^116,216\). The combination of cam deformity and decreased internal rotation of the hip is suggested to lead to an increased risk of hip osteoarthritis later in life\(^3\). The best management for cam deformity and associated femoroacetabular impingement is unclear, with early surgical intervention being advocated\(^21,71\) and also questioned\(^43,189\).

The first aim of this study was to investigate whether current hip and groin symptoms or previous hip and groin related time-loss injuries are associated with decreased HROM. The second aim was to study the association of the presence of a cam deformity with decreased HROM. Additionally this allowed us to examine the influence of a cam deformity on the relationship between hip and groin symptoms and HROM.

Methods

Subjects

All subjects were adult professional football players from the first team of two clubs from the Dutch premier professional league. At the time of examination no player was unable to play due to hip or groin injury. To allow accurate analysis of injury data players were eligible for inclusion if they had played the previous season at the same club, as an injury in the previous season was one of the independent variables. Player characteristics,
questionnaires and HROM measurements were obtained at the starting period of the 2012-2013 season during the screening process as part of the clubs routine medical care. The radiographs were carried out for medical screening and for the purposes of transfer to and from other clubs. Questionnaires and HROM measurements were taken on the same day.

This study complied with the requirements of the declaration of Helsinki. As anonymized data from standard medical care was used in a retrospective design, the Dutch Central Committee on Research Involving Human Subjects (CCMO) confirmed no ethical approval was needed, as stated in the Dutch Medical Research Involving Human Subjects Act (WMO).

**Player characteristics**

Age (years), height (m) and weight (kg) were recorded. Body mass index (BMI) was also calculated. Written informed consent was obtained from all players to use their anonymized data.

**Hip and groin symptoms**

*Current hip or groin pain*

A short questionnaire was performed by the club medical staff in the last two weeks of the pre-season period to determine the presence of hip and groin pain in players; the question "do you have any hip or groin pain?" was included with a dichotomous answer (yes/no) option to determine symptomatic versus asymptomatic players. When answered positively, the painful side was specified (left, right or bilateral). No additional tools, such as body charts were used. Pain was referred to as any hip or groin pain before, during or after exercise; no pain monitoring scales were used. The club medical staff also gave the HAGOS questionnaire to all players. Dominance was determined by asking the players to state their preferred kicking leg.

*Current HAGOS*

The HAGOS is a 37-item patient reported outcome measure covering 6 domains on pain, symptoms, physical activity in daily living (ADL), sports and recreational activity, physical activity and hip and groin related quality of life. Each of these 6 domains run from 0 to 100, where 0 indicates most problems and 100 indicates no problems at all.

*Hip and groin related time-loss injury in the previous season*

The medical staff registered time-loss injuries due to hip or groin pain during the previous season. In line with the consensus statement of injury definition in soccer injury studies, a time-loss injury was registered when a player was unable to participate in ≥1 training or match due to hip and groin symptoms.
Hip range of motion
All range of motion testing was performed in the morning at the start of a training day, before any training activity. There was no warming up before testing. Tests were performed by two physical therapists (>15 years experience in elite sports and orthopaedic rehabilitation). The same therapist performed the same test (either the rotational hip range of motion tests or the bent knee fall out test). Both therapists were blinded for questionnaires used and were unaware whether the player had a cam deformity or not.

Rotational range of motion
Rotational ROM of the hip was measured in supine with the hips and knees in 90° flexion. Internal (IR) and external rotation (ER) were both assessed using a universal goniometer. These were added to give the total range of motion (TR) score\textsuperscript{173,244}. The axis of the goniometer was placed on the apex of the patella. The value was recorded at end range of motion. End range of hip motion was considered at the earliest visible lateral tilting movement of the pelvis, indicating lateral flexion of the lumbar spine that would lead to higher rotational ROM values. Each measurement was performed once. Inter-rater reliability coefficients (ICC) for this measurement of hip rotations has been shown to be 0.91 (coefficient of variation: 5.2%) for ER and 0.95 (coefficient of variation: 7.7%) for IR\textsuperscript{173}. Standard error of measurement reported was 2.5° for external and 2.4° for internal rotation\textsuperscript{173}.

The bent knee fall out test
The bent knee fall out (BKFO) test is used to measure HROM combining hip flexion, abduction and external rotation. The BKFO is performed in a crook lying position (Figure 1A). The knees are flexed to a 90° position using a universal goniometer. Then the knees are moved outward while keeping the soles of the feet together. At the end of the range of movement gentle overpressure is given by the examiner to ensure a relaxed position. The distance from the fibular head to the top of the table is then measured in centimetres with a semi-rigid tape measure to the nearest 0.5 cm. Previous studies report excellent reliability of the BKFO distance with an intra-rater ICC of 0.89 and inter-rater ICC of 0.91. Standard error of measurement (SEM) is 1.0 when using this protocol\textsuperscript{141,167}.

Radiographs
Radiographs were obtained for both hips according to a standardized protocol. For the AP pelvic radiograph, participants were in the standing position with their feet in 15° of internal rotation (using a standard frame). For the frog-leg lateral radiographs the participant was in supine position. The hip and knee were flexed so that the heel was at the level of the joint line of the contralateral knee. The hip was then abducted and externally rotated; a 45° wedge (Figure 1B) supported the leg to maintain a standardized
position. Standard gonadal shields were used. This method has been described in more detail in other studies.\textsuperscript{2,3,222}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{A. The bent knee fall out test. The distance from the fibular head to the top of the couch is measured. B. Frog-leg lateral radiograph. The patients’ upper leg is supported with a 45° wedge cushion (white arrow) to ensure a standardized position.}
\end{figure}

\textbf{Cam deformity}

For the purpose of this study alpha angle measurements were performed on both the AP pelvic and frog-leg lateral views to define the presence of a cam deformity. The alpha angle was automatically calculated using MatLab (MathWorks Inc., Natick, Massachusetts, USA) from a point-set that was manually positioned along the bony contour of the proximal femur. This procedure has been described in other studies.\textsuperscript{5,222} The presence of a cam deformity was defined by a recently validated alpha angle threshold of >60°. The presence of a cam deformity per hip was defined when these were present in either view. The presence per person was defined when a cam was present in either view in either hip. The test-retest reliability (ICC) of alpha angle measurement was previously reported to be 0.81 (95% CI 0.62-0.91) for the AP and 0.92 (95% CI 0.83-0.96) for the frog-leg lateral view\textsuperscript{222}.

\textbf{Statistical analysis}

The distribution of the parameters was tested for normality using the Kolmogorov-Smirnov test. Normally distributed data are presented as mean ± standard deviation (SD) and non-normal data as median (IQR 25% - IQR 75%). Linear regression models associations between HROM (as dependent) variables and the presence/absence of hip or groin symptoms (HGS) as defined by current pain, most and least affected by symptoms, previous injury as well as the presence or absence of a cam deformity, was calculated per hip using univariate linear regression with generalised estimating equations (GEE).
GEE was used to model the interdependency between left and right hips. As the HAGOS contains six domains with separate scores there is not one total score. In order to study associations between the HAGOS and HROM we created a total score as follows; The inter quartile range (IQR) for each domain was calculated. All players were allocated to one of three groups. The group with the most symptoms was determined as those players where two or more domain scores were in the lowest IQR. The group with least symptoms were players in whom two or more domains scored in the highest IQR. Where players did not score two or more domains in the highest or lowest IQR or they had two or three in the highest as well as in the lowest IQR at the same time, they were allocated to the middle group (IQR 25-75). We chose this approach to decrease the risk of a type 1 error because of the large number of analyses that would have been necessary if individual subscales were used.

To adjust for the presence of a cam deformity (as a cam deformity is associated with decreased HROM) when analysing the association between HGS and HROM, a cam deformity was additionally entered as an independent variable using a multivariate linear regression model with GEE. In this way, it can be determined whether or not the association between HROM and HGS is dependent on the presence of cam deformity. After this adjustment interaction effects were calculated by entering the product-variable of HGS and cam deformity in the multivariate model. In case of a significant interaction between a certain HGS variable and cam deformity the association of HROM and that specific HGS variable was presented separately for hips with and without a cam deformity.

Post-hoc analyses were performed to investigate differences in HAGOS scores between players with and without any hip or groin pain and those with and without a hip and groin related time-loss injury in the previous season (HGTI). This was done using Mann-Whitney U tests.

Data were processed using SPSS 20 (IBM, Chicago, US). The α-level for statistical significance was set at p=0.05.

Results

Subject characteristics

The two teams consisted of 67 players. Seven players were not eligible for participation; one player did not perform the x-rays, four were not playing at the team in the previous season and two were preparing for transfer procedure to another club and not available for the physical examinations. Sixty players gave their consent, thus 120 hips could be used for the analyses. Characteristics and an overview of the independent variables of all participants are summarised in Table 1.
Forty-four (73%) players reported current hip or groin pain while 16 (27%) reported no current symptoms. There were 29 (48%) players who scored in the highest IQR on at least two domains of HAGOS, (least affected) and 12 (20%) in the lowest IQR, (most affected). The remaining 19 players had 1 or no domain score in the highest or lowest IQR. None of the players had 2 of 3 domain scores in both the highest and lowest IQR.

Table 1. Player characteristics presented as mean (±SD, range) or median (IQR 25%-75%)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean ± SD, Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.1 ± 4.2, 18-38</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>182.7 ± 7.2, 168-197</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.8 ± 7.9, 62-108</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.3 ± 1.7, 19-28</td>
</tr>
<tr>
<td>Side of dominance</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>44 (73%)</td>
</tr>
<tr>
<td>Left</td>
<td>16 (27%)</td>
</tr>
<tr>
<td>Current hip or groin pain</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>16 (27%)</td>
</tr>
<tr>
<td>Yes, Unilateral</td>
<td>14 (23%)</td>
</tr>
<tr>
<td>Yes, Bilateral</td>
<td>30 (50%)</td>
</tr>
<tr>
<td>HAGOS domain scores</td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>92.5 (78.12-100)</td>
</tr>
<tr>
<td>Symptoms</td>
<td>82.14 (58.03-100)</td>
</tr>
<tr>
<td>ADL</td>
<td>100 (90-100)</td>
</tr>
<tr>
<td>Sports and recreational activity</td>
<td>93.75 (75.05-100)</td>
</tr>
<tr>
<td>Physical activity</td>
<td>100 (75-100)</td>
</tr>
<tr>
<td>Quality of life</td>
<td>82.50 (62.50-100)</td>
</tr>
<tr>
<td>Hip and groin related time-loss injury in previous season</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>51 (85%)</td>
</tr>
<tr>
<td>Yes</td>
<td>9 (15%)</td>
</tr>
<tr>
<td>Cam deformity per person</td>
<td></td>
</tr>
<tr>
<td>(cam present in either view in either hip)</td>
<td>60 (100%)</td>
</tr>
<tr>
<td>No</td>
<td>22 (37%)</td>
</tr>
<tr>
<td>Yes</td>
<td>38 (63%)</td>
</tr>
<tr>
<td>Cam deformity per hip</td>
<td></td>
</tr>
<tr>
<td>(cam present in either view per hip)</td>
<td>120 (100%)</td>
</tr>
<tr>
<td>No</td>
<td>60 (50%)</td>
</tr>
<tr>
<td>Yes</td>
<td>60 (50%)</td>
</tr>
</tbody>
</table>

Abbreviations: SD=standard deviation; IQR=inter quartile range.
Association between hip and groin symptoms and hip range of motion

Current hip or groin pain

The mean total ROM of all hips was 63.2(±13.3, 35-95) degrees. The range of motion in the hips on the side where players reported any current hip or groin pain (n=74 (62%)) was not different from those without pain (n=46 (38%)) for IR (p=0.432), ER (p=0.504), TR (p=0.528) or BKFO (p=0.246), irrespective of the presence of cam deformity (see Figure 2 and Supplementary data Table 1 and 2 for actual values).

**Figure 2.** ROM values (mean, SD and 95% CI) presented for painful (Y) and pain free hips (N) in players with current groin pain; ROM of hips from players in the lowest (LIQR) or highest (HIQR) HAGOS inter quartile range and from players with (Y) or without (N) cam deformity. P-values presented are after correction for presence of a cam deformity.
**Current HAGOS**

Hips from players in the lowest HAGOS IQR, thus most affected (n=12 (20%)) showed less IR (p=0.052) and TR (p=0.059) than those in the highest IQR (n=29 (48%)) however differences were non-significant. No differences were observed for ER (p=0.293) or BKFO (p=0.417, see Figure 2 and Supplementary data Table 1). When adjusted for presence of a cam deformity, the differences for IR and TR were significant (IR: p=0.036, TR: p=0.047, see Supplementary data Table 2). Post-hoc analysis of the data showed that players with current symptoms had lower HAGOS scores than those without (p≤0.01) for all subscales (see Figure 3).

**Hip and groin related time-loss injury (HGTI)**

Hips from players who had a HGTI in the previous season showed less IR (p<0.001) and TR (p<0.001) than those without (see Figure 2 and Supplementary data Table 1); no differences were observed for external rotation (p=0.300) and BKFO (p=0.983). After adjustment for the presence of a cam deformity, the differences for IR (p<0.001) and TR (p<0.001) remained significant (see Figure 2 and Supplementary data Table 1 and 2 for actual values). Seven of the 9 players with a HGTI scored in the lowest HAGOS IQR on two or more domains. Two players were in the middle (IQR 25-75) group. Six of the 12 players in lowest IQR group had previous injury. Post-hoc analysis showed that players with a HGTI in the previous season had lower HAGOS scores compared to those without (p≤0.007) for all subscales (see Figure 4 and Supplementary data Table 3).

**Cam deformity, hip range of motion and hip and groin symptoms (HGS)**

**Cam deformity and HROM**

Hips with a cam deformity showed less yet non-significant IR (p=0.066) and TROM (p=0.062) and higher yet non-significant BKFO values (p=0.078) than hips without (see Figure 2 and Supplementary data Table 1). There were also no differences for ER between hips with and without cam deformity (p=0.245).

**Interaction effects of cam deformity on associations between HGS and HROM**

There were no interaction effects for the presence / absence of cam deformity and the HGS variables ‘current HAGOS’ and ‘HGTI’ on the associations with HROM (see Supplementary data Table 2 for Beta values and all interactions).

Significant interaction effects were found for the presence/absence of a cam deformity and the HGS variable ‘current hip or groin pain’. Painful hips without a cam (n=37) were associated with higher IR (P<0.001) and TR (P=0.002) and higher (thus decreased) BKFO (P=0.046) when compared with asymptomatic hips without a cam (n=23, see Supplementary data Table 4).
Figure 3. HAGOS values in players with or without hip and groin pain. Boxes present the median and IQR25-IQR75 and whiskers the minimum and maximum. Abbreviations: ADL=activities of daily life. SportRec=sports and recreation; PA=physical activities; QoL=quality of life.

Figure 4. HAGOS scores for players with and without a hip and groin related time-loss injury in the previous season. Boxes present the median and IQR25-IQR75 and whiskers the minimum and maximum. Abbreviations: ADL=activities of daily life. SportRec=sports and recreation; PA=physical activities; QoL=quality of life.
Discussion

This is the first study of professional football players examining associations between hip and groin pain, previous injury, hip range of motion and cam deformity. We showed that players with a hip and groin related time-loss injury in the previous season show lower internal rotation and total rotation of their hips. Players who reported the most hip and groin related problems on the HAGOS had lower hip internal and total rotation when compared to those with the least problems. These associations were independent of the presence of a cam deformity. There was no difference in HROM between painful and pain free hips. Secondary findings of this study are that professional footballers have a high prevalence of hip and groin symptoms, even in the pre-season. Furthermore, footballers with previous time-loss hip and groin injuries have lower HAGOS scores even when they are “recovered” and playing again.

Previous studies investigating the association between hip and groin pain and HROM have used different definitions for hip and groin pain; some compared asymptomatic with symptomatic players without time-loss in sports\textsuperscript{167,243} while others considered only athletes with time-loss injury\textsuperscript{60,100,244}. The duration of pain experienced in the populations studied also ranged substantially\textsuperscript{100,167,244}. The relationship between previous injury and HROM has never been studied but seems to play a role. This may indicate that when people return to sport following hip or groin injury, lower HROM may persist and subsequently lead to increased risk of development of hip and/or groin pain. The latter cannot be concluded from this study due to its retrospective design.

Also the association between the degree of hip and groin problems experienced in non-injured athletes, i.e. those without a time-loss injury, and HROM has never been studied. By using the HAGOS questionnaire in addition to a simple clinical question, we have demonstrated that various definitions of hip and groin pain can result in different outcomes with respect to its association with HROM. Simply enquiring whether or not footballers have hip or groin pain may fail to add valuable information as the current findings indicate that the majority of players have some degree of symptoms. The HAGOS may also allow further quantification and analysis of subgroups as those athletes affected to a greater or lesser extent by hip and groin symptoms can be distinguished. We did this by creating one ordinal measure for all six HAGOS domains. However, it should be acknowledged that the HAGOS has not been tested or validated for this specific purpose. Additionally, seven out of nine players with a previous injury scored in the lowest IQR. As may be expected, there was some overlap between the players categorized in this manner. Given this partial overlap, no definite conclusions can be drawn on the association due to the small numbers. It can be questioned if use of a general score based on IQR scores may be worthwhile.
In this cohort, 15% of the players had sustained a hip and groin related time-loss injury in the previous season, which is in line with previously reported prevalence ranges of 4-19%\textsuperscript{247}. The current 15% prevalence, which seems reasonably high, may be related to the definition used. Time-loss in sports was defined as a player who missed at least one training or match\textsuperscript{70}. In contrast to the time-loss prevalence of 15% a significantly higher proportion of players (73%) reported any hip or groin pain in the pre-season. In a recently studied cohort of sub-elite footballers 37% said they suffered groin pain the previous season\textsuperscript{232}; other studies confirm higher but also varying numbers of groin pain being prevalent during a (pre-)season period\textsuperscript{135,245}. These differences may be related to previous findings that only 10% of mild injuries were recalled retrospectively. The shorter the period of symptoms and the longer the duration since the injury occurred, the more likely they were to be forgotten\textsuperscript{107}. A wide variation of injury incidence between teams has been reported for minor injuries\textsuperscript{176}. Surveillance methods on injury and problems experienced should take this into account. Our findings highlight that when groin injury is measured only in terms of time-loss, the prevalence of hip and groin pain is underestimated\textsuperscript{247}.

We emphasize that the procedures to use radiographs for screening purposes are the choice of the individual club. When performed using similar methods they allow standardised analyses, however there is not a sound scientific basis for performing these investigations.

We acknowledge a number of limitations of this study. The dichotomous question posed for experiencing any hip or groin pain could have led to a high number of positive answers. Posing the question in this way may have increased players’ awareness of symptoms. Strict definitions and consequent use are encouraged in future studies\textsuperscript{250}. The presence of cam deformity has been related to decreased hip rotations\textsuperscript{15,120,269}. The results of this study not showing this is almost certainly a type 2 error due to relative low numbers. This may also be the case for the difference of 2.9 cm at the BKFO between hips with (less excursion) and without a cam deformity, for which the p-value approached significance. It is of interest to further investigate if the BKFO is associated with cam deformity.

The strengths of this study are the use of a validated patient reported outcome for hip and groin problems (HAGOS). This sample of elite footballers is homogenous with respect to loading and levels of play. HROM depends on levels of play and therefore no correction for that variable was needed\textsuperscript{142}. Further the use of mathematical software to automatically calculate alpha angles leads to high test-retest reliability and unbiased measurements.
Conclusion

Hip rotation is decreased in non-injured elite footballers with more hip and groin symptoms and with a hip and groin related time-loss injury in the previous season. This is independent of the presence of a cam deformity. Whether decreased hip rotation is a cause or effect remains unclear by this cross sectional design. If these findings are confirmed in a prospective study design it could be that these athletes with more symptoms and/or previous injury may benefit from strategies to improve hip ROM.
Supplementary data

Table 1. Hip range of motion (HROM) scores as mean (SD) and 95% CI for internal, external, total rotation and bend knee fall out (BKFO) for painful and pain free hips, hips of footballers in the lowest and highest HAGOS inter quartile range (IQR), hips of players with and without a time-loss injury in the previous season and hips with and without a cam deformity. P-value corrected for presence of a cam deformity.

<table>
<thead>
<tr>
<th>HROM</th>
<th>Internal Rotation</th>
<th>External Rotation</th>
<th>Total rotational ROM</th>
<th>BKFO</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean (SD)</td>
<td>95% CI</td>
<td>mean (SD)</td>
<td>95% CI</td>
<td>mean (SD)</td>
</tr>
<tr>
<td>Painful hips (n=74)</td>
<td>28 (9.2)</td>
<td>25.8-30.1</td>
<td>36.6 (7.5)</td>
<td>34.8-38.3</td>
<td>64.3 (14)</td>
</tr>
<tr>
<td>Pain free hips (n=46)</td>
<td>26.1 (8.6)</td>
<td>23.5-28.6</td>
<td>35.3 (7.5)</td>
<td>33.1-37.5</td>
<td>61.6 (12)</td>
</tr>
<tr>
<td>Lowest HAGOS IQR (n=29)</td>
<td><strong>23.9 (8.7)</strong></td>
<td><strong>20.3-27.6</strong></td>
<td>34.0 (9.0)</td>
<td>30.2-37.7</td>
<td><strong>58.2 (13.5)</strong></td>
</tr>
<tr>
<td>Highest HAGOS IQR (n=12)</td>
<td><strong>28.9 (7.8)</strong></td>
<td><strong>26.9-31.0</strong></td>
<td>36.6 (6.7)</td>
<td>34.9-38.4</td>
<td><strong>65.6 (11.8)</strong></td>
</tr>
<tr>
<td>Previous injury (n=9)</td>
<td><strong>21.1 (6.8)</strong></td>
<td><strong>17.7-24.5</strong></td>
<td>34.4 (5.4)</td>
<td>31.8-37.1</td>
<td><strong>56.0 (8.2)</strong></td>
</tr>
<tr>
<td>No previous injury (n=51)</td>
<td><strong>28.3 (8.9)</strong></td>
<td><strong>26.6-30.1</strong></td>
<td>36.4 (7.8)</td>
<td>34.8-37.9</td>
<td><strong>64.5 (13.6)</strong></td>
</tr>
<tr>
<td>Cam &gt;60° (n=60)</td>
<td>25.5 (10.3)</td>
<td>22.8-28.2</td>
<td>35.0 (7.3)</td>
<td>33.0-37.0</td>
<td>60.3 (14.0)</td>
</tr>
<tr>
<td>No cam (n=60)</td>
<td>29.0 (7.1)</td>
<td>27.2-30.8</td>
<td>37.2 (7.6)</td>
<td>35.3-39.0</td>
<td>66.2 (11.9)</td>
</tr>
</tbody>
</table>
Table 2. Associations between hip range of motion (HROM) and variables for hip and groin symptoms and interaction effects of cam deformity and hip and groin symptoms (HGS) on associations between HGS and HROM.

<table>
<thead>
<tr>
<th>Outcome; HROM</th>
<th>Predictor; HGS defined by painful hips, hips of players in lowest HAGOS interquartile range (IQR) and hips of players with previous hip and groin injury.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without correction for presence of cam</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>HROM Internal Rotation</td>
<td></td>
</tr>
<tr>
<td>Painful hips</td>
<td>1.965</td>
</tr>
<tr>
<td>Lowest IQR</td>
<td>-5.007</td>
</tr>
<tr>
<td>Previous injury</td>
<td>-7.222</td>
</tr>
<tr>
<td>HROM External Rotation</td>
<td></td>
</tr>
<tr>
<td>Painful hips</td>
<td>0.936</td>
</tr>
<tr>
<td>Lowest IQR</td>
<td>-2.680</td>
</tr>
<tr>
<td>Previous injury</td>
<td>-1.928</td>
</tr>
<tr>
<td>HROM Total Rotation</td>
<td></td>
</tr>
<tr>
<td>Painful hips</td>
<td>2.680</td>
</tr>
<tr>
<td>Lowest IQR</td>
<td>-7.454</td>
</tr>
<tr>
<td>Previous injury</td>
<td>-7.437</td>
</tr>
<tr>
<td>HROM BKFO</td>
<td></td>
</tr>
<tr>
<td>Painful hips</td>
<td>0.603</td>
</tr>
<tr>
<td>Lowest IQR</td>
<td>1.088</td>
</tr>
<tr>
<td>Previous injury</td>
<td>-0.028</td>
</tr>
</tbody>
</table>
Table 3. Hip And Groin Outcome Scores (mean and interquartile range (IQR) 25-75) for players with or without any hip or groin pain and for players with or without a hip or groin related time-loss injury in the previous season.

<table>
<thead>
<tr>
<th>HAGOS</th>
<th>Pain</th>
<th>Symptoms</th>
<th>ADL</th>
<th>SportsRec</th>
<th>PA</th>
<th>QoL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current hip or groin pain</td>
<td>90†</td>
<td>79†</td>
<td>95†</td>
<td>86†</td>
<td>88†</td>
<td>80†</td>
</tr>
<tr>
<td></td>
<td>(81-93)</td>
<td>(64-86)</td>
<td>(90-100)</td>
<td>(76-94)</td>
<td>(75-100)</td>
<td>(65-95)</td>
</tr>
<tr>
<td>No hip or groin pain</td>
<td>99†</td>
<td>93†</td>
<td>100†</td>
<td>100†</td>
<td>100†</td>
<td>95†</td>
</tr>
<tr>
<td></td>
<td>(96-100)</td>
<td>(80-99)</td>
<td>(100-100)</td>
<td>(98-100)</td>
<td>(100-100)</td>
<td>(83-100)</td>
</tr>
<tr>
<td>Previous injury</td>
<td>78†</td>
<td>64‡</td>
<td>90†</td>
<td>69†</td>
<td>75†</td>
<td>60†</td>
</tr>
<tr>
<td></td>
<td>(61-90)</td>
<td>(45-75)</td>
<td>(60-93)</td>
<td>(52-86)</td>
<td>(56-88)</td>
<td>(50-78)</td>
</tr>
<tr>
<td>No previous injury</td>
<td>93†</td>
<td>82‡</td>
<td>100†</td>
<td>94†</td>
<td>100‡</td>
<td>90†</td>
</tr>
<tr>
<td></td>
<td>(88-98)</td>
<td>(71-93)</td>
<td>(95-100)</td>
<td>(84-100)</td>
<td>(88-100)</td>
<td>(75-100)</td>
</tr>
</tbody>
</table>

† P=0.001, ‡ P=0.002, † P=0.000, ‡ P=0.007.

Abbreviations: ADL=activities of daily life. SportRec=sports and recreation; PA=physical activities; QoL=quality of life.

Table 4. Rotational hip range of motion and bent knee fall out (BKFO) values in painful and pain free hips without a cam deformity presented as mean (SD) and 95% CI.

<table>
<thead>
<tr>
<th></th>
<th>Internal Rotation</th>
<th>External rotation</th>
<th>Total Rotation</th>
<th>BKFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painful hips</td>
<td>30.5 (7.2)†</td>
<td>38.6 (6.2)</td>
<td>69.1 (11.3)‡</td>
<td>14.8 (4.5)‡</td>
</tr>
<tr>
<td></td>
<td>(28.1-33.0)</td>
<td>(36.6-40.7)</td>
<td>(65.3-72.9)</td>
<td>(13.3-16.3)</td>
</tr>
<tr>
<td>Pain free hips</td>
<td>26.5 (6.3)†</td>
<td>34.8 (8.3)</td>
<td>61.6 (11.6)‡</td>
<td>13.3 (4.8)‡</td>
</tr>
<tr>
<td></td>
<td>(23.8-29.2)</td>
<td>(31.2-38.4)</td>
<td>(56.6-66.6)</td>
<td>(11.2-15.4)</td>
</tr>
</tbody>
</table>

† P=0.000, ‡ P=0.002, † P=0.046

Abbreviation: BKFO=Bent knee fall out.