Hip and groin pain in athletes
Tak, I.J.R.

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CHAPTER 11

General discussion
Introduction
In chapter 1 the background of this thesis is presented. It gives an overview regarding anatomy and morphology of the hip and groin region, clinical examination, currently used terms and definitions, the injury spectrum and treatment of athletes with groin pain.

Beyond time-loss: patient reported outcome measures
Patient reported outcome measures (PROs) are the gold standard for assessing an individual's perceived status of health. A PRO for athletes preferably allows scoring levels of perceived pain, symptoms, and ability to participate in ADL and sport along with the quality of life, all related to the illness or injury present. PROs add an extra dimension on top of the classically used time-loss definition for the registration of injury. Many PROs are developed in English language versions. Following international accepted guidelines and checklists a Dutch version of these can be obtained with appropriate quality. Chapter 2 and 3 are related to PROs that can be used to quantify hip and groin related levels of symptoms in young and active individuals: the Hip and Groin Outcome Score (HAGOS) and the 33-item International Hip Outcome Tool (iHOT-33). The reliability and validity of these two questionnaires was studied in the target populations, young and active individuals with hip (HAGOS and iHOT-33) and groin (HAGOS) pain.

Chapter 2 describes this process of translation, cross cultural adaptation and validation of the Dutch version of the Hip and Groin Outcome Score (HAGOS). This was performed in a young (mean age 32±9.1 years) active (mean pre-injury Tegner score 6.5) population of 194 patients with hip and groin pain (NPRS≥1) who were seen in primary and secondary health care settings; 99 underwent a conservative management for their groin pain, 44 were seen pre-operatively and 51 had a post-surgical status. The test-retest reliability (studied in 129 patients) is acceptable with intraclass correlations (ICCs) >0.80. The standard error of measurement (SEM) for all domains ranged from 6.5-11.6. The smallest detectable change (SDC) for group level ranged from 1.1-2.7 and for individual level from 18.0-32.2. The internal consistency was good (Cronbach's alpha 0.81-0.92). Every subscale had one strong factor explaining the degree of variance.

Validity testing was performed in 194 subjects. A priori set hypotheses, correlating subscales of the HAGOS with those of the Hip disability and Osteoarthritis Outcome Score and EQ-5D, were tested and 12/15 (80%) were confirmed, thus the construct validity was deemed appropriate. Interpretability was assessed using analysis for the presence of floor and ceiling effects showed that the latter were absent in this group of patients. Floor effects were observed in 21% for the Physical Activity scale. The substantially low scores on the Sports and Recreations and Quality of Life subscales, shows that the validation procedure was carried out in the right population of this PRO. The clinimetric
properties obtained are comparable with those of the original Danish HAGOS.

**Chapter 3** describes this process and outcomes for the Dutch International Hip and Outcome Tool (iHOT-33). A Dutch iHOT-33 version was obtained and tested in a young (mean age 33±8.9 years) and active (mean pre-injury Tegner score 6) population of 214 patients with symptomatic hip joint pathology (NPRS≥1) in a primary and secondary health care setting; 43 came for conservative management, 53 were seen pre-operatively and 118 were evaluated post-surgery. Test-retest reliability was studied in 133 patients and confirmed as acceptable with an ICC of 0.92. The SEM was 6.0. The SDC at group and individual level respectively was 1.1 and 16.7 points. The internal consistency was good (Cronbach’s alpha 0.90).

Validity was tested by means of 15 a priori set hypotheses, correlating iHOT-33 with HOOS and EQ-5D. With 13/15 (87%) hypotheses being correct, validity was confirmed. No floor and ceiling effects were observed for the iHOT-33 total score in the population tested.

The Dutch versions of HAGOS and iHOT-33 presented can be used in both clinical and research settings as they were shown to be reliable and valid. The values obtained allow comparing outcomes of data across studies. The validated Dutch HAGOS can be found at the official website www.koos.nu and is freely available. Administering PROs adds new information about the burden of hip and groin problems experienced by athletes rather than time-loss alone, which is explored as part of chapter 6.

A recent review on clinimetric evidence of PROs for hip and groin pain concluded that these are suitable for evaluation of groups of patients rather than individuals as the smallest detectable change remains relatively large for the latter. We recommend having a small set of targeted PRO’s used, as large variation of PROs will make it hard to compare populations and the results of interventions studied. Both for hip related (HAGOS and iHOT-33) and groin related (HAGOS) problems such questionnaires are now available in Dutch. Depending on the work setting and patients groups encountered a choice can be made for one of these PROs. In the primary health care setting, when no imaging is available and where a PRO is administered often before physical clinical examination occurs, the HAGOS is the PRO of first choice. In secondary health care settings with a focus on hip related disorders, which presence can be confirmed by imaging, the iHOT-33 can also be used based on its clinimetric properties. Other considerations like having either one total score (iHOT-33) or different subscale scores (HAGOS) also affect the choice made. In order to get more insight into specific results of treatment programs several subscales are preferred. Different treatment modalities aiming to improve different functions can then be specifically evaluated.

**Groin pain and range of motion**

Many clinicians intuitively examine hip range of motion (ROM) in injured players and
consider improving it worthwhile during treatment. The literature is however unclear on why this may be helpful. In chapter 4, a review presents the possible role of hip ROM in relation to either instep kicking biomechanics in football and ROM being lower in footballers with hip and groin pain\(^{225}\). The findings support the clinical observation that loss of hip ROM may relate to the complaints of injured players of not being able to maximally kick a ball, as hip movement excursion is then larger when compared to submaximal kicking. However biomechanical considerations imply that ROM is mainly required in extension and rotation, i.e. the back swing of kicking. This is in contrast with most studies focusing on examining hip ROM in flexed or neutral hip positions. Additionally, other body segments actions throughout the kinetic chain seem to play an important role in this backswing and assist in efficient energy transfer. Thoughts are presented on the further study of these relationships. When taking this information into account developing a testing sequence to study whether or not limited multi segmental ROM is related to groin injury seems worthwhile. This is further elaborated upon in chapter 9.

Previous systematic reviews aiming to identify whether or not limited hip ROM itself is either a risk factor for the development of groin pain or that it differentiates injured players from non-injured ones, are not univocal\(^{48,98,99,140,157,202,258}\). We performed a systematic review of the available literature aiming to identify why this controversy exists. Additionally we aimed to translate these findings for both the clinical and research setting. The outcomes of this systematic review\(^{219}\) are presented in chapter 5. We identified 11 studies, 7 of which were prospective and 4 case controlled designs. The methodological quality score (risk of bias assessment) ranged from 29–92% according to the Critical Appraisal Skills Program. We found that terms and definitions used for “groin pain” and “injury” as well as the subjects’ inclusion criteria suffers from significant heterogeneity. This methodological heterogeneity precluded the pooling of data. Assessment methods of ROM measurements were poorly reported. An athlete’s total (internal plus external) rotation range of motion of both hips being lower is the most consistent factor found to be associated with the development (risk factor when < 85°) or presence of groin pain. This is only based on a limited number of studies. However the available literature reports little about the measurement properties of hip ROM assessment and fails to discuss the resultant clinical utility of these findings.

For internal rotation (IR) and external rotation (ER) with hips and knees 90° flexed, assessed with a goniometer, the standard error of measurement (SEM) (intra-rater) was previously reported to be 2° and 3°\(^{173}\). For assessment with hips in neutral extension the SEM (intra-rater) for IR and ER is 2° and 4°\(^{141}\). The minimal detectable change (MDC) for both IR and ER with hips and knees in 90° of flexion is 7°. For assessment with hips in neutral extension the MDC for IR is 6° and ER is 11°. The differences found between the
groups in studies for rotational ROM often exceed the SEM, but not the MDC. This needs to be acknowledged as it influences the interpretation of clinical findings and research work in this field: the clinimetric properties of the ROM assessments studied lack discriminatory ability. Given this lack of discriminatory ability ROM testing is not able to identify individuals at risk for hip or groin injury and questions the clinical applicability of the research findings\(^\text{16}\). The clinician working with this group of patients can detect true differences in hip ROM over time for both internal and external rotation. Both must then be at least \(7^\circ\) when examining the patient with the hips \(90^\circ\) flexed. When examining a patient with the hips in a neutral extension position these differences should then be \(6^\circ\) and \(11^\circ\) respectively.

In new studies data from larger cohorts could be used to improve the accuracy of the estimation of risk. Before pooling data, homogeneity of here above-mentioned items (definitions and measurement techniques) is a prerequisite. Uniform use of terms and definitions as proposed in the Doha agreement\(^\text{250}\) will help and should be acknowledged when conducting new studies. Designing an intervention study aiming to improve ROM in one group while not in the other may further elucidate the relevance of hip ROM. When hip ROM is one of the outcome measures we propose using a single examiner to lower measurement variability. Results should be reported not only for the separate measurements but also for the measurement properties to facilitate interpretation.

The identified literature studied associations between hip ROM and time-loss injury. However in the previous chapters we found time-loss to be the most severe expression of the injury spectrum. Symptoms may pre-exist and accumulate until sport cessation occurs and these also often continue to some degree after a previous time-loss injury\(^\text{232}\). Using recently developed PROs has offered us this information. The dichotomous variable of time-loss (yes/no) impedes studying this; the continuous scale of a PRO seems more suitable as it allows detecting clinical changes on different domains. New prospective studies with repeated measures on the development of groin pain may add valuable information.

**Morphology**
Athletes with hip and groin pain often display lower hip ROM when compared to athletes without\(^\text{157}\). The presence of cam morphology\(^77,204\) was also found to be related to lower hip ROM\(^15\).

Asphericity can be quantified by measuring the alpha angle according to Nötzli\(^\text{169}\): the higher the alpha angle, the less spherical the femoral head. It should be acknowledged that different alpha angle thresholds to define cam morphology are used. Lowering the threshold increases the prevalence of cam morphology\(^\text{53}\). Different thresholds are likely to influence the relation with other variables. The recently published *Warwick agreement on femoroacetabular impingement syndrome*\(^77\) does not define exact cut-off values for cam
morphology. This is because impingement is a dynamic phenomenon dependant upon motion, and as such there is no strict value at which one can be certain that impingement will occur. In our studies presented in chapter 6 and 7 we defined cam morphology by an alpha angle ≥60°. This is based on previous work that studied associations between alpha angles of individuals and the risk to develop end-stage osteoarthritis of the hip. A bi-model distribution of alpha angles was found with a normal distribution up to 60°. The optimal area under the curve to be associated with development of hip OA was 78°.

In chapter 6 we studied the association between hip ROM and either the presence of cam morphology and (previous) groin pain or the current levels of groin symptoms. In players who are still playing we found that hip ROM did not differ between those with current groin pain and those without. We also found that hip ROM was lower in players with worse symptoms when compared to those with less severe symptoms. Players with a groin injury in the previous season having more preseason symptoms than those without. We confirmed these findings and found hip ROM was lower in this group with past history of injury. There were no interaction effects with the presence of cam morphology which itself shows an association with lower hip ROM to some degree. We concluded that higher levels of hip and groin related problems experienced are more related to lower hip ROM than the cam morphology when present. This sheds new light on the relation between hip ROM and the injury spectrum as previous studies compared players with (wide ranges of) time-loss and those without. Additionally, altering the definition of the independent variable thus influences the association found. This is much in line with our review conducted on the relation between hip ROM and groin pain and the identified heterogeneity on injury definitions (chapter 5).

When consulted by an athlete with groin pain, the clinical pattern is the most important and imaging should not distract the clinician’s view. Despite this a recent review identified that imaging is the most common criterion to opt for FAI surgery. The role of ROM is found to be imprecise in this decision. We showed that when lower hip ROM is observed this should not solely be linked to the presence of cam morphology, but rather to the presence of pain. Clinicians need knowledge of the prevalence of imaging findings in suitable athletic populations to better interpret imaging findings into their clinical reasoning.

Hip pathology can be ruled out by negative hip provocation testing using Flexion Adduction Internal Rotation (FADIR) and Flexion Abduction External Rotation (FABER) with a good level of confidence. When only FAIS is suspected it should be kept in mind that imaging does only marginally increase the post-test likelihood of FAIS present in specialized secondary clinical settings, were the pre-test probability of the condition being present is already high. We are not aware of any data on the role of imaging in primary health care settings. Decision making thus still relies on reasoning of the clinical practitioner. When provocation testing remains positive over time despite adequate
conservative treatment and/or marked asymmetrical loss of ROM is found at classical hip examination of the injured side we suggest additional diagnostics. The clinician can bear in mind that the presence of cam morphology is highly prevalent in athletes presenting themselves with adductor-related groin pain\textsuperscript{255}. Its presence does not worsen the long-term outcomes of exercise therapy in cases of adductor-related groin pain\textsuperscript{95}.

Development of cam morphology
Cam morphology is related to an increased risk for hip osteoarthritis development later in life\textsuperscript{5,7}. Cam morphology develops in youth when the physes are open\textsuperscript{4}. Athletic participation in youth was already suggested as long ago as 1971 as a possible factor related to the differences in morphological appearance of the femoral head\textsuperscript{158}. The high prevalence of cam morphology of hips in athletes support these findings\textsuperscript{53} and may be present in asymptomatic non-athletic adult individuals as well\textsuperscript{68,75}. Flexion and external rotation loads, as observed in football may result in a bony response inducing the development of cam morphology\textsuperscript{197}. In the study presented in chapter 7 we examined whether or not a dose-response relationship between loading in youth and cam morphology might exist\textsuperscript{222}. A retrospective study in elite football players was conducted. The age at which they started playing football and the frequency of playing was retrospectively assessed. Radiological imaging data from club medical screening was used to identify cam morphology. We found that participating in football regimens at 12 years of age with a higher frequency (≥4/wk) was associated with a higher prevalence of cam morphology (64%) when compared with participating ≤3/wk (40%). The retrospective design and this being the first study warrants new studies to confirm this dose-response relationship, preferably in a prospective design.

Currently there is no prospective data available on loading doses and development of cam morphology but at present a study is running to identify the development of cam morphology in young footballers. Preliminary data from the group of Palmer et al show that magnetic resonance imaging indicates the first appearance of cam development is visible at the age of 10. The cam morphology first forms as cartilage and goes on to ossify as the subjects aged. This is younger than previously identified by x-ray imaging\textsuperscript{4}. If and how this can be influenced is unclear yet but may be subject of future research.

Considering this and the association with an increased risk for development of hip OA this information may finally result in designing training regimens for young high-level athletes. This may contribute to protect long-term athletes’ health, as osteoarthritis is associated with increased mental problems in former elite athletes later in life\textsuperscript{207}. More studies are needed to confirm this. This is an area that needs to be studied carefully in the light of general low levels of physical activity in children and the need for public health messages to encourage more activity.
Considerations on kicking, range of motion and groin pain: building the concept.

Athletes often report that kicking with maximum speed provokes their groin pain\textsuperscript{224} and that they are forced to switch to submaximal kicking strategies. Biomechanical studies confirm that ball speeds and movement excursions of the hip and knee are decreased in less skilled footballers when compared to high level players. We hypothesized that ROM used within subjects is lower during submaximal kicking when compared to maximal kicking. In chapter \textit{8} we studied and confirmed this in a cohort of 15 experienced footballers\textsuperscript{123}. We found that maximal kicking was associated with higher movement excursions of hip, spine, pelvis and knee in both the AP and rotational directions. At ball impact lower hip flexion was observed as a result of a posterior pelvic tilt that did not occur during submaximal kicking. It was remarkable that the effect sizes for ROM increase during maximal kicking were largest in the trunk region. Studying hip and leg function, searching for a relevant loss, should acknowledge these relations of the lower segments to the trunk. As discussed previously in chapter \textit{4 and 5}, hip function is usually assessed with the hips in 0° or 90° flexion and new ways of testing that account for the sport specific function may be required. This is further discussed in chapter \textit{9}. In line with the hypothesis on impaired biomechanics a recent study observed loss of posterior pelvic tilt in kicking leading to a continuing anterior tilt in semi-elite footballers with a recent history (<12 months) groin pain\textsuperscript{211}. This may hinder a proper kinematic sequencing\textsuperscript{183} and energy transfer\textsuperscript{212} and consequentially negatively affect length tension relationships of the anterior groin structures. As posterior pelvic tilt seems to increase the available hip range of motion and shifts the anterior acetabular region\textsuperscript{200}, possibly allowing the femur to increased movement. This phenomenon may also be observed in patients with FAIS but future studies are needed to examine this.

In chapter \textit{9} we propose a way of assessing hip function in a manner reflecting the joints sporting biomechanical prerequisites\textsuperscript{224}. While kicking a ball the leg swings backward. The movement trajectory used aims to generate a movement trajectory that enables the development of potential energy, which is then converted into kinetic energy. This energy is transferred into the ball, giving it speed. Given the clinical observation that footballers with groin pain often experience problems on maximal kicking, we hypothesized that the biological workspace to create this back swing was decreased when compared to players without pain present. In order to study this we developed a test, studied its reliability and obtained reference values from amateurs and elite players. We found that sport specific hip ROM represented by hip extension, adduction, abduction, internal and external rotation could be measured with acceptable reliability. We showed that the mean total sport specific hip ROM of healthy players was symmetrical for the dominant and non-dominant leg in elite and amateur players. Footballers with unilateral longstanding adductor-related groin pain showed a mean loss of 27% sport specific hip
ROM on the injured side. Asymmetry >17% (studied by ROC curve analysis revealing a sensitivity 91% and specificity 94%) is related to the presence of pain in players with unilateral longstanding adductor-related groin pain.

The measurement properties of this way of testing, like other hip ROM measures identified in chapter 5, is best performed by a single examiner to detect differences and changes over time. The MDC needs to be acknowledged when clinically interpreting any difference observed. The MDC for total sport specific ROM being 25° and the mean difference being 51° between injured and non-injured sides shows that the sport specific function loss in players with groin pain is substantial.

We hypothesize that this restricted sport specific hip ROM decreases their efficiency of movement. If this loss of sport specific ROM is a result of pain rather than a precursor cannot be answered due to the cross sectional design. A prospective study to examine a causal relationship is then needed. Currently we have the Groin Injury Prevention (GRIP) Study running in which we examine the relation of all these ROM variables with the development of groin injury.

Treatment

There is high quality evidence to support the use of exercise therapy in athletes with adductor related groin pain. A manual manipulation of the adductor muscles was shown to speed up the recovery process when compared with exercise therapy. Both were combined with a predefined, time-contingent gradual return to running program. No PROs were used in these studies, as these were not available at that time.

We examined the clinical course of patients who received treatment with a manual manipulation of the adductors when combined with a self-guided return to sports program. We showed that the majority (82% at 2 weeks and 88% at 12 weeks) of these footballers resumed play with improved HAGOS scores. However most still experienced groin symptoms. Within the first 12 weeks after treatment these scores improved but not to normal levels. A manual technique addressing the adductors may be considered as part of treatment for footballers with longstanding adductor-related groin pain to improve pain and function in the short term and thereby making injured players more receptive for stimuli from exercise. Randomized controlled studies aiming to identify the proposed benefits of such manual techniques in the short term during rehabilitation should be conducted. Patients involvement in decision making on return to play rather than leaving this to the clinician alone should be incorporated as treatment is all about this issue: getting back on the pitch not only as quick, but also as fit as possible with least risk for a relapse.
Conclusions

The work contained in this thesis provides Dutch versions of reliable and valid patients reported outcomes measures: the HAGOS and iHOT-33. These can be used for both clinical and research purposes to further study hip and groin related problems in young and active individuals. We advise using the HAGOS for hip and groin related problems in primary and secondary health care settings. Using the iHOT-33 can be advised when hip joint pathology is confirmed. The Dutch version of the HAGOS can be found in the appendix of chapter 2 (page 34) and online at www.koos.nu. The Dutch version of iHOT-33 can be found in the appendix of chapter 3 (page 55).

We found that the previously reported relationship between lower hip ROM, when assessed in hip flexion or neutral extension positions, does not reflect the most relevant biomechanical requirements for sporting movements like kicking. As players with groin pain provoke their pain by kicking we suggested examining hip ROM in a situation reflecting the back swing position of the body. No such test was available and this is further elaborated upon in chapter 9.

In a systematic review we found that the literature on the relationship between hip ROM and groin pain in athletes is heterogenic in many ways. We found evidence that lower total rotation ROM of both hips (<85°) is a risk factor for development of groin pain with total ROM being related to its presence. Measuring hip ROM does not correctly identify athletes at risk due to the poor measurement properties of this type of assessment. The rather large MDC questions the re-assessment of hip ROM over time and this need to be considered by examiners doing so.

The hip is an acknowledged source for groin pain in athletes and hips with cam morphology are prevalent in this population. Cam hips have less internal rotation ROM, which is intuitively felt by many clinicians to be related to groin pain. Therefore we studied whether lower hip rotations were related to the presence of cam morphology or the groin pain present. The latter was confirmed and is a clinical relevant finding for the clinician.

Cam morphology is probably a result of flexion rotation loading in youth, when the physes are open. We found a load dose relationship between loading in youth around the age of 12 and the prevalence of cam morphology of the hip.

Football players with groin pain often complain about their loss of ability to maximally kick a ball. In a study on the biomechanics of kicking we concluded that the role of the trunk is essential as the relative differences in ROM used between submaximal and maximal kicking are large. Whether this is impaired in athletes with groin pain is of interest for the clinician as this then can be addressed in rehabilitation programs.

We showed that assessing hip ROM in a sport specific way, including trunk position, following the recent insight that sporting functions are related to total body action, could be performed reliably. The mean sport specific ROM in non-injured amateurs and
elite footballers is symmetrical. The mean difference in sport specific ROM between the injured and non-injured leg in players with adductor-related groin pain being $51^\circ$ ($136^\circ$ vs $187^\circ$). This difference exceeds the MDC and can be detected clinically. This is the first time that such a study was conducted and the same conceptual approach may yield new information in the field of sports medicine and sports physiotherapy in relation to other types of injury.

Exercise regimens are considered the gold standard in treatment of athletes with adductor-related groin pain. Manual adjuncts seem to speed up the process of recovery. In a case-series of football players with adductor-related groin pain, we showed that a manual manipulation of the adductors when combined with a symptom-guided return to sports approach shows promising results regarding short-term pain relief and functional recovery. These aspects can be considered in the treatment in patients with adductor-related groin pain. We suggest this be further studied with a more robust controlled design and compared with the proven benefits of a structured rehabilitation program.

**Future studies**

Future studies on hip and groin pain in athletes should adopt uniform definitions and tests in clinical examination to define what type of groin complaints are studied. We suggest using patient reported outcome measures to report outcomes rather than time-loss alone. Repeated measures of athletes studied will give insight in development or decrease of complaints over time.

We propose biomechanical considerations regarding sport specific movements and function to advance the field on why athletes suffer more complaints or re-injury after sustaining a groin injury. Energy transfer mechanisms should be recognized in new studies as these are mandatory for high speed movements. As femoroacetabular impingement is a dynamic phenomenon we propose the same mechanisms may lead to compromising the anterior hip structures and should also be studied. These can then be incorporated in treatment regimens that need patient involvement on deciding for the readiness to return to play.

The development of cam morphology and its relation with complaints in younger athletes or osteoarthritis of the hip in the longer run deserves attention in larger prospective studies.