HOW TO GET GRIP ON THE HIP?

DIAGNOSTICS AND POSTOPERATIVE PHYSICAL THERAPY TREATMENT OF YOUNG TO MIDDLE-AGED PATIENTS UNDERGOING HIP ARTHROSCOPY FOR SYMPTOMATIC INTRA-ARTICULAR HIP PATHOLOGY.

MARSHA TIJSSEN

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Diagnostics and postoperative physical therapy treatment of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology.

Marsha Petranel Willemijn Tijssen

The work presented in this thesis was carried out within the Radboud Institute for Health Sciences of the Radboud University Medical Center (The Netherlands), Rijnstate Hospital (The Netherlands) and Sports Medical Center Papendal (The Netherlands).

The publication of this thesis was financially supported by the Radboud University Medical Center (The Netherlands) and Sports Medical Center Papendal (The Netherlands).

Institute for Health Sciences
Radboudumc

Sport Medisch Centrum
PAPENDAL

Paranifmen:	Beate Dejaco Anke M.J. Kuijpers
Cover design:	Mascha Spijkers
Lay-out:	Mascha Spijkers
Printed by:	Ipskamp Printing, Enschede
ISBN:	

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Proefschrift

ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.H.J.M. van Krieken,
volgens besluit van het college van decanen
in het openbaar te verdedigen op
vrijdag 15 december 2017
om 12.30 uur precies

door
Marsha Petranel Willemijn Tijssen
geboren op 11 april 1986
te Boxmeer

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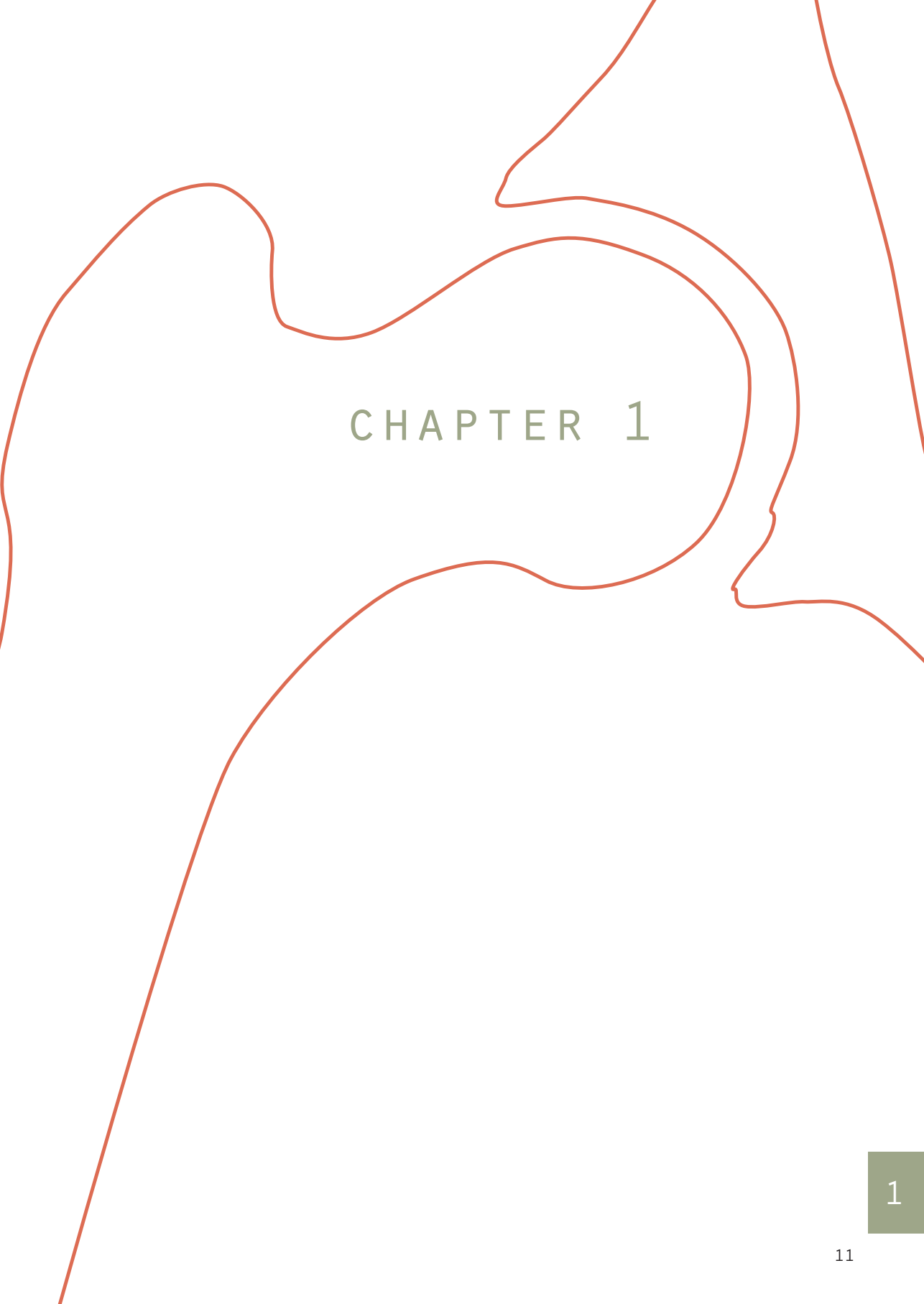

CHAPTER 1

General introduction

The objective of the thesis is to contribute to an evidence based approach for the diagnosis and postoperative physical therapy intervention of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology.

Clinical challenges

Since the early 2000s, there has been a tremendous rise in the use of hip arthroscopy to treat hip joint pathology [1, 2]. Studies have reported a 600% increase in the number of hip arthroscopies performed in the USA between 2006 and 2010 [1, 2]. Medicare data in Australia indicate that the number of patients undergoing hip arthroscopy increased by over 50% between 2010 and 2013 [3]. Exact figures on the number of hip arthroscopies performed in the Netherlands are unknown. Approximate 100 to 150 hip arthroscopies per year are performed at the orthopedic department of Rijnstate Hospital, Arnhem, mostly in young to middle-aged active patients.
Arthroscopy of the hip joint is less invasive than traditional open surgery, has a lower complication rate and still allows for good visualization and treatment of intra-articular (i.e., joint) pathology [4, 5]. The availability of this arthroscopic technique combined with improvements in imaging has led to a better understanding of hip joint pathology, especially in young to middle-aged patients [1, 2, 4]. Traditional open hip surgery is often performed in an older population, whereas hip arthroscopy is often used in a young to middle-aged, active and athletic population [4, 5]. This means that clinicians (both doctors as well as physical therapists) encounter a 'new' population of hip patients with different needs and limitations [6, 7].
The challenges for the clinician are to recognize and accurately diagnose hip joint pathology in these young to middle-aged, active patients and to optimize their treatment. In order to optimize patient care the following questions must first be answered: 1) how can we decrease delay and improve the accuracy of diagnosis of these patients; 2) what should postoperative (physical therapy) care look like; and 3) what are the short- and midterm effects of hip arthroscopy?

It were these questions that led to a collaboration between the orthopedic department of Rijnstate Hospital, the physical therapy department of Sports Medical Center Papendal and The Research Institute for Health Sciences of Radboud University. This collaboration resulted in this thesis, focusing on the optimization of patient care for young to middle-aged active patients with symptomatic hip joint pathology.

In this chapter, we will first describe the hip joint and its pathologies, including intra-articular hip pathology. Surgical treatment options for intra-articular hip pathology will then be reported. Also, the current unresolved clinical diagnostic and treatment challenges are described.

The hip joint & its pathologies

The term 'hip' refers to an anatomical region that is located anterior to the gluteal region, inferior to the iliac crest, and overlying the greater trochanter of the femur, including the groin [8-10].
Pain in the hip region is common [11-13]. The prevalence of hip pain in the general Dutch population has been reported to be 10% and increases with age [11]. As Reiman et al. [13] stated, pain in the hip and/or groin region may originate from many anatomical

structures, such as muscle, tendon, ligament, cartilage or bone. Various methods have been described to classify hip pain [14-17, 46]. Margo et al. [16] described hip pain using three categories based on location; anterior, lateral, and posterior hip pain. Falvey et al. [15] reported a similar approach where the pain is classified by location by using the groin triangle method. Another method of classifying hip pain is by means of the layer concept [14]. Poultsides et al. [17] described the hip region as consisting of four layers, namely the osteochondral layer (consisting of femur, pelvis, and acetabulum), inert layer (labrum, joint capsule, and ligaments), contractile layer (hip muscles), and neuromechanical layer (nerves). Pain in the hip can be related to one or more of these layers [14]. In this concept, the osteochondral layer and inert layer provide static stability to the hip joint, whereas the contractile layer and neuromechanical layer provide dynamic hip stability [17.] Other terms often used for these combinations of layers are intra-articular (osteochondral and inert layer) versus extra-articular (contractile and neuromechanical layer). This intra-articular hip pain is also described in a recent consensus statement on terminology and definitions of groin pain in athletes as so-called hip-related groin pain [46]. This thesis will further focus on hip-related groin pain (i.e., intra-articular hip pain) and pathology.

Intra-articular hip pathology

Intra-articular hip pain has gained increasing interest over the last decade [1, 2]. Intra-articular hip pain refers to pain originating from within the cavity of the hip joint and its capsule (osteochondral and inert layer) [18]. Underlying pathologies of intra-articular hip pain are mostly specific for certain age ranges [19]. Disorders such as hip dysplasia and Slipped Capital Femoral Epiphysis are commonly diagnosed in childhood [19]. Childhood disorders can be inborn or developmental, as well as traumata or infections [19]. Hip osteoarthritis and fractures are examples of pathologies more common in an elderly population [19]. These pathologies can be classified as degenerative disorders or traumata [19]. Until the early 2000s, focus on intra-articular hip pathology was mostly directed towards pathologies within these two age ranges [1, 2]. From that period onwards, advances in imaging and surgical techniques resulted in better identification of potential contributors to intra-articular hip pain and pathology in a young to middle-aged population [9].

In 2001 Ganz et al. [20] described in detail a condition called femoroacetabular impingement (FAI). Two types of anatomical deformities were identified in FAI: cam deformity (in which impingement is caused by an osseous deformity of the femoral head-neck contour) and pincer deformity (which is a focal over-coverage of the femoral head by the acetabulum) [4, 20-22]. Combinations of these two types of deformities were also described as mixed type impingement (see Figure 1) [22]. FAI is now described as a syndrome or motion-related clinical disorder of the hip [21]. A triad of symptoms (i.e., pain), clinical signs (i.e., positive physical examination tests) and imaging findings must be present to diagnose FAI [21]. FAI syndrome is often associated with other hip disorders, such as instability, labral tears, chondral lesions, and ligamentum teres tears [21, 23]. FAI and these conditions are also linked to the development of hip osteoarthritis [9, 24].

Pathogeneses

The pathogeneses of FAI and these associated conditions remains unclear [25-28]. Evidence suggests that FAI is influenced by high impact loading in adolescence as a

higher prevalence of cam-type deformities were found in young soccer players than in their nonathletic peers [25]. However, genetic and evolutionary factors have also been described [25,28]. Labral tears have been described based on traumata, repetitive stress injuries, and degenerative and genetic factors [9, 21, 28]. Similar causes have been described for instability, chondral lesions, and ligamentum teres tears [21, 28]. Based on the high prevalence of these conditions in athletic populations, it is suggested that high impact loading, rotational stresses, and repetitive hyperflexion or hyperextension play a role in the pathogenesis [9]. However, as Agricola et al. [27] and Griffin et al. [21] state, further prospective studies are necessary to provide evidence for the exact pathogeneses of these conditions.

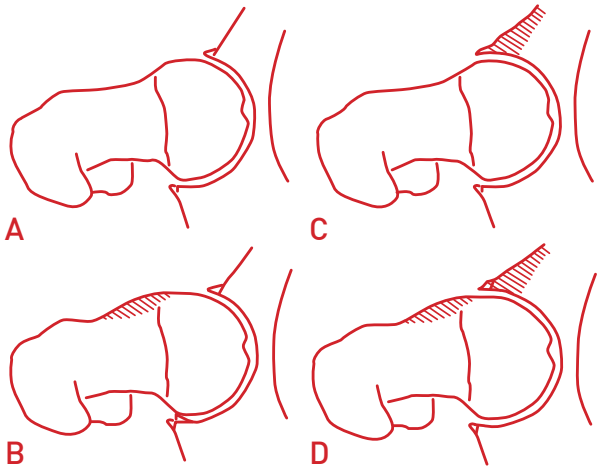

Figure 1 - Osseous abnormalities causing femoroacetabular impingement as described by Philippon et al. [22]. **A:** normal hip anatomy. **B:** cam type deformity. **C:** pincer type deformity. **D:** mixed type impingement.

Incidence & Prevalence

Little information is available on the incidence and prevalence of intra-articular hip pathology in the general population [29, 30]. A recent systematic review by Frank et al. [31] reported a FAI prevalence of 23% in the general population. Incidences of 14% for FAI have also been described [32, 33]. However, data from these studies were based on imaging findings in asymptomatic volunteers only [31-33].

Röling et al. [30] investigated the incidence of symptomatic intra-articular hip pathology in the general population in the Netherlands. They described an incidence of symptomatic hip and/or groin pain in the general population of 0.6% based on a study with patients who reported themselves to a general practitioner with hip and/or groin pain. Seventeen percent of these patients were diagnosed as FAI based on imaging. A further 30% was clinically diagnosed as FAI.

However, for the athletic population, data on the prevalence and incidence of FAI has been described more extensively [9, 34, 35]. A prevalence of up to 70% for FAI has been described in professional athletes [34]. Prevalence up to 90% has been described for acetabular labral tears in patients with mechanical (i.e., symptoms of clicking or locking) hip pain [9, 35]. Isolated ligamentum teres tears and chondral lesions are less

common, but studies found that up to 73% of patients with lesions of the labrum also had chondral damage [23, 36, 37]. These high prevalence and incidence numbers in athletic populations would suggest a role for high-impact loading or overuse as risk factors in the development of FAI and associated conditions [21, 25].

Treating intra-articular hip pathology

To date, treatment of intra-articular hip pathology in young to middle-aged patients often means surgery [1, 2, 4]. The diagnostics (both physical examination and imaging techniques) that lead to the decision of surgery will be discussed later in this chapter.

Surgical treatment of intra-articular hip pathology can be divided into three main areas, open surgical dislocation, arthroscopic assisted surgery combined with mini-open techniques, and sole arthroscopic surgery [4, 5, 38]. Good outcomes (i.e., a decrease of pain and increase of function) have been reported for all three surgical approaches [4]. Hip arthroscopy is advantageous because, it is minimally invasive with minor soft-tissue damage and an easy approach to the peripheral compartment and soft tissues [4]. Furthermore, a lower complication rate, faster rehabilitation rate, and higher rate of return to sports activities have been reported for hip arthroscopy compared to the traditional open surgical dislocation [4, 5].

Hip arthroscopy

Hip arthroscopy was described as early as 1931, by Burman et al. [39]. At that time, difficulties with hip distraction and visualization of the hip were encountered, and it was not until the 1970-1980s that hip arthroscopy was first clinically applied [40, 41]. Due to the development of longer, more flexible arthroscopic instrumentation, as well as, improvements in diagnostic techniques and hip distraction, the ability to perform hip arthroscopies to treat intra-articular hip pathology has progressed, and since the early 2000s, there has been a tremendous rise in the number of hip arthroscopies performed [1, 42]. An exact description of the hip arthroscopic procedure has, amongst others, been described by Byrd et al. [43].

Towards evidence based patient care

As described above, the rise of hip arthroscopies combined with improvements in imaging has led to a better description and recognition of hip joint pathology in the young to middle-aged population [6, 7]. For a clinician, it is important to timely recognize hip joint pathology in these young to middle-aged patients, and to gain insight into the consequences of this condition on activities and participation in daily life, work, and sports [7, 9, 12]. Only then can an accurate diagnosis be established, proper treatment installed, and treatment interventions evaluated [7, 9, 12].

In 2001 the World Health Organization (WHO) published the International Classification of Functioning, Disability, and Health (ICF) in order to classify the consequences of a health condition (disease or disorder) (see Figure 2) [13, 44]. Within this model, the consequences of health conditions are distinguished on several levels; body functions and structures (impairments), activities (activity limitations), and participation (participation restrictions) [13, 44]. Physical therapists have adopted this model in order to organize and document information on functioning and disability of patients in clinical practice [13]. Furthermore, its use has been advocated in order to systematically analyze and document health conditions and work towards an evidence-based

diagnosis and treatment intervention [13]. Therefore, this model seems well-suited to assess the current challenges for clinicians working with young to middle-aged active patients with symptomatic intra-articular hip pathology.

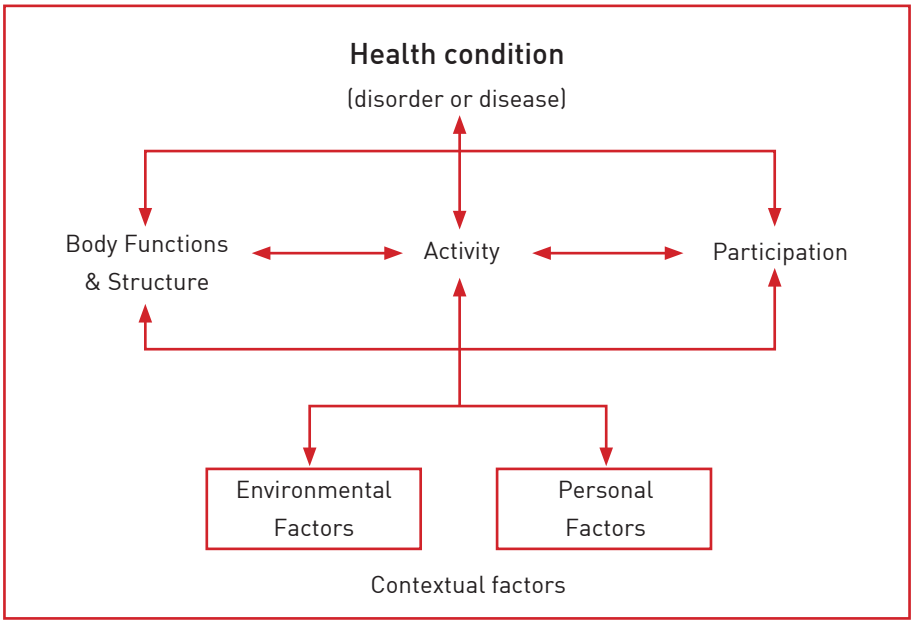

Figure 2 - The International Classification of Functioning, Disability and Health (ICF) model based on the World Health Organization (WHO) [13, 44].

Body functions and structure

Body functions and structures, as described by the ICF model, are impairments [44]. Many symptoms and impairments have been described in patients with symptomatic intra-articular hip pathology, such as groin pain and pain in the back, buttock, or thigh, as well as mechanical symptoms such as clicking and locking of the hip [9, 21, 45]. Stiffness, restricted range of motion and giving way are commonly reported, and both insidious onset and trauma have been described as the onset of the symptoms [21, 45]. As Griffin et al. [21] and Weir et al. [46] propose that these symptoms and impairments may be attributed to intra-articular hip pathology, but can also be caused by other clinical entities, such as adductor-related groin pain or inguinal-related groin pain.

To differentiate between diagnoses, clinicians use the symptoms and impairments, combined with information from physical examination and imaging [12, 13]. However, as Reiman et al. [47] describe, diagnoses of intra-articular hip pathology based on physical examination is a challenge. Many different physical diagnostic tests have been described with different names and different test procedures [7, 48]. In general, these tests have shown a high sensitivity, but low specificity [7, 48]. Therefore, it is difficult to further differentiate between diagnoses based on physical examination findings [13].
The accuracy of imaging modalities to detect intra-articular hip pathology is moderate to good [21]. However, these imaging modalities are expensive and not readily

available for every clinician (e.g., physical therapists working with patients suspected of intra-articular hip pathology) [47]. Furthermore, a high prevalence of radiographic abnormalities has been shown in asymptomatic individuals, raising doubt about the sole use of these radiographic modalities for the diagnosis of intra-articular hip pathology [34, 49].

Thus, the differential diagnosis of intra-articular hip pathology based on symptoms and impairments, physical examination, and imaging is a challenge. As Clohisy et al. [45] have shown, this challenge results in a mean time from symptom onset to diagnosis of 3.1 years, in which patients see an average of 4.2 clinicians and inaccurate diagnoses are common. Therefore, the question arises; how do we recognize and timely diagnose intra-articular hip pathology patients? In **Chapters 2 and 3** we attempt to answer this question.

Activity limitations & Participation restrictions

In addition to body functions and structures, the ICF model incorporates activity limitations and participation restrictions as important indicators of a health condition (disease or disorder) [44]. Patient-Reported Outcomes questionnaires (PROs) are commonly used to investigate experienced activity limitations and participation restrictions [50]. PROs are questionnaires completed by patients to measure their general health or their health in relation to a specific illness or condition [51, 52]. A number of PROs have been developed for patients with intra-articular hip pathology. However, most PROs are developed for older patients with hip osteoarthritis [50, 53]. Use of these PROs in the evaluation of young to middle-aged active patients with intra-articular hip pathology led to ceiling effects, because patients achieve the maximum score and cannot improve beyond a certain scale, despite potentially continuing to experience activity limitations and participation problems [50, 53]. As Thorborg et al. [53] and Lodhia et al. [50] stated, there is a need for PROs specifically developed for young to middle-aged active patients with intra-articular hip pathology in order to identify relevant activity restrictions and participation problems. Therefore, in **Chapters 4–6**, we investigate which PROs are valid and reliable in the evaluation of patients with symptomatic intra-articular hip pathology and translate and validate two of these PROs into Dutch.

Postoperative physical therapy intervention within the ICF model

The WHO states that any clinician working with patients should be able to optimize a structured and individualized treatment and/or rehabilitation plan for these patients based on the ICF model and the patient's specific question or aim [13, 44]. The information gained from patients regarding impairments, activity limitations, and participation restrictions should be used to develop and adapt physical therapy treatment [3, 7, 12]. Information on postoperative physical therapy interventions for hip arthroscopy patients is scarce [3, 7]. A few rehabilitation protocols have been described, which all include physical therapy treatment and exercises [54-60]. These protocols differ in therapy frequency, intensity, goals, and duration [54-60]. Furthermore, it is unclear what the short-, mid- and long-term effects of these postoperative physical therapy interventions are [7]. Only a few case studies have described clinical outcome data for postoperative physical therapy interventions in hip arthroscopy patients [55, 56, 61-63]. Thus, no evidence-based postoperative physical therapy intervention protocols are available, and it is unknown which activity limitations and participation restrictions may exist

after hip arthroscopic surgery and rehabilitation [3, 7]. Moreover, no information on long-term prognosis is available. So the question; 'are we treating the patients in the right way?' remains unanswered. We attempt to answer this question in **Chapters 7 and 8** of this thesis.

Objective and outline of the thesis

The objective of this thesis is to contribute to an evidence-based approach to the diagnosis and postoperative physical therapy intervention of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology.

Chapters 2 and 3 focus on the clinical diagnosis of patients with symptomatic intra-articular hip pathology. **Chapter 2** describes the findings of a systematic review of the available physical diagnostic tests for symptomatic intra-articular hip pathology and their accuracy. **Chapter 3** describes the diagnostic accuracy results of impairments and these physical tests in hip arthroscopy patients when compared to surgical results in a retrospective cohort study. **Chapters 4–8** focus on monitoring of activity limitations and participation restrictions of hip arthroscopy patients and optimizing postoperative physical therapy interventions. **Chapter 4** presents a systematic review addressing which questionnaires would be useful for the monitoring of patients with symptomatic hip joint pathology. Translation, cross-cultural adaptation, and validation of two of the identified questionnaires into Dutch is performed in **Chapters 5 and 6. Chapter 7** presents a prospective cohort study in which the short- and mid-term results of hip arthroscopy combined with our own postoperative rehabilitation protocol are evaluated. Results from this study led to the development of a feasibility study for a randomized controlled trial (RCT) into two different postoperative rehabilitation strategies. The study protocol for this feasibility study is described in **Chapter 8.** Eventually, findings of all included studies are combined, conclusions are drawn, and recommendations for further research are made in the general discussion to be found in **Chapter 9.**

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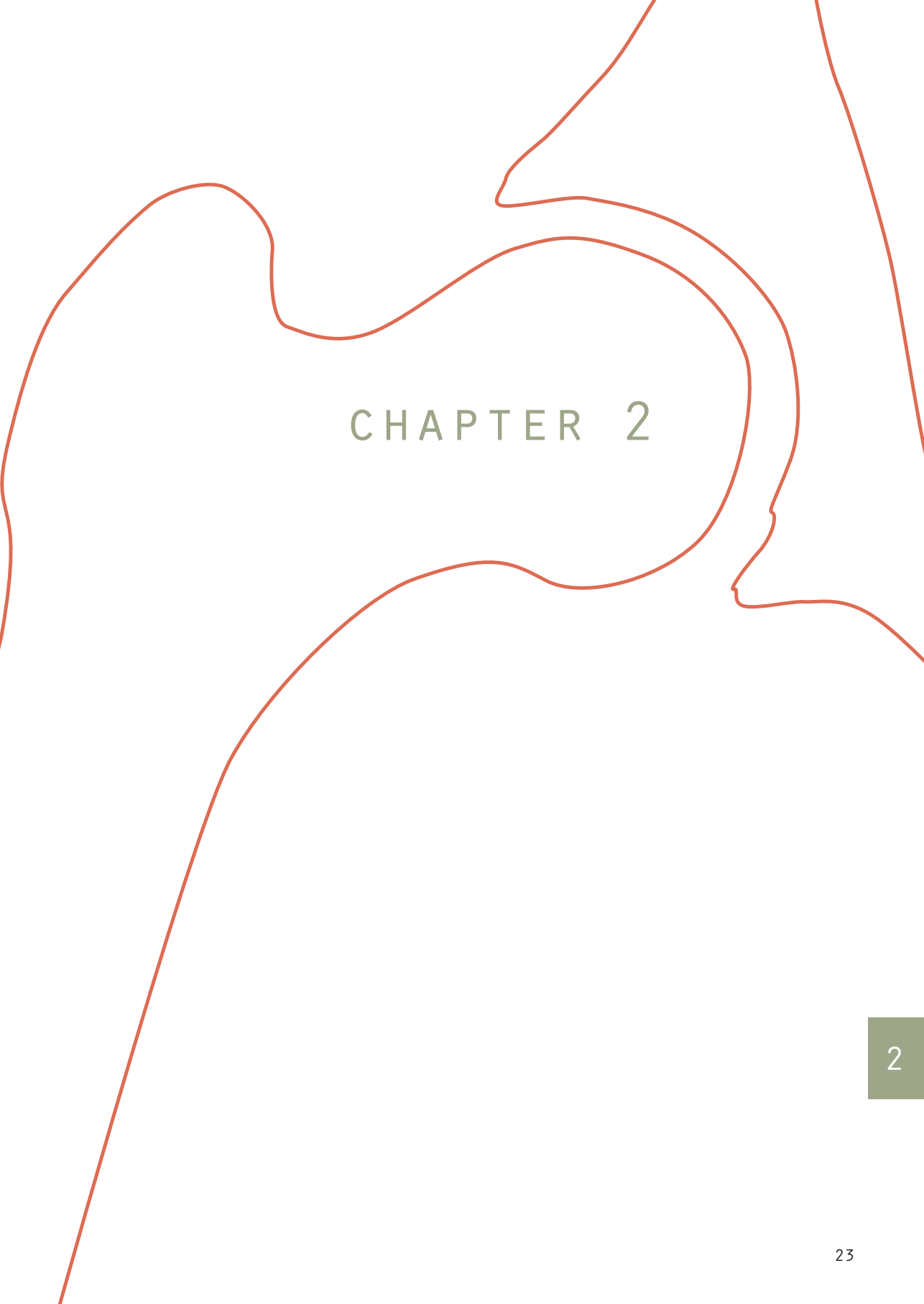

CHAPTER 2

Diagnostics of femoroacetabular impingement and labral pathology of the hip: a systematic review of the accuracy and validity of physical tests.

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Arthroscopy, 2012, 28(6), 860 – 871.

Abstract

Purpose: Femoro-acetabular impingement (FAI) and labral pathology have been recognized as causative factors for hip pain. The clinical diagnosis is now based on MRI-A (magnetic resonance imaging-arthrogram) because the physical diagnostic tests available are divers and information on diagnostic accuracy and validity is lacking. The purpose of this systematic review was to identify the diagnostic accuracy and validity of physical tests that are used to asses FAI and labral pathology of the hip joint.
Methods: We performed a computerized literature search using PubMed, Medline, Web of Science, PEDro, the Cochrane Library, and CINAHL (Cumulative Index to Nursing and Allied Health Literature) (through EBSCO). Studies describing tests and diagnostic accuracy studies were included. All included studies were assessed by the Levels of Evidence for Primary Research Questions list. All diagnostic accuracy studies were assessed by the QUADAS (Quality Assessment of Diagnostic Accuracy Studies) score.
Results: We included 21 studies in which 18 different tests were described. For 11 of these tests diagnostic accuracy figures were presented. Sensitivity was examined for all tests. Other diagnostic accuracy figures were often lacking, and when available, these were low. All articles describing tests had level IV or V evidence. All diagnostic accuracy studies, except 1, had level II or III evidence. Three articles had a good QUADAS score.
Conclusions: In previous studies a wide range of physical diagnostic tests have been described. Little is known about the diagnostic accuracy and validity of these tests, and if available, these figures were low. The quality of the studies investigating these tests is too low to provide a conclusive recommendation for the clinician. Thus, currently no physical tests are available that can reliable confirm or discard the diagnoses of FAI and/or labral pathology of the hip in clinical practice.
Level of Evidence: Level III, systematic review of Level III studies.

Introduction

Femoroacetabular impingement (FAI) and acetabular labral pathology have been recognized as common causes of hip pain and dysfunction [1-3]. The exact prevalence of acetabular labral pathology and FAI in the general population is unknown [4]. Figures in the symptomatic population vary considerably [5, 6]. However, FAI is increasingly recognized as a causative factor of many intra-articular hip lesions [7]. It is foremost associated with labral pathology [5, 6, 8, 9]. Both FAI (i.e., cam or pincer impingement) and labral pathology are associated with the development of osteoarthritis of the hip [5, 7-9].

Through the development of hip arthroscopy, FAI and labral pathology can now better be treated with fewer complications and a faster rehabilitation rate [10,11]. Recent studies have shown that this treatment is effective [6, 7, 11]. It leads to improvements in symptoms and range of motion, as well as a full return to sport activity [5, 7, 11]. Furthermore, it is expected that this treatment will delay the progression of osteoarthritis [9, 12]. An adequate and timely diagnosis is important, but studies have shown that the mean time to diagnosis of hip joint pathology is greater than 2 years [2, 6, 8, 13]. Patients often see multiple health care providers before the definitive diagnosis is obtained and sometimes even undergo unnecessary surgery.

As Martin et al. [2] and Tibor and Sekiya [3] described, an important part of recognizing intra-articular hip pain is the patient's history and physical examination. Furthermore, it is necessary for the clinician to recognize the need for additional investigations such as MRI-A (magnetic resonance imaging-arthrogram) [1-3, 8, 14]. Several studies on the clinical presentation of FAI and labral pathology have been conducted, and most of these focused on the patient's history and symptoms [5, 9, 15, 16]. There is less evidence regarding the physical tests that are used for examination of the hip joint [3, 17-20]. Many different tests are used to diagnose FAI and labral pathology [18, 20]. Frequently, these tests have different names but are similar or have the same name but are conducted in different manners. There is also a lack of information regarding the diagnostic accuracy of these tests, such as sensitivity, specificity, likelihood ratios and predictive values [2, 14, 17, 18].
Therefore, the purpose of this study was to identify the diagnostic accuracy and validity of physical tests that are used to asses FAI and labral pathology of the hip joint.

Materials and Methods

The objective of this study was to identify (1) which physical diagnostic tests are used to asses intra-articular hip pathology, especially FAI and labral pathology; (2) the diagnostic accuracy and validity of these tests and (3) the quality of the diagnostic accuracy studies describing these tests.

Search Strategy

We performed a computerized literature search (Table 1) using PubMed, Medline, Web of Science, PEDro, the Cochrane Library, and CINAHL (Cumulative Index to Nursing and Allied Health Literature) (through EBSCO).
All relevant articles published between January 1980 and April 1, 2011 were identified. The search was conducted by two reviewers (MT and LW). The following terms or combination of terms was used: hip*, groin*, exam*, test*, asses*, diagnos*, arthromet*, acetabul*, labr*, intra-articular, impingement, femoro-acetabular im-

pingement, disorder*, patholog*, pain*, injur*, lesion*, tear*, reliab*, valid* and accur*. Terms were searched as key words or "free-text" terms in all databases. The reference lists of the retrieved articles were checked for additional references.

Table 1 - Overview of Search Strategy for Systematic Review.

	Search Terms	PubMed	PEDro	Cochrane Library	Web of Science	CINAHL	Medline	Total
1.	hip	95,518					79,943	
2.	groin	7,870					6,913	
3.	1 or 2	102,886	6	9,611	83.157	20,767	86,577	
4.	exam	1,914,696					56,531	
5.	test	1,347,475					57,687	
6.	diagnos	2,414,400					75,408	
7.	asses	1,529,078					62,512	
8.	arthromet	494					491	
9.	4 or 5 or 6 or 7 or 8	5,750,915	0	277,825	96.867	735,185	99,994	
10.	acetabul	12,852					10,934	
11.	labr	11,406					5,093	
12.	intra-articular	10,539					8,621	
13.	impingement	4,433					4,263	
14.	femoro-acetabular impingement	337					40	
15.	10 or 11 or 12 or 13 or 14	37,514	0	1,906	23,340	3,553	27,269	
16.	disorder	1,199,468					80,938	
17.	patholog	2,301,141					85,804	
18.	injur	398,152					80,785	
19.	pain	416,900					85,619	
20.	lesion	541,230					82,515	
21.	tear	28,722					25,112	
22.	16 or 17 or 18 or 19 or 20 or 21	4,147,258	0	148,578	96.162	394,507	99,489	
23.	reliab	242,893					73,281	
24.	valid	305,724					67,588	
25.	accur	367,036					62,386	
26.	23 or 24 or 25	800,664	0	40,082	97.647	111,485	100,000	
27.	3 and 9 and 15 and 22 and 26	306	0	46	13	65	15	
	27 and limits	169	0	46	12	65	15	307

Search terms and combinations of search terms are presented in the left column. "Limits" used in the last search term were based on inclusion and exclusion criteria of the study. The number of results per database is presented in the other columns.

Study Selection

The 2 reviewers (MT and LW) independently screened all publications by title and abstract for possible inclusion in the study. All identified publications were then retrieved in full and independently assessed by the 2 reviewers for inclusion in the study. Inclusion and exclusion criteria are presented in Table 2. Disagreements between reviewers were resolved by consensus. If consensus was not reached, the final

decision was made by a third reviewer (RvC). The reviewers were not blinded to the authors, journal of publication, or date of publication.

Table 2 - Inclusion and Exclusion Criteria Used for Systematic Review.

Inclusion Criteria	Exclusion criteria
Article published in English, German, or Dutch and available as full-text article	Asymptomatic study population
All study designs	Intra-articular hip pathology other than FAI and/or labral pathology
Study population aged between 10 and 80 yr	Studies reporting no separate findings for population with FAI and/or labral pathology v none or other pathology
Study with (among others) goal to specifically investigate which clinical diagnostic tests are available for diagnosis of FAI and/or labral pathology	Studies with research solely into agreement and inter-rater and intrarater reliability
Study with (among others) goal to specifically investigate diagnostic accuracy or validity of clinical diagnostic tests for diagnosis of FAI and/or labral pathology	Diagnostic accuracy study using no new data but using data extracted from other research (e.g., systematic reviews)

Quality Assessment

General Quality Assessment

The Levels of Evidence for Primary Research Questions list was used to determine the level of evidence of all included studies [21]. This list was developed to define and compare the levels of evidence of studies with different study designs to recommend a clinical advice. It contains 5 levels, Level I being the best and Level V being the worst level of evidence. Each study is scored based on research question, content and design.

Quality assessment of Diagnostic Accuracy Studies

The QUADAS (Quality Assessment of Diagnostic Accuracy Studies) tool was used for the quality assessment of the diagnostic accuracy studies [22, 23]. It consists of 14 items which can be scored yes, no, or unclear. The inter-rater agreement has been reported to be 90% between 2 reviewers [22]. The Cochrane Collaboration recommends this tool for the assessment of the quality of primary studies on diagnostic accuracy [24]. If half of the items or fewer scored yes, a study was "poor". Studies that scored yes for three-fourths of the items or more were graded "good". All studies in between were graded "moderate". Before the start of the review process, a pilot study was performed in which the QUADAS tool was used to score 5 articles, achieving an overall agreement of 91% between the 2 reviewers (MT and LW).

The 2 reviewers (MT and LW) independently assessed all included articles with the relevant quality-assessment tools. For all quality assessments, any disagreements between reviewers were resolved by consensus. If consensus was not reached, a decision was made by a third reviewer (RvC).

Results

The search identified a total of 307 studies. Based on the title and abstract, 245 studies were excluded. There were 16 doubles, and 25 studies were excluded based on full-text assessment, which left a total of 21 studies to be included (Figure 1). Of these studies, 7 described tests for diagnosing FAI and/or labral pathology and 14 focused on diagnostic accuracy. There were minor disagreements between reviewers regarding inclusion of studies, but consensus was reached in all cases.

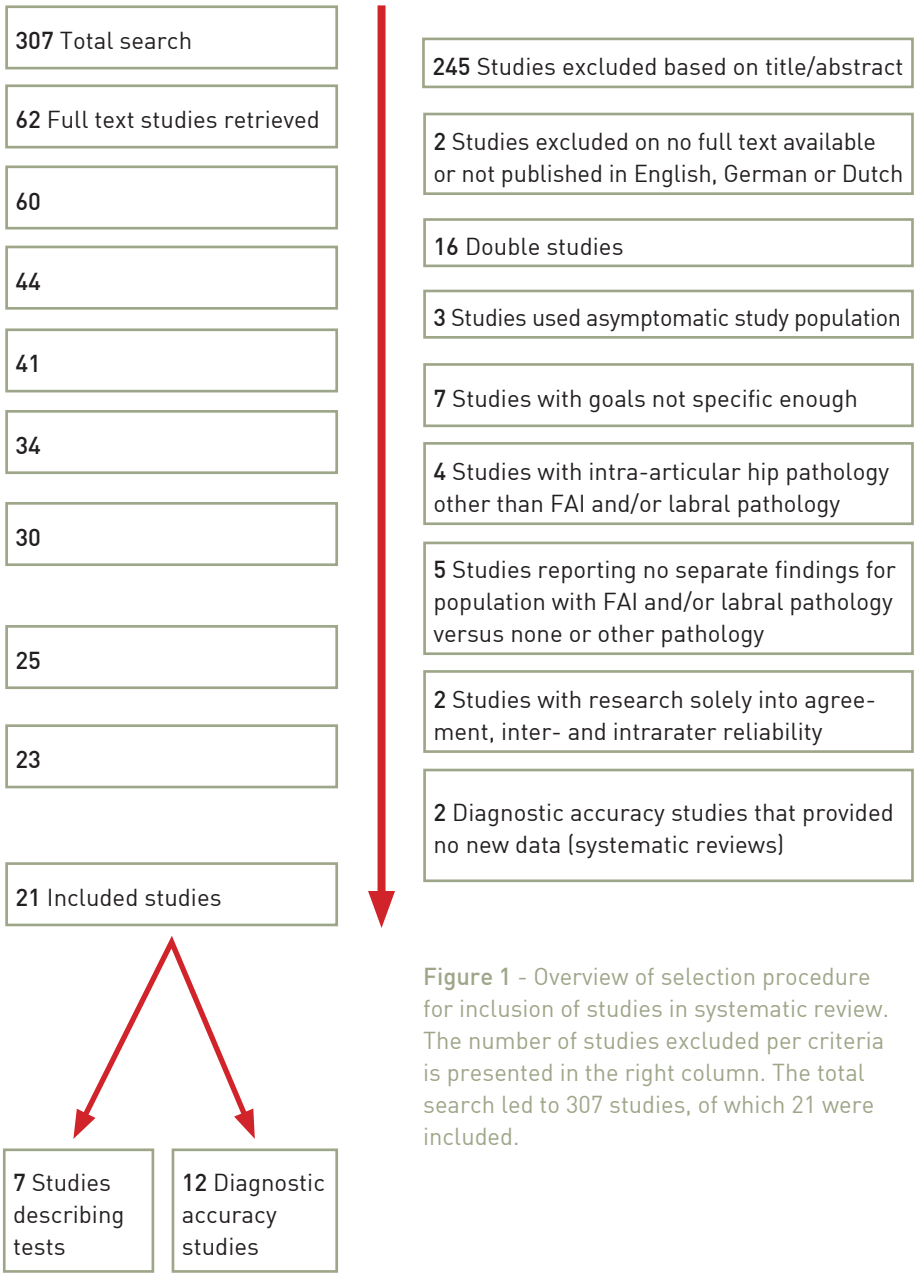

Figure 1 - Overview of selection procedure for inclusion of studies in systematic review. The number of studies excluded per criteria is presented in the right column. The total search led to 307 studies, of which 21 were included.

Clinical Diagnostic Tests

In the 21 included studies, a total of 18 different physical tests were described (Table 3). Ten tests appeared under multiple names or test executions.

Twenty studies described a combined flexion, adduction and internal rotation maneuver of the hip. The anterior hip impingement test, in which the leg was specifically moved into 90° of flexion, adduction and internal rotation simultaneously, was described most.

The FABER (flexion-abduction-external rotation) test, also called the Patrick sign, was described in 12 studies. This test is a combination of flexion, abduction and external rotation of the hip. Because this test was originally designed to diagnose sacroiliac pathology, authors have stated that it is important to distinguish between pain posterior or anterior to the hip [20, 32, 33].

Flexion – extension maneuvers were described in 9 studies. These maneuvers often had several different names and executions. Common factors were the movement from flexion to extension with several rotations and abductions/adductions. These tests can be compared with the McMurray tests of the knee [20, 32].

The resisted straight-leg raise (RSLR) test was described in 8 studies. This test consisted of hip flexion against resistance of the examiner with the fully extended leg in 30° or 45° of hip flexion while the patient lay supine. Several other tests were sporadically described. Most of these tests were derived from existing hip maneuvers, such as the Thomas Test.

Table 3 - Clinical Diagnostic Tests With Test Executions and Corresponding Diagnoses.

Test	Test Execution	Diagnoses
Flexion–adduction–internal rotation tests		
Anterior hip impingement test	Patient lies supine while the examiner moves the affected leg into 90° of flexion, adduction, and internal rotation until end range is achieved. Pain in any location marks a positive result.[1,2,14,16,32,38-40]	FAI/labral pathology
Impingement sign/flexion–internal rotation test	Patient lies supine while the researcher brings the involved leg into flexion/internal rotation. Pain predominating in flexion/ internal rotation, pain exclusively in flexion/internal rotation, and reduced pain-free flexion amplitude under internal rotation all are positive results.[25,26,37]	FAI/labral pathology

Table 3 - Continued

Test	Test Execution	Diagnoses
Internal rotation–flexion–axial compression maneuver/internal rotation over pressure test (IROP)	Patient lies supine while the researcher brings the affected leg into internal rotation and flexion, followed by axial compression through the knee. Pain is a positive result.[34,36]	FAI/labral pathology
Flexion–adduction–axial compression test	Patient lies supine while the researcher brings the affected leg into 90° of flexion and slight adduction. Then, axial compression on the joint is performed. Pain is a positive result.[25]	Labral pathology
Flexion–adduction–internal rotation test (FADDIR)	The patient lies in the lateral recumbent position. The examiner stands behind the patient. The leg is positioned into the FADDIR position. Reproduction of the patient's pain is a positive result for FAI. Freehill and Safran[27] described the same test but using in a supine position. The point where the combination of flexion/adduction and internal rotation causes pain should be noted.[20,27-29,32]	FAI/labral pathology
Abduction–external rotation tests		
FABER test/Patrick sign	The patient lies supine. The affected leg is simultaneously flexed, abducted, and externally rotated so that the patient's lateral ankle rests on the contralateral leg just proximal to the knee. While the SIAS is being stabilized, the knee is lowered toward the table. A positive test result may be indicated by either a decrease in ROM compared with the non-affected leg or reproduction of pain.[1,2,13,14,20,29,30,32-34,38]	FAI/labral pathology

Table 3 - Continued

Test	Test Execution	Diagnoses
Flexion-extension maneuvers		
Fitzgerald test/labral stress test	The hip is brought into acute flexion, external rotation, and full abduction and is then extended with internal rotation and adduction. The patient lies supine. Extension with abduction and external rotation from the fully flexed, adducted, and internally rotated position completes the test. Pain or a click is a positive result[27,31]	Labral pathology
Dynamic external rotatory impingement test (DEXRIT)/supine abduction–external rotation test	The patient is in the supine position and is instructed to hold the contralateral leg in flexion beyond 90°. The examined hip is brought into 90° of flexion or beyond and is passively taken through a wide arc of abduction and external rotation. A positive test will re-create the patient's pain.[20,28,32]	FAI/labral pathology
Dynamic internal rotatory impingement test (DIRIT/DIRI)	The patient is in the supine position and is instructed to hold the contralateral leg in flexion beyond 90°. The examined hip is brought into 90° of flexion or beyond and is passively taken through a wide arc of adduction and internal rotation. A positive test will re-create the patient's pain.[20,28,33]	FAI/labral pathology
Hip quadrant position/scour test	The patient lies supine while the examiner brings the affected leg into flexion and adduction. The leg is then rotated. A positive test will re-create the patient's pain or shows a restriction in ROM. Maslowski et al.[34] described the same test only with axial compression through the joint.[29,30,32]	FAI/labral pathology

Table 3 - Continued

Test	Test Execution	Diagnoses
McCarthy test	The patient lies supine while the examiner rolls the affected hip in a wide arc of internal and external rotation from flexion to extension. A positive sign re-creates the patient's pain in a specific position. Plante et al.[28] described the same test but with internal rotation and adduction combined and with external rotation and abduction combined. This test is also described by Martin et al.[20] but with axial compression during the whole movement and is called the scour test.[14,20,28,29,32]	FAI/labral pathology
Lateral rim impingement test	The patient lies in the lateral position while the examiner brings the affected leg from flexion to extension in continuous abduction while externally rotating the hip. A reproduction of the patient's pain is a positive result.[20,29]	FAI
Remaining tests		
Thomas test	Patient lies supine with the legs pulled to the chest. The affected leg is lowered off the edge of the table (from flexion to extension). A click (as perceived by patient/researcher) or recognizable pain marks a positive result.[13,29,36]	Labral pathology
Hyperextension–external rotation test	The patient lies in the end position of the Thomas test (1 leg bent and 1 leg free of the table). The examiner externally rotates the leg in neutral abduction-adduction and in adduction. Pain reproduction is a positive result.[27]	FAI/labral pathology

Table 3 - Continued

Test	Test Execution	Diagnoses
RSLR test/Stinchfield test	The patient lies supine and is asked to raise the straight leg to 45° of hip flexion. The patient is asked to resist manual force applied just proximal to the knee by the researcher. Recognizable pain or weakness is a positive result. Troelsen et al.[38] and Maslowski et al.[34] performed the same test but only raised the leg until 30°.[1,14,20,27,32,33]	FAI/labral pathology
Log-roll test/passive supine rotation test	The patient lies supine while the examiner places both hands on the upper leg. The involved leg is then rolled inward and outward. Pain or a restriction during this maneuver is a positive result.[1,14,20,33]	FAI/labral pathology
Posterior hip impingement test/ posterior rim impingement	The patient lies at the edge of the examining table and the legs hang freely at the hip. Both legs are drawn up to the chest and then the affected leg is lowered off the table, fully abducted, and externally rotated. Pain is a positive result.[1,14,20,33]	FAI/labral pathology
Foveal distraction	The patient lies in the supine position with the affected leg 30° abducted. Axial traction is placed on the leg. A relief of pain or pain reduction is a positive result.[20,28,29]	FAI/labral pathology

Tests are divided into categories based on similarities in execution. Tests with several names but the same execution are presented in 1 row, and the names are divided by virgules. ROM, range of motion; SIAS, spina iliaca anterior inferior.

Diagnostic Accuracy of Clinical Tests

A total of 14 studies examined 11 physical tests (Table 4). For the anterior hip impingement test, the impingement sign, the flexion-adduction-axial compression test, the FABER test, the Fitzgerald test, and the hip quadrant position a high sensitivity was reported (0.9 to 1.0). For the other tests, the sensitivity was low to moderate.
The specificity was described for 7 physical tests and was not available for the flexion-adduction-axial compression test, the Fitzgerald test, the log-roll test, and the posterior impingement test. A specificity of 0.9 to 1.0 was reported for the anterior hip impingement test, the FABER test, the RSLR, and the Thomas test.
A high positive predictive value (PPV) of 0.9 to 1.0 was reported for all tests except for the internal rotation-flexion-axial compression maneuver, the log-roll test, and the posterior impingement test.
Only Maslowski et al. [34] described the FABER test and the hip quadrant position and provided a negative predictive value (NPV) of 0.9 and higher. All other values were low to moderate or not calculable.
The positive likelihood ratio (LOR+) was considered large if values above 10 were produced [35]. Only McCarthy et al. [13] showed an LOR+ of 11.125 for the Thomas test. All other authors' varied between 0.73 and 1.55 presenting no or minimal changes in the positive likelihood of the disease [35]. McCarthy et al. [13] also produced a moderate negative likelihood ratio (LOR-) of 0.12, whereas all other studies showed small or minimal decreases in the likelihood of the disease.
For the log-roll test and the posterior impingement test no PPV, NPV, LOR+ and LOR- values were provided. Overall, 6 studies examining 7 tests provided information for all diagnostic accuracy figures 2, [34-38]. Except for the studies by Troelsen et al. [38], McCarthy et al. [13], and Maslowski et al. [34] the reported values were moderate to low.

Table 4 - Clinical Diagnostic Tests for FAI and/or Labral Pathology With Diagnostic Accuracy and Validity.

Author (Year of Publication)	Study Population	Diagnosis Made by Authors	Reference Standard Used to Confirm or Discard Diagnosis	Sensitivity	Specificity	LOR+	LOR-	PPV	NPV
Anterior hip impingement test									
Martin et al.[2] (2008)	N = 49 (24♀/25♂) mean age 42y (range 18-68, SD 15)	Acetabular labral tear	50% improvement of VAS after intra-articular injection and MRA	0.78	0.10	0.86	2.3	0.53	0.25
Sink et al.[16] (2008)	N = 35 (30 ♀/5♂) mean age 16y (range 13-18)	FAI in combination with labral pathology	X-ray (35), MRI (4) and MRA (24)	1.0	NA	NA	NA	1.0	NA
Clohisy et al.[1] (2009)	N = 51 (53 hips) mean age 35y (range 15-61)	Symptomatic FAI in combination with labral pathology	Clinical diagnosis with X-ray	0.88	NA	NA	NA	1.0	0
Burnett et al.[39] (2006)	N = 66 (47♀/19♂) mean age 38y (range 15-64)	Acetabular labral tear	Arthroscopy	0.95	NA	NA	NA	1.0	0
Troelsen et al.[38] (2009)	N = 18 (16♀, 2♂) median age 43y (range 32-56)	Labral pathology	MRA	0.59	1.0	0	0.41	1.0	0.13

Table 4 - Continued

Author (Year of Publication)	Study Population	Diagnosis Made by Authors	Reference Standard Used to Confirm or Discard Diagnosis	Sensitivity	Specificity	LOR+	LOR-	PPV	NPV
Philippon et al.[20] (2009)	N = 301, (153♂/ 148♀) mean age 39.9y (range 11-72)	FAI	Arthroscopy	0.99	NA	NA	NA	NA	
Impingement sign									
Nogier et al.[37] (2010)	N = 292 (111♀/181♂) mean age 35y (SD 10)	FAI	Complete physical examination with radiography	0.2 - 0.7	0.44 - 0.86	1.25 – 1.55	0.68 -0.93	0.63 -0.67	0.44-0.53
Santori and Villar[26] (2000)	N = 58 (33♀/25♂) mean age 36.7y (range 10-70)	Acetabular labral tear	Arthroscopy	1.0	NA	NA	NA	1.0	NA
Hase and Ueo[25] (1999)	N = 10 (7♀/10♂) mean age 28.7y (range 13-67)	Acetabular labral tear	Arthroscopy	0.7	NA	NA	NA	1.0	NA
Internal rotation-flexion-axial compression manoeuvre/internal rotation over pressure test									
Narvani et al.[36] (2003)	N = 18 (5♀/13♂) mean age 30.5y (range 17-48, SD 8.45)	Acetabular labral tear	MRA	0.75	0.43	1.32	0.58	0.27	0.86
Maslowksi et al.[34] (2010)	N = 50 mean age 60.2 y (range 22-84)	Labral tear, FAI	80% improvement of pain on a 10cm VAS scale after intra-articular hip injection or 80% pain relief	0.89	0.15	1.05	0.73	0.19	0.86

Table 4 - Continued

Author (Year of Publication)	Study Population	Diagnosis Made by Authors	Reference Standard Used to Confirm or Discard Diagnosis	Sensitivity	Specificity	LOR+	LOR-	PPV	NPV
Flexion-adduction-axial compression test									
Hase and Ueo[25] (1999)	N = 10 (7♀/10♂) mean age 28.7y (range 13-67)	Acetabular labral tear	Arthroscopy	0.7	NA	NA	NA	1.0	NA
FABER test/ Patrick sign									
Martin et al.[2] (2008)	N = 49 (24♀/25♂) mean age 42y (range 18-68, SD 15)	Acetabular labral tear	50% improvement of VAS after intra-articular injection and MRA	0.6	0.18	0.73	2.2	0.45	0.29
Clohisy et al.[1] (2009)	N = 51 (53 hips) mean age 35y, (range 15-61)	Symptomatic FAI in combination with labral pathology	Clinical diagnosis with radiography	0.69	NA	NA	NA	1.0	0
Mitchell et al.[30] (2003)	N = 25 (9♀/16♂) Mean age 30.9 y, (range 16-56)	Labral tear, rim lesion	Arthroscopy	0.88	NA	NA	NA	1.0	0
Troelsen et al.[38] (2009)	N = 18 (16♀, 2♂) median age 43y (range 32-56)	Labral pathology	MRI-A	0.41	1.0	0	0.59	1.0	0.09
Philippon et al.[40] (2007)	N = 301, (153♂/ 148♀) mean age 39.9y (range 11-72)	FAI	Arthroscopy	0.97	NA	NA	NA	NA	NA

Table 4 - Continued

Author (Year of Publication)	Study Population	Diagnosis Made by Authors	Reference Standard Used to Confirm or Discard Diagnosis	Sensitivity	Specificity	LOR+	LOR-	PPV	NPV
Maslowksi et al.[34] (2010)	N = 50 mean age 60.2 y (range 22-84)	Labral tear, FAI	80% improvement of pain on a 10cm VAS scale after intra-articular hip injection or 80% pain relief	0.88	0.24	1.16	0.5	0.18	0.91
Fitzgerald test									
Fitzgerald[31] (1995)	N = 56, mean age 36.5 y (range 18 – 75)	Labral tear	Hip joint surgery (marcanisation in 7 subjects)	0.96	NA	NA	NA	1.0	0
Hip Quadrant Position/Scour test									
Mitchell et al.[30] (2003)	N = 25 (9♀/16♂) Mean age 30.9 y, (range 16-56)	Labral tear, rim lesion	Arthroscopy	1.0	NA	NA	NA	1.0	NA
Maslowksi et al.[34] (2010)	N = 50 mean age 60.2 y (range 22-84)	Labral tear, FAI	80% improvement of pain on a 10cm VAS scale after intra-articular hip injection or 80% pain relief	0.88	0.43	1.54	0.28	0.23	0.95

Table 4 - Continued

Author (Year of Publication)	Study Population	Diagnosis Made by Authors	Reference Standard Used to Confirm or Discard Diagnosis	Sensitivity	Specificity	LOR+	LOR-	PPV	NPV
Thomas test									
McCarthy et al.[13] (1995)	N = 59 (32♀/27♂) Mean age 37y (range 17-69)	Acetabular labral tear	Arthroscopy	0.89	0.92	11.125	0.12	0.94	0.86
RSLR Test/Stinchfield test									
Clohisy et al.[1] (2009)	N = 51 (53 hips) mean age 35y (range 15-61)	Symptomatic FAI in combination with labral pathology	Clinical diagnosis with radiography	0.56	NA	NA	NA	1.0	0
Troelsen et al.[38] (2009)	N = 18 (16♀, 2♂) median age 43y (range 32-56)	Labral pathology	MRI-A	0.06	1.0	0	0.94	1.0	0.06
Maslowksi et al.[34] (2010)	N = 50 mean age 60.2 y (range 22-84)	Labral tear, FAI	80% improvement of pain on a 10cm VAS scale after intra-articular hip injection or 80% pain relief	0.75	0.38	1.21	0.66	0.19	0.89

Table 4 - Continued

Author (Year of Publication)	Study Population	Diagnosis Made by Authors	Reference Standard Used to Confirm or Discard Diagnosis	Sensitivity	Specificity	LOR+	LOR-	PPV	NPV
Log roll test									
Clohisy et al.[1] (2009)	N = 51 (53 hips) mean age 35y (range 15-61)	Symptomatic FAI in combination with labral pathology	Clinical diagnosis with radiography	0.30	NA	NA	NA	NA	NA
Posterior impingement test									
Clohisy et al.1 (2009)	N = 51 (53 hips) mean age 35y (range 15-61)	Symptomatic FAI in combination with labral pathology	Clinical diagnosis with radiography	0.21	NA	NA	NA	NA	NA

Data are arranged per test and then per study. Therefore some studies are cited more than once. Tests with several names but the same execution are presented in 1 row; the names are divided by virgules. MRI, magnetic resonance imaging; MRI-A, magnetic resonance imaging-arthrogram; NA, not applicable (data were not calculated in study and/or could not be calculated based on available figures); VAS, visual analogue scale.

General Quality Assessment

The general quality assessment performed by the Levels of Evidence list [21] showed that all studies describing physical diagnostic tests were rated Level IV or V (Table 5). All diagnostic accuracy studies were rated Level II or III except for the study by Nogier et al. [37], which scored Level IV.

Table 5 – Overview of Included Studies With Corresponding Level of Evidence.

Author (Year of Publication)	Test Description or Diagnostic Accuracy Study	Level of Evidence
Braly et al.[29] (2006)	Test description	V
Domb et al.[32] (2009)	Test description	V
Freehill and Safran[27] (2011)	Test description	V
Martin et al.[14] (2006)	Test description	V
Martin et al.[33] (2010)	Test description	V
Martin et al.[20] (2010)	Test description	IV
Plante et al.[28] (2011)	Test description	V
Burnett et al.[39] (2006)	Accuracy	II
Clohisy et al.[1] (2009)	Accuracy	II
Fitzgerald[31] (1995)	Accuracy	II
Hase and Ueo[25] (1999)	Accuracy	III
Martin et al.[2] (2008)	Accuracy	III
Maslowski et al.[34] (2010)	Accuracy	III
McCarthy et al.[13] (1995)	Accuracy	III
Mitchell et al.[30] (2003)	Accuracy	III
Narvani et al.[36] (2003)	Accuracy	III
Nogier et al.[37] (2010)	Accuracy	IV
Philippon et al.[40] (2009)	Accuracy	II
Santori and Villar[26] (2000)	Accuracy	III
Sink et al.[16] (2008)	Accuracy	III
Troelsen et al.[38] (2009)	Accuracy	III

The second column describes whether the research described tests (test description) and, if so, investigated the diagnostic accuracy and validity of the tests (accuracy).

Quality of Diagnostic Accuracy Studies

All included diagnostic accuracy studies were cohort studies or cross-sectional studies, and the QUADAS score was used for quality assessment. Based on the overall score, 4 articles were graded as poor, 7 as moderate, and 3 as good (Table 6). With the exception for the study by Narvani et al. [36] a disadvantage of all studies was the use of a study population in which there was a high suspicion or confirmation of intra-articular hip pathology.

Table 6 - Quality Assessment of Diagnostic Accuracy Studies for FAI and/or Labral Pathology by Means of QUADAS Tool.

Author (Year of Publication)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Final Score
Burnett et al.[39] (2006)	N	Y	Y	U	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Good
Clohisy et al.[1] (2009)	N	U	Y	Y	Y	U	N	N	N	U	U	Y	Y	Y	Poor
Fitzgerald[31] (1995)	N	N	Y	U	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Moderate
Hase and Ueo[25] (1999)	N	N	Y	U	Y	Y	Y	U	N	N	N	Y	Y	Y	Poor
Martin et al.[2] (2008)	N	Y	N	U	Y	Y	Y	N	Y	U	U	Y	Y	Y	Moderate
Maslowski et al.[34] (2010)	N	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Moderate
McCarthy et al.[13] (1995)	N	Y	Y	U	Y	Y	Y	N	Y	U	N	Y	Y	Y	Moderate
Mitchell et al.[30] (2003)	N	N	Y	U	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Moderate
Narvani et al.[36] (2003)	Y	N	N	N	Y	N	Y	N	Y	Y	Y	Y	N	Y	Moderate
Nogier et al.[37] (2010)	N	Y	N	Y	Y	Y	N	N	N	N	N	Y	N	N	Poor
Philippon et al.[40] (2009)	N	Y	Y	U	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Good
Santori and Villar[26] (2000)	N	N	Y	U	Y	U	Y	U	Y	N	N	Y	Y	Y	Poor
Sink et al.[16] (2008)	N	Y	N	U	Y	U	Y	Y	Y	U	U	Y	Y	Y	Moderate
Troelsen et al.[38] (2009)	N	Y	N	U	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Good

The final score was deemed poor if there were 7 yes answers or fewer; moderate, 8 to 10 yes answers; and good, 11 yes answers or more.

Discussion

This review identified 21 studies describing 18 physical diagnostic tests for the assessment of FAI and/or labral pathology of the hip joint. Of the studies, 7 gave a description of these tests and 14 were diagnostic accuracy studies. Many physical tests were the objective of previous studies, but results show that there was a lack of diagnostic accuracy parameters or these parameters had poor values. This was supported by our finding that based on the QUADAS score, only 3 out of 14 diagnostic accuracy studies were of good quality. These 3 studies investigated the anterior hip impingement test, the FABER test, and the RSLR test (Video 1, available at www.arthroscopyjournal.org) [38-40]. However, because of several methodological problems, none of these tests are appropriate to reliably confirm of discard the diagnosis of FIA and/or labral pathology.

The first methodological issue is that in each of the 3 studies, there were some flaws that resulted in a lower strength of evidence. The number of subjects per study dif–fered from 18 to 301 [38-40]. Because variation among subjects can be expected, a group of 18 subjects is too small to reliable interpret diagnostic accuracy figures. Furthermore, all 3 studies used a study population in which there was a high suspicion of intra-articular hip pathology, increasing the risk of spectrum bias. These 2 flaws led to difficulties in interpretation of the diagnostic accuracy figures. This was confirmed by the fact that the sensitivity ranged from 0.59 to 0.99 for the anterior hip impingement test and from 0.41 to 0.97 for the FABER test [38-40]. In addition, only Troelsen et al. [38] provided the specificity, resulting in a LOR+ and LOR-. However, the usefulness of these figures is questionable because these were based on 18 subjects only. Two studies reported high PPV values of 1.0 for all 3 investigated tests [38, 39]. Yet, the PPV and NPV were of limited use because the disease prevalence figures in these studies were not comparable to those in clinical practice. This was because of study populations in which there was a high suspicion or even confirmation of the disease but also because general prevalence figures of FAI and/or labral pathology are unknown [2, 4]. The second methodological issue is that the results of these 3 studies could not be combined because of slight differences in test executions. For example, a positive FABER test described by Philippon et al. [40] consisted of a decreased range of motion, whereas Troelsen et al. [38] described pain as a positive result (Video 1). This was seen more often in the literature, where many tests have different names but are similar or have the same name, but are conducted in different manners [20, 33].

To a certain extent, the results of this systematic review are comparable to those presented in 2 previous systematic reviews concerning labral pathology. Burgess et al. [17] studied the validity and accuracy of clinical diagnostic tests for labral pathology and concluded that there is too little information to draw a conclusion for clinical practice. They included only 5 articles with an equal number of tests, for which only the sensitivity and specificity values were reported. Moreover, the tests were not described as they were originally developed. Leibold et al. [18] investigated the con-current criterion-related validity of physical examination tests for hip labral lesions. They found that a negative result on the flexion-adduction-internal rotation test, the impingement provocation test, the flexion-internal rotation test, the flexion-adducti-on-axial compression test, the Fitzgerald test, or a combination of these provided the clinician with the greatest confidence that labral pathology was absent. However, this

conclusion was premature as it was based on sensitivity data and a narrative discussion only. Both reviews included labral pathology only [17, 18]. In the absence of major trauma, isolated labral pathology is uncommon [6]. Therefore, other causative factors of hip pai should be considered and investigated. FAI is increasingly recognized as a causative factor for many intra-articular hip lesions, and FAI and labral pathology are the most common indications for hip arthroscopy [8, 41]. Therefore, we included studies investigating physical diagnostic tests for these 2 pathologies.

To our knowledge, this is the first systematic review that addresses the accuracy and validity of physical diagnostic tests for FAI and/or labral pathology. A possible limitation of this study was that other intra-articular pathology and radiographic investigations were not included.

Conclusion

There exists a wide range of physical diagnostic tests for FAI and/or labral pathology and little information on the diagnostic accuracy and validity. The methodological quality of the diagnostic accuracy studies is moderate to poor. Uniformity in tests executions is warranted, and these should be thoroughly investigated for diagnostic accuracy and validity. For now, no (combination of) physical diagnostic tests are available that can reliable confirm or discard the diagnoses of FAI and/or labral pathology in clinical practice.

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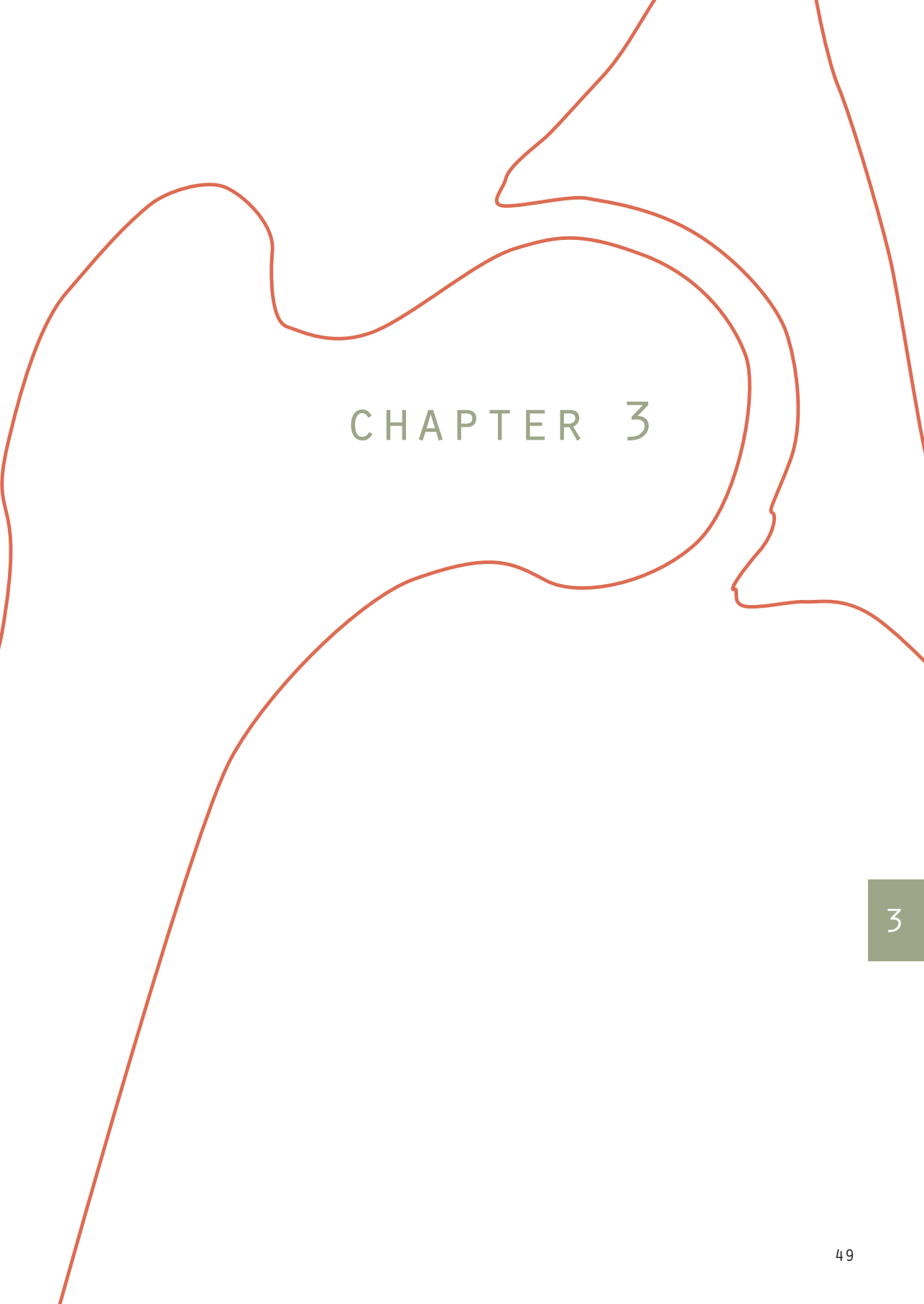

CHAPTER 3

Hip joint pathology: relationship between patient history, physical tests, and arthroscopy findings in clinical practice.

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Scandinavian Journal of Medicine & Science in Sports, 2017, 27(3), 342 – 350.

Abstract

The purpose of this retrospective cohort study was to; 1) describe the clinical presentation of femoroacetabular impingement (FAI) and hip labral pathology; 2) describe the accuracy of patient history and physical tests for FAI and labral pathology as confirmed by hip arthroscopy.
Patients (18 – 65 years) were included if they were referred to a physical therapist to gather pre-operative data and were then diagnosed during arthroscopy. Results of pre-operative patient history and physical tests were collected and compared to arthroscopy.
Data of 77 active patients (mean age: 37 years) were included. Groin as main location of pain, the Anterior Impingement Test (AIT), Flexion-Abduction-External-Rotation (FABER) test and Fitzgerald test had a high sensitivity (range 0.72 – 0.91). Sensitivity increased when combining these tests (0.97) as either groin as main location of pain and a positive FABER test or a positive AIT and a positive FABER test were the shortest most sensitive combinations.
The results of this study point out that in clinical practice absence of groin as main location of pain combined with a negative FABER test or the combination of a negative AIT and a negative FABER test are suggested to rule out the diagnosis of symptomatic FAI and/or labral pathology.
Keywords: hip, examination, clinical assessment, diagnostic accuracy.

Introduction

Femoroacetabular impingement (FAI) and hip labral pathology have been recognized as common causes of hip pain and dysfunction [1, 2]. Patients with these conditions report pain and functional limitations as well as an inability to have an active lifestyle and participate in sports [3-5]. There is also growing evidence that FAI and labral pathology might be risk factors for development of osteoarthritis of the hip [6, 7]. Due to the development of hip arthroscopy, FAI and labral pathology can now be better treated with fewer complications and a faster rehabilitation rate [4, 8].

An accurate diagnosis of FAI and/or hip labral pathology without delay is important. However, several studies reported a mean time to diagnosis of longer than two years [9, 10]. This might be attributable to a lack of familiarity with the symptoms associated with the pathology [4, 5]. Also symptoms of FAI and/or labral pathology overlap with symptoms of other musculoskeletal conditions of the hip, pelvis and lumbar spine [2, 11]. Furthermore, studies have shown that there are currently no physical tests available that can reliably confirm or reject the diagnosis of FAI and/or labral pathology in clinical practice [12-15]. A wide range of physical diagnostic tests has been described, but little is known about the diagnostic accuracy and validity of these tests [12, 14, 15]. If available, the accuracy and validity figures of these tests were low and the quality of the diagnostic accuracy studies poor [14, 15]. So, to date, a clinician suspecting FAI or hip labral pathology has no insight in which physical tests are indicative for the diagnosis.

In order to improve the accuracy of and reduce time to diagnose FAI and/or hip labral pathology previous studies showed that a combination of patient history and clinical examination findings should be emphasized [12, 15, 16]. However, to our knowledge the diagnostic accuracy of such combinations has not yet been investigated. Therefore the aims of this study were to; 1) describe the clinical presentation of FAI and hip labral pathology; 2) describe the accuracy of patient history and physical tests (individually and combined) for FAI and hip labral pathology as confirmed by hip arthroscopy. We hypothesized that combining patient history parameters and physical tests for the diagnosis of symptomatic FAI and hip labral pathology would lead to a higher diagnostic accuracy then any individual test alone.

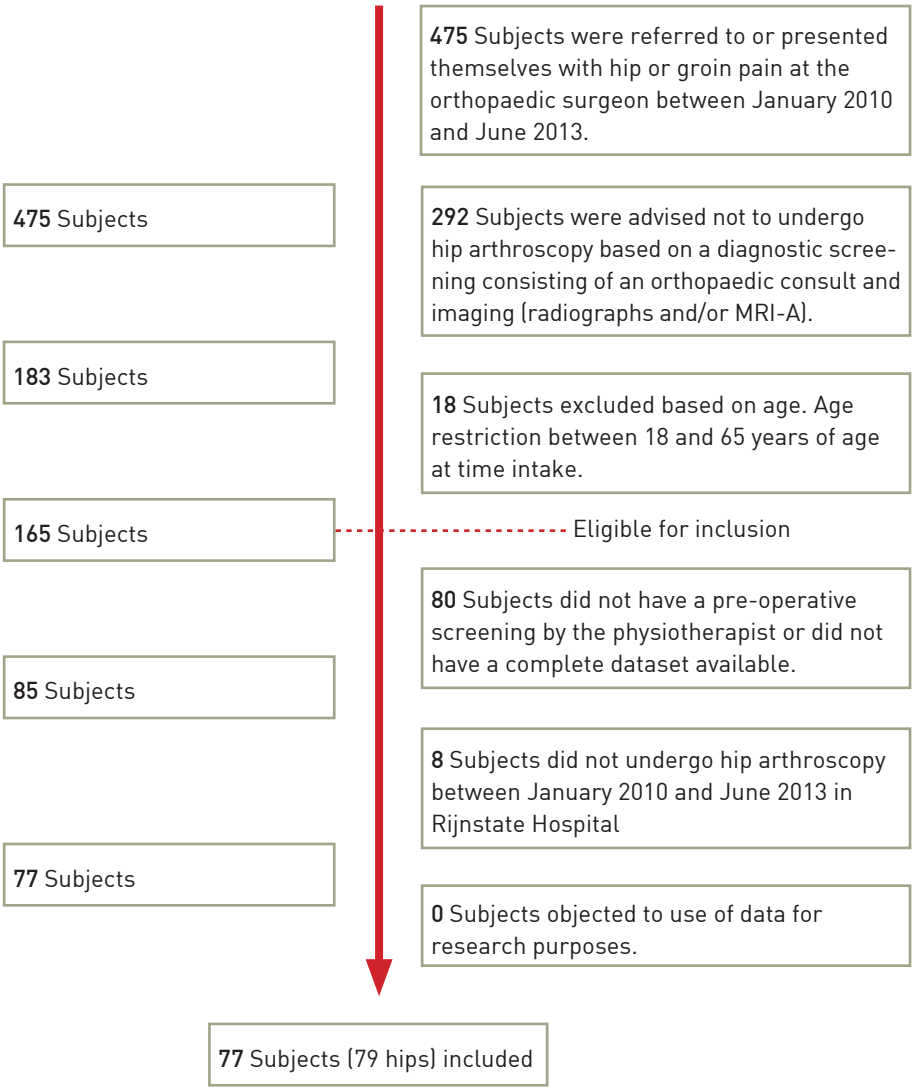
Materials and Methods

Study population

All patients admitted to the orthopaedic department at Rijnstate Hospital (aged between 18 and 65 years) who after a diagnostic screening (including imaging) by a single orthopaedic surgeon (EV) were offered arthroscopic surgery (plus a pre-operative intake by a physiotherapist (MT)) were included. Imaging (either radiographs and/or Magnetic Resonance Imaging Arthrography (MRI-A)) was performed as described in previous studies [17,18]. An inclusion criteria was the presence of at least one imaging finding correlated to intra-articular hip pathology (Appendix A) [17, 19]. Patients with signs of hip osteoarthritis (Tönnis grade ≥ 2 or joint space ≤ 2.0 millimeter) were not offered hip arthroscopy and therefore excluded from the study [20]. All included patients underwent hip arthroscopy between January 2010 and June 2013 by the same orthopaedic surgeon (EV). Data from a total of 77 patients (79 hips) could be included in this retrospective cohort study (Figure 1). The study design was approved by the

local ethics committee, (CMO Arnhem-Nijmegen) registration number 2013/083, and was performed in accordance with the ethical standards as described in the 1964 Declaration of Helsinki.

1A.



1B.

Subjects were referred to or presented themselves with hip or groin pain at the orthopaedic surgeon.	Subjects underwent diagnostic screening after which was hip arthroscopy was decided on.	Subjects had a pre-operative screening by the physiotherapist.	Subjects underwent hip arthroscopy between January 2010 and June 2013 in Rijnstate Hospital.

Figure 1 - Flow chart of subject in- and exclusion **(1A)** and data collection **(1B)**.

Study protocol

Data collection

Data from the orthopaedic screening were used for initial diagnosis and surgery. Data from the pre-operative intake with the physiotherapist were used to provide baseline measurements for postoperative rehabilitation and were not used for initial diagnosis. The physiotherapist (MT) and the orthopaedic surgeon (EV) who performed the pre-operative intakes, orthopaedic screenings and surgeries had six and ten years of experience in this field, respectively.

Patient history and physical evaluation

Data collection was based on patient history and physical examination performed by the physiotherapist (Table 1-4, Appendix B). Concerning patient history particular attention was paid to the area of pain, mechanical symptoms such as clicking or locking and the perceived activity limitations. All subjects underwent a standardized physical examination including physical diagnostic tests. Physical diagnostic tests were executed and scored as described in Appendix B [15].

Arthroscopy

Arthroscopy was performed in supine position. A 70° arthroscope was used to adequately visualize and probe the acetabulum, acetabular labrum, ligaments and the anterior, superior, and posterior aspects of the femoral head. Pincer-type impingement was identified when there was bone overgrowth, a pincer projection causing labral displacement or a crossing sign to be seen over the labrum with fluoroscopy. Cam-type impingement was defined during arthroscopic physical examination, especially during flexion and internal rotation and by the presence of local abnormalities coherent with cam-type impingement, such as chondral lesions. In all cases in which surgically treatable pathology was identified such treatment was performed arthroscopically.

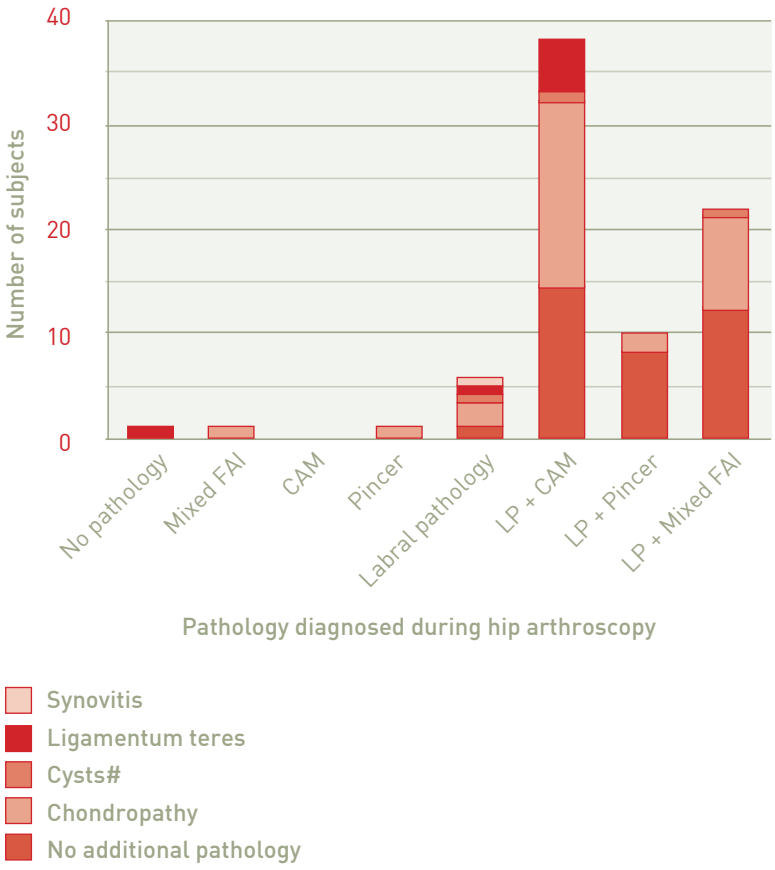
Statistical analyses

Statistical analyses were performed with SPSS 22.0 (IBM Statistics SPSS). Variables from patient history and physical examination were collected and analysed with descriptive statistics. The diagnostic accuracy of patient history and physical tests compared to arthroscopy was established by use of sensitivity, specificity, and likelihood ratio (LR) calculated with crosstabs. In order to investigate if a combination

of patient history and clinical examination parameters would prevail over individual parameters, all parameters with a sensitivity of ≥ 0.7 were combined [21]. All possible combinations of these parameters were investigated. Only combinations that led to a higher sensitivity than the best individual test in that combination, were adopted. Because the study population was expected to have intra-articular pathology, i.e. inclusion based on progression through arthroscopic surgery, specificity and LR figures were not incorporated into the combination analysis.

Results

This study included 77 subjects (79 hips) (Table 1). Thirteen subjects had bilateral complaints, but only two were arthroscopically treated for both sides. All subjects, but one, were diagnosed with intra-articular hip pathology (prevalence 98.7%). The majority of subjects (76%) were diagnosed with FAI combined with labral pathology of the hip (Figure 2).



FAI = Femoroacetabular impingement. **LP** = Labral pathology. **#** = Rupture.

Figure 2 - Overview of intra-articular hip pathology of study population diagnosed during hip arthroscopy.

Table 1 - Patient demographic characteristics.

Characteristics	Group with intra-articular pathology (n=78) - mean (SD) or nr. (%)	Patient without intra-articular pathology (n=1)
Age	37.0 (10.9)	23.4
Gender - male/female	43/35 (55/45)	female
Injured side - right/left/both sides	33/32/13 (42/41/17)	left
Time between intake and surgery (weeks)	11.6 (9.4)	19.8
Duration of symptoms in years	3.2 (4.3)	1.0
Main location of symptoms:		
Groin (including C-sign)	68 (87)	-
Lateral side hip	7 (9)	1
Lumbar spine	1 (1)	-
Gluteal area	1 (1)	-
ASIS area	1 (1)	-
Minimal experienced pain(n = 52)*	0.5 (1.3)	0.0
Maximal experienced pain(n = 56)*	6.7 (2.0)	6.7
Work - yes/no	59/19 (76/24)	yes
Sport - yes/no	64/14 (82/18)	yes
Sport history– yes/no(n = 62)	50/12 (81/19)	yes

* = Experienced pain was measured with a Visual Analogue Scale (VAS) [34]. SD = Standard deviation. - = Not applicable.

Patient history

Table 1 and 2 show an overview of parameters of patient history. Parameters for which accuracy could be calculated are presented in Table 2. The accuracy of the patient history parameters related to intra-articular hip pathology was poor. Only groin as main location of pain had a sensitivity higher than 0.7.

Table 2 - Diagnostic accuracy of patient history parameters.

Parameter (n = 79)	Sensitivity (CI)	Specificity (CI)	Likelihood ratio + (CI)	Likelihood ratio - (CI)
Origin of complaints*				
Traumatic	0.16 (0.09 – 0.26)	1 (0.31 – 1)	-	0.84 (0.76 – 0.93)
Acute	0.33 (0.23 – 0.45)	1 (0.31 – 1)	-	0.67 (0.57 – 0.79)
Groin as main location of pain	0.87 (0.77 – 0.93)	1 (0.05 – 1)	-	0.13 (0.07 – 0.23)
Clicking*	0.57 (0.45 – 0.68)	1 (0.31 – 1)	-	0.43 (0.34 – 0.56)
Giving way	0.28 (0.19 – 0.40)	1 (0.05 – 1)	-	0.72 (0.62 – 0.83)
Locking	0.26 (0.17 – 0.37)	1 (0.05 – 1)	-	0.74 (0.65 – 0.85)
Perceived stiffness	0.40 (0.29 – 0.52)	0 (0 – 0.95)	0.40 (0.3 – 0.52)	-
Perceived mobility restrictions	0.22 (0.14 – 0.33)	1 (0.05 – 1)	-	0.78 (0.7 -0.88)

* = Only applicable in case of labral pathology [12,25]. Therefore only subjects within the labral pathology group are regarded as positive. (CI) = 95% Confidence Interval. - = Infinity.

Table 3 - Diagnostic accuracy of physical diagnostic tests

Test (n = 79)	Sensitivity (CI)	Specificity (CI)	Likelihood ratio + (CI)	Likelihood ratio - (CI)
Anterior impingement test (AIT)	0.91 (0.82 – 0.96)	0 (0 – 0.95)	0.91 (0.85 - 0.98)	-
Flexion-Abduction-External rotation (FABER) test	0.81 (0.7 – 0.88)	0 (0 – 0.95)	0.81 (0.72 – 0.9)	-
Thomas test*	0.11 (0.05 – 0.2)	0.67 (0.13 – 0.98)	0.33 (0.06 – 1.8)	1.34 (0.89 – 2.01)
Resisted Straight Leg Raise test	0.21 (0.13 – 0.32)	0 (0 – 0.95)	0.21 (0.14 – 0.33)	-
Scour test	0.5 (0.35 – 0.65)	-	-	-
Fitzgerald test*	0.72 (0.61 – 0.82)	0.33 (0.02 – 0.87)	1.08 (0.48 – 2.45)	0.83 (0.16 – 4.41)

* = Only applicable in case of labral pathology [35]. Therefore only subjects within the labral pathology group are regarded as positive. (CI) = 95% Confidence Interval. - = Infinity.

Combining patient history and physical tests

The following parameters were included in the final analysis: presence of groin as main location of pain, AIT, FABER test and Fitzgerald test (Table 4). Combining these parameters did improve the accuracy for almost all combinations (range 0.91 – 0.97). Groin as main location of pain and a positive FABER test or a positive AIT and a positive FABER test led to the shortest most sensitive combinations (0.97).

Table 4 - Overview of combined parameters with moderate to good sensitivity in diagnosing FAI and/or hip labral pathology.

Test (at least one test +) (n = 79)	Sensitivity (CI)	Specificity (CI)	Likelihood ratio + (CI)	Likelihood ratio - (CI)
Groin pain and AIT and FABER and Fitzgerald*	0.97 (0.9 – 1)	0 (0 – 0.69)	0.97 (0.94 – 1.01)	-
Groin pain and AIT and FABER	0.97 (0.9 – 1)	0 (0 – 0.95)	0.97 (0.94 – 1.01)	-
Groin pain and AIT and Fitzgerald*	0.95 (0.86 – 0.98)	0 (0 – 0.69)	0.95 (0.9 – 1)	-
Groin pain and FABER and Fitzgerald*	0.97 (0.9 – 1)	0 (0 – 0.69)	0.97 (0.94 – 1.01)	-
Groin pain and FABER	0.97 (0.9 – 1)	0 (0 – 0.95)	0.97 (0.94 – 1.01)	-
Groin pain and Fitzgerald*	0.91 (0.81 – 0.96)	0.33 (0.02 – 0.87)	1.36 (0.61 – 3.04)	0.28 (0.04 – 2.07)
AIT and FABER and Fitzgerald*	0.97 (0.9 – 1)	0 (0 – 0.69)	0.97 (0.94 – 1.01)	-
AIT and FABER	0.97 (0.9 – 1)	0 (0 – 0.95)	0.97 (0.94 – 1.01)	-
AIT and Fitzgerald*	0.93 (0.85 – 0.98)	0 (0 – 0.69)	0.93 (0.88 – 0.99)	-
FABER and Fitzgerald*	0.91 (0.81 – 0.96)	0 (0 – 0.69)	0.91 (0.85 – 0.98)	-

AIT = Anterior Impingement test. FABER = Flexion-Abduction-External rotation test.* = Only applicable in case of labral pathology [12,25]. Therefore only subjects within the labral pathology group are regarded as positive. (CI) = 95% Confidence Interval. - = Infinity.

Physical diagnostic tests

Overall accuracy of the physical diagnostic tests was poor (Table 3). Only the Anterior Impingement test (AIT), Flexion-Abduction-External-Rotation (FABER) test and Fitzgerald test had a moderate to high sensitivity (range 0.72 – 0.91).

Discussion

This study confirmed our hypothesis that combining patient history parameters and physical tests for the diagnosis of symptomatic FAI and/or hip labral pathology leads to a higher diagnostic accuracy then any individual test alone. Furthermore, this study shows that these combinations can be used to help rule out the diagnosis of symptomatic FAI and/or hip labral pathology in clinical practice. We showed that there currently is no single parameter with an excellent accuracy for diagnosing FAI and/or labral pathology. Only four parameters of patient history and physical tests had a sensitivity of $\geq$ 0.7: groin as main location of pain, AIT, FABER test and Fitzgerald test. The AIT was the best individual test with a sensitivity of 0.91. Sensitivity increased when combining these tests (0.97) as either groin as main location of pain and a positive FABER test or a positive AIT test and a positive FABER test were the shortest, most sensitive combinations. Therefore, an absence of groin as main location of pain combined with a negative FABER test or the combination of a negative AIT and a negative FABER test are suggested to rule out the diagnosis of symptomatic FAI and/or labral pathology.

This study provides the clinician with a detailed clinical presentation (i.e., patient history and physical tests) of FAI and/or hip labral pathology. We found FAI and/or hip labral pathology to be present in a relatively young, active population who had experienced pain/discomfort several years before being diagnosed. Some patient history parameters as found in this study are consistent with earlier reports. Groin as main location of pain had a sensitivity of 87% and similar sensitivity figures have been described by others [4, 22, 23]. This is contradictory to pain patterns described in hip osteoarthritis where also the area around the knee joint is reported as main location of pain [24]. Our results also showed that some parameters often used to describe the clinical presentation of FAI and/or hip labral pathology might not be as useful as previously considered [25, 26]. Traumatic or acute origin of complaints, giving way, locking, perceived stiffness and mobility restrictions of the hip all had a sensitivity of 0.5 or less (range 0.11 – 0.5) while other studies have reported sensitivities up to 1.0 [5, 25]. An explanation might be that these symptoms are often grouped together as mechanical symptoms increasing sensitivity [12]. Yet, as each of these symptoms might refer to a different pathology it is questionable if grouping them improves diagnostic utility [5].

To describe the accuracy of physical diagnostic tests for FAI and/or hip labral pathology, the authors choose to use six tests found in an earlier systematic review [15]. The AIT, FABER test and Fitzgerald test were found to have the highest sensitivity and this coincides with other reports [15, 16]. However, the Thomas test, RSLR test and Scour test all had a sensitivity of 0.5 or less (range 0.11 – 0.5). This is in contradiction with some earlier studies [25, 27] which might be explained by differences in study populations. For example, positive results for some of these tests, i.e. Thomas test, Fitzgerald test and RSLR test, may be the result of pain from structures outside the hip such as the iliopsoas muscle [29, 30]. Therefore, differences in study populations (presence/absence of additional injuries) can lead to differences in sensitivity figures. The lack of well defined, reliable and valid tests for diagnosing symptomatic FAI and/or hip labral pathology leads to the use of tests which may diagnose other structures around the hip as well. This is an area that deserves further attention in future research [11, 15].
In line with earlier research advocating the use of a combination of patient history

and clinical examination findings [12, 15], this study investigated the accuracy of a combination of tests. With either the combinations of the groin as main location of pain and a positive FABER test or the combination of a positive result on the AIT and a positive FABER test this study found two short and highly sensitive test combinations (0.97). Only Maslowski et al.[30] investigated such a combination before and found an increase in sensitivity, but decrease in specificity when combining the FABER test, Stinchfield test (i.e. Resisted Straight Leg Raise test), Scour test and Internal Rotation Over Pressure test. However, these data were compared to pain relief on intra-articular injection instead of surgery which is the gold standard. The accuracy of intra-articular injections in diagnosing intra-articular hip pathology compared to hip arthroscopy has not been extensively investigated yet [31]. A high sensitivity can be used to rule out a specific condition [5, 32]. This suggests that if the groin is not the main location of pain and the FABER test is negative or both the AIT and the FABER test are negative, these might be useful combinations for ruling out symptomatic FAI and/or hip labral pathology. This suggestion is supported by a recent studies [5, 11].

A limitation of this study is the limited sample size. Eventually only 77 patients (79 hips) could be included in this study. Also the data collection of this study was retrospective. Because of the retrospective study design a power calculation for sample size could not be performed. In order to confirm our results the study should be replicated with a prospective design and adequate sample size.
Comparison of the pre-operative diagnosis with post-operative results in a prospective design might have given a better idea of the relationship for patient history and physical examination findings. Unfortunately these data were not available.
Another limitation and one of the major overall problems with diagnostic accuracy studies for FAI and/or hip labral pathology is the study population [5, 14]. As hip surgery (arthroscopy or open surgery) is the gold standard [33] a high prevalence of subjects with intra-articular hip pathology can be expected. The prevalence of hip pathology in our study was 98.7%. It made correct interpretation of accuracy values for patient history and physical examination other than sensitivity difficult and these values were therefore not incorporated in the statistical analysis. However, tests with high sensitivity can be very helpful for the initial diagnoses or screening of patients increasing speed and accuracy of diagnosis [5]. So, at the present level of knowledge the results found in this study can be very helpful for the clinician. However, in order to confirm our study findings prospective research in a larger group of patients with adequate power and more heterogeneous disorders is still necessary.

Perspective

Femoro-acetabular impingement (FAI) and hip labral pathology are still a diagnostic challenge. This study informs the clinician about a detailed clinical presentation of these pathologies. Furthermore, it shows that there currently is no parameter of patient history and physical tests that is accurate for the diagnosis of FAI and/or hip labral pathology in clinical practice. This means that the clinician should combine parameters in order to confirm or reject the diagnosis of FAI and/or hip labral pathology. As the results of this study point out an absence of the groin as the main location of pain and at the same time a negative FABER test or the combination of a negative AIT and a negative FABER test are suggested to rule out the diagnosis of symptomatic FAI and/or hip labral pathology as major cause of hip and groin pain.

This may be of particular interest for the clinician working in sports medicine, orthopaedic or general practice. However, as Reiman et al., (2014) state for clinicians working with patients with a high suspicion of intra-articular hip pathology, parameters that help rule in the diagnosis are still warranted. Therefore more studies in larger groups of patients with different types of injuries are needed.

Acknowledgments

The authors thank Thomas Diemel, BSc., for his assistance with the data collection for this study.

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Appendix A - Parameters used to evaluate hip joint imaging.

Parameter RX/MRI-A*	Definition	Normal value, abnormal value
Parameters RX		
Alpha angle (AA)	Angle between the femoral neck axis and a line connecting the head center with the point of beginning asphericity of the head-neck contour [17-19].	<50°, >50°
Lateral center edge angle (LCEA)	Angle formed by a vertical line through the center of the femoral head and a line connecting the femoral head center with the lateral edge of the acetabulum [17-19].	20-39°, >39°
Crossover sign	Present if the anterior rim runs more laterally in the most proximal part of the acetabulum and crosses the posterior rim distally [17-19].	Anterior rim line projects medially to the posterior wall line
Protrusio acetabuli	Present if the femoral head touches or crosses the ilio-ischial line [17-19].	
Joint space	The distance between the roof of the acetabulum and the femoral head [17-19].	>2.5mm, <2.5mm
Parameters MRI-A		
Labral pathology	Disruption of cartilage ring (labrum) in hip joint [17-19].	-
Cam deformity	Angle between the femoral neck axis and a line connecting the head center with the point of beginning asphericity of the head-neck contour [17-19].	<50°, >50°
Cysts	Subchondral cysts [17-19].	-
Chondropathy	Contrast material-filled defect, area of cartilage signal intensity alteration at acetabulum or femoral head [17-19].	-
Ligamentum Teres rupture	Disruption of ligamentum Teres within hip joint [17-19].	-

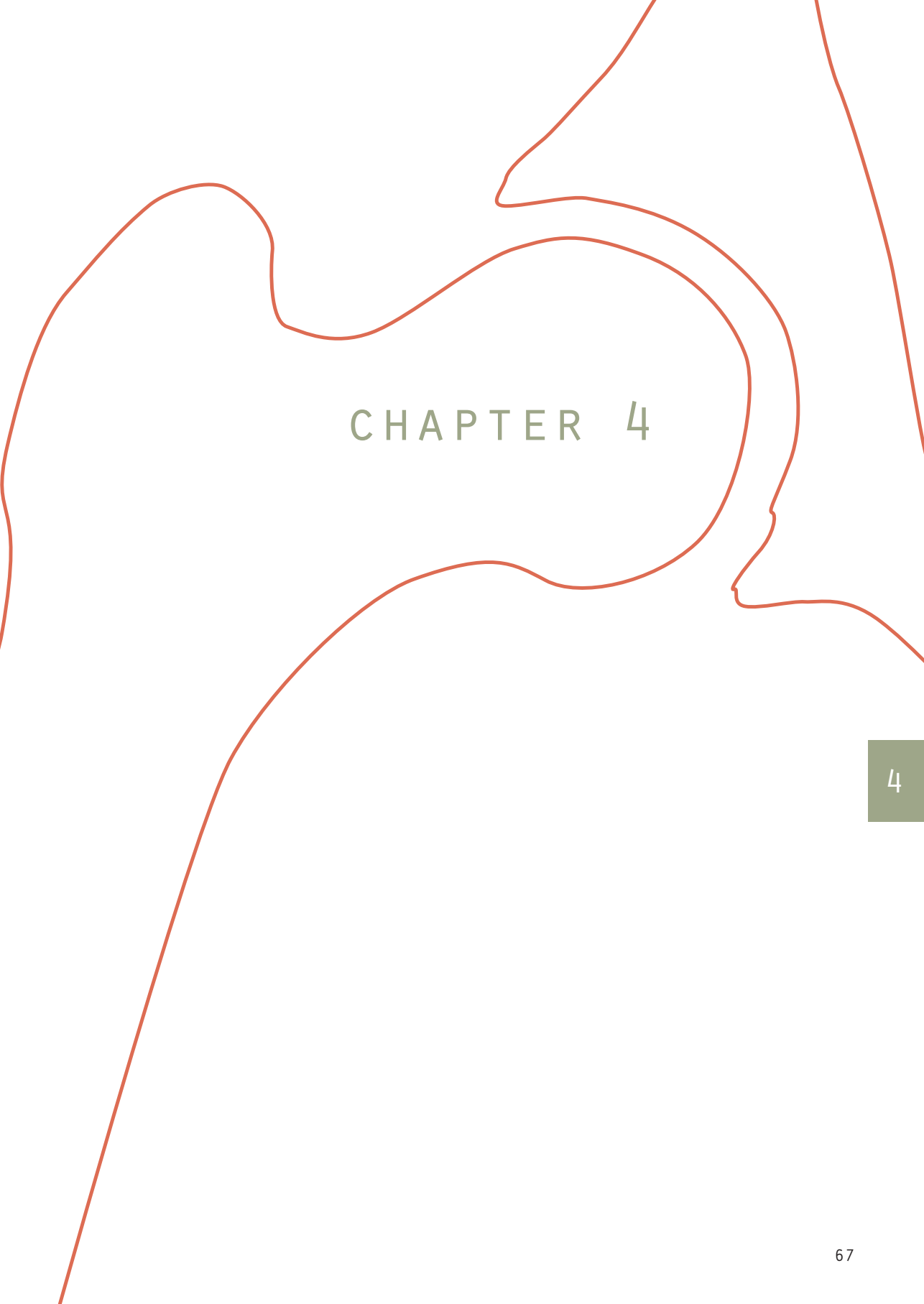
*RX/MRI-A = radiographic imaging/magnetic resonance imaging arthrography. - = Not applicable.

Appendix B - Physical diagnostic tests used to evaluate the hip joint.

Test	Test execution	Diagnoses
Anterior hip impingement test (AIT)	Patient lies supine while the examiner moves the affected leg into 90° of flexion, adduction and internal rotation until end range is achieved. Pain in any location marks a positive result [15].	FAI*/labral pathology
Flexion-Abduction-External Rotation (FABER) test/ Patrick sign	Patient lies supine. The affected leg is simultaneously flexed, abducted and externally rotated so that the subject's lateral ankle rests on the contralateral leg just proximal to the knee. While stabilizing the ASIS the knee is lowered towards the table. A positive test result may be either a decrease in ROM compared to the non-affected leg or reproduction of pain [15].	FAI*/labral pathology
Thomas test	Patient lies supine with the legs pulled to the chest. The affected leg is lowered off the edge of the table (from flexion to extension). A click (as perceived by patient/researcher) or recognizable pain marks a positive result [15].	Labral pathology
Resisted Straight Leg Raise Test/Stinchfield Test	Patient lies supine and is asked to raise the straight leg to 45° of hip flexion. The patient is asked to resist manual force applied just proximal of the knee by the researcher. Recognizable pain or weakness is a positive result. Maslowski et al.[30] performed the same test but only raised the leg until 30° [15].	FAI*/labral pathology
Hip Quadrant Position/ Scour test	The patient lies supine while the examiner brings the affected leg into flexion and adduction. The leg is then rotated. A positive test will recreate the patient's pain or shows a restriction in ROM. Maslowksi et al.[30] described the same test only with axial compression through the joint [15].	FAI*/labral pathology
Fitzgerald test/ Labral stress test	The hip is brought into flexion, external rotation and full abduction and is then extended with internal rotation and adduction. The patient lies supine. Extension with abduction and external rotation from the fully flexed, adducted and internally rotated position completes the test. Pain or a click are positive results [15].	Labral pathology

Tests with several names but the same execution are presented in one row, the names are separated by /.
*FAI = Femoroacetabular impingement.

4



CHAPTER 4

Patient-Reported Outcome questionnaires (PROs) for young to middle-aged adults with hip and groin disability: a systematic review of the clinimetric evidence.

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British Journal of Sports Medicine, 2015, 49(12), 812.

Abstract

Background: To recommend Patient-Reported Outcome questionnaires (PROs) to measure hip and groin disability in young-aged to middle-aged adults.
Methods: A systematic review was performed in June 2014. The methodological quality of the studies included was determined using the COnsensus-based Standards for the selection of health Measurement INstruments list (COSMIN) together with standardised evaluations of measurement properties of each PRO.
Results: Twenty studies were included. Nine different questionnaires for patients with hip disability, and one for hip and groin disability were identified. Hip And Groin Outcome Score (HAGOS), Hip Outcome Score (HOS), International Hip Outcome Tool-12 (IHOT-12) and IHOT-33 were the most thoroughly investigated PROs and studies including these PROs reported key aspects of the COSMIN checklist. HAGOS and IHOT-12 were based on studies with the least ratings of poor study methodology (23% and 31% respectively), whereas IHOT-33 and HOS had a somewhat larger distribution (46%). These PROs all contain adequate measurement qualities for content validity (except HOS), test-retest reliability, construct validity, responsiveness and interpretability.
Conclusions: HAGOS, HOS, IHOT-12 and IHOT-33 can be recommended for assessment young-aged to middle-aged adults with pain related to the hip joint, undergoing non-surgical treatment or hip arthroscopy. At present, HAGOS is the only PRO also aimed for young-aged to middle-aged adults presenting with groin pain and can be recommended for use in this population.
Trial registration number; CRD42014009995.

Introduction

Treatment interventions, such as hip arthroscopy, endoscopic groin hernia repair and specific exercise regimens, are advancing rapidly to manage hip and groin disability in young-aged to middle-aged adults [1-3]. This area of sports medicine is a 'hot topic' that needs to be advanced with rigorous research [1].

Patient-Reported Outcome questionnaires (PROs) are considered the gold standard when measuring the efficacy of interventions from the patient's perspective [4]. Prior to recommending or discarding specific PRO questionnaires, a systematic investigation of their clinimetric properties is required [5]. A systematic review from 2010 of PROs for patients with hip and/or groin disability showed that most PROs were developed for people aged over 50 with hip osteoarthritis and/or in need of a hip replacement [6]. The year 2011 saw two new systematic reviews on PROs evaluating patients undergoing hip arthroscopy [7, 8]. Combined, these three systematic reviews agreed that the Hip Outcome Score (HOS) was the best available PRO for patients undergoing hip arthroscopy [6-8]. However, these conclusions were based on only six studies and the consensus was that more research was needed in this area [6-8].
In the past 3 years, several publications concerning the development and evaluation of PROs for young-aged to middle-aged adults, including patients undergoing surgical as well as those undergoing non-surgical treatment, have emerged and been debated [9-16]. These recommend instruments other than the HOS as the most appropriate in this setting involving younger patients [9-16]. Therefore, we systematically evaluated the clinimetric evidence pertaining to PROs for young-aged and middle-aged patients with hip or groin problems.

Methods

We performed a systematic review of the literature concerning assessment of hip and/or groin disability: (1) to identify PROs to assess young-aged to middle-aged adult patients with hip and/or groin disability in clinical practice, or in studies or clinical databases concerning outcome of various types of surgical, medical or exercise treatment and (2) to evaluate PRO study quality, and the clinimetric properties of available PROs in this population. The study protocol was pre-registered in PROSPERO (CRD42014009995), in May 2014.
The groin is anatomically located in the anterior-medial part of the hip region, and the hip and groin region share vascular and neural supply [17]. The pathologies of the hip joint and the groin often present simultaneously, and the symptoms can be overlapping [18-21]. We therefore searched for PROs concerning both regions.

Definitions

Clinimetric properties

Clinimetrics, derived from psychometrics, is the discipline concerned with measurement of variables in tests and questionnaires [22]. The term 'clinimetric properties' in this study was defined as measurement properties of questionnaires concerning validity, reliability and responsiveness [5].

Psychometric theory

Clinimetric properties can be assessed using Classical Test Theory (CCT) and Item Response Theory (IRT). CCT predict outcomes of testing such as the difficulty of items or the ability of the persons being tested. CCT assumes that an observed score can be decomposed into a 'true' score and an 'error' score, and the reliability co–efficient can be formulated as the ratio of true variance to (true+error) variance. The term 'classical' contrasts with recent psychometric theories such as IRT. This theory assumes that the score is unidimensional and creates an interval-scaled measure [22].

Patient-Reported Outcome
A PRO is any report coming directly from a patient concerning a health condition and its treatment [4, 23]. PRO questionnaires include items, instructions and guidelines for scoring and interpretation, and are used to measure outcomes from the perspective of the patient [4].

Disability
Disability in this study refers to the health dimensions within the methodological framework of The International Classification of Functioning, Disability and Health (ICF) as categorised at one of three levels: impairment (body structure and function), disabilities (activities), and participation problems (participation) [24].

Literature search strategy

A comprehensive, systematic literature search was conducted in the following bi-bliographic databases: MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, PsycINFO, SportsDiscus and Web of Science, all from January 2009 to June 2014. Relevant studies from a previous systematic review from our group [6], including studies on the same topic, were also included. This study included similar search strategies and bibliographic databases as the previous study [6], where the databases were searched up to January 2009.
Our search strategy was:
Hip OR groin OR inguinal hernia
AND
outcome assessment* OR self assessment* OR questionnaire*
AND
reliability OR validity
The terms were searched as key words (in MEDLINE named MESH terms) where possible, and also as "free-text" words. From the retrieved and selected references, reference lists were checked for further relevant studies. Finally, specific searches for identified questionnaires were carried out, and experts in the field were contacted for possible additional references.

Study selection

Two reviewers (KT and EMB) independently carried out the selection among the retrieved references of possible studies for inclusion, based on titles and abstracts. All eligible studies were obtained in full text and evaluated according to the inclusion criteria. Excluded studies were identified and presented with the reasons for exclusi-on following the PRISMA guidelines (Figure 1) [25].

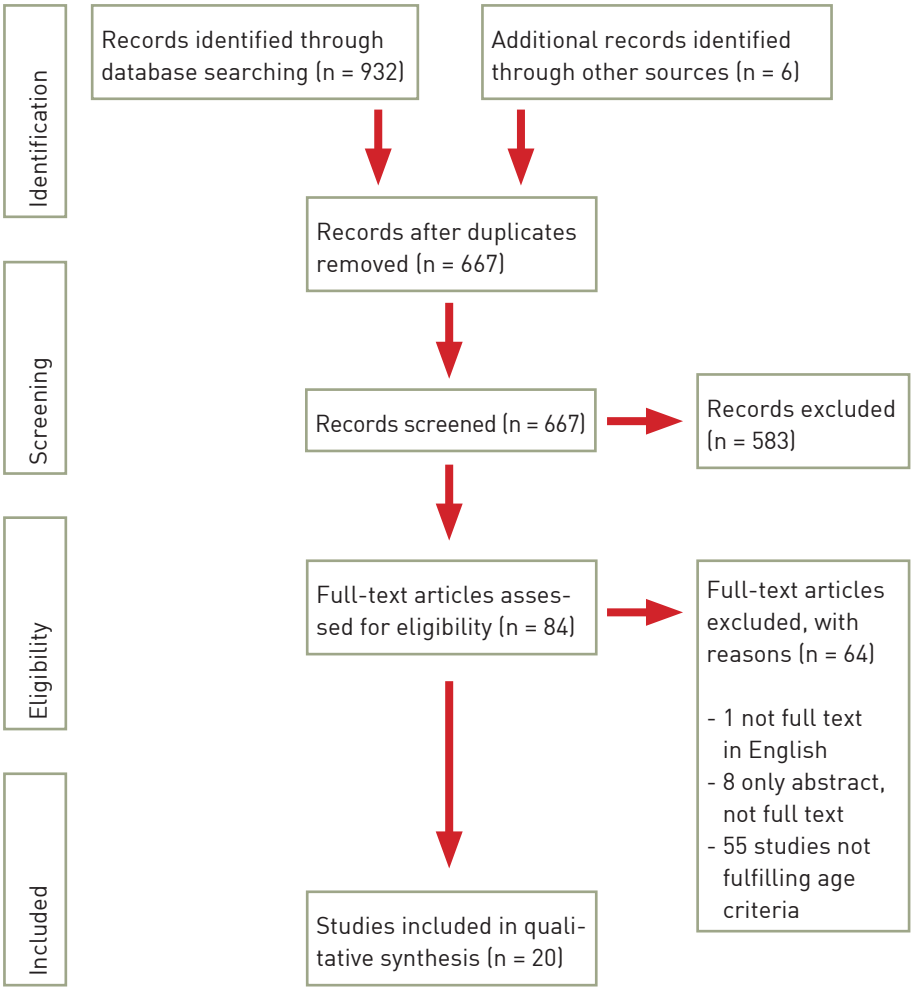

Figure 1 - PRISMA flowchart.

Inclusion criteria

Inclusion criteria for this study were as follows:

1. The retrieved study was published in English as a full report.
2. All patients were aged ≥18 and with a mean age ≤ 50. If only median age was reported then median age was ≤ 50.
3. Clinimetric properties in the study were evaluated with CCT or IRT.
4. The main purpose of the study was to evaluate one or more clinimetric properties of a PRO applied in a patient population with hip and/or groin disability.
5. The study included a PRO specifically concerning hip and/or groin disability, containing items related to impairment (body structure and function), disabilities (activities) or participation problems (participation), according to the ICF.
6. Data on hip and/or groin disability could be separated from disabilities of other anatomical regions.

Characteristics of studies and instruments

Information on the evaluation of clinimetric properties of the PRO(s), time of administration, target population (diagnosis/clinical features), study population, and mode of administration were included whenever possible. Extracted information from the identified questionnaires included full name of the questionnaire, abbreviation of the name of the questionnaire, assessment dimensions, and number of rating scales.

Methodological quality of included studies

The methodological quality of the included studies was determined by the COnsensus-based Standards for the selection of health Measurement INstruments list (COSMIN) [26]. The COSMIN checklist is based on an international Delphi study in which 57 experts participated. COSMIN has proven high inter-rater agreement [26, 27]. It contains three steps and has 11 areas (boxes) with several questions and criteria. Nine boxes can be used to assess whether a study meets the standard for good methodological quality (boxes A to I). Only the boxes corresponding to the properties assessed in the study will be evaluated. Each item is rated as excellent, good, fair or poor in accordance with the criteria described by Terwee et al [28]. A methodological study quality score per box is determined by the item with the lowest score ('worse score counts') [28]. Two reviewers (MT and BH) conducted the review process individually, and a third reviewer (Robert van Cingel, RvC) was consulted for consensus, in cases of disagreement.

Data extraction and evaluation of clinimetric properties

Based upon the guidelines for systematic reviews [25, 29], we used a criteria list for evaluative purposes and described the operationalization of it explicitly. The criteria list in question was recently published by Terwee et al [5], and was designed to evaluate of PROs and their clinimetric properties, where group comparisons are needed. This criteria list has recently been applied in other the systematic reviews on PROs including young-aged to middle-aged patients with hip and groin disability [6-8], and was considered the best available instrument for our purpose. In our previous systematic review [6], the methodological issues of the criteria list were discussed and refined in the study group, which is in accordance with recommendations in the original article [5]. This refined version was also used for the present review.

The criteria list described the clinimetric properties: content validity, internal consistency, construct validity, floor and ceiling effects, test-retest reliability, inter-tester reliability, agreement, responsiveness and interpretability. Inter-tester reliability is only relevant for PRO questionnaires if observer-administration is introduced. The clinimetric properties were rated as positive (+), indeterminate (±), negative (–) or no information available ( ) (see online supplementary Appendix 1). In order to avoid systematic errors in the study design or execution, two reviewers (MT and BH) independently rated the clinimetric properties of each questionnaire according to the criteria list. Uncertainty or disagreement was resolved by discussion with a third reviewer (RvC). Where further information of the studies was needed, the authors of these studies were contacted for clarification if required. The PRO ratings in the individual studies are described in online supplementary Appendix 1, all in accordance with the recommendations by Terwee et al [5].

Results

The new search (2009 - 2014) identified 661 publications in total. Six publications [31-36] identified from our previous systematic review and similar search (1980-2009)[6] were also included, since they fulfilled the inclusion criteria. Following the screening of titles and abstracts, 583 publications were excluded. Of the remaining 84 publications, which were read in full, 64 publications were excluded, as they did not fulfil our inclusion criteria (Figure 1). Twenty studies were finally included in the systematic review [11, 12, 14, 31-47] involving 4996 patients, as our final data for reviewing (Table 1). A total of 10 PROs were identified in the included studies (Table 2). Nine PROs considered the hip region, and one questionnaire considered the hip as well as the groin region.
The intertester reliability of the independent ratings based on the COSMIN ratings was good (κ=0.74, CI 95% 0.66 to 0.82). Disagreement here was mainly caused by differences in interpretation to the exact COSMIN criteria. In a few cases disagreement was caused by reading errors where one of the reviewers had overlooked specific information. In all cases consensus was reached by discussion between the two reviewers.
The intertester reliability of the independent ratings of clinimetric properties was very good (κ=0.90, CI 95% 0.86 to 0.95). Disagreement here was minimal and mainly caused by reading errors where one of the reviewers had overlooked specific information on a specific clinimetric property. In all cases consensus was reached by discussion between the two reviewers.

Methodological quality of the included studies

The methodological quality of the included studies evaluated by the COSMIN checklist can be seen in Table 3. The most commonly evaluated PROs were: HOS in eight studies, Copenhagen Hip And Groin Outcome Score (HAGOS) in four studies, International Hip Outcome Tool-33 (IHOT-33) in four studies and iHOT-12 in three studies. The studies concerning the HOS, HAGOS, IHOT-33 and IHOT-12 questionnaires [11, 12, 14, 31-47] covered all important methodological quality aspects, except criterion validity, which is usually not relevant for PROs of this kind (Table 2).

Table 1 - Description of included studies in the systematic review.

Authors	Name of questionnaire	Clinimetric evaluation(s)	Time of administration	Target population	Study population
Christensen et al. 2003[31]	NAHS	Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Agreement	Clinical visit	Young patients with articular and musculo-skeletal hip pain preoperative and postoperative	N=64 31 ♀, 33 ♂ Mean (SD) 40.9 (24.8) y Range (18-76 y)
Griffin et al. 2012[38]	IHOT-12	Content validity Construct validity Test-retest reliability Responsiveness	Clinical visit / postoperative	Young active patients with articular and musculoskeletal hip disease	N=104/1833/80 48/821/42 ♀, 56/1012/38 ♂ Mean 36.5/39.3/38.1 y
Henkus et al. 2011[3]	SUSHI	Content validity Construct validity Floor and ceiling effects Responsiveness	Preoperative / postopoperative	Young patients with articular hip pathology	N=100 32 ♀, 68 ♂ Mean (SD) 44.9 (9.8) y
Hinman et al. 2014[40]	HAGOS, HOOS, HOS, IHOT-33, mHHS, NAHS	Test-retest reliability Agreement Responsiveness	Clinical visit	Young active patients with hip/groin pain (FAI)	N=30 15 ♀, 15 ♂ Mean (SD) 24 (4) y Range (18 - 30 y)
Jónasson et al. 2014[41]	IHOT-12	Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Agreement Responsiveness Interpretability	Preoperative/ postoperative	Patients with hip pain preoperative and postoperative (FAI)	N=502 165 ♀, 337 ♂ Mean (SD) 37 (13.4) y Range (15-75 y)

Table 1 - Continued.

Authors	Name of questionnaire	Clinimetric evaluation(s)	Time of administration	Target population	Study population
Kemp et al. 2013[11]	HAGOS, HOOS, HOS, IHOT-33, mHHS	Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Agreement Responsiveness Interpretability	Postop.	Hip arthroscopy (Labral tear/FAI/Chondropathy)	N=50 26 ♀, 24 ♂ Mean (SD) 37.4 (11.3) y Range (18-57 y)
Lee et al. 2014[42]	HOS	Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Responsiveness Interpretability	Preoperative / postoperative	Hip arthroscopy (Labral tear/FAI/Snapping hip)	N=60 26 ♀, 34 ♂ Mean 38.4 y Range (16-80 y)
Martin et al. 2006[32]	HOS	Content validity Internal consistency Construct validity	Clinical visit / postoperative	Hip arthroscopy (Labral tear)	N=507 273 ♀, 232 ♂ Mean (SD) 38 (13) y Range (13-66 y)
Martin et al. 2007[33]	HOS	Construct validity	Postoperative	Hip arthroscopy	N=107 56 ♀, 51 ♂ Mean (SD) 42 (14) y Range (14-79) y

Table 1 - Continued.

Authors	Name of questionnaire	Clinimetric evaluation(s)	Time of administration	Target population	Study population
Martin et al. 2008[34]	HOS	Test-retest reliability Agreement Responsiveness Interpretability	Preoperative / postoperative	Hip arthroscopy (Labral tear/ FAI/chondral lesions/ capsular laxity)	N=126 59 ♀, 67 ♂ Mean (SD) 41 (16) y Range (13-80) y
Mohtadi et al. 2012[12]	IHOT-33	Content validity Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Responsiveness	Clinical visit / preoperative / postoperative	Young active patients with articular and musculoskeletal hip pathology	N= 433 234 ♀, 196 ♂, 3 unknown Mean (SD) 40 y Range (18-60 y)
Naal et al. 2011[43]	HOS	Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Responsiveness	Preoperative/ postoperative	Hip arthroscopy/ surgical dislocation (FAI)	N= 85 36 ♀, 49 ♂ Mean (SD) 33 (12) y
Naal et al. 2013[44]	HSAS	Content validity Construct validity Floor and ceiling effects Test-retest reliability Responsiveness	Preoperative/ postoperative	Hip arthroscopy (FAI)	N=30/29 7/12 ♀, 21/17 ♂ Mean (SD) 25.6/32.5 (8/8.8) y

Table 1 - Continued.

Authors	Name of questionnaire	Clinimetric evaluation(s)	Time of administration	Target population	Study population
Polesello et al. 2012[4]	IHOT-33, IHOT-12		Clinical visit	Young patients with hip pain	N=30 Mean (SD) ← 40 y
Potter et al. 2005[35]	mHHS	Construct validity Interpretability	Postoperative	Hip arthroscopy (Labral tear)	N = 33 19 ♀, 14 ♂ Mean 34.6 y Range (21-56 y)
Rothenfluh et al. 2008[36]	WOMAC-12	Internal consistency	Clinical visit	FAI	N = 100 55 ♀, 45 ♂ Mean (SD) 31.7 (9.7) y Range (13-42 y)
Seijas et al. 2014[46]	HOS	Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Agreement Responsiveness	Preoperative/ postoperative	Young patients with symptomatic articular hip pathology	N=100 36 ♀, 64 ♂ Mean (SD) 41.5 (12.1) y Range (18-65 y)
Thomeé et al. 2014[47]	HAGOS	Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Agreement Responsiveness Interpretability	Preoperative/ postoperative	Patients with hip pain preoperative and postoperative (FAI)	N=502 165 ♀, 337 ♂ Mean (SD) 37 (13.4) y Range (15-75 y)

Table 1 - Continued.

Authors	Name of questionnaire	Clinimetric evaluation(s)	Time of administration	Target population	Study population
Thorborg et al. 2014[14]	HAGOS	Content validity Internal consistency Construct validity Floor and ceiling effects Test-retest reliability Agreement Responsiveness Interpretability	Clinical visit	Patients with articular and musculoskeletal hip/groin pain	N=101 50 ♀, 51 ♂ Mean (SD) 36 (11) y Range (18-63 y)

/ Indicates different subgroups with data of each subgroup provided were used to investigate questionnaire. Data from these subgroups are split by /. ♀ Indicates female and ♂ indicates male. FAI, femoro-acetabular Impingement; HAGOS, Hip and Groin Outcome Score; HOOS, Hip disability and Osteoarthritis Outcome Score; HOS, Hip Outcome Score; HSAS, Hip Sports Activity Scale; IHOT, International Hip Outcome Tool; mHHS, modified Hawrris Hip Score; NAHS, Non-Arthritic Hip Score; SUHSI, Super Simple Hip Score; WOMAC-12, Western Ontario and McMaster Universities Osteoarthritis index-12.

Table 2 - Included PRO questionnaires for patients with hip and/or groin disability.

Abbreviation	Full name	Measurement dimension(s)	Number of Rating scales
HAGOS	Hip And Groin Outcome Score	Symptoms, pain, ADL, sport/recreational function, Participation in Physical Activity, QOL	6
HOOS	Hip Disability and Osteoarthritis Outcome Score	Pain, symptoms, ADL, sport/recreational function, QOL	5
HOS	Hip Outcome Score	ADL, sport	2
HSAS	Hip Sports Activity Score	Sport	1
IHOT-33	International Hip Outcome Tool-33	Symptoms, function, sport, occupational function, QOL	1
IHOT-12	International Hip Outcome Tool-12	Symptoms, Function, sport, occupational function, QOL	1
mHHS	modified Harris Hip Score	Pain, function, ADL,	1
NAHS	Non- Arthritic Hip Score	Pain, symptoms, ADL, activities	1
SUSHI	Super Simple Hip Score	General, pain, limitations, activity	1
WOMAC-12	Western Ontario and McMaster Universities Osteoarthritis index 12	Pain, ADL/physical function	2

ADL, Activities of Daily Living; PRO, Patient-Reported Outcomes; QOL, (Quality Of Life)

Table 3 – Scores of articles rated by COSMIN checklist.

Authors (year)	Name of questionnaire	IRT used	Score IRT	Internal consistency	Reliability	Measurement error	Content validity	Structural validity	Hypothesis testing	Cross-cultural validity	Criterion validity	Responsiveness
Christensen et al. 2003[31]	NAHS	No		Poor		Poor		Poor		Fair		
Castillo et al. 2013[37]	NAHS	No		Poor	Fair	Fair		Poor	Fair	Poor		
Griffin et al. 2012[38]	IHOT-12	No			Fair		Excellent	Fair	Fair			Fair
Henkus et al. 2011[39]	SUSHI	No					Poor		Fair			Fair
Hinman et al. 2014[40]	HAGOS, HOOS, HOS, IHOT-33, mHHS, NAHS	No			Fair	Fair						
Jónasson et al. 2014[41]	IHOT-12	No		Good	Poor	Poor		Excellent	Fair	Poor		Fair
Kemp et al. 2013[11]	HAGOS, HOOS, HOS, IHOT-33, mHHS	No		Poor	Good	Good		Poor	Poor			Fair
Lee et al. 2014[42]	HOS	No		Poor	Fair			Poor	Fair	Poor		Poor
Martin et al. 2006[32]	HOS	Yes	Good	Good			Poor	Good	Poor			
Martin et al. 2007[33]	HOS	No							Poor			
Martin et al. 2008[34]	HOS	No			Fair	Fair						Fair

Table 3 – Continued.

Authors (year)	Name of questionnaire	IRT used	Score IRT	Internal consistency	Reliability	Measurement error	Content validity	Structural validity	Hypothesis testing	Cross-cultural validity	Criterion validity	Responsiveness
Mohtadi et al. 2012[12]	IHOT-33	No		Poor	Fair		Excellent	Poor	Fair			Fair
Naal et al. 2011[43]	HOS	No		Poor	Fair	Fair		Poor	Fair	Poor		
Naal et al. 2013[44]	HSAS	No			Fair		Poor		Fair	Poor		Poor
Polesello et al. 2012[45]	IHOT-33, IHOT-12	No								Poor		
Potter et al. 2005[35]	mHHS	No							Poor			
Rothenfluh et al. 2008[36]	WOMAC-12	Yes	Excellent	Excellent				Excellent				
Seijas et al. 2014[46]	HOS	No		Poor	Good	Good			Fair	Poor		Poor
Thomeé et al. 2014[47]	HAGOS	No		Fair	Poor	Poor		Excellent	Fair	Fair		Fair
Thorborg et al. 2014[14]	HAGOS	No		Fair	Fair	Fair	Excellent	Good	Excellent			Fair

Empty boxes indicate not applicable. COSMIN, Consensus-based Standards for the selection of health Measurement Instruments; HAGOS, Hip and Groin Outcome Score; HOOS, Hip disability and Osteoarthritis Outcome Score; HOS, Hip Outcome Score; HSAS, Hip Sports Activity Scale; IHOT, International Hip Outcome Tool; IRT, Item Response Theory; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; SUHSI, Super Simple Hip Score; WOMAC-12, Western Ontario and McMaster Universities Osteoarthritis index-12.

The studies appraising the HOS, HAGOS, IHOT-33 and IHOT-12 exhibited the following distribution of ratings for poor methodology (number of poor ratings/number of total ratings): HOS (16/35=46%), HAGOS (5/22=23%), IHOT-33 (6/13=46%) and IHOT-12 (4/13=31%).
IRT-based and CTT-based analyses were only performed for HOS. IRT-based analysis was not performed in the studies concerning HAGOS, IHOT-12 and IHOT-33, as these studies were developed using only CTT-based analyses [11, 12, 14, 38, 40, 41, 45, 47].
Unidimensionality and structural validity can, however, also be evaluated by CTT, and IRT is therefore not a pre-requisite for evaluating these methodological aspects. The studies assessing these four questionnaires (HOS, HAGOS, IHOT-12 and IHOT-33), [11, 12, 14, 32, 33, 34, 38, 40-47] adequately address all important measurement aspects.

The other studies, including: modified Harris Hip Score (mHHS) [11, 35, 40] in three studies, Hip disability and Osteoarthritis Outcomes Score (HOOS) [11, 40] in two studies, Non-Arthritic Hip Score (NAHS) [31, 37, 40] in three studies, Hip Sports Activity Scale (HSAS) [44] in one study, Super Simple Hip Score (SUSHI) [39] in one study and Western Ontario and McMaster Universities Osteoarthritis Index-12 (WOMAC-12) [36] in one study had either no evaluation of their methodological quality concerning content validity specifically for young-aged and middle-aged patients, or a poor rating on this aspect. Furthermore, structural validity was either not assessed, or displayed poor methodology in all these studies, except in the study using WOMAC-12 [36]. The studies concerning mHHS, HOOS, NAHS, HSAS, SUSHI and WOMAC showed the following distribution of ratings for poor methodology (number of poor ratings/number of total ratings): mHHS (4/9=44%), HOOS (3/8=38%), NAHS (6/12=50%), HSAS (3/5=60%), SUSHI (1/3=33%) and WOMAC (0/3=0%). Of these questionnaires, WOMAC-12 was the only assessed by IRT, such that important aspects of reliability and validity could not be assessed [36]. As content and structural validity are vital aspects in relation to a study's ability to measure the PROs internal and external validity, no information or poor methodology on these aspects, makes it impossible to fully evaluate these PROs at present, based upon available studies on these PROs (HOOS, HSAS, mHHS, SUSHI and WOMAC-12).

Overall quality of PROs

The ratings of the individual PRO reports can be found in online supplementary Appendix 2. The ratings of the clinimetric properties of the included PROs are synthesised and presented in Table 4.
Overall, HAGOS, IHOT-33 and IHOT-12 received the best ratings concerning their psychometric properties (six positive scores out of eight relevant scores). HOS followed with five positive scores out of eight relevant scores. Then HOOS, mHHS and NAHS followed with four positive scores out of eight relevant scores, and last came HSAS and SUSHI with two positive scores out of eight relevant scores. WOMAC-12 was mainly developed with IRT and could only be evaluated for internal consistency.

Content validity

Content validity was defined as the extent to which the domain of interest is comprehensively sampled by the items in the questionnaire [5]. The HAGOS, IHOT-33, IHOT-12 and NAHS showed good content validity in the use of target population and investigators or experts in the item selection [12, 14, 31, 38]. During the development of the HOS, the

target population was not used in the item generation process [32]. For HSAS, a target population was not used in the development of the questionnaire [44]. The study investigating SUSHI had a doubtful design or the item generation process, as no investigators or experts were involved [39]. For the remaining PROs, no information was found on content validity in young-aged to middle-aged adults.

Table 4 - Quality of the questionnaires based on psychometric properties.

Name per questionnaire	Content validity	Internal consistency	Construct validity	Floor and ceiling effects	Test-retest reliability	Agreement	Responsiveness	Interpretability
HAGOS	+	+	+	-	+	-	+	+
HOOS		±	+	-	+	-	+	+
HOS	-	±	+	+	+	±	+	+
HSAS	-		±	+	+		-	
IHOT-33	+	±	+	+	+	-	+	+
IHOT-12	+	±	+	+	+	-	+	+
mHHS			+	-	+	-	+	+
NAHS	+	±	±	+	+	±	+	
SUSHI	±		+	+			-	
WOMAC-12		±						

+, positive rating; ±, indeterminate rating; -, negative rating; blank, no information available; HAGOS, Hip and Groin Outcome Score; HOOS, Hip disability and Osteoarthritis Outcome Score; HOS, Hip Outcome Score; HSAS, ip Sports Activity Scale; IHOT, International Hip Outcome Tool; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; SUHSI, Super Simple Hip Score;WOMAC-12, Western Ontario and McMaster Universities Osteoarthritis index-12.

Internal consistency

Internal consistency is the extent to which items in a (sub) scale are inter-correlated and is a measure of homogeneity of a (sub)scale [5]. Appropriate factor analysis was performed for HAGOS with high Cronbach's alpha leading to positive ratings for internal consistency [14, 47]. HOOS, HOS, IHOT-12, IHOT-33, NAHS and WOMAC-12 all scored indeterminate ratings for internal consistency. This was due to a lack of appropriate factor analysis and/or missing Cronbach's alpha for each subscale in most of the studies investigating these clinimetric properties for these PROs [11, 12, 31, 32, 37, 38, 42, 43, 45, 46].

Construct validity

Construct validity is the extent to which scores on PROs relate to other measures, in a manner that is consistent with theoretically derived hypotheses concerning the domains that are measured [5]. All PROs except HSAS, NAHS and WOMAC-12 scored a positive rating for construct validity. Indeterminate ratings for HSAS and NAHS were given based on a lack of information concerning a priori hypotheses and WOMAC-12 was not assessed for construct validity [31, 36, 37, 44].

Floor and ceiling effects

Floor and ceiling effects are present if the questionnaire fails to demonstrate a worse score in the patients who clinically deteriorated and an improved score in patients who are clinically improved [5]. Three questionnaires showed floor and ceiling effects,

namely HAGOS, HOOS and mHHS [11, 14 47]. While mHHS is a single score, HAGOS and HOOS hold six and five separately scored subscales, respectively, which are administered separately. For HAGOS, floor effects were found for the subscale Participation in Physical Activity (PA) before intervention (surgical and non-surgical) in two studies [14, 47], and ceiling effects for the subscales Activities of Daily Living (ADL) [11, 47] and PA [11,14] after intervention (surgical and non-surgical) in two studies, respectively. For HOOS ceiling effects for the subscales, ADL en sport/recreation were found after surgical intervention (hip arthroscopy) [11].

Test-retest reliability

Test-retest reliability is the extent to which the same results are obtained on repeated administrations of the same questionnaire when no change in clinical status has occurred [5]. Information on test-retest reliability was found for eight questionnaires of which all had a positive rating [12, 14, 34, 37, 38, 40-44, 47]. No test-retest reliability results were available for SUSHI and WOMAC-12 [36, 39].

Agreement

Agreement is the ability to produce exactly the same scores with repeated measurements [5]. Information on agreement was found for seven questionnaires. Martin et al.[34] demonstrated a minimal important change (MIC) for use in individual patients, which was larger than the smallest detectable change (SDC) for HOS, but this was contradicted by Kemp et al.[11]. HAGOS, HOOS, IHOT-33, IHOT-12 and mHHS all got a negative rating concerning agreement, as their SDCindividual were generally larger than the MIC [11, 41, 47]. NAHS received an indeterminate rating as no MIC was presented.

Responsiveness

Responsiveness was defined as the ability to detect important change over time in the concept being measured[5]. Responsiveness was investigated for nine questionnaires and found to be good for seven of them, including HAGOS, HOS, HOOS, IHOT-12, IHOT-33, mHHS, and NAHS [11, 14, 34, 40, 41, 46, 47]. The HSAS and SUSHI scored a negative rating since these studies only reported standardised response means as measures of responsiveness [39, 44].

Interpretability

Interpretability is the degree to which one can assign qualitative meaning to quantitative scores [5]. Only HAGOS, HOOS, HOS, IHOT-33, IHOT-12 and mHHS received a positive rating concerning this property as these were the only PROs for which mean and SD scores of at least two subgroups or MIC were presented [11, 14, 34, 41-43, 47].

Discussion

We identified 20 studies, including nine PROs applied in the assessment of young-aged to middle-aged adults with hip disability, and one PRO for assessing hip and groin disability, also in young-aged to middle-aged adults.

In our previous systematic review [6], only the HOS, mHHS and NAHS had been evaluated in young-aged to middle-aged adults with hip and/or groin disability. We identified that the HOS had adequate clinimetric properties to assess young-aged to middle-aged patients undergoing hip arthroscopy [6], which was also confirmed in this

updated version [6]. However, the HOS is no longer the only PRO that can be considered a relevant and valid measure of hip disability in young-aged to middle-aged adults.
HAGOS, IHOT-33 and IHOT-12 have also been thoroughly investigated, and these PROs contain adequate clinimetric qualities for assessing young-aged to middle-aged patients with hip disability. Furthermore, HAGOS measures pain and difficulties not only related to the hip but also to the groin region [14]. This is important since disability related to the groin region is a common problem in young and physically active people [19, 21].

The present study showed that studies on HAGOS and IHOT-12 had the least ratings of poor methodology (23-31%), whereas studies investigating the IHOT-33 and HOS had a somewhat larger distribution of poor ratings (46%). The studies assessing these four PROs include sufficient coverage of all important measurement aspects and have, overall, sufficient quality to make it possible to conclude on the quality of their clinimetric properties [26, 28]. These PROs all showed adequate measurement qualities for content validity (except HOS), construct validity, test-retest reliability, responsiveness and interpretability [5]. Ceiling effects were seen for some of the subscales in the HAGOS, HOOS and in mHHS [11, 14, 47]. According to the criteria described by Terwee et al.5 floor and ceiling effects are present if >15% of patients display highest (100 point) or lowest (0 point) possible score [5, 6]. Floor and ceiling effects should however, always be considered in the relevant context.
In the HAGOS (PA) subscale, a maximal PA score of 100 means that patients cannot deteriorate or improve any further, as they report that they are 'never' or 'always' able to participate in their preferred physical activities for as long as they want, and that they are 'never' or 'always' able to perform their preferred physical activities at their normal performance level. In this group of individuals, further deterioration or improvement seems of no clinical relevance, as such answers strongly indicate that these individuals are already functioning at the lowest or highest possible physical level [16]. A postintervention ceiling effect may, therefore, be an effect of successful treatment and not necessarily a sign of a PROs poor clinimetric quality.
Concerning agreement, no PROs receive a positive rating, including HAGOS, HOS, IHOT-12 and IHOT-33. Lack of precision at the individual level is due to a considerable measurement variation (SDCindividual), indicating that quite large differences are needed to be reliably detected for an individual in the clinic [40]. In the two studies that included a direct head-to-head comparison on HAGOS, HOS, IHOT-12 and IHOT-33, SDC ranged from 10 to 20 points for patients 12-24 months after undergoing hip arthroscopy [11], and 20-30 points for patients with a primary complaint of hip and groin pain seeking either a physiotherapist or an orthopaedic surgeon for treatment [40]. However, at the group level, the HAGOS, HOS, IHOT-12 and IHOT-33 have very low measurement variation, where SDC at the group level ranged from 1 to 3 points for patients 12-24 months after undergoing hip arthroscopy [11], and 2-6 points for patients with a primary complaint of hip and groin pain seeking treatment for wither a physiotherapist or an orthopaedic surgeon [40], making these PROs highly capable of detecting small differences at group level (SDC group), when considering a group of 23-50 patients [11, 40].

Methodological limitations

A limitation of our study is that no gold standard exists to evaluate clinimetric properties of PRO questionnaires, and our chosen criteria list may therefore be disputed. There are other criteria lists available [48, 49], but in the absence of a gold standard we utilised the most comprehensive criteria list available to evaluate the PRO's clinimetric properties [5].
The COSMIN checklist [26, 28] and Terwee's criteria list [5] used in our study were developed to evaluate study quality and clinimetric properties of PRO questionnaires, respectively, primarily based on CCT [5, 6, 28]. IRT is a relatively new method to evaluate PROs in healthcare and has some potential advantages over CTT [22, 50]. The Rasch model, which is a mathematical model applied in IRT, has been used to develop and internally validate measures, and it uses a logistic function that creates an interval- scaled measure [22, 50]. The COSMIN checklist and Terwee criteria list are mainly developed to evaluate clinimetric properties of questionnaires based upon CTT [5, 6, 28], and this is a limitation of our study. In the future, criteria that evaluate methods and results of studies using IRT models must be further developed, since this method has gained acceptance [5, 6, 28], and studies concerning development and/or evaluating of questionnaires based on IRT, as also shown by this review, are now more frequent.

A recent study by Schellingerhout et al.[51] synthesized the different studies by taking the methodological quality of the studies and the consistency of their results into account. The possible overall rating for a measurement property was 'positive', 'indeterminate', or 'negative', accompanied by levels of evidence, similar to that proposed by the Cochrane Back Review Group [52,53]. In the present study we did not follow this approach, since the COSMIN checklist is not able to rate the overall methodology of the study, but instead rates nine individual items concerning PRO study quality. Currently, there is no clear method to handle a study with poor methodology for one or more items, but good, fair or excellent for other items; a situation common among the studies included (see Table 2). Therefore, we decided on a more pragmatic approach, where we identified the total distribution of ratings for poor methodology in studies on each questionnaire. In our opinion, this provides a better overall view of PROs based on studies with a large proportion of poor methodology. HAGOS and IHOT-12 had the smallest proportion of items with a poor methodology score, but they still showed poor methodology score in 23% and 31% of items, respectively, suggesting that the study quality of studies developing and evaluating PROs can still be improved considerately.

Several systematic reviews evaluate the efficacy of different treatment modalities for young-aged to middle-aged patients with hip and/or groin disability [2, 54, 55]. None of these considered the quality of the outcome measures applied in the included studies. Earlier, reviews were mainly concerned with obvious methodological qualities such as randomisation procedures, control groups, blinding, compliance, drop-out, intention to treat etcetera [56]. Measurement properties have rarely been evaluated in the same methodologically stringent manner [56]. A risk of bias may have been introduced with the possibility of unqualified instruments being selected when investigating and reporting the efficacy of different treatment modalities [2, 54, 55]. The present study provides valuable information regarding clinimetric properties of PROs for young-aged to middle-aged adults with hip and/or groin disability.

Conclusions

HAGOS, HOS, IHOT-12 and IHOT-33 can be recommended in the assessment of young-aged to middle-aged adults with pain and dysfunction related to the hip joint. There is insufficient evidence to recommend the other identified instruments, namely, HOOS, HSAS, mHHS, NAHS, SUHSI and WOMAC-12, at present. The HAGOS is the only PRO aimed for young-aged to middle-aged adults addressing pain and dysfunction not only in the hip but also in the groin area. HAGOS can be recommended for assessment in this population. The methodological quality of the existing reports varies greatly and can be considerably improved.

Acknowledgements

The authors would like to thank Dr Robert van Cingel, PT, PhD, from Sports Medical Centre Papendal, for his assistance as a third reviewer consulted for consensus in cases of disagreement in COSMIN ratings and ratings of measurement properties of each PRO.

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CHAPTER 5

Translation, cross-cultural adaptation and validation of the Dutch Hip And Groin Outcome Score according to the COSMIN checklist in young physically active individuals with hip or groin pain.

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Abstract

Introduction: The Hip And Groin Outcome Score was developed in Danish language as patient reported outcome measure for young and active individuals with hip and groin pain. Aim of this study was to translate and validate a Dutch version in the target population.
Materials and methods: Translation (Danish to Dutch) and validation were performed following existing guidelines and the COSMIN checklist. Young (18-50 years) and active (Tegner score >2) individuals presenting with hip and groin pain (numeric pain score ≥1) in primary health care and hospital setting were included. Reliability (test-retest, internal consistency) was assessed in clinically stable patients. Construct validity was studied by calculating Spearman's correlations between HAGOS subscales and subscales of the Hip disability and Osteoarthritis Outcome Score and EQ5D, based on 15 a priori set hypotheses of which at least 75% should be confirmed. Interpretability was deemed good when floor and ceiling effects were present in <15%.
Results: A Dutch version of the HAGOS was obtained. Its reliability was tested in 129 and validity in 194 participants. Test-retest reliability was good with intraclass correlations ranging 0.83-0.87. Internal consistency was good with Cronbach's alpha ranging 0.81-0.92. Construct validity was found good as 80% of the hypotheses were confirmed. Floor effects (21%) were found present for the Physical Activity subscale of HAGOS.
Conclusion: The Dutch HAGOS is a reliable and valid patient reported outcome and performs similar when compared to the original version in its target population. It can be used in clinical as well as research settings.

Introduction

Studying young active patients who experience pain or symptoms in their hip or groin region is a matter of current interest [1]. There is a paucity of well-documented high quality intervention studies and none of these use specific Patient-Reported Outcome questionnaires (PROs) in order to assess the patients perceived health status [2]. However, in patients undergoing hip arthroplasty surgery PROs are used, but these do not have sufficient content validity for young and active individuals with hip and groin problems.

PROs are currently considered the gold standard in the assessment of musculoskeletal conditions where the perspective of patients and health-related quality of life are of main interest [3, 4]. Recently the Copenhagen Hip and Groin Outcome Score (HAGOS) was developed [5]. The HAGOS specifically targets young to middle-aged, physically active individuals with hip and groin pain. The HAGOS consists of six separate subscales assessing: pain, symptoms, physical function in daily living, physical function in sport and recreation, participation in physical activities and hip and/or groin related quality of life [5]. The HAGOS was developed in accordance with the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) recommendations [6, 7]. The COSMIN checklist is a standardized tool, used to guide the design or report studies on measurement properties [8].

Before a PRO can be used to assess patients functioning, it should be translated towards the language of interest. The HAGOS is a Danish questionnaire, originally developed in Copenhagen [5]. It has been translated to other languages [5, 9, 10]. In a previous study the English version of the HAGOS was translated to Dutch and validated in a group of middle aged to older men undergoing abdominal hernia surgery [9]. This is however not the target population of this PRO. The procedures followed were not according international guidelines as translations and adaptations were neither made from the original language nor was this done in cooperation with the originators of the HAGOS [11]. As a result this version is not available on the 'KOOS website' and cannot be accessed.

The aim of this study was to translate and cross-culturally adapt the original HAGOS into Dutch language and validate this version in young and active individuals with hip and groin pain according to existing guidelines and the COSMIN checklist [6, 7, 11].

Materials and methods

Translation

The translation of the Danish HAGOS was performed according to existing guidelines [11]. An individual bilingual, medical health professional and a bilingual non-medical translator independently performed forward translation from Danish (DK) to Dutch (NL) language. A consensus meeting in which these two DK-NL versions were harmonized into a preliminary Dutch version was organized. In situations where differences between translators occurred, the English version, translated, harmonized and published in 2011 [5], was used to advise in the consensus process. This preliminary version was tested until data saturation was achieved in 10 physically active patients with hip and/or groin pain, for wording and understanding, by experienced health-professionals. The responses from patients and feedback from health professionals were evaluated and consensus was reached on cultural adaptations and rephrasing. A bilingual (fluent in Danish and Dutch language) non-medical translator translated HAGOS back into Danish. The original author (KT) of the HAGOS compa-

red the back-translation with the original Danish version. Comments of the original author were discussed in a point wise fashion with the bilingual translator.
Final adjustments were incorporated and consensus on the Dutch version of HAGOS was made between translators and the original author of HAGOS. Minor discrepancies were found on a few items concerning wording, understanding and phrasing. These were found to be small and were solved by consensus with the originator aiming for better patient understanding. All steps were documented. After this process face validity was thought acceptable. The Dutch version of HAGOS was then published at www.koos.nu and can be found in Appendix 1.

Study protocol

The validity and reliability of the Dutch version of the HAGOS was studied using the COSMIN criteria checklist [6, 7].
Besides undergoing physical clinical examination according to the Doha agreement [1] and completion of the Dutch version of the HAGOS, patients completed the Dutch Hip disability and Osteoarthritis Outcome Score [12] (HOOS-NL), the Dutch EuroQol 5D (EQ-5D) [13] and the Numeric Pain Rating Scale (NPRS) for average pain experienced, pain during sports and pain after sports participation [15]. Tegner activity scores [15] were used to assess current and pre-injury activity levels (See Appendix 2 for psychometric properties of the questionnaires used in this study). The questionnaires, except for the Tegner score, were used to establish construct validity. The Dutch HAGOS consists of 37 items, grouped in 6 subscales (Symptoms (S), Pain (P), ADL, Sports/Rec (SR), Physical Activity (PA) and Quality of Life (QoL)). The HOOS-NL contains 36 items, grouped in 5 subscales (P, S, ADL, SR and QoL). The EQ5D assesses 5 health levels (Mobility (M), Self Care (SC), Daily Activities (DA), Pain/Discomfort (P/D) and Anxiety/Depression (A/D)). Additionally overall health is rated on a 0-100 VAS scale and a total score can be calculated [16].
The HAGOS was reassessed after the initial assessment in order to establish test-retest reliability. An invitation to fill in the questionnaires was sent after 4 days. Anchor questions to check for changes in perceived health status between the two test occasions were used by assessing Global Perceived Effect (GPE, on a 7-point Likert scale) scores [17, 18]. Patients with a GPE of 3, 4, 5 (respectively scoring "slightly worse", "unchanged" or "slightly better score") at the second assessment were included for the test-retest reliability analysis as this was considered a non-clinically relevant change between the assessments [19]. Consequently patients with a GPE of 1 and 2 (respectively meaning "worse than ever" or "much worse") and 6 and 7 (respectively meaning "much improved" or "totally recovered") were excluded. Patients performed both assessments at home and were asked to do this under similar conditions, such as time of assessment and physical activities performed during the day of assessment. To optimize the response rate, patients were contacted by phone/text message/mail to remind them to complete the questionnaires for the second time, 5-7 days following the first completion.
This study complied with the requirements of the declaration of Helsinki [20]. The local medical ethics committee (Slotervaart Hospital / Reade, Amsterdam, The Netherlands) approved this study under number P1432. All patients signed informed consent before participation.

Population

A multicenter prospective cohort study was designed to test the translated Dutch version of HAGOS for its validity and reliability. The target population of the HAGOS consists of young to middle aged active individuals with hip and/or groin pain [5]. We therefore included patients who

1; presented themselves with hip or groin pain in one of the clinical settings (hospitals and centers for sports medicine and (sports) physical therapy in The Netherlands),

2; were aged 18-50 years,

3; were physically active (Tegner score >2) and

4; showed at least 1 positive hip or groin provocation tests 1 reproducing the patients pain and/or were evaluated after hip arthroscopy AND had hip or groin pain during or after sports (NPRS ≥1).

The clinical entity approach was used to categorize patients according to the Doha agreement [1]. Patients with a post-operative status were not physically examined. Patients were excluded when they were not fluent in Dutch or did not have access to a computer with Internet.

Questionnaires

All questionnaires were available for the patients through a web-based system with a self-checking function to avoid missing data on full completion and submission of the questionnaires. Patients who completed both assessments were included in the test-retest reliability analysis. When this study was performed the translation and validation the Dutch iHOT-33 was undertaken at the same time. The reassessment therefor comprised 102 questions. For the validity analyses a single set of data from the first assessment was used.

Reliability

Reliability of a PRO refers to the degree to which the questionnaire is free from measurement error [6, 7]. Test-retest reliability, internal consistency and measurement error were used to describe reliability [6, 7].

Test-retest reliability is the extent to which the same results are obtained on repeated measures when no change in clinical status has occurred. Patients in this study, except for those who had undergone hip surgery, were asked to complete the Dutch HAGOS twice. These assessments were performed independently, i.e. patients did not have any access to answers of the first assessment. Intraclass correlation coefficients (ICC) with 95% confidence intervals (CI) were calculated. An ICC of > 0.70 for every subscale was considered acceptable [21].

The HAGOS is considered a reflective model thus internal consistency was assessed [6, 7]. Internal consistency is the degree of interrelatedness among the items of a PRO. Cronbach's alpha is the coefficient that describes how well a set of items focuses on a single idea or construct [22]. Cronbach's alpha was determined to assess the internal consistency of the Dutch HAGOS subscales, based on the initial assessment data and was deemed good when Cronbach's alpha ≥ 0.70 [21]. A factor analysis can be performed to identify common components among sets of items and explain the degree of variance. A factor analysis for the subscales was performed with the eigenvalue set at > 1 to check that our translation did not affect the internal consistency of the original HAGOS.

Measurement error is the systematic and random error of a patient's score that is not attributed to true changes in the construct to be measured. This was analyzed by the standard error of the mean (SEM) and calculated according the formula: standard deviation (SD) x √1-ICC, the SD being the standard deviation from scores from all patients at the initial assessment. The smallest detectable change (SDC) was then calculated as SEM x 1.96 x √2 at an individual level (SDCind) and SEM x 1.96 x √2/√n at group level (SDCgroup) [23].

Validity

Validity of a PRO determines the degree to which the questionnaire measures the construct(s) it is assumed to measure [6,7].

Construct validity is the degree to which the scores of a PRO are consistent with hypotheses based on the assumption that the questionnaire validly measures the construct to be measured. This was considered when >75% (≥12/15) of the a priori set hypotheses were confirmed.

The subscale scores of the Dutch HAGOS were compared with the HOOS-NL, EQ-5D and NPRS scores. Spearman's correlation coefficients were calculated. All a priori expected correlations between scores can be found in Table 1. Strong correlations were defined as $r \geq 0.7$ (or $r \geq -0.7$, when a maximum achievable score of one scale correlates with a minimum achievable score on the comparative scale), moderate correlations were defined as $0.5 \leq r < 0.7$ (or $-0.5 \leq r < -0.7$) and weak correlations as $r < 0.5$ (or $r < -0.5$) [24]. As the development of HAGOS was based on the HOOS, similar subscales were expected to have high correlations except for QoL. This correlation was expected to be between 0.5 and 0.7 as the HAGOS QoL asks 2 questions on patients' mood and how much they feel restricted by their hip/groin, which will probably result in lower scores in the target population than HOOS QoL questioning on how patients trust their hip and general problems experienced. HAGOS P was expected to correlate strong with the average NPRS score. As the NPRS during and after sports specifically relates to sports, which is not the case for the HAGOS P subscale, we expected moderate correlations. The HAGOS PA score was expected to correlate weak with HOOS S and HOOS P as it is known that athletes may experience pain and symptoms but may tend to keep on playing sports. A moderate correlation between HAGOS P and EQ5D P/D was expected as EQ5D asks very generally for pain and discomfort and the HAGOS asks specific questions on recognizable situations. The same applied for HAGOS ADL and EQ5D DA. We also expected weak correlations between HAGOS PA and EQ5D M and EQ5D SC as the HAGOS PA specifically targets all activities that are preferred and the EQ5D specifically targets basic health issues regarding mobility and self care which are usually handled well by young active individuals with hip and groin pain.

Table 1 - Expected correlations (strong, moderate or weak) between scores at baseline as a priori set hypotheses.

Correlation between HAGOS P and	HOOS P	Strong
	EQ5D P/D	Moderate
	NPRS average	Strong
	NPRS during sports	Moderate
	NPRS after sports	Moderate
Correlation between HAGOS S and	HOOS S	Strong
	EQ5D P/D	Moderate
Correlation between HAGOS ADL and	HOOS ADL	Strong
	EQ5D DA	Moderate
Correlation between HAGOS SR and	HOOS SR	Strong
Correlation between HAGOS PA and	HOOS P	Weak
	HOOS S	Weak
	EQ5D M	Weak
	EQ5D SC	Weak
Correlation between HAGOS QoL and	HOOS QoL	Moderate

HAGOS/HOOS: P=Pain, S=Symptoms, ADL=Activities of daily living, PA=Physical activity, QOL=Quality of life.
EQ5D: M=Mobility, SC=Self Care, DA=Daily Activities, P/D=Pain/Discomfort and A/D=Anxiety/Depression.

Interpretability

Interpretability is the degree to which one can assign qualitative meaning - that is, clinical or commonly understood connotations – to an instrument's quantitative scores or change in scores [6,7]. This includes the distribution of scores and floor and ceiling effects. Floor and ceiling effects were determined as percentage of the patients with respectively the lowest (0) and highest (100) score HAGOS subscale. Floor and ceiling effects were considered present when more than 15% of the patients scored the lowest (0) or highest (100) maximum subscale score, based on the initial assessment of the HAGOS [21].

Statistical analysis

Descriptive statistics were used to calculate the demographic variables and outcomes of questionnaires. Data are presented as mean (± standard deviation (SD, range)) or as median (interquartile range 25% (IQR25)-interquartile range 75% (IQR75)). Reliability was established by calculating ICC's (type 3.1, two way mixed effects model for absolute agreement) and 95% confidence intervals. Unpaired t-tests and Mann-Whitney U tests were used to check for differences in age, physical activity levels (Tegner scores and hours of sports participation per week) and pain (NPRS) scores between the total group and the subgroup used for the reliability analyses. In order to check the a priori formulated hypotheses Spearman's correlations for non-parametric data were calculated. Statistical analysis was performed with IBM SPSS Statistics V.20 (Armonk, New York, USA). The α-level of significance was set at 0.05.

Results

Figure 1 represents a flow chart of the patient recruiting process, which took place from March 2015-April 2016. The characteristics of all participants at baseline are presented in Table 2.

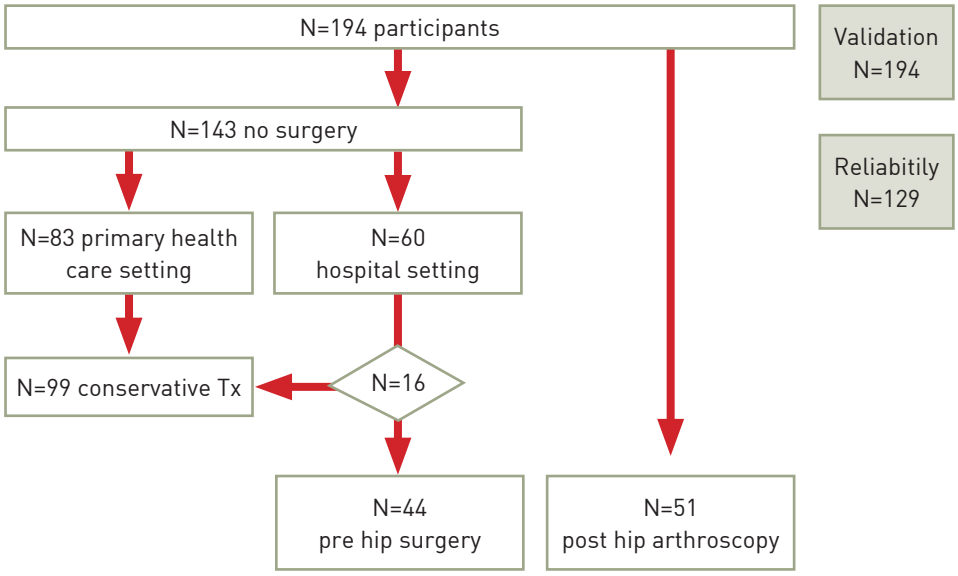

Figure 1 - Flowchart of the participating patients.

There were 194 patients who completed the first set of questionnaires so these could be used for validation purposes. Three major groups could be distinct;
1: patients that came for conservative treatment,
2: patients that were assessed pre-operatively,
3: patients that were assessed postoperatively. The most prevalent clinical entity in group 1 was 'adductor related groin pain followed by ilipsoas related groin pain either found in combination or as single entity.
The second questionnaire was returned by 140/143 patients (these 3 did not respond despite a reminder). There were no missing data. Of these 140, 129 reported no clinical relevant changes (a GPE score of 3, 4 or 5) whereas 11 did (2 patients scored a GPE 2, 9 patients scored a GPE 6) that were therefor excluded for reliability assessment. There were no differences between age, pain levels (NPRS) and activity levels (Tegner and hours of sports participation per week) between the total group (n=194) and those who were assessed for the reliability assessments (n=129, all $p>0.1$). The average time between both assessments was 7.3 (±4.5, range 4-26) days.

Table 2 - Participants' characteristics (n=194 for the total group; 108/194 males and 86/194 females)

Characteristic	Mean (±SD, range), median (IQR25-IQR75) or absolute numbers (%)
Age (years)	
Total	32 (9.1, 18-50)
Male	32 (8.7, 18-49)
Female	33 (9.6, 18-50)
Activity level (Tegner score)	
Pre-injury	
Total	6.5 (4-8.8)
Male	7 (6-9)
Female	4.5 (3-7)
Current	
Total	3 (2-6)
Male	5 (2-7)
Female	2 (1.75-4)
Hours sport/week	
Pre-injury	
Total	3.5 (2.0, 0-15)
Male	3.6 (1.8, 0-12)
Female	3.5 (2.3, 0-15)
Current	
Total	2.3 (2.0, 0-15)
Male	2.5 (1.7, 0-6)
Female	2.1 (2.3, 0-15)
Pain (NPRS)	
Average	
Total	4.7 (2.4, 1-9)
Male	4.4 (2.3, 1-8)
Female	5.0 (2.5, 1-9)
During Sport	
Total	6.5 (2.6, 1-10)
Male	6.5 (2.6, 1-10)
Female	6.5 (2.7, 1-10)
After Sport	
Total	6.8 (2.5, 1-10)
Male	6.7 (2.4, 1-10)
Female	6.9 (2.6, 1-10)

Clinical presentation participants without surgery (n=143)		
1 Clinical entities	No surgery (n=99)	Pre surgery (n=44)
Adductor related	56 (only Adductor 24)	8
Iliopsoas related	31 (only Iliopsoas 6)	8
Inguinal related	14 (only Inguinal 3)	2
Symphysis related	6 (only Symphysis 0)	1
• Mixed (>1) clinical entities	25	-
2 Hip		
Hip joint suspicion / related	41	42
• Mixed (hip + ≥1) clinical entity	26	17
3 Other	2	

Reliability

The HAGOS subscale scores on initial and re-assessment with corresponding ICC's of 129 patients are presented in Table 3. The internal consistency, assessed with Cronbach's alpha, for the HAGOS subscales ranged between 0.81-0.92 (see Table 4). The factor analysis showed that every subscale had one strong factor with an eigenvalue > 1 as in the original version of HAGOS explaining the degree of variance (see Table 4).

Table 3 - Descriptives and reliability measures for the HAGOS subscales.

Sub-scale	Test mean (SD)	Retest mean (SD)	ICC (95% CI)	SEM	SDCg	SDCi
Symptoms	59.7 (17.5)	61.0 (18.2)	0.86 (0.81-89)	6.5	1.5	18.0
Pain	64.7 (18.9)	64.7 (18.6)	0.87 (0.82-0.90)	6.8	1.6	18.8
ADL	69.0 (22.4)	69.3 (22.2)	0.84 (0.78-0.88)	8.9	1.1	24.6
Sports/ Recreation	48.9 (24.3)	51.0 (24.2)	0.83 (0.77-0.87)	10.0	2.3	27.7
Physical Activity	31.8 (28.1)	33.0 (27.9)	0.83 (0.77-0.87)	11.6	2.7	32.2
Quality of Life	41.2 (18.5)	43.5 (19.7)	0.87 (0.82-0.90)	6.7	1.6	18.6

ICC: Intra class correlation (95% confidence interval), SEM: Standard error of measurement, SDCg: Smallest detectable change for group level, SDCi: Smallest detectable change for individual level.

Table 4 - Internal consistency expressed by Cronbach's alpha, eigen-values and explained degree of variance in %.

Sub-scale	Calpha	EV	DoV (%)
Symptoms	0.81	3.3	47
Pain	0.90	5.3	53
ADL	0.88	3.4	68
Sports/ Recreation	0.92	5.2	64
Physical Activity	0.89	1.8	90
Quality of Life	0.83	3.0	60

Calpha: Cronbach's alpha; EV: eigen value ; DoV: degree of explained variance in %

Validity

Table 5 presents the Spearman's correlations between HAGOS and HOOS/EQ5D sub-scales. The a priori hypotheses were tested to study construct convergent (expected correlation between measures assessing same construct) and divergent (different constructs) validity. The correlations between HAGOS P and average pain in ADL (NPRS ADL), pain during sports and pain after sports were -0.71, -0.49 and -0.52 respectively. From the 15 a priori set hypotheses 12 (80%) were confirmed.

Table 5 - Spearman's correlations between HAGOS and HOOS/EQ5D (n=194).

HAGOS						
HOOS	Pain	Symptoms	ADL	Sports / Recreation	Physical Activity	Quality of Life
Pain	0.91^	0.72	0.80	0.73	0.43^	0.58
Symptoms	0.71	0.86^	0.68	0.66	0.29^	0.55
ADL	0.84	0.73	0.89^	0.69	0.41	0.58
Sports / Recreation	0.77	0.67	0.71	0.85^	0.49	0.56
Quality of Life	0.54	0.45	0.49	0.42	0.34	0.41*
EQ5D						
Mobility	-0.61	-0.56	-0.60	-0.61	-0.40^	-0.51
Self Care	-0.37	-0.39	-0.47	-0.41	-0.28^	-0.41
Daily Activities	-0.63	-0.50*	-0.58^	-0.54	-0.41	-0.60
Pain / Discomfort	-0.70*	-0.58^	-0.61	-0.52	-0.41	-0.60
Anxiety / Depression	-0.20	-0.21	-0.25	-0.15	-0.26	-0.38
VAS Health	0.51	0.48	0.47	0.41	0.37	0.46
Total / Utility	0.57	0.72	0.64	0.57	0.44	0.62

^ Represents matched hypotheses and * unmatched hypotheses. All $p<0.000$.

Interpretability

A floor effect in this group of patients was observed with 21.1% reporting a lowest possible score for the HAGOS Physical Activity subscale. See Table 6 for all data.

Table 6 - HAGOS subscale scores (for n = 194) at baseline with frequency of lowest (floor effect) and highest (ceiling effect) scores.

	Mean (SD)	Min - Max	Floor effect (%)	Ceiling Effect (%)
Symptoms	59.5 (18.5)	11.0-96.4	0.0	0.0
Pain	64.9 (19.4)	10.0-100.0	0.0	2.1
ADL	69.0 (23.8)	5.0-100.0	0.0	11.3
Sports and Recreation	49.9 (24.6)	0.0-100.0	0.5	3.6
Physical Activity	34.1 (28.5)	0.0-100.0	21.1	4.6
Quality of Life	43.4 (20.1)	5.0-100.0	0.0	2.1

Discussion

This study following the COSMIN checklist shows that the Dutch HAGOS is a reliable, internally consistent and valid measurement tool to assess physical functioning in young and active individuals with hip and groin pain.

Reliability

Test-retest reliability is good with all ICC's > 0.80. The SEM of the subscales ranged from 6.5-11.6. The SDC on group level ranges from 1.1-2.7 and on individual levels from 18.0-32.2. This is in line with the original HAGOS [5] that scores well in a recent review on quality assessment of PROs [4]. The SDC values show that the Dutch HAGOS, like the original HAGOS, is more sensitive to detect changes in groups than in individuals. The mean (7.3) number of days between first and second assessment being relatively low was a consequence of the choice of convenience to assess patients in primary health care, usually having their second appointment for treatment within a week. However it was considered adequate as the number of questions to be answered at that moment was 102, thereby reducing the chance of recall bias.
Cronbach's alpha, ranges from 0.81-0.92 for all subscales which is almost similar wto the original HAGOS [5] and somehow higher than that described for the Swedish version [10]. Every subscale had one strong factor, explaining the variance to a large extent, similar to both the original HAGOS [5] and the Swedish version [10].

Validity

The construct validity was found appropriate as >75% (≥12/15) of the predefined hypothesis was confirmed. The construct validity of HAGOS subscales were tested against the HOOS subscales. As the HAGOS was developed based on the HOOS it was not surprising that the same subscales showed strong correlations thus convergent construct validity was found. The EQ5D was used to test hypotheses on divergent construct validity, which were confirmed. We chose to use the EQ5D to decrease patient burden as it contains a lower number of questions than the SF-36 [25] which is often used for validation purposes. The Pain subscale of HAGOS was expected to correlate strong with the average NPRS, which was confirmed. It was thought to show a moderate correlation with pain during and after sports. With correlations of 0.49 and 0.52 these were weak to moderate. We therefore propose to assess pain during and after sports separately together with the HAGOS when the clinician finds these variables worthwhile.

Interpretability

Floor or ceiling effects, defined present when >15% of the scores were lowest or highest as possible for a subscale, were found to be present as 21% scored a floor effect in the Physical Activity subscale. There was no ceiling effect observed. According to the COSMIN checklist floor and ceiling effects should not be present because patients can then not change anymore in that same direction (better or worse). As the HAGOS does not have a total score but separate subscales it can be questioned how much of a problem this is. It has been stated that this floor effect lowers the psychometric quality of the HAGOS [26]. On the contrary it is clinically observed that while patients' symptoms decrease, it takes time to re-participate on the pre-injury level. Until that moment the PA subscale, while other scales improve, distinct those being much-somehow restricted from those who are free of symptoms, fit and non-restricted [27]. This may yield clinically relevant information as return to sports and return to play are hard to define along strict criteria [28]. To what specific extent the PA subscale aids on this issue should be examined in further studies [27].

Observation of the subscale scores of this population it is obvious that the SR, PA and QoL scores are lower than those of other domains. The population studied experiences less problems in their daily life, as reflected by ADL scores that are the highest from all domains. This shows that the population that was identified through the inclusion criteria was the right group for this validation study: young and active being troubled and restricted by hip and groin pain Them feeling more restricted in sports and recreation (SR subscale) than in ADL strengthens the population criteria being physically active. These same findings were observed in the original study describing the development of the HAGOS and in the Swedish translation and validation study [10]. In a study on older patients who had undergone inguinal disruption surgery this was not observed [9]. The floor effect that we have found for the PA subscale in the current study was also found in the validation of the original HAGOS [5] as well as the Swedish validation study [10] but not in the study of Brans et al.[9] on older subjects. This shows the importance and eventual differences in outcomes of validations studies of PRO's in different populations.

Limitations

We acknowledge some limitations of this study. The electronic questionnaire system only allowed submission when data were complete. This may result in bias as data from those not fully completing a questionnaire could not be used for analyses. We do however not know if and how this may have affected the data.

Furthermore, we used the Tegner scale, originally designed to assess levels of physical activity in patients with knee injury [15], to address activity levels pre and post injury. The Tegner scale shows adequate construct validity [29]. Just after finishing the preparations for the current study, the Hip Sports Activity Scale (HSAS) was published [30]. This English activity rating scale was not available in Dutch language at that time.

Conclusion

The Dutch HAGOS is a reliable and valid patient reported outcome as tested in a group of young and active patients in primary healthcare setting and in those following hip arthroscopy. It can be used in clinical as well as research settings.

Acknowledgements

We are grateful to all patients who participated.

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Appendix 1 - Dutch version of HAGOS as validated in this study.

HAGOS

Vragenlijst betreffende heup en/of lies problemen

Datum vandaag:_____/_____/_____ **Geboortedatum:**_____/_____/_____

Naam:_____

INSTRUCTIES: Deze vragenlijst vraagt naar uw mening over het functioneren van uw heup en/of lies. Geef aan hoe uw heup en/of lies de **afgelopen week** gefunctioneerd heeft. Deze informatie helpt ons bij te houden hoe u zich voelt en hoe goed u in staat bent om uw normale activiteiten uit te voeren.

Beantwoord alle vragen door het juiste hokje aan te kruisen. Kruis per vraag één hokje aan bij het antwoord dat het meest op u van toepassing is. Als een vraag geen betrekking heeft op u of u het gevraagde niet ervaren heeft in de afgelopen week, maak dan een keuze welk antwoord het meest van toepassing zou zijn.

Symptomen

Deze vragen betreffen symptomen van uw heup en/of liesklachten en de beperkingen daarbij gedurende de afgelopen week en welke moeite u heeft ervaren.

S1 Voelt u ongemak in uw heup en/of lies?

Nooit	Zelden	Af en toe	Vaak	Altijd
☐	☐	☐	☐	☐

S2 Hoort u klikken of andere geluiden in uw heup of lies?

Nooit	Zelden	Af en toe	Vaak	Altijd
☐	☐	☐	☐	☐

S3 Heeft u er moeite mee om uw benen zijwaarts ver naar buiten te brengen?

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

S4 Heeft u moeite met het nemen van volledige passen tijdens het lopen?

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

S5 Ervaart u plotselinge scheuten/steken in uw heup en/of lies?

Nooit	Zelden	Af en toe	Vaak	Altijd
☐	☐	☐	☐	☐

Stijfheid

De volgende vragen hebben betrekking op de mate van stijfheid in uw heup en/of lies. Stijfheid geeft beperkingen bij op gang komen of is een gevoel van beperking of ongemak waarmee u de heup en/of lies beweegt. Geef aan in welke mate u stijfheid heeft ervaren in uw heup en/of lies gedurende de afgelopen week.

S6 **Hoe erg is de stijfheid van uw heup en/of lies 's morgens bij het wakker worden?**

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

S7 **Hoe erg is de stijfheid van uw heup en/of lies na zitten, liggen of rusten later op de dag?**

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

Pijn

P1 **Hoe vaak is uw heup en/of lies pijnlijk?**

Nooit ☐ Maandelijks ☐ Wekelijks ☐ Dagelijks ☐ Altijd ☐

P2 **Hoe vaak heeft u pijn in gebieden, anders dan de heup en/of lies, waarvan u denkt dat ze wel met de heup en/of lies klachten te maken hebben?**

Nooit ☐ Maandelijks ☐ Wekelijks ☐ Dagelijks ☐ Altijd ☐

De volgende vragen hebben betrekking op de mate van pijn in de afgelopen week in uw heup en/of lies. Geef de mate van pijn aan die u ervaart tijdens de volgende activiteiten?

P3 **Het volledig naar achteren strekken van de heup**

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

P4 **Uw heup zo ver mogelijk buigen**

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

P5 **Trap op of af lopen**

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

P6 **' s Nachts terwijl u in bed ligt (pijn die uw slaap verstoort)**

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

P7 **Zitten of liggen**

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

De volgende vragen hebben betrekking op de mate van pijn in de afgelopen week in uw heup en/of lies. Geef de mate van pijn aan die u ervaart tijdens de volgende activiteiten?

P8 Staan

Geen ☐ Beetje ☐ Matig ☐ Veel ☐ Heel veel ☐

P9 **Lopen op een harde ondergrond (asfalt, beton, etc)**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

P10 **Lopen op een oneffen ondergrond**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

Lichamelijk functioneren, dagelijks leven.

De volgende vragen hebben betrekking op uw fysieke functioneren. Geef voor elke activiteit aan hoeveel moeite u ermee heeft gehad in de afgelopen week door uw heup en/of lies problemen.

A1 **Trap op lopen**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

A2 **Voorover buigen (iets oppakken vanaf de grond)**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

A3 **In en/of uit de auto stappen**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

A4 **In bed liggen (draaien in bed of het langdurig met uw heup in dezelfde houding liggen)**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

A5 **Zwaar huishoudelijk werk (vloeren boenen, stofzuigen, zware dozen tillen, etc)**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

Functie, sport en vrije tijd

De volgende vragen hebben betrekking op uw fysieke vermogen. Beantwoord alle vragen door het juiste hokje aan te kruisen. Als een vraag geen betrekking heeft op u of u het niet ervaren heeft in de afgelopen week, maak dan een keuze welk antwoord het beste past. Geef aan hoeveel moeite u heeft ervaren in de afgelopen week door uw heup en/of lies problemen bij de volgende activiteiten.

SP1 **Hurken**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

SP2 **Rennen**

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

SP3 Draaien/wenden keren als u staat op het been.

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

SP 4 Lopen op een oneffen ondergrond

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

SP5 Rennen zo snel als u kunt

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

SP6 Het been krachtig naar voren en/of naar de zijkant bewegen, als bij trappen en schaatsen, etc.

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

SP7 Plotselinge explosieve bewegingen met snel voetenwerk zoals versnellen, remmen, richtingsveranderingen, etc.

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

SP8 Situaties waarin het been zover mogelijk gestrekt wordt in een uiterste stand (als dat het been zover mogelijk van het lichaam af gebracht wordt)?

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

Participatie in fysieke activiteiten

De volgende vragen hebben betrekking op uw mogelijkheid tot deelname aan uw favoriete activiteiten. Fysieke activiteiten zijn zowel sporten als andere inspannende activiteiten. Geef aan hoeveel moeite u heeft ervaren bij deelname in uw favoriete activiteiten in de afgelopen week door uw heup en/of lies problemen.

PA1 Bent u in staat om de door u gewenste activiteiten te doen zo lang als u zou willen?

Altijd	Vaak	Soms	Zelden	Nooit
☐	☐	☐	☐	☐

PA2 Bent u in staat om deel te nemen aan de gewenste fysieke activiteiten op uw normale prestatieniveau?

Altijd	Vaak	Soms	Zelden	Nooit
☐	☐	☐	☐	☐

De kwaliteit van het leven

Q1 Hoe vaak bent u zich bewust van uw heup en/of lies problemen?

Nooit	Maandelijks	Wekelijks	Dagelijks	Altijd
☐	☐	☐	☐	☐

Q2 Heeft u uw manier van leven aangepast om activiteiten te vermijden die potentieel schadelijk zijn voor uw heup en/of lies?

Helemaal niet	Beetje	Matig	Veel	Volledig
☐	☐	☐	☐	☐

Q3 Hoeveel problemen heeft u in het algemeen van uw heup en/of lies?

Geen	Beetje	Matig	Veel	Heel veel
☐	☐	☐	☐	☐

Q4 Beïnvloeden uw heup en/of lies problemen uw stemming op een negatieve manier?

Helemaal niet	Zelden	Soms	Vaak	Altijd
☐	☐	☐	☐	☐

Q5 Voelt u zich beperkt door uw heup en/of lies problemen?

Helemaal niet	Zelden	Soms	Vaak	Altijd
☐	☐	☐	☐	☐

Bedankt voor het beantwoorden van alle vragen!

Appendix 2 – Psychometric properties of used questionnaires

The Dutch Hip Osteoarthritis Outcome Score (HOOS-NL)

The HOOS-NL was tested for its validity and reliability. The HOOS_NL was compared with subscales of the RAND-36, Oxford Hip Score (OHS) and Visual Analogue Scale (VAS) for pain. Correlations for comparable domains were; pain r=0.76/0.75, Activities of daily living r=0.68/0.72. Correlations between HOOS subscales and OHS were r= -0.62 and -0.88. Subscale for pain correlated with VAS pain scores r= -0.76 en -0.68. Test-retest reliability (ICC) was 0.75 - 0.97 (CI=95%) on group level. The standard error of the mean (SEM) was between 3.71 – 10.07 for all subscales.

EQ-5D-5L

The test-retest reliability of the EQ-5D-5L revealed ICC's of 0.77.
Validity analyses revealed r=0.53 (range 0.48-0.58, $p<0.0001$) for the sum scores when compared to the World Health Organisation 5 Well Being Questionnaire (WHO-5). SEM and SDC were not reported.

Numeric Pain Rating Scale

The ICC for test-retest reliability was high: 0.97-0.99. The construct validity was tested and found good with a correlation of r=0.94 (95% CI: 0.93-0.95).

Tegner score

The Tegner score has been found reliable (ICC=0.97, CI=95%), showed acceptable criterion validity and construct validity (r=0,66).
The Tegner score showed acceptable floor and ceiling effects and responsiveness to change.

6

CHAPTER 6

Translation, cross-cultural adaptation and validation of the Dutch international Hip Outcome Tool-33 (iHOT-33) according to the COSMIN checklist in young physically active individuals with symptomatic hip joint pathology.

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Accepted for publication by the Journal of Orthopaedic & Sports Physical Therapy, August 2017.

Abstract

Study design: Prospective cohort.
Background: The International Hip Outcome Tool 33 (iHOT-33), developed in English, has been shown to be a valid, reliable questionnaire for young physically active individuals with hip joint pathology.
Objectives: Translate and validate the iHOT-33 in Dutch in the target population.
Methods: Translation and cross-cultural adaptation of the iHOT-33 was performed following existing guidelines. Young (18-50 years), active (Tegner score ≥ 3) individuals presenting with symptomatic hip joint pathology (Numeric Pain Rating Score (NPRS) ≥ 1) in primary healthcare/hospital setting were included. The iHOT-33, Hip disability and Osteoarthritis Outcome Score, EuroQol 5D, NPRS and Global Perceived Effect score were completed by 214 patients. Reliability was determined based on internal consistency and measurement error in 214 patients, test-retest reliability in a subgroup of 133 patients. Hypothesis testing was used to determine construct validity. Interpretability was analyzed by distribution of scores, floor and ceiling effects and minimal important change (MIC).
Results: Intraclass correlation coefficient (ICC) for test-retest reliability was 0.92. Smallest detectable change at individual and group level respectively were 16.69 and 1.14 points. Cronbach's alpha was 0.9. Principal component analysis revealed four domains of the iHOT-33 NL. Eighty-seven percent of the hypotheses used for construct validity were confirmed. No floor and ceiling effects were detected for the iHOT-33 NL total score. The MIC was 10.65 points.
Conclusion: The iHOT-33 NL is a reliable and valid patient-reported outcome questionnaire for young physically active individuals with symptomatic hip joint pathology. It can be used in research and clinical settings.
Keywords: patient-reported outcome, groin pain, quality of outcome measures.

Introduction

Hip joint pathology is a common cause of hip pain and dysfunction [1]. Historically, hip joint pathology often referred to osteoarthritis of the hip in an older population [2, 3]. Over the past decade, the number of studies of hip joint pathology in young physically active individuals has increased rapidly [4, 5]. Typical diagnoses in this population are femoroacetabular impingement (FAI), acetabular labral tears, cysts and chondral damage [1, 6]. However, there is a lack of high quality intervention studies for this population and only few intervention studies use specific Patient-Reported Outcome questionnaires (PROs) [7, 8].

Patient-Reported Outcome questionnaires are currently considered the gold standard in the assessment of musculoskeletal conditions where the patients perspective and health-related quality of life are of main interest [9]. Until recently, there has been a lack of PROs for young physically active individuals with hip and groin pain [10, 11]. A systematic review into the clinimetric properties of PROs to be used for this population identified only four questionnaires that can be recommended: the Hip And Groin Outcome Score (HAGOS), the Hip Outcome Score (HOS) and the international Hip Outcome Tool – 12 (iHOT-12) and – 33 (iHOT-33) [10].
The iHOT-33 is the only questionnaire specifically developed for young active individuals with different types of hip joint pathology, which has been advised to use in both research and clinical settings [12]. Earlier studies have shown that the original English version of the iHOT-33 is valid and reliable for use in a population of young physically active individuals with symptomatic hip joint pathology [10, 12-15]. In order to use the iHOT-33 in research and/or clinical settings in the Netherlands the aim of this study was to translate and cross-culturally adapt the iHOT-33 into Dutch language and validate this version in young and active individuals with symptomatic hip joint pathology according to existing guidelines and the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) checklist.

Methods

Translation & Cross-cultural adaptation

The translation of the English iHOT-33 was performed according to existing guidelines [16]. Forward translation of the English version of the iHOT-33 (EN) into Dutch (NL) was performed by two native bilingual Dutch translators who worked independently from each other (one medical healthcare professional and one non-medical translator). Both these EN-NL versions were compared and synthesized into one preliminary Dutch iHOT-33 version in a consensus meeting. In situations where differences between translators occurred, the original English version [12] was used to advise in the consensus process. This preliminary Dutch version of the iHOT-33 (iHOT-33 NL) was tested by experienced healthcare professionals in the target population, 10 physically active patients with hip and/or groin pain. These patients were encouraged to make comments with their answers. Comments and responses from the patients and healthcare professionals were evaluated and consensus was reached on rephrasing and cultural adaptations. The preliminary Dutch version of the iHOT-33 (iHOT-33 NL) was then translated back into English by an independent native English non-medical translator who was bilingual and had no knowledge of the study objectives or design. This translation was subsequently compared with the original questionnaire by an expert committee consisting of medical healthcare professionals (IT, T, R, MT).

Minor discrepancies between these two versions of the iHOT-33, the original version and backward translation, were found concerning wording, understanding and phrasing. These discrepancies were found to be small and were discussed, solved and adjusted within the expert committee aiming for better patient understanding. After this process, face validity, the degree to which the questionnaire looks as though it reflects the measured construct, was thought acceptable. Permission for the translation and cross-cultural adaptation was obtained from the originator of the iHOT-33 (personal communication with dr. N. Mohtadi). Appendix 1 contains the iHOT-33 NL final version.

Study protocol

A multicenter prospective cohort study was performed to test the validity and reliability of the Dutch iHOT-33 NL based on the COSMIN checklist [17]. The COSMIN checklist is a standardized tool, used to guide the design and/or reporting of studies on measurement properties of PROs [18].

All patients were clinically evaluated using Dutch versions of the iHOT-33, the Hip disability and Osteoarthritis Outcome Score (HOOS) [19], the EuroQol 5D (EQ-5D) 20 and three Numeric Pain Rating Scales (NPRS) [21] for average pain experienced, pain during sports and pain after sports participation. These questionnaires (in this order) were used to establish construct validity. Tegner Activity scores were used to assess current and pre-injury activity levels [22].

The iHOT-33 NL was repeated within seven days after the initial assessment in order to establish test-retest reliability. All patients performed both assessments at home. Patients were asked to perform these assessments under similar conditions, such as time of assessment and physical activities performed during the day of assessment. The order in which patients answered the questionnaires was the same for both assessments. To optimize the response rate, patients were contacted by phone, text message or mail to remind them to complete the questionnaires for the second time, five to seven days following the first completion. This study was performed in line with the requirements of the declaration of Helsinki [23]. The local medical ethics committee (Slotervaart ziekenhuis/ Reade Amsterdam) approved this study under number P1432. All patients signed informed consent before participation.

Study population

The target population of the iHOT-33 is young active individuals with hip joint pathology [12]. Therefore, we included all patients who;

1) presented themselves with hip and/or groin pain at one of the clinical settings (hospitals and centers for sports medicine and (sports) physical therapy in the Netherlands);
2) were between 18 and 50 years of age;
3) were physically active (pre-injury Tegner Activity Scale $\geq$ 3) [22];
4) were scheduled for conservative or operative treatment of intra-articular hip pathology based on physical examination and imaging (see Appendix 2) [24-26]; and/or
5) were evaluated after hip arthroscopy AND still reported pain (NPRS $\geq$ 1) of the hip and/or groin during or after sports.

The physical examination was based on the Doha agreement meeting on terminology and definitions in groin pain in athletes combined with earlier studies [24-26]. Patients with a postoperative status were not physically examined. Patients who; 1) were not

fluent in Dutch; and/or 2) did not have access to a computer with internet were excluded from the study. The minimum number of patients to be included in this studies validity and reliability analysis was a priori set at, n = 165, based on the criteria of the COSMIN checklist [17].

Questionnaires

The iHOT-33 NL is a disease-specific questionnaire that consists of 33 questions grouped in four domains, namely symptoms and functional limitations (S), sports and recreational physical activities (SR), job-related concerns (W) and social, emotional, and lifestyle concerns (QoL) [12]. The iHOT-33 NL does not score the four domains separately. An overall score is calculated by taking the mean of the individual responses based on a Visual Analogue Scale (VAS) ranging from 0 to 100 in which 100 is the best possible score [12]. Higher scores thus reflect better physical functioning and health-related quality of life [19].

The HOOS-NL was initially developed for an older population with hip osteoarthritis and contains 36 questions, grouped in five subscales (pain (P), symptoms (S), activities of daily life (ADL), sports/recreational activities (SR) and quality of life (QoL) [19]. No overall score is calculated; every question is scored based on a 5-point Likert score in which a higher score represents less symptoms. A final score per domain is calculated with zero being the worst and 100 (no symptoms) being the best possible score [19].

The EQ-5D assesses general experienced health status in five levels (mobility (M), self care (SC), daily activities (DA), pain/discomfort (P/D) and anxiety/depression (A/D) on a 3-point scale [20]. Additionally, overall health is related on a 0-100 Visual Analogue Scale (VAS) and a total score can be calculated [27].

The NPRS assesses experienced pain on a scale consisting of 11 numbers from zero to 10 in which zero represents no pain and 10 represents the worst pain one can imagine [21]. The patient is asked to choose a level of pain concurrent with the pain felt during the last week, during sports activities or after sports activities [21].

All included questionnaires were made available to patients by means of a web-based system with a self-checking function to avoid missing data on full completion and submission of the questionnaires. Therefore patients had no option but to answer all questions per assessment and there were no missing data per questionnaire. For the validity analysis all completed questionnaires from the first assessment were used. Patients who failed to complete the first assessment were excluded from the validity analyses. Patients who failed to fully complete the second assessment were excluded from the test-retest reliability analysis (see Figure 1). As this study was part of the translation and validation of the Dutch Hip And Groin Outcome Score (HAGOS NL) as well the assessments comprised of 102 questions.

Statistical analysis

All statistical analysis were performed with IBM SPSS Statistics version 22.0 (Armonk, New York, USA). Descriptive statistics were used to calculate the demographic variables and outcomes of questionnaires. Significance level was set at 0.05.

Reliability

The reliability of a PRO indicates the degree to which the questionnaire is free from measurement error and is analyzed by test-retest reliability, internal consistency and measurement error [28].

Test-retest reliability is the extent to which the same results are obtained on repeated administrations of the same PRO when no change in clinical status has occurred [28]. Patients in this study were asked to complete the iHOT-33 NL twice. These assessments were performed independent of each other, i.e. patients were not able to access answers of the first assessment. Global Perceived Effect (GPE, on a 7-point Likert scale) scores were used to check for changes in perceived health status between the two test occasions [29, 30]. Patients with a GPE score of three to five (referring to a 'slightly worse', 'unchanged' or 'slightly better' health status) at the second assessment were included for the test-retest reliability analysis as this was, a priori, considered a non-clinically relevant change between assessments [31]. All patients with a GPE score of one, two, six or seven were consequently excluded from test-retest analysis [31]. Test-retest reliability was assessed by means of intra-class correlation coefficients (ICC) (two-way random effects model, absolute agreement) with 95% confidence intervals [32]. An ICC of > 0.70 was considered acceptable [32]. Unpaired t-tests and Mann-Whitney U tests were used to check for differences in age, physical activity levels (Tegner scores and hours of sports participation per week) and pain (NPRS) scores between the total group and the subgroup used for the reliability analyses.

The iHOT-33 NL is considered a reflective model [17]. Therefore, internal consistency, the degree of interrelatedness among the items of a PRO was assessed using Cronbach's alpha [33]. Conbrach's alpha was based on the initial assessment and was deemed good if ≥ 0.8 and excellent if ≥ 0.9 [32].

A principal component analysis to identify common components among sets of items and explain the degree of variance was performed for the four subscales to check that our translation did not affect the internal consistency of the original iHOT-33 [32]. This analysis was based on data from the initial assessment and was performed with varimax rotation and the eigenvalue set at > 1.

Furthermore, the measurement error, that is the systematic and random error of a patient's score that is not attributed to true changes in the construct to be measured, was analyzed by the standard error of the mean (SEM), calculated by the formula: SD x $\sqrt{1}$-ICC [28], where the SD is the standard deviation from scores from all patients at the initial assessment. The smallest detectable change (SDC) was then calculated as SEM x 1.96 x $\sqrt{2}$ at an individual level (SDCind) and SEM x 1.96 x $\sqrt{2}/\sqrt{n}$ at group level (SDCgroup) [34].

Validity

The validity of a PRO determines the degree to which the questionnaire measures the construct(s) it purports to measure [28]. The construct validity refers to the extent to which scores on a particular measure relate to other measures, consistent with theoretically derived hypotheses concerning the constructs that are being measured [28]. Fifteen hypotheses between the iHOT-33 NL, HOOS NL, EQ-5D NL and NPRS were a priori formulated in order to test construct validity which was considered good when $> 75\%$ (11) were confirmed (see Table 1) [32]. Spearman's correlation coefficients for nonparametric data were used to check the a priori formulated hypotheses in the construct validity analysis. Strong correlations were defined as $r \geq 0.7$ (or $r \geq -0.7$ when a maximum achievable score of one scale correlates with a minimum achievable score on the comparative scale), moderate correlations were defined as $0.5 \leq r < 0.7$ (or $-0.5 \leq r < -0.7$) and weak correlations as $r < 0.5$ (or $r < -0.5$) [35].

Interpretability

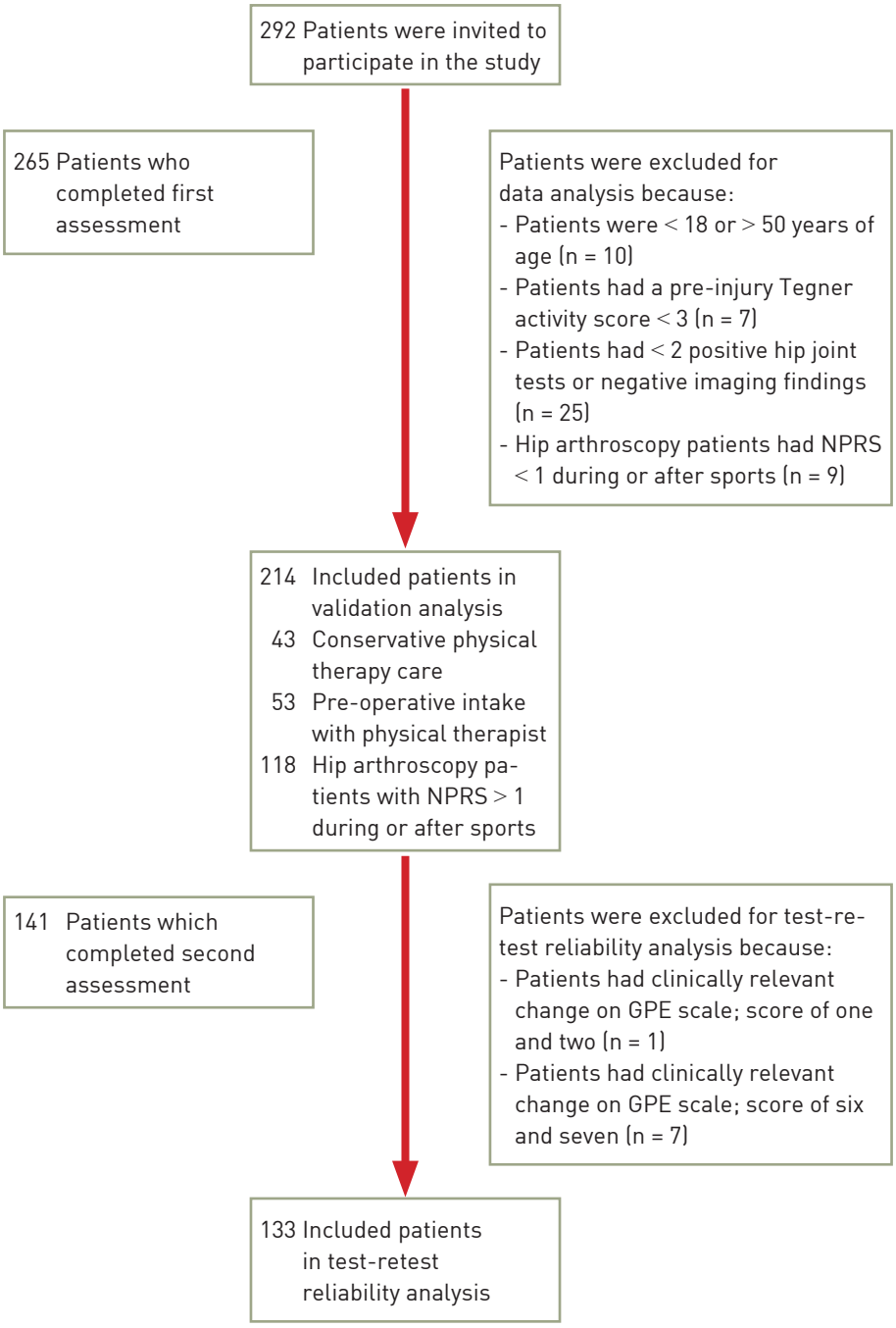
Interpretability is the degree to which one can assign qualitative meaning - that is, clinical or commonly understood connotations – to an instrument's quantitative scores or change in scores [28]. This includes the distribution of scores, floor and ceiling effects and an estimation of the minimal important change (MIC) [32].

Floor and ceiling effects were determined as percentage of the patients with respectively the lowest (0) and highest (100) maximum score of the iHOT-33 NL. The presence of floor and ceiling effects was considered if more than 15% of the patients respectively scored, the lowest (0) or highest (100) maximum score, based on the initial assessment of the iHOT-33 NL [32]. The MIC was calculated as 0.5 x SD [36], where the SD is the standard deviation from scores from all patients at the initial assessment.

Results

Figure 1 represents a flow chart of the patient inclusion process, which took place from March 2015 to August 2016. There were 214 patients who fully completed the first assessment and could be included in the validation analysis. Three major groups could be distinguished: 1) patients that came for conservative treatment (n = 43); 2) patients that were assessed pre-operatively (n = 53); 3) patients that were assessed postoperatively (n = 118).

A total of 141 patients returned the second assessment. Of these 141 patients, 133 reported no clinical relevant change (a GPE score of three, four or five). One patient scored a GPE of two, seven patients scored a GPE of six and these were excluded for test-retest reliability assessment. The characteristics of all included patients at baseline are presented in Table 2. There were no significant differences between age, pain levels and activity levels between the total group (n = 214) and those who were in the reliability assessments (n = 133) (all $p > 0.75$). The average time between both assessments was 8.53 days (range 1 – 23, SD 8.69).



NPRS: Numeric Pain Rating Scale. GPE: Global Perceived Effect scale.

Figure 1 - Flow chart of patient in- and exclusion.

Table 1 - A priori set hypotheses and actual Spearman's correlation coefficients for the iHOT-33 NL compared to the HOOS NL, EQ-5D NL and NPRS (n = 214).

	HOOS NL				
Subscales	**Pain**	**Symptoms**	**ADL**	**Sports/ Recreation**	**Quality of life**
iHOT-33 NL					
a priori	≥0.70	≥0.70	0.5≤r<0.7	≥0.70	0.5≤r<0.7
actual correlation	0.76*	0.69*	0.75*	0.75*	0.53*

	EQ-5D NL						
Subscales	**Mobility**	**Self-Care**	**Usual activities**	**Pain/ Dis-comfort**	**Anxiety/ Depres-sion**	**Health score**	**Overall score**
iHOT-33 NL							
a priori	-0.5≤r<-0.7	<-0.50	-0.5≤r<-0.7	-0.5≤r<-0.7	<-0.50	-0.5≤r<-0.7	-0.5≤r<-0.7
actual correlation	-0.65*	-.035*	-0.60*	-0.63*	-0.40*	-0.58*	-0.52*

	NPRS		
Questionnaires	**NPRS Average**	**NPRS During sport**	**NPRS After sport**
iHOT-33 NL			
a priori	-0.5≤r<-0.7	-0.5≤r<-0.7	-0.5≤r<-0.7
actual correlation	-0.68*	-0.56*	-0.64*

HOOS NL: Hip disability and Osteoarthritis Outcome Score. iHOT-33 NL: international Hip Outcome Tool. EQ-5D NL: EuroQol 5D. NPRS: Numeric Pain Rating Scale. ADL: activities of daily living. *: correlations were statistically significant with $p \leq 0.05$

Table 2 - Baseline characteristics of included patients (n = 214).

Characteristics	Mean (±SD), median (IQR25-IQR75) or absolute numbers (percentages)
Total number of included patients	214 (100%)
Male	108 (50.5%)
Female	106 (49.5%)
Age (years)	
Total	32.73 (±8.92)
Male	32.16 (±8.89)
Female	33.32 (±8.97)
Affected hip	
Left	114 (53.3%)
Right	100 (46.7%)
Pain (NPRS)	
Average	
Total	4.67 (±2.47)
Male	4.50 (±2.25)
Female	5.03 (±2.65)
During sport	
Total	6.32 (±2.66)
Male	6.34 (±2.51)
Female	6.30 (±2.74)
After sport	
Total	6.65 (±2.54)
Male	6.56 (±2.54)
Female	6.74 (±2.65)
Tegner Activity Scale	
Pre-injury	
Total	6 (4 – 8)
Male	7 (5 – 9)
Female	4 (3 – 7)
Current	
Total	3 (2 – 6)
Male	4 (2 – 6.75)
Female	2.5 (1 – 4)
Sport (hours/week)	
Pre-injury	
Total	3.29 (±2.08)
Male	3.43 (±1.87)
Female	3.16 (±2.18)
Current	
Total	2.10 (±1.85)
Male	2.35 (±1.52)
Female	1.85 (±2.10)

SD: standard deviation. IQ: interquartile range 25%-75%. NPRS: Numeric Pain Rating Scale.

Reliability

The iHOT-33 NL initial test scores, retest scores and the reliability analyses results are presented in Table 3. Wilcoxon's paired test revealed no statistically significant difference between the test and retest scores ($0.06 \leq p \geq 0.97$), except for questions 16 ($p = 0.00$) and 18 ($p = 0.01$). The principal component analysis revealed that the four iHOT-33 NL subscales each had one strong factor with an eigenvalue > 1 as in the original iHOT-33 explaining the degree of variance (see Table 4).

Table 3 - Reliability analysis of the iHOT-33 NL (n = 133, n = 214).

Questionnaire	Test mean (± SD)	Retest mean (± SD)	Difference-mean test retest (±SD)	P	SEM	ICC (95% CI)	SDC ind	SDC grp	Cronbach's alpha
iHOT-33 NL	46.77	46.30 (± 20.1)	0.47 (± 22.8)	0.66 (± 11.9)	6.02	0.92 (0.88 – 0.94)	16.69	1.14	0.90

iHOT-33 NL: international Hip Outcome Tool. SD: standard deviation. SEM: standard error of the mean. ICC: intraclass correlation coefficient. 95% CI: 95% confidence interval. SDC ind: smallest detectable change at individual level. SDC grp: smallest detectable change at group level.

Table 4 - Internal consistency of the four subscales of the iHOT-33 NL based on principal component analysis (n = 214).

iHOT-33 NL	Cronbach's alpha	Eigen value	Degree of variance explained in %
Symptoms and functional limitations	0.95	9.04	56.48
Sports and recreational physical activities	0.91	3.68	61.29
Job-related concerns	0.85	3.14	78.55
Social, emotional and lifestyle concerns	0.91	3.68	52.58

iH6OT-33 NL: international Hip Outcome Tool.

Validity

Spearman's correlation coefficients between the iHOT-33 NL, HOOS NL, EQ-5D NL and NPRS are presented in Table 1. All a priori formulated hypotheses were tested and 13/15 (87%) were confirmed.

Interpretability

The distribution of the scores of all questions of the iHOT-33 NL at baseline and the MIC are presented in Table 5. No floor and ceiling effects were present in this study population with regard to the iHOT-33 NL total score. One question showed a floor effect (15.89%) and two showed ceiling effects (15.42 – 21.03%). The MIC of the total iHOT-33 NL score was 10.65 points.

Table 5 - Distribution of scores of the iHOT-33 NL with floor and ceiling effects and minimal important change (n = 214).

Question	Test mean (± SD)	Range	Floor effect (%)	Ceiling effect (%)	MIC
Q1	34.55 (± 28.72)	0 – 100	17 (7.05%)	3 (1.40%)	14.36
Q2	46.96 (± 29.42)	0 – 100	8 (3.74%)	14 (6.54%)	14.71
Q3	41.91 (± 32.31)	0 – 100	15 (7.01%)	17 (7.05%)	16.16
Q4	55.48 (± 30.62)	0 – 100	3 (1.40%)	32 (14.95%)	15.31
Q5	43.79 (± 31.96)	0 – 100	10 (4.67%)	16 (7.48%)	15.98
Q6	53.76 (± 30.76)	0 – 100	2 (0.94%)	26 (12.15%)	15.38
Q7	51.68 (± 29.42)	0 – 100	2 (0.94%)	20 (9.35%)	14.71
Q8	57.71 (± 33.52)	0 – 100	9 (4.21%)	32 (14.95%)	16.76
Q9	53.49 (± 28.75)	0 – 100	3 (1.40%)	22 (10.28%)	14.38
Q10	62.17 (± 30.02)	0 – 100	3 (1.40%)	32 (14.95%)	15.01
Q11	59.31 (± 28.14)	0 – 100	1 (0.47%)	20 (9.35%)	14.07
Q12	55.84 (± 29.65)	0 – 100	3 (.140%)	25 (11.68%)	14.83
Q13	55.50 (± 30.48)	0 – 100	3 (1.40%)	33 (15.42%)	15.24
Q14	56.34 (± 33.09)	0 – 100	8 (3.74%)	31 (14.49%)	16.55
Q15	60.75 (± 31.95)	0 – 100	2 (0.94%)	45 (21.03%)	15.98
Q16	44.10 (± 27.26)	0 – 100	4 (1.87%)	4 (1.87%)	13.63
Q17	37.11 (± 30.03)	0 – 100	24 (11.21%)	11 (5.14%)	15.02
Q18	32.63 (± 27.35)	0 – 100	15 (7.01%)	6 (2.81%)	16.68
Q19	29.79 (± 28.27)	0 – 100	30 (14.02%)	9 (4.21%)	14.14
Q20	41.67 (± 29.22)	0 – 100	8 (3.74%)	13 (5.39%)	14.61
Q21	29.47 (± 42.61)	0 – 100	8 (3.74%)	10 (4.67%)	21.31
Q22	30.93 (± 27.13)	0 – 100	24 (11.21%)	5 (2.34%)	16.57
Q23	65.24 (± 45.91)	0 – 100	3 (1.40%)	7 (3.27%)	22.96
Q24	18.34 (± 33.13)	0 – 100	3 (1.40%)	14 6.54%)	16.57
Q25	19.63 (± 32.62)	0 – 100	7 (3.27%)	2 (0.94%)	16.31
Q26	19.50 (± 32.66)	0 – 100	2 (0.94%)	3 (1.40%)	16.33
Q27	36.84 (± 29.84)	0 – 100	22 (10.28%)	11 (5.14%)	14.92
Q28	18.37 (± 32.49)	0 – 100	3 (1.40%)	24 (11.21%)	16.25
Q29	47.28 (± 28.24)	0 – 100	3 (1.40%)	17 (7.94%)	14.12
Q30	55.09 (± 31.06)	0 – 100	6 (2.80%)	25 (11.68%)	15.53
Q31	51.58 (± 30.84)	0 – 100	8 (3.74%)	23 (10.75%)	15.42
Q32	57.05 (± 46.77)	0 – 100	1 (0.47%)	15 (7.01%)	23.39
Q33	29.25 (± 27.33)	0 – 100	34 (15.89%)	6 (2.80%)	16.67
Total score	46.27 (± 21.3)	5.41 – 94.08	0 (0%)	0 (0%)	10.65

iHOT-33 NL: international Hip Outcome Tool. SD: standard deviation. MIC: minimal important change.

Discussion

The results of this study show that the iHOT-33 NL is a reliable, internally consistent and valid measurement tool to asses physical functioning in a Dutch population of young, physically active individuals with symptomatic hip joint pathology.

Reliability

The test-retest reliability of the iHOT-33 NL was good, ICC value 0.92 (0.88 – 0.94). This is higher than the test-retest reliability of the original iHOT-33, ICC 0.78, and comparable to values found in earlier studies which ranged from ICC 0.87 to 0.96 [12-15, 37-39]. No significant differences were found between test results from the first and second assessment of the iHOT-33 NL, except for questions 16 and 18. Questions 16 and 18 ask about pain experienced in general and after (sports) activities. The mean differences between the test-retest measurements for these questions respectively were 8.19 and 4.60 points. Based on the MIC values found in this study (question 16 13.63 points, question 18 16.68 points), the mean differences in test-retest scores are significantly different, but can be interpreted as clinically non-relevant [36]. Also, in order to establish if no relevant change in clinical status occurred the GPE score was used and all patients who reported a GPE score of one, two, six or seven were already excluded from reliability analysis [31].

The SEM of the iHOT-33 NL was 6.02, the SDC 16.69 points at individual level and 1.14 points at group level. This is in line with the original iHOT-33 as well as current iHOT-33 translations in German and Spanish [13, 14, 37, 39]. The SDC values show that the Dutch iHOT-33 is more sensitive to detect changes at group level than at individual level similar as the original iHOT-33 [13, 14].

The average time between the two measurements, 8.53 days, was relatively low. This was a consequence of the choice of convenience to assess patients in primary health care, usually having a second appointment for treatment within the first two weeks after reporting themselves with hip and/or groin pain. However, as this study was part of the translation and validation of the HAGOS NL as well the assessments each comprised of 102 questions which decreases the chance of recall bias.

Internal consistency was good to excellent with a Cronbach's alpha of 0.90 for the iHOT-33 NL total score and 0.85 – 0.95 for the four subscales [33]. The original iHOT-33 reported a slightly higher Cronbach's alpha of 0.99 [12]. The three known translations of the iHOT-33 in German, Spanish and Chinese reported values ranging from 0.96 – 0.98 [37-39]. Every subscale had one strong factor, explaining the degree of variance to a large extent, similar to the original iHOT-33.

Validity

The construct validity was deemed to be good (87% of hypotheses confirmed) based on the COSMIN checklist which requires at least 75% of all hypotheses to be confirmed [32]. Only 2 hypotheses proved incorrect as the correlation between the iHOT-33 NL and the symptoms subscale of the HOOS was slightly lower than expected (r 0.69 versus expected > 0.70), whereas the correlation with the ADL subscale of the HOOS was higher than expected (r 0.75 versus expected $0.50 < r < 0.70$.)

The iHOT-33 NL was compared to the HOOS to establish convergent construct validity. In general, strong to moderate correlations were found which was hypothesized as both questionnaires are specifically developed to assess functioning in patients with hip and/or groin pain. The correlations between the ADL subscale and QoL subscale of the HOOS were expected to be moderate because the HOOS is originally developed for an older, assumed to be less active population [12, 19]. This proved correct for the QoL subscale, but the ADL subscale showed a strong correlation indicating that young, active patients with hip pain might experience similar problems in daily life activity as do older patients. The symptoms subscale correlated slightly worse

than expected, which can indicate that these young, active patients might experience different symptoms than the older patients who are the target population of the HOOS. To our knowledge, correlations between the iHOT-33 and HOOS have not been previously investigated. Other translation and validation studies have used the HOS and Western Ontario and McMaster Universities Arthritis Index (WOMAC) to establish convergent construct validity [37-39]. The HOS however is not available in Dutch language whereas the WOMAC has not been specifically developed for patients with hip and/or groin pain only [37-39].
Correlations between the iHOT-33NL and the EQ-5D were investigated to assess divergent construct validity and this was established. The EQ-5D was used for this validation purpose instead of the often used Short Form-36 because it contains a lower number of questions and therefore decreases patient burden [27].
A comparison between the iHOT-33 NL and the NPRS scales was made in order to investigate whether or not the iHOT-33 NL answers were influenced by pain only. Therefore moderate correlations between the two questionnaires were expected and this was confirmed.

Interpretability

The mean iHOT-33 NL total score was 46.27 points with a MIC of 10.65 points and no floor or ceiling effects were found. This is comparable to the original (mean total score 32 points, no floor or ceiling effects), Spanish (mean total score 39.37 points, MIC 12.5 points) and Chinese (mean total score 32.65 points, no floor or ceiling effects) versions of the iHOT-33 which were also validated in the target populations [12, 38, 39].
Although no floor or ceiling effects for the total iHOT-33 NL score were found, one question showed a floor and two showed ceiling effects. According to the COSMIN checklist no floor or ceiling effects should be observed, because a patient cannot change anymore in that direction (better or worse) [28]. However, the floor and ceiling effects found in this study only occurred in three individual questions whereas the iHOT-33 is to be interpreted as a total (subscale) score. No other studies have reported floor or ceiling effects, but not all have examined individual questions for these effects [10, 13, 15]. Further studies are advocated to establish possible floor or ceiling effects for these individual questions and its clinical implications.

Limitations

Some study limitations are acknowledged. The electronic questionnaire system only allowed for submission of fully completed questionnaires. Therefore, data from patients who did not fully complete every question could not be included and this may result in bias. However, it is unknown, how much and how this may have affected the data.
Another limitation is the selection of the study population. At the moment the gold standard for diagnosing intra-articular hip pathology remains hip surgery [6]. Although many of our patients diagnosed with hip joint pathology eventually underwent hip arthroscopy we did not use this as inclusion criteria. However, we tried to be as accurate as possible by using reliable examination techniques advocated in a recent consensus statement [24-26]. This situation is comparable to clinical practice [1, 6, 25].
The Tegner Activity Scores used in this study are originally developed to assess levels of physical activity in patients with knee injury [22]. At the time this study was developed no specific hip activity scales were available. Recently the Hip Sports Activity Scale (HSAS) was published for this purpose [40].

Finally, the MIC calculation as applied in this study was based on a rule of thumb as described by Norman et al [36]. At the moment there is no consensus on the methods by which the MIC should be measured. As long as no consensus is reached the authors decided the description by Norman et al.,[36] is as good as any. An investigation into the responsiveness of the iHOT-33 NL would have helped to resolve this issue and this is certainly warranted for future research.

Conclusion

This study following existing guidelines for translation and cross-cultural adaptation as well as the COSMIN checklist shows that the iHOT-33 NL is a reliable, internally consistent and valid measurement tool to asses physical functioning in a Dutch population of young, physically active individuals with symptomatic hip joint pathology. It can be used both in research and clinical settings, conservative and pre/postoperative care.

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Appendix 1 - Dutch version of IHOT-33 as validated in this study.

iHOT33 Internationale heup uitkomst instrument

Kwaliteit van Leven Vragenlijst voor jonge, actieve patiënten met heupproblemen.

Naam

Geboortedatum

Datum van vandaag

Over welke heup gaat deze vragenlijst?
Als we u van te voren gevraagd hebben naar een heup in het bijzonder kruis die dan aan. Geef anders de heup aan die de meeste klachten veroorzaakt.

☐ Links

☐ Rechts

Instructies

- Deze vragenlijst vraagt naar de problemen die u mogelijk ervaart in uw heup, hoe deze problemen uw leven beïnvloeden en naar de emoties die u mogelijk voelt vanwege deze problemen.
- Geef de ernst aan door de lijn onder elke vraag te markeren met een streepje.
  ›› Als u een streepje uiterst **links** plaatst betekent dit dat **u zich duidelijk beperkt voelt**.
  Bijvoorbeeld:

DUIDELIJK BEPERKT ——/—— HELEMAAL GEEN PROBLEMEN

›› Als u een streepje uiterst **rechts** plaatst betekent dit dat u denkt dat **u helemaal geen problemen hebt** met uw heup. Bijvoorbeeld:

DUIDELIJK BEPERKT ——————/ HELEMAAL GEEN PROBLEMEN

›› Als het streepje in het midden van de lijn gezet wordt geeft dat aan dat u gemiddeld beperkt bent, of in andere woorden, tussen de extremen "duidelijk beperkt" en "helemaal geen problemen". Het is belangrijk om het streepje te zetten op het einde van de lijn als de extreme beschrijving uw situatie accuraat omschrijft.

Tip: als u een activiteit niet doet, stel dan voor hoe uw heup zou voelen als u het zou moeten proberen.

- Beschrijf met uw antwoorden alstublieft de gemiddelde situatie van de afgelopen **maand**.

Sectie 1 | Symptomen en functionele beperkingen

De volgende vragen gaan over symptomen die u kunt ervaren in uw heup en over de functie van uw heup met betrekking tot dagelijkse activiteiten.
Denkt u hierbij alstublieft aan hoe u zich meestal gevoeld heeft in de afgelopen maand en antwoord overeenkomstig.

V01 Hoe vaak doet uw heup/ lies pijn?

DUIDELIJK BEPERKT —————————— HELEMAAL GEEN PROBLEMEN

V02 Hoe stijf is uw heup na zitten of rusten gedurende de dag?

EXTREEM STIJF _____ HELEMAAL NIET STIJF

V03 Hoe moeilijk is het voor u om lange afstanden te lopen?

EXTREEM MOEILIJK _____ HELEMAAL NIET MOEILIJK

V04 Hoeveel pijn heeft u in uw heup tijdens het zitten?

EXTREME PIJN _____ HELEMAAL GEEN PIJN

V05 Hoeveel moeite heeft u met lang staan?

ERNSTIGE MOEITE _____ HELEMAAL GEEN MOEITE

V06 Hoe moeilijk is het voor u om op de vloer/grond te komen en weer op te staan?

EXTREEM MOEILIJK _____ HELEMAAL NIET MOEILIJK

V07 Hoe moeilijk is het voor u om op oneffen ondergrond te lopen?

EXTREEM MOEILIJK _____ HELEMAAL NIET MOEILIJK

V08 Hoe moeilijk is het voor u om op uw aangedane zijde te liggen?

EXTREEM MOEILIJK _____ HELEMAAL NIET MOEILIJK

V09 Hoeveel moeite heeft u met het stappen over obstakels?

ERNSTIGE MOEITE _____ HELEMAAL GEEN MOEITE

V10 Hoeveel moeite heeft u om de trap op/af te lopen?

ERNSTIGE MOEITE _____ HELEMAAL GEEN MOEITE

V11 Hoeveel moeite heeft u om vanuit een zittende positie op te staan?

ERNSTIGE MOEITE _____ HELEMAAL GEEN MOEITE

V12 Hoeveel ongemak heeft u bij het nemen van grote passen?

EXTREEM ONGEMAK _____ HELEMAAL GEEN ONGEMAK

V13 Hoe moeilijk is het voor u om in en/of uit een auto te stappen?

EXTREEM MOEILIJK _____ HELEMAAL NIET MOEILIJK

V14 Hoeveel last heeft u van kraken, gevoel van blokkeren of klikken in uw heup?

ERNSTIGE LAST _____ HELEMAAL GEEN LAST

V15 Hoeveel moeite is het voor u om sokken, kousen of schoenen aan/uit te trekken?

EXTREEM MOEILIJK _____ HELEMAAL NIET MOEILIJK

V16 Hoeveel pijn heeft u over het algemeen in uw heup/lies?

EXTREME PIJN _____ HELEMAAL GEEN PIJN

Sectie 2 | Sport en recreatieve activiteiten

De volgende vragen gaan over uw heup wanneer u deelneemt aan sport en recreatieve activiteiten. Denkt u hierbij alstublieft aan hoe u zich meestal gevoeld heeft in de afgelopen maand en antwoord overeenkomstig.

V17 Hoe bezorgd bent u over uw mogelijkheid om uw gewenste fitheidsniveau te behouden?

EXTREEM BEZORGD _____ HELEMAAL NIET BEZORGD

V18 Hoeveel pijn ervaart u in uw heup na activiteiten?

EXTREME PIJN _____ HELEMAAL GEEN PIJN

V19 Hoe bezorgd bent u dat de pijn in uw heup toe zal nemen als u deelneemt aan sport of recreatieve activiteiten?

EXTREEM BEZORGD _____ HELEMAAL NIET BEZORGD

V20 Hoeveel is uw kwaliteit van leven achteruit gegaan omdat u niet kunt deelnemen aan sport / recreatieve activiteiten?

EXTREEM ACHTERUIT GEGAAN _____ HELEMAAL NIET ACHTERUIT GEGAAN

V21 Hoe bezorgd bent u over wenden/ keren tijdens uw sport of recreatieve activiteiten?

☐ Dit doe ik niet in mijn activiteiten

EXTREEM BEZORGD _____ HELEMAAL NIET BEZORGD

V22 Hoeveel is uw prestatieniveau afgenomen in uw sport of recreatieve activiteiten?

EXTREEM AFGENOMEN _____ HELEMAAL NIET AFGENOMEN

Sectie 3 | Werk gerelateerde zaken

Denkt u hierbij alstublieft aan hoe u zich meestal gevoeld heeft in de afgelopen maand en antwoord overeenkomstig.

☐ Ik werk niet vanwege mijn heup (sla deze sectie over)

☐ Ik werk niet, door andere redenen dan mijn heup (sla deze sectie over).

V23 Hoeveel moeite heeft u met het duwen, trekken, tillen of dragen van zware objecten op uw werk?

☐ Ik doe deze activiteiten niet op mijn werk.

ERNSTIGE MOEITE _____ **HELEMAAL GEEN MOEITE**

V24 Hoeveel moeite heeft u met hurken of door de knieën gaan?

ERNSTIGE MOEITE _____ **HELEMAAL GEEN MOEITE**

V25 Hoe bezorgd bent u dat door uw werk uw heup slechter wordt?

EXTREEM BEZORGD _____ **HELEMAAL NIET BEZORGD**

V26 Hoeveel moeite heeft u op uw werk vanwege een beperkte beweeglijkheid van uw heup?

ERNSTIGE MOEITE _____ **HELEMAAL GEEN MOEITE**

Sectie 4 | Sociale, emotionele en levensstijl zorgen

De volgende vragen gaan over sociale, emotionele en levensstijl gerelateerde zorgen die u mogelijk heeft met betrekking tot uw heupprobleem. Denkt u hierbij alstublieft aan hoe u zich meestal gevoeld heeft in de afgelopen maand en antwoord overeenkomstig.

V27 Hoe gefrustreerd bent u over uw heupprobleem?

EXTREEM GEFRUSTREERD _____ **HELEMAAL NIET GEFRUSTREERD**

V28 Hoeveel moeite heeft u met seksuele activiteiten vanwege uw heup?

☐ Dit is voor mij niet relevant

ERNSTIGE MOEITE _____ **HELEMAAL GEEN MOEITE**

V29 Hoeveel wordt u afgeleid door uw heupprobleem?

EXTREEM AFGELEID _____ **HELEMAAL NIET AFGELEID**

V30 Hoe moeilijk is het voor u om spanning en stress kwijt te raken door uw heupprobleem?

EXTREEM MOEILIJK _____ **HELEMAAL NIET MOEILIJK**

V31 Hoe moedeloos bent u door uw heupprobleem?

EXTREEM MOEDELOOS _____ HELEMAAL NIET MOEDELOOS

V32 Hoe bezorgd bent u over het optillen of dragen van kinderen door uw heup?

☐ Dit doe ik niet in mijn activiteiten

EXTREEM BEZORGD _____ HELEMAAL NIET BEZORGD

V33 Hoe vaak bent u zich bewust van de beperking in uw heup?

CONTSTANT _____ HELEMAAL NIET BEWUST

Appendix 2 - Physical diagnostic tests and imaging used for patient inclusion.

Subjects were diagnosed with intra-articular hip pathology based on the Doha agreement meeting on terminology and definitions in groin pain in athletes[26] combined with earlier studies of our group [24]. Intra-articular hip pathology was suspected when both hip joint related physical examination tests were positive for pain and/or impaired range of motion combined with at least one abnormal/aberrant imaging finding in patients who reported themselves with hip and/or groin pain[24, 26].

Table 1 - Physical diagnostic tests and imaging used for patient inclusion.

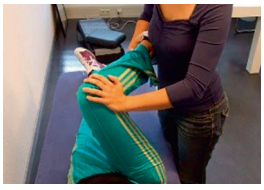
Physical diagnostic test	Definition	Example
Anterior hip impingement test (AIT)	Patient lies supine while the examiner moves the affected leg into 90° of flexion, adduction, and internal rotation until end range is achieved. Pain in any location marks a positive result [24].	
Flexion-Abduction-External Rotation (FABER) test	Patient lies supine. The affected leg is simultaneously flexed, abducted, and externally rotated so that the subject's lateral ankle rests on the contralateral leg just proximal to the knee. While stabilizing the ASIS the knee is lowered toward the table. A positive test result may be either a decrease in ROM compared to the non-affected leg or reproduction of pain [24].	

Table 1 - Continued.

Parameter RX/MRI-A	Definition	Normal value, abnormal value
Parameters RX		
Alpha angle (AA)	Angle between the femoral neck axis and a line connecting the head center with the point of beginning asphericity of the head-neck contour [41, 42].	<50°, >50°
Lateral center edge angle (LCEA)	Angle formed by a vertical line through the center of the femoral head and a line connecting the femoral head center with the lateral edge of the acetabulum [41, 42].	20-39°, >39°
Crossover sign	Present if the anterior rim runs more laterally in the most proximal part of the acetabulum and crosses the posterior rim distally [41, 42].	Anterior rim line projects medially to the posterior wall line
Protrusio acetabuli	Present if the femoral head touches or crosses the ilio-ischial line [41, 42].	
Joint space	The distance between the roof of the acetabulum and the femoral head [41, 42].	>2.5mm, <2.5mm
Parameters MRI-A		
Labral pathology	Disruption of cartilage ring (labrum) in hip joint [41-43].	NA
Cam deformity	Angle between the femoral neck axis and a line connecting the head center with the point of beginning asphericity of the head-neck contour [41-43].	<50°, >50°
Cysts	Subchondral cysts [41-43].	NA
Chondropathy	Contrast material-filled defect, area of cartilage signal intensity alteration at acetabulum or femoral head [41-43].	NA
Lig. Teres #*	Disruption of ligamentumTeres within hip joint [41-43].	NA

RX/MRI-A: RX radiographic imaging. MRI-A: magnetic resonance imaging arthrography. * = MRI-A Lig. Teres# means Ligamentum Teres rupture. NA: Not applicable.

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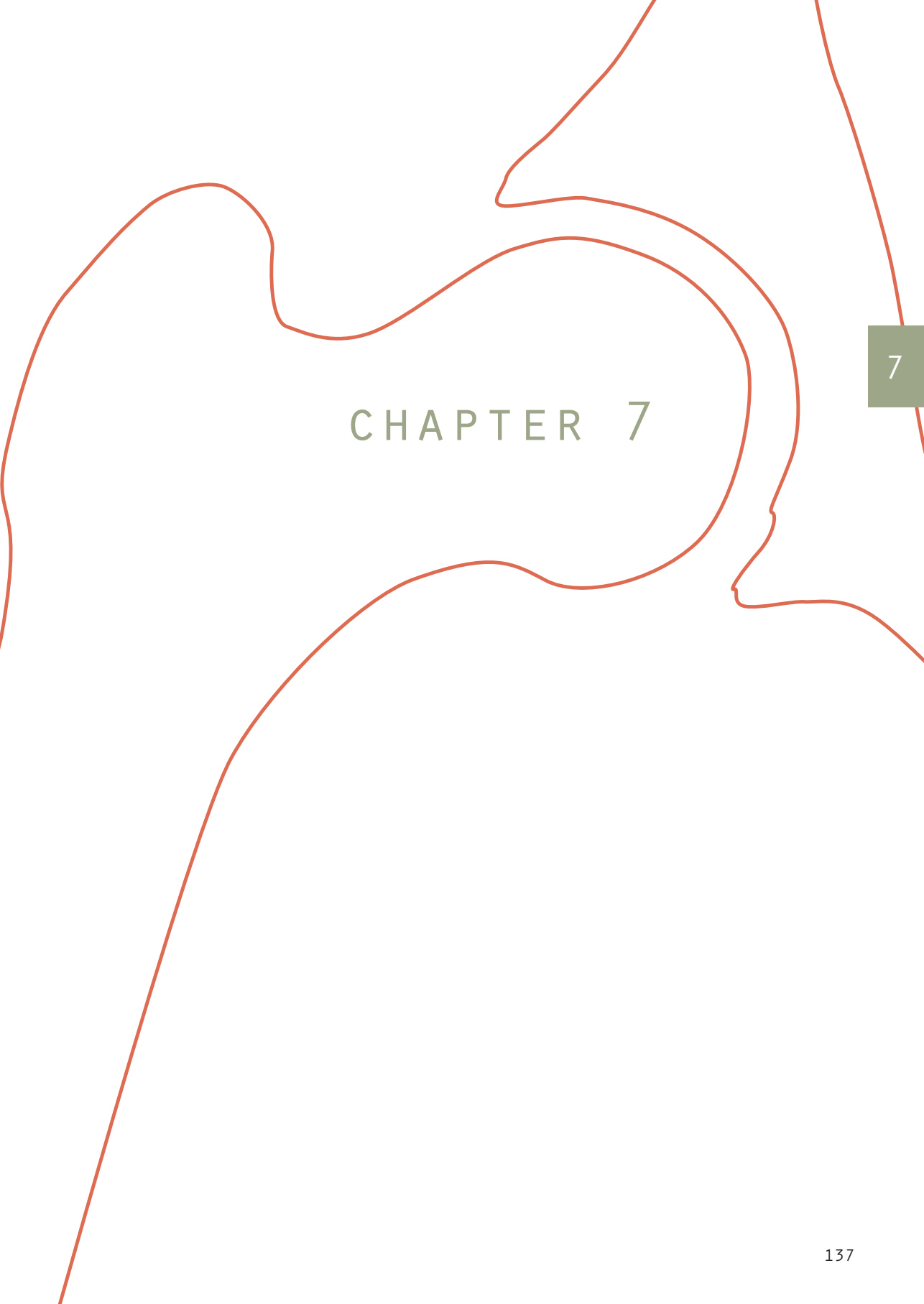

CHAPTER 7

A clinical observational study on patient-reported outcomes, hip functional performance and return to sports activities in hip arthroscopy patients.

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Physical Therapy in Sport, 2016, 20, 45 - 55.

Abstract

Objectives: To describe data of short- and midterm results of hip arthroscopy patients based on patient-reported hip function, hip functional performance and return to sports activities.
Design: Observational cohort study.
Setting: Sports medical center.
Participants: 37 recreational athletes (21 men) at least six months after finishing rehabilitation for hip arthroscopy.
Main outcome measures: International Hip Outcome Tool 33 (IHOT-33), Pain Visual Analogue Scale (VAS), Global Perceived Effect Scale (GPE), sports questionnaires and hip functional performance tests.
Results: At a mean follow-up time of 2.3 years, 81% of participants reported improvement on the GPE and 84% returned to sports activities. The mean IHOT-33 score was 69.3; the mean VAS score was 35.0. Range of motion (ROM) and strength were within the 90% Limb Symmetry Index (LSI) limit, except for hip internal rotation ROM. A full recovery of hip functional performance, as measured with balance and hop tests, was established based on the 90% LSI limit.
Conclusions: The overall short- and midterm results of these follow-up data show good recovery of hip arthroscopy patients on patient-reported outcomes, functional performance and return to sports activities. The functional performance tests used in this study seem adequate for measuring recovery in hip arthroscopy patients.
Keywords: Hip arthroscopy, Clinical outcomes, Functional performance.

Introduction

Over the last decade, the use of hip arthroscopy in the treatment of intra-articular hip pathology has increased [1]. Femoroacetabular impingement (FAI), labral pathology, cysts and chondral damage are a few of the pathologies for which this operation technique is currently used [2, 3]. Studies investigating hip arthroscopy have focused mostly on diagnosis, arthroscopic procedures and surgical outcomes and less on clinical outcomes such as recovery of hip function and return to sports activities [4-6]. At present, most outcome data are based on Patient-Reported Outcome questionnaires (PROs) [7, 8], which give an indication of hip function from a patient's perspective, but do not measure actual hip functional performance [5]. Functional performance consists of two components, quantity and quality of movement [9]. Quantity of movement components include, for example, range of motion (ROM) and muscle strength [9-11]. Quality of movement refers to how the movement is performed. Components like the occurrence of dynamic knee valgus, (lateral) trunk flexion or pelvic drop while landing from a jump can be assessed by video analysis or observation [9-11]. Both components of functional performance give information about the amount of recovery, compensation strategies and eventually, sport readiness [9, 12-14]. These data are, therefore, important indicators of recovery and might also indicate possible risk factors for future new injuries [14, 15]. As hip arthroscopy is often performed in a young and active population who have a desire to return to an active/sports lifestyle, insight on recovery is important [4, 12, 14-16].

To date little information is available on recovery of hip functional performance in a population of hip arthroscopy patients [5, 6, 17]. Two case studies (total n = 2) have described data on functional performance linked to postoperative rehabilitation after hip arthroscopy [18, 19]. However, only very short term follow-up results were available (within four months post-rehabilitation) and the participants were both (semi)-professional athletes [18, 19]. A recent systematic review including hip arthroscopy patients diagnosed with FAI found that only 34% of the studies reported ROM data and only 14% reported data on return to sports [6]. Therefore, the aim of this study was to describe data regarding short- and midterm results of hip arthroscopy patients based on patient-reported hip function, hip functional performance and return to sports activities.

Materials and Methods

Study population and design

In this prospective clinical observational study, all patients that underwent hip arthroscopy at Rijnstate Hospital between January 2010 and April 2014 and finished a standardized rehabilitation protocol at Sports Medical Center Papendal (see Appendix 1) at least six months before the start of this study were contacted by telephone to invite them for a follow-up measurement. Patients willing to participate received information letters and after providing written informed consent, they were invited for the actual follow-up measurement. The study design was approved by the local ethics committee (CMO) Arnhem-Nijmegen, registration number 2013/361. All subjects received information letters and signed an informed consent. A flow chart of patient inclusion is presented in Figure 1.

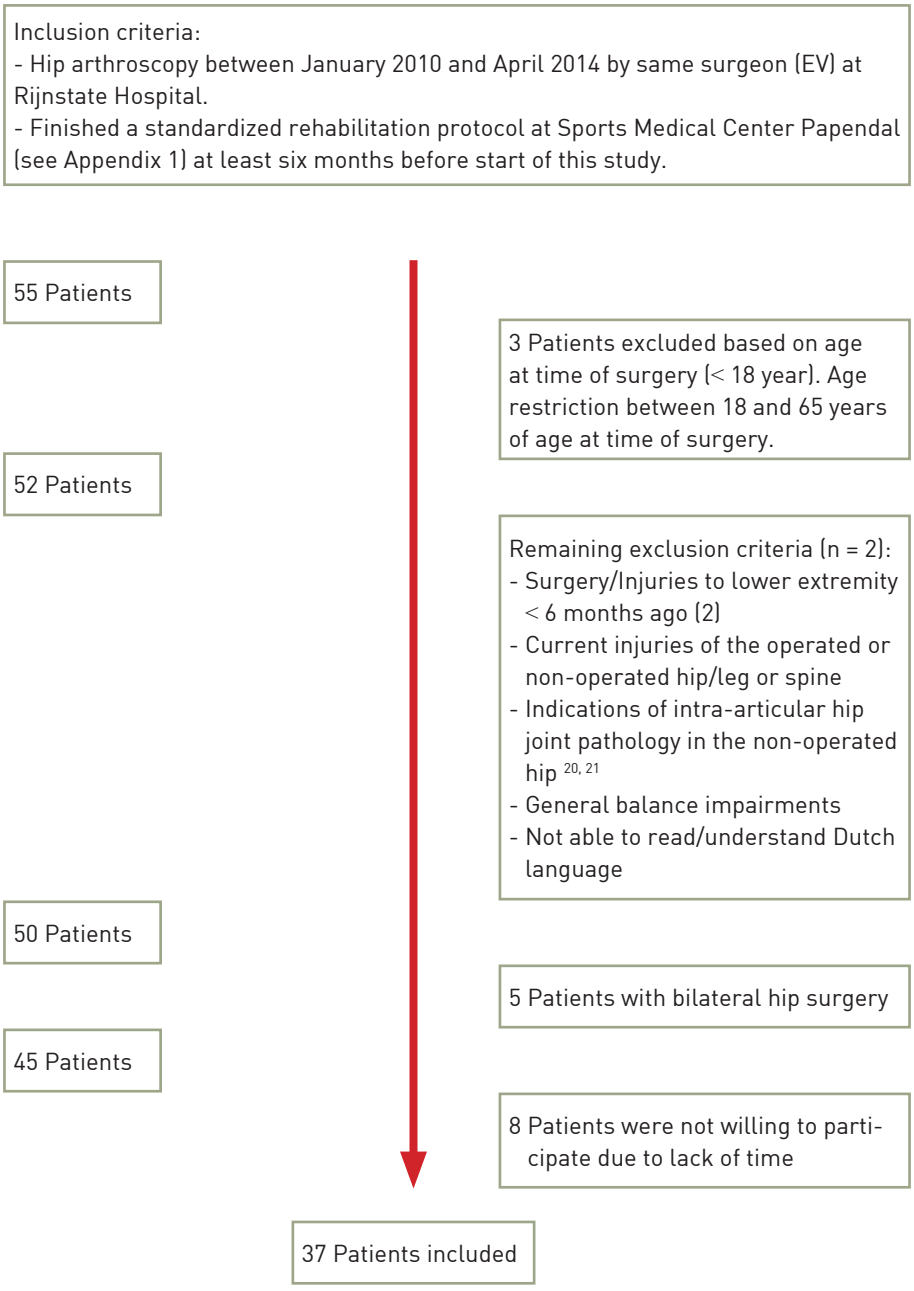


Figure 1 - Flow chart of patient in- and exclusion.

Study protocol

During the visit to our institution, participants completed five questionnaires before starting the standardized physical examination, which included testing bilateral hip range of motion, hip muscle strength, balance and hop tests (Table 1) [13]. Two researchers (MH, BS) who were blinded to the exact diagnosis, as well as to the course of the postoperative rehabilitation process, performed the tests. Afterwards, a different researcher (MT), who was blinded to the earlier assessment findings, analyzed the videotaped performance tests to score the quality of movement. The non-operated leg was tested first during all functional assessments. To ensure that the non-operated leg could serve as a reference for the operated leg, all patients with current injuries, previous injuries (< six months ago) or indications for possible intra-articular hip pathology of the non-operated leg were excluded (n = 2) (Figure 1). Indications for possible intra-articular hip pathology were described according to a recent consensus statement [20] and included the presence of groin pain and/or a positive anterior impingement test and/or a positive Flexion-Abduction-External Rotation (FABER) test [20, 21]. Previous studies have shown that the use of the unaffected limb as a comparison when examining patients with unilateral lower limb injury should be considered reasonable [22, 23].

Table 1 - Test executions of functional performance tests.

Test	Test execution	Test results quantity of movement	Test results quality of movement	Test execution image
Range of motion	All measurements are taken until the clinician reaches a firm end feel or when pelvic movement is necessary for additional movement of the limb 13. Reported intra-rater reliability in literature 0.50-0.97 [13, 28, 29]. Flexion: supine position with hip in 0° of abduction, adduction and rotation and knee flexed. Pelvis stabilized with belt to prevent rotation or tilting. Axis of goniometer at greater trochanter, stationary arm along midline of pelvis, moving arm along midline of femur. Extension: prone position with hip in 0° of abduction, adduction and rotation. Pelvis stabilized with belt to prevent rotation or tilting. Axis of goniometer at greater trochanter, stationary arm along midline of pelvis, moving arm along midline of femur. Abduction: supine with hip in 0° of flexion, extension and rotation. Axis of goniometer at ASIS, stationary arm along imaginary line between 2 ASISs, moving arm along midline of femur. Adduction: see abduction. Contralateral hip abducted to allow full adduction for measured hip. External rotation 0° flexion: supine with 0° hip flexion and 90° knee flexion (lower leg over edge table). Hip measured in 0° abduction, contralateral hip in 30° abduction. Axis of goniometer at midpoint patella, stationary arm vertically perpendicular to supporting surface, moving arm along midline of lower leg. Internal rotation 0° flexion: see external rotation in 0° flexion. External rotation 90° flexion: sitting with 90° hip flexion/knee flexion. Hip measured in 0° abduction, contralateral hip in 30° abduction. Axis of goniometer at midpoint patella, stationary arm vertically perpendicular to supporting surface, moving arm along midline of lower leg. Internal rotation 90° flexion: see external rotation in 90° flexion. **Practice attempts:** 2 times per direction per leg.	Average of two measurements in degrees	-	-

Table 1 - Continued.

Test	Test execution	Test results quantity of movement	Test results quality of movement	Test execution image
Hip strength	Participant is instructed to gradually build maximum force in 5 seconds and maintain this force for another 5 seconds using the make method [13]. Reported intra-rater reliability in literature 0.87-0.90 [13, 28, 29]. Flexion: sitting with both hip and knee joint in 90° of flexion. Hip in 0° of abduction, adduction and rotation. Hands folded across chest. Measured leg 1 cm of surface. HHD just proximal to the knee at flexion surface thigh. Extension: see range of motion extension. Measured leg 1 cm of surface. HHD just proximal to the knee at extension surface thigh. Abduction: side lying on non-tested side with trunk neutral and pelvis perpendicular to testing surface. Non-tested hip/knee flexed. Tested hip in abduction with 0° rotation and flexion/extension. Manually stabilize pelvis through iliac crest. HHD at lateral aspect distal thigh. Adduction: see abduction. With tested leg being leg on the surface in 0° hip flexion/extension and rotation. Non tested leg is in hip flexion/knee flexion and is supported on surface. Lift tested leg 1cm from surface. HHD at medial aspect distal thigh. External rotation 0° flexion: see range of motion external rotation in 0° flexion. HHD above ankle at lateral aspect. Internal rotation 0° flexion: see range of motion internal rotation in 0° flexion. HHD above ankle at medial aspect. Abduction +†: see abduction. Pelvis rotated forward. Tested hip in abduction, external rotation and extension. Knee extension: see flexion. HHD above ankle at anterior aspect. Knee flexion: see extension. Knee flexed 90° and HHD at just proximal to ankle. P**ractice attempt:** 2 times per direction per leg.	Average of three measurements in Newton	-	-

Table 1 - Continued.

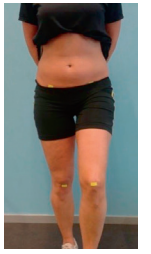
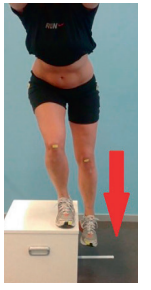
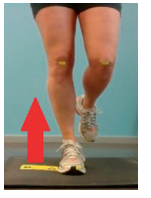
Test	Test execution	Test results quantity of movement	Test results quality of movement	Test execution image
Single leg balance test	Participant stands on one leg for 30 seconds with an upright posture and the non-stance leg lifted in 30° of hip flexion. The angle between a horizontal line and an imaginary line interconnecting right and left ASISs is determined before and after measurement with a goniometer [10]. Reported intra-rater reliability in literature 0.58 [47]. **Practice attempt:** 10 seconds per leg.	Degrees difference between angle before and after measurement.	Dynamic knee valgus Lumbopelvic control	
Single leg squat test	Participant stands on one leg on 20-cm box with arms folded across chest. Squats down to 60° knee angle five times at rate one squat per two seconds [10, 34]. Reported intra-rater reliability in literature 0.61-0.80 [34]. **Practice attempt:** 3 squats per leg.	Score based on criteria Crossley et al. 34: 1)Overall impression 2) Trunk position 3) The pelvis in space 4) Hip joint 5) Knee joint	Dynamic knee valgus Lumbopelvic control	
Single leg vertical jump	Participant stands on one leg with hands placed behind back and performs countermovement jump attempting to maximize jump height on Projump contactmat three times (Biometrics, the Netherlands) [30]. Reported intra-rater reliability in literature 0.89 [30]. **Practice attempt:** 2 submaximal hops per leg.	Highest jump in cm	Dynamic knee valgus Lumbopelvic control	

Table 1 - Continued.

Test	Test execution	Test results quantity of movement	Test results quality of movement	Test execution image
Single leg hop for distance	Participant stands on one leg with hands placed behind back and performs single-leg hop as far as possible with controlled landing (balance for two seconds and no extra hops) on the same leg. Executes this three times [30]. Reported test-retest reliability in literature 0.80-0.96 [48]. **Practice attempt:** 2 submaximal hops per leg.	Furthest jump in cm	Dynamic knee valgus Lumbopelvic control	
Single leg side hop	Participant stands on one leg with hands placed behind back and jumps side to side over 40 cm wide strips as many times as possible in 30 seconds. Landing within 40 cm range or on strips is recorded as false 30. Reported test-retest reliability in literature 0.87-0.93 30. **Practice attempt:** 2 submaximal hops per leg.	Number of successful jumps	-	

CM, centimeter; ASIS, anterior superior iliac spine; HHD, handheld dynamometer; † Abduction + = abduction with hip extension and external rotation; - Not applicable

Patient-reported outcomes questionnaires and sports activity

Several PROs were used in this study. First, hip function was measured using the IHOT-33 [24]. This scale consists of 33 questions regarding hip disease and quality of life, with each scored on a visual analogue scale (VAS) where zero represents the worst and 100 represents the best score. A final score is calculated by summing up the scores of all questions answered and dividing it by the number of questions answered [7, 24]. A higher final score (maximum 100) represents a better quality of life en less symptoms, with 100 representing no symptoms. Activity level was measured with the Tegner Activity Scale and a sports activity questionnaire [25]. The Tegner Activity Scale measures physical activity level based on a zero to ten scale in which zero represents sick leave based on (hip) injury whereas ten stands for participation in national or international elite level competitive sports [25]. The sports activity questionnaire used in this study was based on the sports module questionnaire [26] and consists of 18 questions regarding current and former activity levels, new or recurrent injuries and patient satisfaction after hip arthroscopy (see Table 2 and 3). In order to establish self-reported improvement, a Global Perceived Effect (GPE) scale was used (Table 3) [27].

Hip functional performance – quantity of movement

Range of motion of hip flexion, extension, abduction, adduction, external and internal rotation were determined using a goniometer (Fysiosupplies 20cm) [13, 28, 29]. Strength tests of these same directions were performed using a handheld dynamometer (HHD) (microFET 2, Hoggan Health Industries, USA); the make method and average outcome of the three trials were used as the final score [13, 28, 29]. Previous studies have shown high intra-rater reliability for these measurement instruments [13, 28, 29]. The balance and hop tests consisted of the single leg balance test, single leg squat test, single leg hop for distance, single leg vertical jump and single leg side hop [14, 17, 30]. The balance and hop tests chosen in this study were based on earlier research of postoperative knee rehabilitation (i.e. ACL rehabilitation) combined with recommendations from recent clinical practice guidelines for non-arthritic hip pain [13, 30-32]. See Table 1 for an overview of all functional performance tests, exact test executions and reliability figures. Pain scores (VAS) were taken whenever the measurements provoked pain and were asked for after completion of each individual test.

Hip functional performance – quality of movement

The quality of movement assessments were based on frontal plane video analyses of the single leg squat test, single leg vertical jump and single leg hop for distance and were conducted using the Kinovea 0.8.[15] software to measure lumbopelvic control and dynamic knee valgus [10, 33]. Reflectorized markers were placed at the anterior superior iliac spine (ASIS), the distal point of the trochanter major, the midpoint of the patella and the distal phalange of the hallux. Lumbopelvic control was defined as the ability to maintain both ASIS at a horizontal level during the performance tests, as measured by the difference in angle of the ASIS line both at the beginning and aft the end of each test [10]. Altered lumbopelvic control was defined as a > 10° drop in the ASIS of the nonstance leg versus the stance leg during takeoff or landing or at the maximum squat depth of a 60° knee angle (Figure 2a) [10]. Dynamic knee valgus was defined as the point at which the midpoint of the patella moved inward and ended up medial to the hallux during landing or at a maximum squat depth of a 60° knee angle (Figure 2a) [10]. Dynamic

knee valgus was defined when the midpoint of the patella moved inward and ended up medial to the hallux during landing or at maximum squat depth at 60° knee angle (Figure 2b) [10, 11, 30]. Altered lumbopelvic control and dynamic knee valgus were scored as present when three out of five for the single-leg squat test or two out of three test executions for the hop tests were positive.

2a. Altered lumbopelvic control

2b. Dynamic knee valgus

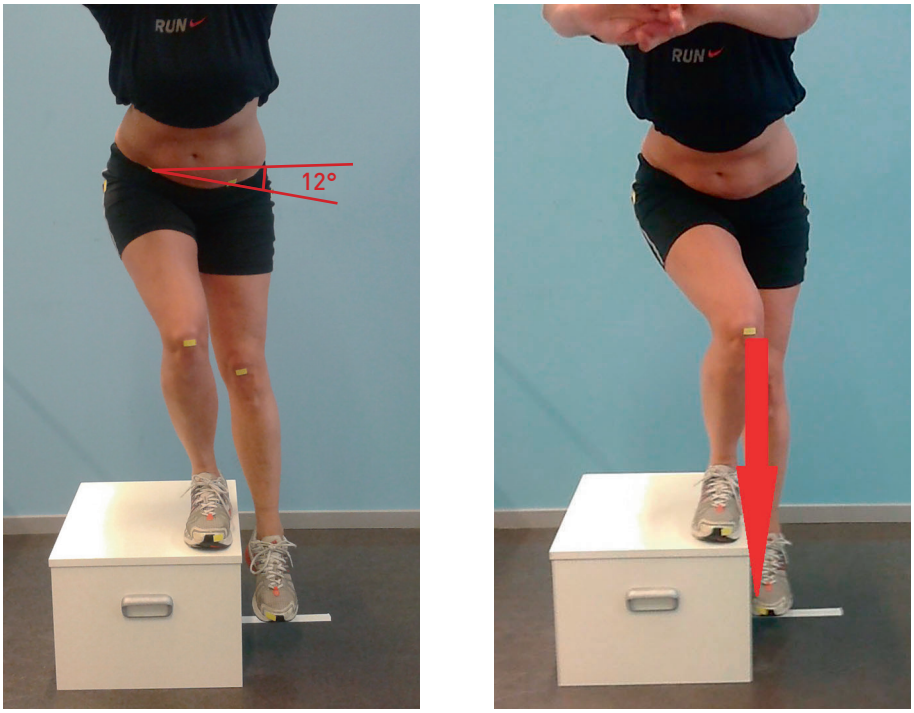


Figure 2 - Example of altered lumbopelvic control (2a) and dynamic knee valgus (2b) during single leg squat test [10].

Statistical analysis

Statistical analysis was performed with IBM SPSS Statistics 22.0. Descriptive statistics were used to calculate demographic variables and outcomes of questionnaires. A Limb Symmetry Index (LSI) was calculated by dividing the score of the operated hip by the non-operated hip times 100 for all physical tests [9]. A score of $\geq$ 90% was considered adequate [9]. A comparison was made between pre- and postoperative data as well as data of the operated versus non-operated leg using paired sampled T-tests, marginal homogeneity tests, McNemar tests and Wilcoxon Matched Pair Signed Rank tests. Significance level was set at 0.05.

Results

A total of 37 patients (21 males) with a mean age of 40.5 years (range 23-62 years) were included (Table 2/Figure 1). All had undergone unilateral hip arthroscopy. Revision hip arthroscopy was performed in two cases (Table 2).

Table 2 - Demographic characteristics of the study population at follow-up.

Characteristics/Variables	Outcome Mean (SD); range or number (%)
n	37
Follow-up in months	26.8 (11.6); 7.5-45.3
Gender (male/female)	21/16 (57%/43%)
Age in years	40.5 (9.0); 23-62
BMI in kg/m2	24.6 (3.2); 20.0-33.6
Operated side (right/left)	23/14 (62%/38%)
Dominant leg operated	22 (59%)
Revision arthroscopy	2 (5%)
Surgical Treatment	
Labral fixation	*3 (8%)*
Labral resection	*7 (19%)*
FAI	*3 (8%)*
Labral fixation + FAI	*7 (19%)*
Labral resection + FAI	*10 (27%)*
Other†	*7 (19%)*
Duration of postoperative rehabilitation in months	6.0 (2.2); 2-12
Hip injury > 4 weeks after rehabilitation‡	6 (16%)
Other injuries lower extremity/spine > 4 weeks after rehabilitation‡	9 (24%)

SD, Standard deviation; † Other (lig. Teres resection, nettoyage/chondropathy, synovectomie); ‡ Patients who have experienced injury lasting more than 4 weeks and which started after hip arthroscopy rehabilitation was finished.

Patient-reported outcomes questionnaires and sports activity

At a mean follow-up period after hip arthroscopy of 2.2 years (range 0.6-3.8 years), 81% of the participants (30 patients) reported minor to full improvement on the GPE. This corresponded with the average IHOT-33 score of 69.3 and VAS score of 35.0. Eighty-four percent of all participants (31 patients) had successfully returned to sports or activity, although only 19% returned to the same sport at the same level as the pre-injury condition (Table 3). Sports frequency significantly decreased ($p = 0.04$) and there was a trend ($p = 0.09$) towards low impact sports when comparing most reported sports activities before the symptoms began and at follow-up. This was confirmed via the significant decrease ($p = 0.04$) in the Tegner Activity Scale from a mean of 6.8 before the symptoms began to 6.2 at follow-up. Since the end of the rehabilitation period, six patients (16%) experienced a new hip injury on the operated hip and nine patients (24%) experienced other lower extremity or spine injuries lasting more than four weeks (Table 2 and 3).

Table 3 - Patient-Reported Outcomes Questionnaires and Sports Activity before first symptoms and at follow-up.

Variables	Before first symptoms Mean (SD); range or number (%)	Follow-up Mean (SD ; range or number (%)	P-value before symptoms vs. follow-up
n	37	37	-
IHOT-33 total score†	-	69.3 (21.4); 18.5-97.8	-
Function		70.6 (21.3); 16.2-98.8	
Sports		60.5 (27.5); 9.5-99.7	
Job		68.9 (25.9); 8.3-100	
Lifestyle		74.2 (20.6); 16.9-100	
Visual Analogue Scale	-	35.0 (25.2); 0-88	-
Global Perceived Effect scale	-		-
Full recovery		7 (19%)	
Much improvement		15 (40%)	
Minor improvement		8 (22%)	
No improvement		4 (11%)	
Minor deterioration		2 (5%)	
Much deterioration		1 (3%)	
Worse than ever		0 (0%)	
Tegner Activity Scale	6.8 (2.2); 2-11	6.2 (1.9); 2-10	0.04*
Return to sport/activity	-		-
Yes		7 (19%)	
Yes, different sport		13 (35%)	
Yes, lower level		11 (30%)	
No, injuries		3 (8%)	
No, other reasons		3 (8%)	
5 most reported sports activities‡			0.09
Jogging	7 (19%)	4 (11%)	
Soccer	7 (19%)	3 (8%)	
No sports	5 (13%)	6 (17%)	
Cycling	4 (11%)	5 (13%)	
Fitness	4 (11%)	8 (22%)	
Other	10 (27%)	11 (29%)	
Sports frequency			0.04*
No sports	5 (13%)	6 (16%)	
1x per week	4 (11%)	8 (22%)	
2x per week	10 (27%)	9 (24%)	
3-5x per week	15 (41%)	14 (38%)	
>5x per week	3 (8%)	0 (0%)	

SD, Standard deviation; * P-value ≤ 0.05 on paired sampled T-tests, marginal homogeneity tests and Wilcoxon Matched Pair Signed Rank tests; † IHOT-33 total score = total score of complete questionnaire. Function = symptoms and functional limitations. Sport = sports and recreational activities. Job = job related concerns. Lifestyle = social, emotional and lifestyle concerns; ‡ Other sports before were: dance, darts, field hockey, korfball, horse riding, pilates, squash, survival, volleyball, walking, wrestling. Other sports at follow-up were: darts, walking, swimming, motorcross, horse riding, squash, survival, tennis, gymnastics, volleyball; - Not applicable.

Hip functional performance

Range of motion (ROM) of the operated versus the non-operated hip was within the 90% LSI limit, except for internal rotation in both 0° (LSI = 89.3%) and 90° of hip flexion (LSI = 87.6%) (Table 4). Although within the 90% LSI limit, the differences in ROM between both hips were significant for all directions except hip abduction and adduction. Ten patients reported pain during internal rotation ROM in 90° of hip flexion with a mean VAS score of 43.3. No pain was reported during the other range of motion tests. Based on the 90% LSI limit, no differences between legs were found for hip strength (Table 4). Only hip abduction strength significantly differed between both legs. No pain was reported during hip strength testing.

Table 4 - Results of quantity of movement assessments at follow-up.

Variables	Operated hip mean (SD)	Non-operated hip mean (SD)	LSI %	P-value operated vs. non-operated
n	37	37	-	-
Passive range of motion (degrees)				
Flexion	95.9 (12.8)	99.2 (10.2)	96.7	0.00*
Extension	15.8 (5.4)	17.5 (5.2)	90.3	0.02*
Abduction	29.6 (7.0)	31.1 (8.2)	95.2	0.14
Adduction	16.5 (6.5)	16.5 (4.8)	100	0.91
External rotation 0° flexion	46.2 (10.3)	49.7 (11.7)	93.0	0.00*
Internal rotation 0° flexion	38.5 (14.8)	43.1 (12.6)	89.3	0.02*
External rotation 90° flexion	53.7 (11.4)	58.5 (11.4)	91.8	0.02*
Internal rotation 90° flexion	34.5 (13.2)	39.4 (11.1)	87.6	0.00*
Strength (Newton)				
Flexion	301.4 (81.4)	312.0 (87.4)	96.6	0.07
Extension	206.6 (68.5)	206.0 (68.9)	100.3	0.88
Abduction	251.1 (84.6)	262.9 (76.4)	95.5	0.05*
Adduction	209.4 (56.8)	207.4 (59.5)	101.0	0.69
External rotation 0° flexion	110.0 (36.4)	114.2 (38.1)	96.3	0.20
Internal rotation 0° flexion	82.7 (24.1)	82.2 (27.1)	100.6	0.89
Abduction +†	246.4 (89.3)	256.8 (82.5)	96.0	0.06
Knee extension	400.4 (155.7)	410.3 (156.7)	97.6	0.19
Knee flexion	270.5 (85.9)	277.2 (86.4)	97.6	0.18
Balance and hop tests				
Single leg balance test (°)	0.11 (2.6)	0.59 (3.2)	186.4	0.45
Single leg squat test			-	0.40
Poor	4 (11.1%)	5 (13.9%)		
Fair	20 (55.6%)	20 (55.6%)		
Good	12 (33.3%)	11 (30.6%)		
Single leg vertical jump (cm)	10.1 (3.2)	9.7 (3.6)	104.1	0.20
Single leg hop for distance (cm)	84.1 (33.6)	83.7 (31.7)	100.5	0.88
Single leg side hop (number)	25.8 (14.2)	23.4 (12.7)	110.3	0.02*

LSI, Limb Symmetry Index in which results of operated hip are presented as % of non-operated hip; † Abduction + = abduction with hip extension and external rotation; * P-value ≤ 0.05 on paired sampled T-tests and Wilcoxon Matched Pair Signed Rank tests; - Not applicable.

The LSIs of the quantity of movement assessments of the jump and balance tests were all within or above the 90% LSI limit. None of the differences between the operated and non-operated legs were significant except for the single leg side hop (p = 0.02), in which the operated leg performed better (Table 4). Quality of movement assessments showed no significant differences in dynamic knee valgus and lumbopelvic control between the operated and nonoperated legs (Table 5). No pain was reported during the quantity and quality of movement assessments.

Table 5 - Results of quality of movement assessments at follow-up.

Variables	Operated hip		Non- operated hip		P-value Operated vs non-operated	
	% LP	% DKV	LP	DKV	LP	DKV
n	37	37	37	37	-	-
Single leg squat test	27	21.6	35.1	18.9	0.61	1.00
Single leg vertical jump	10.8	21.6	8.1	5.4	1.00	0.11
Single leg hop for distance	13.5	13.5	5.4	13.5	0.38	1.00

LP Lumbopelvic control; DKV, Dynamic knee valgus; % Percentage of participants with altered lumbopelvic control or dynamic knee valgus during take-off or landing; * P-value ≤ 0.05 on McNemar tests; - Not applicable.

Discussion

This clinical observational study of follow-up data described short- and midterm results of hip arthroscopy patients based on patient-reported hip function, hip functional performance and return to sports activities. To our knowledge, this is the first study to use these functional performance tests in the evaluation of hip arthroscopy patients. It is also the first study to compare these tests with patient-reported outcomes and return to sports over a longer period of time after hip arthroscopy. Most of the patients (81%) reported improvement and 84% reported successful return to sports or leisure activities. However, only 19% of the patients returned to the same sport at the same level as the pre-injury condition. The hip ROM and strength, as quantity of movement components, were within the predefined 90% LSI limit, except for hip internal rotation ROM in 0 and 90 degrees of hip flexion. The balance and hop tests were both analyzed from a quantitative and qualitative perspective and were also within the predefined 90% LSI limit. Therefore, a full recovery of hip functional performance, was reported.

The results found in this study regarding patient-reported outcomes are similar to earlier studies [24, 35]. We found an average IHOT-33 score of 69.3 (SD = 21.4), which is comparable to the 72 (SD = 20.1) and 65 (SD = 19.3) found in previous research [24, 35]. The VAS score reported in this study (35.0, SD 25.2) reflects Nielsen et al.'s (37.0, SD = 29.0) [36]. Eighty-one percent of the patients in this study reported minor to full improvement on the GPE. This is comparable to Ha et al.'s recent study (86%) [37], and is higher than the results found in earlier studies [38, 39]. The short and mid-term results found in this study regarding PROs indicate patients have a relatively good self-reported hip function and little pain after hip arthroscopy.

Besides patient-reported hip function this study investigated hip functional performance. According to the International Classification of Functioning, Disability and Health (ICF) model, patients should be evaluated within the context of their functioning [40]. This functional performance consists of both quantity and quality of movement components and has not been extensively investigated for hip arthroscopy patients [6, 14, 41].
For the quantity of movement components, this study only found internal rotation ROM to be outside the predefined 90% LSI limit. These results are better than previous reports by Kemp et al. [39] and Casartelli et al. [38] who found ROM and strength deficits in their patients after hip arthroscopy. Kemp et al. [39], compared patients with persistent chondrolabral pathology after hip arthroscopy to healthy controls and found less hip internal rotation (-5°) and more extension ROM (+ 5°), as well as less hip adduction (0.27 Nm.kg-1), extension (0.25 Nm.kg-1), flexion (0.31 Nm.kg-1) and external rotation (0.09 Nm.kg-1) strength in hip patients [39]. Casartelli et al. [38] found a significant deficit (18%) in hip flexion strength of the operated leg when comparing patients to a control group. Both studies used a control group instead of the nonoperated hip as comparator [38, 39]. Also, Kemp et al. [39] used torque normalized for body weight. These differences might explain the discrepancies with the results of our study. To the authors' knowledge, no previous studies have reported data on the quantity of movement of balance and hop tests in a population of hip arthroscopy patients.
Concerning quality of movement only Charlton et al. [41] reported data from a group of hip arthroscopy patients. They found deficits one to two years after hip arthroscopy when evaluating the quality of movement of the single leg squat test for the operated leg compared to the non-operated leg and compared to healthy controls. Hip adduction and knee valgus were higher for hip arthroscopy patients and were positively correlated with hip flexor and extensor strength [41]. Our study did not find poorer quality of movement for the operated leg. However, Charlton et al. [41] used significance and healthy controls to establish differences whereas we study used the LSI and operated leg as comparator. Also, Charlton et al. [41] only used the single leg squat test instead of multiple functional performance tests. When comparing our data of the quality of movement of the balance and hop tests between both legs, the operated leg often performed slightly better (LSI > 100%). These differences were not significant, except for lumbopelvic control during the single leg side hop test. The fact that the operated leg often performed slightly better might be due to the use of functional performance exercises during postoperative rehabilitation (Appendix 1).

This study found a return to sports or activities rate of 84%, although only 19% of the patients returned to the same sport at the same level as the pre-injury condition.
There was also a significant decrease in sports frequency ($p = 0.04$) and a trend towards low impact sports after surgery ($p = 0.09$). The relatively low return to pre-injury sports level and trend towards low impact sports was confirmed by Charlton et al. [41].
However, earlier studies [5, 16, 42, 43] reported higher rates of post-surgical return to sports at the pre-surgery level (69 – 88%). The level of competition (professional athletes are more likely to return to same level of sport due to financial/contractual obligations), time of evaluation after surgery and percentage of acetabular cartilage lesions at the time of surgery may influence the rate of return to sport [5, 44]. In this study, all participants were recreational athletes and the time of evaluation at follow-up differed between 0.6 – 3.8 years post-surgery. This might explain the differences with earlier studies, which were often performed in professional athletes shortly after surgery

(< one year follow-up) [5, 16, 42]. When participants in our study were asked about the main reasons for not returning to the same sport at the same level as was performed pre-surgery, a lack of time/motivation and/or new injuries of the lower extremities and spine were reported. Previous studies suggested that a lack of functional performance might lead to decreased sport activities and the development of new injuries [10, 41, 45]. Our study did not confirm these findings since only deficits for hip internal rotation ROM were found. Further research is necessary to establish return to sports rates, factors for decreased sports participation and possible relationships with functional performance in this patient population.

A limitation of this study is the sample size, with only 37 patients included. A second limitation of this study is the use of the LSI limit as an indicator of recovery. Both LSI and significance can be used to establish differences between legs [38, 46]. Because significant differences give an indication of statistically relevant differences instead of clinically relevant differences, and because of earlier studies on functional performance in lower extremity injuries, we decided to use the LSI as outcome parameter [17, 31, 46]. However, further research is warranted to establish the amount of symmetry necessary to indicate good recovery/less risk of re-injury in order to decide which indicator for recovery should be used. Moreover, use of a LSI requires use of the nonoperated leg as comparator. In this study no radiographic data of the nonoperated hips were available so it is unclear if possible morphological changes were present in these non-operated hips. By excluding subjects with hip pain or positive results on tests recently defined as indicators for intra-articular hip pathology [20], the authors tried to exclude patients with symptomatic morphological changes of the non-operated hip.
A final limitation is that the patient population was heterogeneous in age, the follow-up period post-surgery as well as the perioperative diagnosis (Table 2 and 3). However, there was an equal distribution of participants between various pathologies. Also, the recovery parameters used in this study were based on intra-individual parameters (before/after symptoms, injured/noninjured leg). Still, this might have led to some bias. As at the moment, information on hip functional performance in combination with PROs and return to sports activities for hip arthroscopy patients is under exposed; this study tries to add to the current knowledge. Future research should focus on larger groups of patients combined with control groups and standard time points for follow-up measurements [5, 17].

Conclusion

The overall short- and midterm results of these follow-up data show good recovery of hip arthroscopy patients on patient-reported outcomes, functional performance and return to sports or activity; 81% of all patients reported improvement and 84% reported return to sports/activity. Only internal rotation ROM in 0 and 90 degrees of hip flexion had a LSI limit of less than 90%. All other measures of hip functional performance were within or above this 90% LSI limit. The functional performance tests used in this study seem adequate in order to measure recovery for hip arthroscopy patients

Acknowledgements

The authors thank Maarten Heeres (MH) and Bert-Jan van Schaik (BS) for their assistance in the data collection of this study.

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Appendix 1 - Postoperative rehabilitation protocol after hip arthroscopic surgery.

Appendix 1A - Four phases of rehabilitation protocol with goals, precautions, criteria for progression and proposed exercises.

Phases	Treatment goals*	Precautions	Progression criteria to next phase
Pre-operative intake	- Inform about rehabilitation process - Teach walking with crutches - Advice on direct postoperative ROM/weight bearing restrictions (based on per operative treatment) - Perform baseline measurements of both legs for postoperative comparison - Check if adaptations in workspace or at home are in order	-	-
Phase 1 – Protection	- Advice on how to reduce pain/swelling/inflammation - Improve tissue recovery/walking with crutches - Improve passive ROM within restrictions with mobilizations/exercises - Prevent muscular inhibition/Start neuromuscular training hip and trunk muscles - Start isometric hip muscle exercises (without weight bearing mostly open kinetic chain on floor) - Start cardio training with cycle ergometer or in swimming pool - Start walking in pool - Start core stability exercises - Start stretching exercises/mobilizations for the lumbar spine, pelvis, knee and ankle and joint activation	- Be aware of specific weight bearing and ROM restrictions - Be careful with hip muscle flexor load in order to avoid inflammation - Similar hip pain as pre-operatively identified by patient is normal for first 2-6 weeks	- Be aware of specific weight bearing and ROM restrictions - Be careful with hip muscle flexor load in order to avoid inflammation - Similar hip pain as pre-operatively identified by patient is normal for first 2-6 weeks

Appendix 1A - Continued

Phases	Treatment goals*	Precautions	Progression criteria to next phase
Phase 2 – Progressive joint loading and functional restoration	- Improve tissue recovery by gradually increasing walking without crutches - Improve passive and active ROM with mobilizations/exercises - Progress stretching exercises/mobilizations for the lumbar spine, pelvis, knee and ankle - Improve hip muscle strength starting with closed kinetic chain exercises (weight bearing) working towards open kinetic chain exercises (external weights) - Improve trunk (core stability) and lower leg muscle strength (closed kinetic chain external weights) - Increase cardio training with crosstrainer/ stepping machine - Increase walking distance - Regain normal gait pattern with crutches	- Be careful with hip muscle flexor load in order to avoid inflammation - Be careful with stretching exercises towards end range of motion - Do not perform plyometric exercises	- Passive ROM recovered until ≥ 90% of non-operated leg - Hip strength ≥ 70% of non-operated leg for all muscles except hip flexors ≥ 60% - Hip functional performance tests (no plyometrics) ≥ 80% of non-operated leg - Pain free and normal gait pattern with crutches - Correct recruitment hip and trunk muscles during closed kinetic chain exercises with at least full body weight used.
Phase 3 – Activity restoration	- Regain full hip endurance strength by performing both closed and open kinetic chain exercises based on functions in daily life and low impact sports - Progress trunk and lower leg muscle strength by core stability and complete kinetic chain exercises - Start with agility training, plyometrics and cutting and rotational exercises - Regain cardio vascular endurance by treadmill/jogging - Progress optimizing neuromuscular control/propriocepsis/ balance hip joint	- Be careful with hip muscle flexor load in order to avoid inflammation - Be careful with uncontrolled stretching exercises in end range of motion - Do not perform team sports with repetitive rotations/cutting maneuvers - Do not perform sports with repetitive tackles/falls	- Passive and active ROM ≥ 90% of non-operated leg - Hip strength ≥ 80% of non-operated leg for all muscles except hip flexors ≥ 70% - Hip functional performance tests ≥ 90% of non-operated leg - Trunk and lower leg strength ≥ 90% of non-operated leg - Pain free and correct motion during agility training

Appendix 1A - Continued

Phases	Treatment goals*	Precautions	Progression criteria to next phase
Phase 4 – Return to sport	- Regain full hip strength - Start to perform sport specific exercises without pain/discomfort - Increase agility training and cutting and turning exercises - Increase plyometrics - Progress to return to sports/activity	-	- Passive and active ROM ≥ 90% of non-operated leg - Hip strength ≥ 90% of non-operated leg - Hip functional performance tests ≥ 90% of non-operated leg - Trunk and lower leg strength ≥ 90% of non-operated leg - Pain free and correct motion during sport specific exercises

General recommendations for use throughout each phase are:

- Use a Visual analogue scale (VAS) and the International Hip Outcome Tool 33 (IHOT-33) pre-operative, at the start of each phase, at the end of rehabilitation and at one and two year follow-up.
- Measure ROM by means of goniometer or inclinometer.
- Quantify strength by means of Hand Held Dynamometer or isokinetic strength testing.
- Use hip functional performance maneuvers (see Article) pre-operative, at the start of each phase, at the end of rehabilitation and at one and two year follow-up. An exception is made for all tests at start of phase 1 (directly post operative) and for the plyometric tests at start of phase 2.
- Check and treat if necessary mobility of lumbar spine, pelvis, knee and ankle joint at regular basis (at least once every phase).

ROM, Range of motion; - Not applicable; * Treatment = these are short and general indications of treatment and exercises to be executed within each phase. The authors had no intention of providing all possible exercises and mobilizations.

Appendix 1B - General information on the selected arthroscopic procedures

Labral resection	Labral fixation	Osteoplasty	Capsular modifications	Microfracture procedure	Lig. Teres resection
- 2 weeks no weight bearing (crutches) - Restrict hip ROM for 2 weeks: flexion < 90°, ab/adduction and rotations < 25° - Precaution: hip joint inflammation	- 2 weeks no weight bearing, 2 weeks partial weight bearing (crutches) - Restrict hip ROM for 2 weeks: flexion < 90°, ab/adduction and rotations < 25° - Precaution: hip joint inflammation, tendinitis hip flexors	- 2 weeks no weight bearing, 2 weeks partial weight bearing (crutches) - Restrict hip ROM for 2 weeks: flexion < 90°, ab/adduction and rotations < 25° - Precaution: hip joint inflammation, tensile/ compression forces to hip joint	- 2 weeks no weight bearing, 2 weeks partial weight bearing (crutches) - Restrict hip ROM for 4 weeks: flexion < 90°, ab/adduction and rotations < 25° - Precaution: hip joint/ capsular inflammation, tension affected capsular tissue Note: ROM restrictions mentioned above are based on capsular modification anterior region	- 4 weeks no weight bearing, 2-4 weeks partial weight bearing (crutches) - Restrict hip ROM for 2 weeks: flexion < 90°, ab/adduction and rotations < 25° - Precaution: hip joint inflammation, reinitiation of inflammatory response, tensile/ compression forces to hip joint	- 2 weeks no weight bearing, 2 weeks partial weight bearing (crutches) - Restrict hip ROM for 2 weeks: flexion < 90°, ab/adduction and rotations < 25° - Precaution: hip joint inflammation, tendinitis hip flexors
*Phase 1: PO Phase 2: 4 weeks Phase 3: 8 weeks Phase 4: 12 weeks Discharge: 16 weeks	*Phase 1: PO Phase 2: 4 weeks Phase 3: 8-10 weeks Phase 4: 12-14 weeks Discharge: 20 weeks	*Phase 1: PO Phase 2: 4 weeks Phase 3: 8weeks Phase 4: 12 weeks Discharge: 16 weeks	*Phase 1: PO Phase 2: 4 weeks Phase 3: 8-10 weeks Phase 4: 12-14 weeks Discharge: 20 weeks	*Phase 1: PO Phase 2: 8 weeks Phase 3: 16 weeks Phase 4: 20-22 weeks Discharge: 24-32 weeks	*Phase 1: PO Phase 2: 4 weeks Phase 3: 8 weeks Phase 4: 12 weeks Discharge: 16 weeks

General recommendations for all above mentioned arthroscopic procedures are:

- Above criteria are general estimates. Progression of weight bearing and ROM should be based on these estimates as well as perceived pain and limitations as reported by the patient.
- Therapy frequency should be based on goals and progression criteria to be achieved. Two supervised therapy sessions per week plus home-based exercises are recommended for the initial six weeks.

ROM, Range of motion; PO, post-operative; * The timelines here are estimates for the clinician. Progression from one phase to the other should mainly be based on goals to be achieved.

8

CHAPTER 8

Physical therapy aimed at self-management versus usual care physical therapy after hip arthroscopy for femoroacetabular impingement: study protocol for a randomized controlled trial.

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Trials Journal, 2016, 17, 17 - 91.

Abstract

Background: Femoroacetabular impingement has been recognized as a common cause of hip pain and dysfunction, especially in athletes. Femoroacetabular impingement can now be better treated by hip arthroscopy. It is unclear what postoperative rehabilitation of hip arthroscopy should look like. Several rehabilitation protocols have been described, but none presented clinical outcome data. These protocols also differ in frequency, duration and level of supervision. We developed a rehabilitation protocol with supervised physical therapy which showed good clinical results and is considered usual care in our treatment center. However it is unknown if, due to the relatively young age and low complication rate of hip arthroscopy patients, rehabilitation based on self-management might lead to similar results. The aims of this pilot study are 1) to determine feasibility and acceptability of the self-management intervention 2) to obtain a preliminary estimate of the difference in effect between physical therapy aimed at self-management versus usual care physical therapy in patients who undergo hip arthroscopy for femoroacetabular impingement.
Methods: 30 participants (18 – 50 years) scheduled for hip arthroscopy will be included and randomized (after surgery) to either self-management or usual care physical therapy in this assessor-blinded randomized controlled trial. After surgery, the self-management group will perform a home-based exercise program three times a week and will receive physical therapy treatment once every two weeks during 14 weeks. The usual care group will receive physical therapy treatment two times a week during 14 weeks and will perform an additional home-based exercise program once a week. Assessment will occur preoperatively and at six, 14, 26 and 52 weeks after surgery. Primary outcomes are feasibility, acceptability and preliminary effectiveness. Feasibility and acceptability will be determined by the willingness to enroll, recruitment rate, adherence to treatment, patient satisfaction, drop-out rate and adverse events. Preliminary effectiveness will be determined using the following outcomes: the International Hip Outcome Tool 33 and hip functional performance as measured with the Single Leg Squat Test 14 weeks after surgery.
Discussion: The results of this study will be used to help decide on the need, feasibility and acceptability of a large scale randomized controlled trial.
Trial registration: This protocol was registered with the Dutch Trial Registry (NTR5168) at 8 May 2015.
Keywords: Hip joint, Femoroacetabular impingement, Arthroscopy, Rehabilitation, Physical therapy.

Introduction

Intra-articular hip pathology has gained increasing interest over the past decade [1]. Especially, femoroacetabular impingement (FAI) has been recognized as common cause of hip pain and dysfunction [1, 2]. The incidence of FAI in the general population has been reported to range from 4% in healthy women to 24% in healthy men [3, 4]. Moreover, 23% of people with radiographic confirmed FAI complain of hip pain [5]. FAI occurs when the proximal femoral head does not permit normal range of motion in the acetabular socket [2]. This impingement can be based on abnormal morphology of the femoral head (cam impingement), acetabular rim (pincer impingement) or both [2]. FAI can cause other intra-articular hip pathology, such as labral pathology and chondral damage [2]. It is also thought to lead to development of secondary osteoarthritis of the hip [3, 6-9]. One of the most commonly used options to treat FAI over the last years has been hip arthroscopy [1]. This arthroscopic technique is often performed to treat intra-articular hip pathology and the number of procedures performed has increased considerably over the last 10 years [1]. Due to the development of hip arthroscopy, FAI can now be better treated with fewer complications and a faster rehabilitation rate [10, 11].

It is unclear which type of rehabilitation is most beneficial for the postoperative FAI population. Several postoperative rehabilitation protocols have been described which all include physical therapy treatment and exercises [10, 12-19]. Yet, therapy goals, frequency and duration of these protocols differ [10, 12-19]. More importantly, the studies describing these rehabilitation protocols provide little to no information with regard to clinical outcome data [11]. Only a few case studies have described clinical outcome data for postoperative interventions in hip arthroscopy patients [10, 14, 16, 17]. So, the clinician can choose from different rehabilitation protocols, but there is little information on the effects achieved. Based on the differences in existing rehabilitation protocols and the lack of clinical outcome data we developed a rehabilitation protocol for hip arthroscopy patients. This protocol combines information retrieved from the available literature on postoperative rehabilitation with the clinical experience of the lead researcher (MT) and orthopedic surgeon (EV) [10-19]. The protocol has been satisfactorily used as usual care in clinical practice over the last five years [20]. Current results of this protocol show that at a mean follow-up time of 2.3 years after surgery, 81% of patients reported improvement on the Global Perceived Effect (GPE) Scale and 84% returned to sports activities. A full recovery of hip functional performance, as measured with balance and hop tests, was established [20].

The majority of the available rehabilitation protocols (including our own) is based on supervised physical therapy with a small, additional home-based exercise program. A self-management strategy (i.e., increasing the home-based exercise program and decreasing supervision) would lead to a more cost-effective and widely applicable rehabilitation [11, 20]. Rehabilitation based on self-management might be adequate as hip arthroscopy is often performed in a young to middle aged, healthy population with little risk of complications. Until now this has not been prospectively investigated. Currently, one randomized controlled trial is performed into the efficacy of postoperative physical therapy for FAI [21]. However, these authors compare physical therapy versus a control group (one in-hospital physical therapy visit combined with an information brochure) instead of a self-management group [21]. A comparison between physical therapy aimed at self-management and usual care physical therapy

in patients treated for FAI by means of hip arthroscopy seems warranted. Because of the lack of earlier randomized controlled trials (RCT's) in this field executing a pilot controlled study into the feasibility, acceptability and preliminary effectiveness is necessary before planning and conducting a larger scale RCT [22].

The aims of this pilot study are 1) to determine feasibility and acceptability of the self-management intervention 2) to obtain a preliminary estimate of the difference in effect between two rehabilitation strategies, self-management versus usual care physical therapy (according to the developed protocol), in patients who undergo hip arthroscopy for femoroacetabular impingement.

Methods/Design

Study design

This study protocol describes a parallel-designed, 2-arm, assessor-blinded RCT. Outcomes will be assessed at six, 14, 26 and 52 weeks after surgery in which the 14 weeks assessment will be the main outcome assessment. The study protocol has been developed based on the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) guidelines [23]. The study design was approved by the local ethics committee; Commissie Mensgebonden Onderzoek (CMO) Arnhem-Nijmegen (2015-1730) and registered with the Dutch Trial Registry (NTR5168) at 8 May 2015. All participants will be asked to sign informed consent before start of the study.

Participants

A total of 30 participants (18 – 50 years of age) scheduled for hip arthroscopy at Rijnstate Hospital, Arnhem the Netherlands, and living in the near proximity of this hospital (< 50 kilometers) will be included in this study. Participants are eligible if: 1) they experienced hip/groin pain for at least three months: 2) are diagnosed with FAI by one of two orthopedic surgeons (ET/MW) based on symptoms, clinical signs and imaging findings [24]: 3) are willing to sign informed consent, and 4) are willing to participate in the rehabilitation program at Sports Medical Center Papendal (SMCP), Arnhem the Netherlands. Participants will be excluded if: 1) they are professional athletes: 2) there is radiographic evidence of hip osteoarthritis (> Tonnis grade 1:3): 3) there are contra-indications for the hip arthroscopy procedure: 4) there are other pathologies, such as cardiovascular disease, that can influence therapy effects: 5) there is an inability to speak or understand the Dutch language, and 6) there is an inability to comply with postoperative rehabilitation and exercises due to other reasons, such as a lack of time etcetera.

Study procedure

Potential participants will be identified by the orthopedic surgeons (EV/MW) and will be advised to undergo a preoperative intake with a physical therapist (MT) at Sports Medical Center Papendal, Arnhem the Netherlands. This is part of usual preoperative care. At the preoperative intake all participants will be informed about the study (including information on both interventions). Two weeks after this preoperative intake participants will be contacted by the lead researcher (MT) in order to inform if they want to participate in the study. If so, they are invited for a baseline assessment two to four weeks before surgery. At this assessment (BD) they will also receive instructions about direct postoperative treatment and sign an informed consent (MT). Surgery

will be performed by one of two surgeons (EV/MW) at Rijnstate Hospital, Arnhem the Netherlands. Randomization will occur directly after surgery. Participants will be divided into two groups (self-management group versus usual care physical therapy group) which will both be treated by the same physical therapist (MT). The self-management group will receive physical therapy treatment once every two weeks (week 2, 4, 6, 8, 10, 12, 14) leading to a total of seven sessions in 14 weeks whereas the usual care physical therapy group will receive physical therapy treatment two times a week during 14 weeks (24 sessions). The self-management group will be asked to perform an additional home-based exercise program three times per week. The usual care physical therapy group will be asked to perform a similar program once a week. Participants in the self-management group that report a deterioration on the International Hip Outcome Tool 33 (IHOT-33) at six weeks after surgery compared to the baseline/preoperative measurement or that experience complications from surgery as described in Figure 1 will be offered a transition to the usual care physical therapy group. In case of (serious) adverse events further participation of the study will be decided on by consultation with the responsible surgeon and participant. No adverse events or serious adverse events are expected. In case of (serious) adverse events the responsible surgeon will be in charge of treatment immediately. All adverse events will be documented by the main researcher (MT). Re-assessment will be performed by one blinded assessor (BD) and will occur at six, 14, 26 and 52 weeks after surgery. A flow chart of the study procedure is shown in Figure 1.

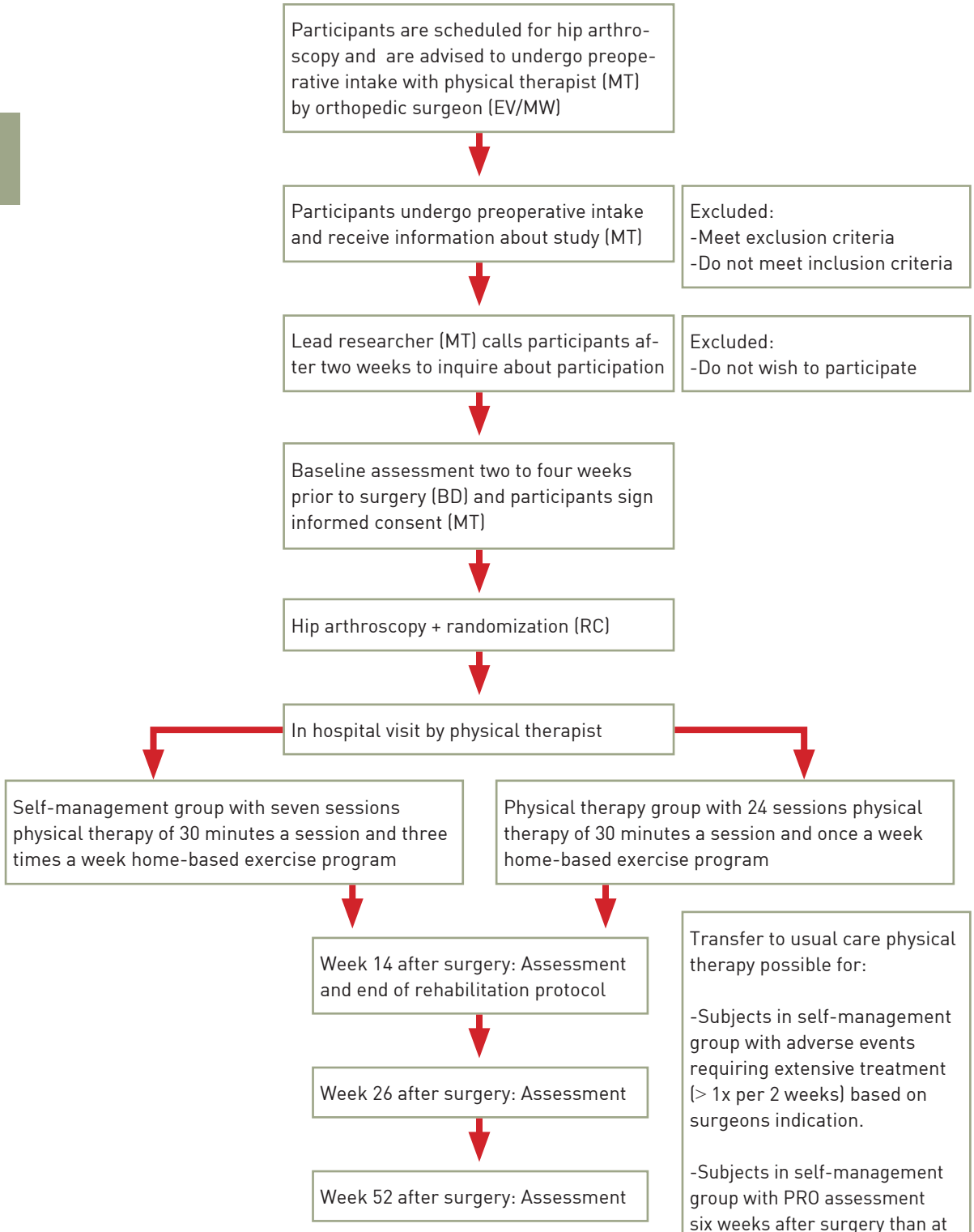

Figure 1 - Flow chart of study procedure.

Blinding and randomization

The surgeons (EV/MW) and assessor (BD) executing the assessments will be blinded to group allocation. The statistician (ST) will be blinded to group allocation until completion of the statistical analysis. However, it is impossible to blind the physical therapist (MT) executing the rehabilitation protocol and the study participants. Participants will be asked not to reveal group allocation when visiting the orthopedic surgeon postoperatively as well as when undergoing follow-up measurements by the blinded assessor (BD). Before randomization, participants will be asked to state group preference. This information will be used to later investigate if group preference influenced study results.

Randomization is done on the individual level through a computer-generated random-sequence table. Pre-stratification is applied for gender. Opaque, sequentially numbered, sealed envelopes are prepared for each stratum (that is, gender) by a researcher (RC) who is not involved in enrolling the participants, in assigning them to their groups or performing follow-up measurements. Every envelope will contain a paper indicating the treatment allocation. Participants will receive their envelope during the first consultation with the physical therapist after surgery (two weeks postoperative).

Hip arthroscopy procedure and immediate postoperative care

Arthroscopy will be performed by one out of two orthopedic surgeons (EV/MW) with respectively 10 and three years of experience in this field of expertise. Spinal needles are placed under image intensifier control to mark the anterior and anterolateral portals. Guide wires and cannulated trocars will be used to introduce cannulae, arthroscopes, and other instruments. A 70° arthroscope will be used to adequately visualize the acetabulum, acetabular labrum, ligaments and the anterior, superior, and posterior aspects of the femoral head. These areas of the hip will be inspected and also probed to assess labral attachment and articular cartilage softening. Pincer-type impingement is typically found in the superior anterior quadrant and will be identified when there is bone overgrowth, a pincer projection causing labral displacement or a crossing sign to be seen over the labrum with fluoroscopy. In order to establish cam-type impingement traction will be released and the peripheral compartment will be investigated. Cam-type impingement will be defined during arthroscopic physical examination, especially during flexion and internal rotation and by the presence of local abnormalities coherent with cam-type impingement, such as chondral lesions. In all cases in which surgically treatable pathology is identified such treatment will be performed arthroscopically. Immediate postoperative care will be the same for both groups. Participants will stay in the hospital during one night. They will receive a visit from the physical therapist in the hospital to improve gait function with crutches and get initial advice for the first postoperative week at home. A follow-up visit with the orthopedic surgeon will be scheduled six weeks after surgery.

Study interventions

Physical therapy treatment at Sports Medical Center Papendal will start two weeks after surgery for both groups. For the first two postoperative weeks both groups will start self-mobilizations and basic stability exercises unsupervised on a daily basis at

home as explained to them preoperatively and during immediate postoperative care in the hospital.

Self-management group
The self-management group will conduct exercises three times a week at home with supervision and treatment by a physical therapist once every two weeks. The content of the therapy will be exactly similar to the usual care physical therapy group, except for the frequency as to which the participant will meet with the physical therapist. This means that the amount of hands on physical therapy as well as instructions concerning adjustments to the exercises and education will differ.

Usual care physical therapy group
The usual care physical therapy group will receive hands on physical therapy care and conduct exercises supervised by a therapist twice a week and unsupervised (at home) once a week.

Content of postoperative rehabilitation protocol
The content of the physical therapy protocol consists of hands on physical therapy care, exercises, education, cardiovascular training and return to sports. This protocol is based on previous literature combined with our own clinical experience [10-20]. For a complete overview of the postoperative rehabilitation protocol for both groups see Table 1-3 and Appendix 1A/B [20]. The exact content each therapy session will be reported in the therapy records. Treatment that is delivered, but also treatment that has not been delivered (including reasons why) will be reported at every session by the physical therapist.

Table 1 - Overview of postoperative rehabilitation protocol - hands on physical therapy care [25].

Technique	Aim	Description	Timeframe	Dosage
Soft tissue massage and trigger point therapy of iliopsoas, rectus femoris, sartorius, adductor group, gluteus medius/minimus, tensor fascia latae and quadratus lumborum	Address soft tissue restrictions with aim of pain reduction and mobility improvement of the hip and pelvis	Sustained pressure to each trigger point (with muscle on stretch).	Week 2 - 14	30 – 60 seconds per trigger point
		Longitudinal massage along the muscle belly		< 5 minutes per muscle
Manual mobilizations of the hip	To improve mobility and pain-free movement of the hip (especially flexion and internal/external rotation)	Traction directed inferior with hip in maximum lose packed position. Traction applied with traction belt directed inferior/laterally with hip in flexion (and if necessary rotations)	Week 2 – 8	3- 5 sets 30-60 seconds
Manual mobilizations of the lumbar spine	To improve mobility and pain-free movement of the hip and lumbar spine	Unilateral posterior-anterior assecory glides grade 3 or 4. Gentle gapping mobilizations with subject/participant lying on his/her side	Week 2 – 8	3- 5 sets 30-60 seconds
Manual mobilizations of the pelvis	To improve mobility and pain-free movement of the hip and pelvis	Mobilizations of the ilium in anterior or posterior direction or mobilization of the sacrum	Week 2 – 8	3- 5 sets 30-60 seconds

The physical therapy protocol is performed by one physical therapist (MT) and is semi-structured. The hands on physical therapy care will be based on subject specific indications and clinical presentation such as pain and range of motion (ROM) restrictions. In case multiple techniques are indicated the order will be as follows: manual mobilizations of lumbar spine, pelvis and hip before soft tissue massage and trigger point therapy.

Table 2 - Overview of postoperative rehabilitation protocol - exercises [20, 21, 25-28].

Exercise	Aim	Description	Timeframe	Dosage
Self-mobilizations of the hip, pelvis and lumbar spine	To help improve mobility and pain-free movement of the hip, pelvis and lumbar spine and prevent adhesions of the hip capsule	See additional file 3A; row 1 exercises 1-5 See additional file 3A; row 1 exercise 6	Week 0 – 2 Week 2 – 8	1 minute per exercise, 3 times per day 1 minute per exercise
Anterior and posterior hip stretch	To help improve hip flexion and extension mobility	See additional file 3A; row 2 exercises 1-2	Week 2 – 8	3- 5 sets 30 seconds
Hip muscle retraining	To optimize neuromuscular control and stability of the hip	See additional file 3A; row 3 exercises 1-5	Week 0 – 4	3 sets 12-20 repetitions
Hip muscle strengthening (focus on extensor/rotator strengthening)	To optimize neuromuscular control, stability and strength of the hip	See additional file 3A; row 4- 5 exercises 1-9	Week 4 – 14	3 sets 8 – 12 repetitions with increasing load based on experienced fatigue
Functional hip muscle strengthening	To optimize neuromuscular control, stability and strength of the hip in patient specific (sport) activities	Exercises based on patient specific goals or (sport) demands such as kicking in soccer or throwing/ smashing in volleyball/tennis	Week 10 – 14	3 sets 8 – 12 repetitions with increasing load based on experienced fatigue

The physical therapy protocol is performed by one physical therapist (MT) and is semi-structured. Loads will be adjusted based on the participants functional performance and rehabilitation goals.

Table 3 - Overview of postoperative rehabilitation protocol – cardiovascular training and return to sports [11].

Exercise	Aim	Description	Timeframe	Dosage
Stationary cycling	Improve cardiovascular fitness and hip range of motion	Upright home trainer with set height to avoid hip flexion over 90 degrees (start with 15 minutes)	Week 0 – 4	Daily
		If cycling is main sport or participant does not desire return to (any) sport activities	Week 4 – 14	3 times a week
Cross trainer	Improve cardiovascular fitness and hip functional performance	Start with 15 minutes at moderate intensity (60 – 80% maximum heart rate)	Week 5 – 10	3 times a week
Treadmill/Jogging	Improve cardiovascular fitness and hip functional performance	Start with interval training at moderate intensity preferable outside on grass/track	Week 10 – 14	3 times a week
Acceleration/cutting/agility skills	Initiate return to sports performance	Zig-zag jogging, speedladder skills	Week 8 – 12	2 times a week
Sport-specific drills	Initiate return to sports performance	Exercises based on patient specific goals or (sport) demands such as kicking in soccer or throwing/ smashing in volleyball/tennis	Week 10 – 14	2 times a week

The physical therapy protocol is performed by one physical therapist (MT) and is semi-structured. Specific return to sport exercises will be tailored for each individual participant based on 1) sport activity 2) desired level of sport activity and 3) current level of function.

Hands on physical therapy care
Hands on physical therapy care consists of manual mobilizations, massage and trigger point therapy by a physical therapist (MT) (Table 1) [25]. These modalities will be performed by the physical therapist based on subject specific indications and clinical presentation such as pain and range of motion (ROM) restrictions. Mobility restrictions and mobility progression will be measured with a goniometer (Fysiosupplies 20cm) and reported in the therapy records.

Exercises
The exercises consist of strength and stability exercises as well as self-mobilizations of the hip, pelvis and lumbar spine [20, 21, 25-28]. These exercises will be performed statically and dynamically and will be tailored to the participants level of fitness. Loads will be adjusted based on the participants functional performance and rehabilitation goals. From week 10 these exercises will be adjusted to the specific sports/activity demands of each participant, for example kicking and cutting/pivoting in soccer players. For an overview of exercise progression and exercises see Table 2 and Appendix 1A/B.

Education
Education will consist of information on joint protection, postoperative weight-bearing (use of two crutches during four weeks starting with flat foot weight-bearing and gradually increasing to full weight-bearing) and regaining complete function in activities of daily life, work and sports as well as information on the importance of the home-based program [11]. The education will start preoperatively (participants will also receive an information booklet prior to surgery) and will continue throughout the complete postoperative rehabilitation. It will be tailored based on the participants level of function and knowledge.

Cardiovascular training and return to sports
Cardiovascular training will be started by means of a bicycle ergometer for the first four weeks in all participants. Participants in the home program, who do not have access to a bicycle ergometer, are offered use of a bicycle ergometer at Sports Medical Center Papendal, Arnhem the Netherlands. After four weeks a distinction will be made for participants for whom cycling is the main sport or whom do not perform sports; they will continue cardiovascular training by means of the bicycle ergometer. All other participants will progress by means of a cross trainer and further in the rehabilitation process towards jogging. Specific return to sport exercises will be tailored for each individual participant based on 1) sport activity 2) desired level of sport activity and 3) current level of function (Table 3) [11].

Outcome assessment

The complete rehabilitation will take 14 weeks, excluding the preoperative intake and follow-up assessments. These assessments are all conducted by the same researcher (BD) blinded to group allocation and are conducted at the following time points:
T0 – preoperative
T1 – 6 weeks postoperative
T2 – 14 weeks postoperative
T3 – 6 months postoperative (26 weeks)
T4 – 1 year postoperative (52 weeks)
For an overview of outcomes, outcome measures and assessment time points see Table 4.

Table 4 - Overview of outcomes, outcome measures and assessment time points.

Outcomes	Outcome measures	Assessment time point*
Feasibility and acceptability		
Number of therapy sessions + exact content of therapy	Therapy records	14, 26, 52 weeks
Adherence home-based exercise program	Log book	14 weeks
Adherence to log book completion	Log book	14 weeks
Willingness to enroll	Study records	01-06-2016 (final inclusion date)
Patient satisfaction	Questionnaire	14 weeks
Eligible patients	Study records	01-06-2016 (final inclusion date)
Recruitment rate	Study records	01-06-2016 (final inclusion date)
Drop-out rate	Questionnaire	14, 24, 52 weeks
Adverse events	Questionnaire	14, 24, 52 weeks
Other treatment/co-interventions	Log book/Questionnaire	14, 26, 52 weeks
Preliminary estimate of effect		
Perceived hip function and health-related QoL†	International Hip Outcome Tool 33 (IHOT 33)	0, 6, 14, 26, 52 weeks
Hip functional performance	Single Leg Squat Test (SLST)	0, 6, 14, 26, 52 weeks
Other outcomes		
Activity level	Modified Tegner Activity Scale	0, 14, 26, 52 weeks
Sports activity level	Hip Sports Activity Score (HSAS)	0, 14, 26, 52 weeks
Rating of change	Global Perceived Effect Scale (GPE)	14, 26, 52 weeks
Range of motion	Goniometer	0, 14, 26, 52 weeks
Strength	Hand Held Dynamometer	0, 14, 26, 52 weeks
Hip functional performance hop/jump	Single Leg Hop Test/Star Excursion Balance Test	0, 14, 26, 52 weeks
Patient history	Questionnaire	0 weeks
Patient demographics	Questionnaire	0 weeks
Surgical procedure + exact perioperative diagnosis	Surgical report	Following surgery
Medication use	Questionnaire	0, 14, 26, 52 weeks

*Assessment time point = point at which assessment is performed in weeks after surgery or calendar date (in case of study records being the outcome measurement).

0 weeks = preoperative baseline assessment. † QoL = Quality of Life.

Feasibility and acceptability
Feasibility of the study intervention will be assessed by adherence to the physical therapy program [22]. In order to establish adherence to the physical therapy program the number of therapy sessions will be recorded. Also, the exact content of both therapy interventions (based on therapy records) will be compared. Participants will be asked to fill out a log book in which adherence to the home-based exercise program will be reported as well as exercise intensity, fatigue and experienced pain. This log book will also be used to monitor and account for additional training/sports activities undertaken during the duration of the trial. Both the content of the log book as well as adherence to log book completion will be registered. Acceptability of the study intervention will be assessed evaluating willingness to enroll and by means of a patient satisfaction questionnaire to be answered 14 weeks after surgery [22]. In order to assess feasibility of the study design, the number of eligible patients, recruitment rate, drop-out rate and adverse events will be assessed [22]. Drop-outs and adverse events will be asked for in general questionnaires to be filled out at every assessment. Participants will be asked not to use or undergo other treatments then the ones suggested in this trial or start additional training/sports activities during the duration of the trial. This will be monitored by means of the before mentioned questionnaire as well as the log book.

Preliminary estimate of effect
The preliminary estimate of the difference in effect will be determined on health-related quality of life measured by the International Hip Outcome Tool 33 (IHOT-33) and functional performance measured by the Single Leg Squat Test (SLST). The IHOT-33 score consists of 33 questions, regarding hip disease and quality of life, each scored on a Visual Analogue Scale (VAS) with zero representing the worst and 100 representing the best score [29]. A final score is calculated by summing up the scores of all questions answered and dividing it by the number of questions answered [29]. Earlier studies have shown that this a reliable and valid questionnaire specifically developed to be used in a young population with intra-articular hip pathology [30]. The SLST consists of a squat task in which a subject stands on one leg on 20-cm box with arms folded across chest. The subjects then squats down to 60° knee angle five times at rate one squat per two seconds [31]. This performance is scored based on five criteria [32]. This test has shown good inter- and intra-rater reliability in a population of subjects with hip pain [31, 32].

Other outcomes
Other outcomes consist of Patient-Reported Outcome questionnaires (PROs), functional performance tests and general patient information. Three PRO questionnaires will be used, namely the Modified Tegner Activity Scale, the Hip Sports Activity Scale (HSAS) and Global Perceived Effect Scale (GPE). The Modified Tegner Activity Scale measures general physical activity level based on a zero to ten scale [33]. The HSAS measures sports activity level on a similar zero to ten scale and is specifically developed for hip patients [34]. Both questionnaires have been shown to have good reliability van validity in populations with lower extremity injuries [30]. The GPE will be used to measure the participants perceived change. This scale measures perceived change following treatment on a six-point ordinal scale. It has shown good validity in monitoring individual improvement after interventions [35].

In order to establish functional performance the following quantitative measurements will be executed: hip ROM measurements, hip strength measurements, the Single Leg Hop Test and the Star Excursion Balance Test. Range of motion of hip flexion, extension, abduction, adduction, external and internal rotation will be determined with a goniometer (Fysiosupplies 20cm) [11, 36]. Strength tests of these same directions are performed with a Hand Held Dynamometer (microFET 2, Hoggan Health Industries, USA) using the make method and average outcome of three trials as final score [11, 36]. The Single Leg Hop Test and Star Excursion Balance Test will be executed as described in earlier studies [31]. Both these tests have shown reliability and validity for use in a population of subjects with hip pathology based on recent systematic reviews [31].
General patient information such as patient history, patient demographics, surgical procedure, exact perioperative diagnosis and medication use will be gathered based on questionnaires and surgical reports.

Data and statistical analysis

Statistical analysis will be performed with IBM SPSS Statistics 22.0. The primary aims are to establish feasibility, acceptability and to obtain an estimate of the difference in effect between the self-management and usual care physical therapy group. A testing strategy for difference in effect of the primary outcomes IHOT-33 and SLST will be pre-specified as follows: first, IHOT-33 will be tested at the 0.05 level and if statistically significant (and only then) SLST will be tested (hierarchical testing at significance level 0.05). The pre-specification allows for valid inference on the primary endpoints. Explorative, the effect adjusted for age and subgroup of FAI (as diagnosed perioperative) will be investigated. The other endpoints will be analyzed descriptively. Changes from baseline to different time points will be analyzed with Ancova (baseline as covariate) providing an estimate of the effects and its 95%-confidence interval. Descriptive statistics including means and standard deviations (SDs) at each time point of each outcome will be reported. Longitudinal analysis using linear mixed models will also be performed.

Sample size

In line with the aim of obtaining an estimate of the difference in effect between the self-management and physical therapy group, the target sample size aims to achieve a reasonable precision (i.e. half-width of the 95%-confidence Interval) of this difference at week 14 in the IHOT-33 score using an Ancova analysis with baseline value of the outcome measure, IHOT-33, as covariate. We assume a standard deviation of 25 and test-retest reliability of 0.85 [29, 30]. With 15 subjects per group (i.e. 30 subjects in total) this leads to a precision of the difference of 9.4.

Discussion

This study provides a protocol for a pilot randomized controlled study into the feasibility, acceptability and preliminary effectiveness of two physical therapy rehabilitation strategies, self-management versus usual care physical therapy, in patients who undergo hip arthroscopy for femoroacetabular impingement. This study will identify feasibility and acceptability by means of willingness to enroll, the number of eligible patients, recruitment rate, adherence to treatment, patient satisfaction, possible drop-out rates and adverse events [22]. Additionally it will obtain a preliminary estimate

of the difference in effect of the two physical therapy rehabilitation strategies in order to assist in future power calculations for a larger RCT [22].

There is little published clinical evidence to support or refute the use of postoperative rehabilitation in hip arthroscopy patients [8, 11, 20, 21]. The rehabilitation protocol as described in this study is based on information retrieved from the available literature on postoperative rehabilitation combined with the clinical experience of the lead researcher (MT) and orthopedic surgeon (EV) [10-20]. To the authors knowledge no studies have been performed into self-management after hip arthroscopy for FAI.

The study was designed based on the principles of a randomized controlled clinical trial with precision analysis as such that one can expect to find a precision of the difference between both groups of 9.4. This precision analysis is performed in order to establish data for a larger randomized controlled trial. The initial outcomes (IHOT-33 and SLST) used to determine a preliminary estimate of the difference in effect are reliable and valid for use in a population of hip arthroscopy patients and are translated and validated into the Dutch language [29-31] [Tak et al., 2015 Unpublished data]. These outcomes are widely recommended for use in this particular population and will provide for comparison to other studies such as the before mentioned trial by Bennell et al. [21, 29-31].

The findings of this study will help decide on the need, feasibility and acceptability of the development of a larger randomized controlled trial for physical therapy in hip arthroscopy patients treated for FAI. Also, the pilot data will give an idea about the effect of postoperative care for hip arthroscopy patients and will possible help guide clinical decision making.

Trial Status

This trial is ongoing since the 1th of June 2015. At the time of submission of this protocol six subjects have been included in the study over a six month recruitment period. None of the participants have completed the follow-up period yet. No adverse events have been reported yet.

Acknowledgements

We thank dr. Marc Wagener for his help in recruiting and surgically treating participants. There is no additional funding for this study protocol and Britt Dorrestein for her help with patient inclusion and measurements.

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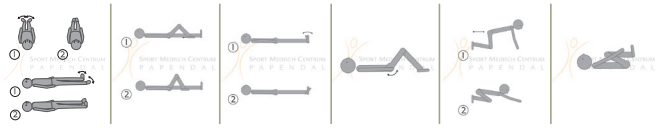
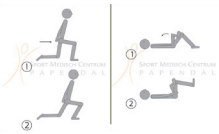
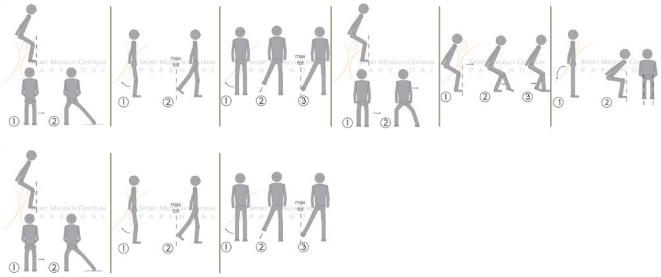
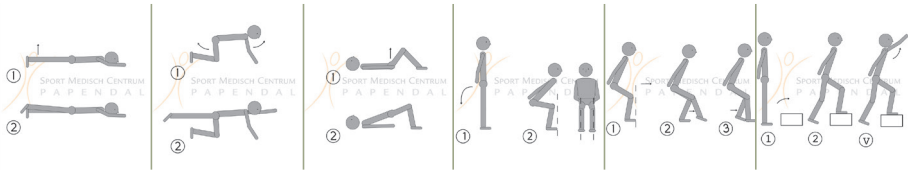
Appendix 1A - Specific examples of exercises included in exercise program.

Exercise goal and time of execution	Examples of specific exercises
Self-mobilizations of the hip, pelvis and lumbar spine Week 0-8	
Anterior and posterior hip stretch Week 2-8	
Hip muscle retraining Week 0-4	
Hip muscle strengthening (focus on extensor/rotator strengthening) Week 4-14	
Functional hip muscle strengthening Week 10-14	Exercises based on patient specific goals or (sport) demands throwing/smashing in combination with one leg stabilization in such as one leg exercises combined with kicking for soccer or in volleybal/tennis.

Appendix 1B - Example of exercise progression in exercise program.

Example of exercise progression of hip extension



CHAPTER 9

General discussion

Evidentially.....

An evidence-based approach to.....

Since the early 2000s, the rise of hip arthroscopies together with improvements in imaging led to a better understanding of hip joint pathology, especially in the young to middle-aged population [1, 2]. Traditional open hip surgery is often performed in an older population, whereas hip arthroscopy is often executed in young to middle-aged, active and athletic patients [1, 2]. This means that clinicians (doctors and physical therapists) encounter a 'new' population of hip patients with different needs and limitations, which results in 'new' diagnostic and treatment challenges [3].

As described in **Chapter 1**, the existing evidence is unable to answer questions needed to optimize the diagnoses and treatment of these young to middle-aged patients with symptomatic intra-articular hip pathology, such as; 1) how can we decrease delay and improve accuracy of these patients; 2) what should postoperative (physical therapy) care look like; and 3) what are the short- and mid-term effects of hip arthroscopy?
Therefore, the main objective of this thesis was to contribute to the development of an evidence-based approach for the diagnosis and postoperative physical therapy intervention of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology. The results of the studies described in this thesis form a framework for this evidence-based approach.

The first part of this general discussion debates the value of physical tests in the diagnoses of intra-articular hip pathology based on the results in **Chapters 2 and 3**. Also, the role of Patient-Reported Outcome questionnaires (PROs) for the monitoring of activity limitations and participation restrictions in these young to middle-aged patients is discussed based on the findings in **Chapters 4-6**. The second part of this general discussion focuses on the current role of postoperative physical therapy interventions for symptomatic intra-articular hip pathology based on the data from **Chapter 7** and implications for the study protocol described in **Chapter 8**. Directions for future research are described in the third part. Finally, this chapter closes with concluding remarks.

Clinical diagnostic challenges within the ICF model

In **Chapter 1**, the International Classification of Functioning, Disability, and Health (ICF) model was described [3, 4]. The ICF was developed by the World Health Organization (WHO) in order to classify the consequences of a health condition (disease or disorder) based on several levels; body functions and structures (impairments), activities (activity limitations), and participation (participation restrictions) [3, 4]. Physical therapists have adopted this model in order to organize and document information on functioning and disability of patients in clinical practice [3,4]. Furthermore, its use has been advocated in order to systematically analyze and document health conditions and work towards an evidence-based diagnosis and treatment intervention [3,4]. In this thesis, we have used this model to assess the current diagnostic and treatment challenges for clinicians working with young to middle-aged active patients with symptomatic intra-articular hip pathology. The studies described in **Chapters 2–6** try to answer the diagnostic challenges based on this ICF model (see Figure 1).

Body functions and structures

Body functions and structures (i.e., symptoms and impairments such as pain or limited range of motion) can be used by the clinician to recognize a certain health condition [3, 4]. Patient history, physical tests, and imaging can be used to identify these impairments [3, 4]. However, as described in **Chapter 1**, the differential diagnosis of intra-articular hip pathology based on patient history, physical examination, and imaging remains a challenge [5]. Therefore, in **Chapter 2**, we investigated which physical tests are available for clinicians aiming to diagnose intra-articular hip pathology (specifically FAI, labral pathology or both). A total of 21 studies were included in this systematic review, in which 18 different physical diagnostic tests were described. However, based on an assessment based on the Levels of Evidence for Primary Research Questions and the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool, it was concluded that no physical tests were available that could reliably confirm or discard the diagnosis of FAI, hip labral pathology or both in clinical practice. Two other recent systematic reviews confirmed these findings [6, 7]. Reiman et al.[7] performed a systematic review with meta-analysis into the diagnostic accuracy of physical tests for FAI and/or hip labral pathology. They found that only flexion-adduction-internal rotation tests possess a screening accuracy for FAI and/or hip labral pathology in clinical practice. Pacheco-Carillo et al.[6] performed a similar review and stated that the diagnostic accuracy of physical examination tests to assess FAI is limited.

Limited diagnostic accuracy

There are several reasons why these systematic reviews all conclude that the diagnostic accuracy of physical tests to assess intra-articular hip pathology (especially FAI, hip labral pathology or both) is limited [6-8].

First, most physical diagnostic tests specifically developed for FAI and/or hip labral pathology are based on the mechanical principle that hip flexion combined with internal rotation causes impingement in the hip joint and, therefore, pain and limited range of motion [6-8]. Studies have proven this is correct [9, 10]. However, other structures outside the hip joint (e.g., the adductor group or iliopsoas muscle) might also be impingent with this maneuver and cause pain and symptoms when affected or overused [3, 11]. Furthermore, positive results on other physical tests, such as the Thomas test,

Fitzgerald test, and Resisted Straight Leg Raise (RSLR) test, might be completely dependent on structures outside the hip joint, such as the iliopsoas muscle [3, 11]. Therefore, differences in study populations (presence/absence of additional injuries) can lead to different diagnostic accuracies. Future diagnostic accuracy studies should, therefore, carefully report the presence or absence of additional injuries or even investigate the possibility of these injuries being overrepresented in the study populations based on the anamnesis, physical examination and imaging.

The second reason that diagnostic accuracy for physical tests in FAI and/or hip labral pathology remains limited, concerns the use of hip surgery/arthroscopy as the gold standard for diagnostic accuracy studies [3, 11]. A prerequisite to investigate a test's diagnostic accuracy (i.e., sensitivity, specificity, and likelihood ratios) is the use of a gold standard to confirm the expected condition [12]. For symptomatic intra-articular hip pathology, this gold standard is hip surgery/arthroscopy [13]. In other words, to investigate the accuracy of the physical tests diagnosing intra-articular hip pathology, surgery has to have been performed to be certain of the diagnoses [13]. Practically, this leads to a biased sampling of patients, as only those patients with a high suspicion of intra-articular hip pathology will be operated on because surgery without indication is unethical [13]. This will lead to high test sensitivities, but low test specificities and, therefore, less clinical utility [11, 13]. In the search for alternative gold standards for the diagnosis of intra-articular hip pathology, other less invasive modalities (such as radiographic imaging, Magnetic Resonance Imaging (Arthrography) (MRI-(A)), Computed Tomography (CT), ultrasound, and diagnostic injections) have been suggested [14-16]. Although these less invasive modalities cannot rightfully be considered the 'gold standard' for intra-articular hip pathology, a small number of highly specialized radiologists using precise protocols together with improvements in (imaging) techniques could lead to imaging or diagnostic injections becoming acceptable reference standards [14-16].

Third, there is a dearth of high-quality diagnostic accuracy studies addressing the physical tests for FAI and/or hip labral pathology [6-8]. Study populations are small, different tests and test procedures have been described, and poor descriptions of the study designs have been reported [6-8].

Future high-quality studies should focus on the determination of the clinical utility of physical diagnostic tests in a larger spectrum of patients, with and without intra-articular hip pathology, with imaging or injection as the proxy gold standard. Only then can the clinical utility of these physical diagnostic tests for intra-articular hip pathology be established.

Current clinical utility

Even in the absence of high-quality studies for clinical utility of physical tests in a large spectrum of patients, clinicians still need to be able to diagnose their patients. Therefore, the use of combinations of patient history information and physical diagnostic tests has been suggested to increase diagnostic accuracy in clinical practice [7, 8, 17]. In **Chapter 3** we investigated if combining information from patient history and physical diagnostic tests would increase diagnostic accuracy for intra-articular hip pathology, compared to hip arthroscopy findings. We found that an increase in sensitivity could be achieved by combining tests as such that in clinical practice absence of groin as main location

of pain combined with a negative Flexion-Abduction-External Rotation (FABER) test or the combination of a negative Anterior Impingement Test (AIT) and a negative FABER test could be used to rule out the diagnosis of symptomatic FAI and/or labral pathology (seeFigure 1.). These findings are not yet confirmed in other studies [18]. However, recent consensus statements on groin pain and FAI do advocate the use of these specific hip tests in the diagnosis of patients with hip-related groin pain [19, 20]. Both these statements indicate that combinations of patient history parameters and physical tests should be used to establish the diagnosis of intra-articular hip pathology [19, 20].

Activity limitations & Participation restrictions

In addition to body functions and structures, the ICF model includes activity limitations and participation restrictions as important indicators of a health condition (disease or disorder) [4]. As described in **Chapter 1**, PROs are a commonly used method to investigate experienced activity limitations and participation restrictions [21, 22]. We investigated which PROs are available for young to middle-aged active patients with symptomatic intra-articular hip pathology twice over the last five years. The first systematic review published in 2011 stated that there was no conclusive evidence for the use of a single PRO in the evaluation of patients undergoing hip arthroscopy [23]. Based on the available psychometric evidence, a combination of the Non-Arthritic Hip Score (NAHS) and the Hip Outcome Score (HOS) was recommended for patients undergoing hip arthroscopy [23].
However, within several years after finishing this systematic review, several new PROs were developed specifically for young to middle-aged active patients with symptomatic hip joint pathology and more studies were executed within this target population, which prompted the need for a new systematic review with quality analysis [24]. This review, described in Chapter 4, concluded that four questionnaires (Hip And Groin Outcome Score (HAGOS), HOS, international Hip Outcome Tool (iHOT-12), and iHOT-33) could be recommended for use in a young to middle-aged population of patients with pain related to the hip joint. We translated, cross-culturally adapted, and validated two of these questionnaires into Dutch (generating the HAGOS-NL and iHOT-33-NL), which both proved valid, reliable, and internally consistent for use in a population of young to middle-aged patients with symptomatic hip joint pathology **(Chapters 5 & 6)**.

Other studies have also found these four questionnaires to be valid and reliable for use in a population of patients with symptomatic hip joint pathology [25-27]. Hinman et al. [25] investigated the test-retest reliability of six PROs (modified Harris Hip Score (mHHS), Hip dysfunction and osteoarthritis Score, NAHS, HOS, iHOT 33 and HAGOS) for patients with FAI and concluded that the majority of these PROs were reliable and precise enough for use at group level. Ramisetty et al. [27] performed a systematic review into the available PROs for use in hip preservation surgery in order to appraise the quality of the PROs and concluded that the HOS, HAGOS, and iHOT-33 scored better than other instruments and that the iHOT-33 scored best. These findings were later confirmed by Kemp et al. [26]. Use of these four questionnaires in larger groups of patients over time is necessary to establish adequate responsiveness values and clinically important differences, as well as comparable study results, which will increase clinical utility of the questionnaires [25-27].

Although the use of PROs is advocated to detect activity limitations and participation restrictions in patients, over the last years, there has been a tendency for the sole

use of these PROs in order to investigate or evaluate interventions or treatment [28]. It should be noted that the sole use of PROs as evaluative instruments has important limitations [28]. First, a PRO is developed to measure a specific concept (construct) in a standardized way [28]. For example, the iHOT-33 measures symptoms and functional limitations (S), sports and recreational physical activities (SR), job-related concerns (W) and social, emotional, and lifestyle concerns (QoL) [29]. Although this questionnaire measures several constructs, it does not mean that these four constructs cover the major limitations patients experience [28, 29]. Furthermore, these PROs give an indication of the function, for example of the hip, based from a patient's perspective, but do not measure integrated hip and leg function [30, 31]. The latter can be important in determining exact recovery, as well as for identifying risk factors for possible future new or recurrent injuries [30, 31]. Additional measures (such as functional performance tests, imaging, return to work/sports data or information on injury recurrence) might be helpful in the development and evaluation of interventions or treatment [11, 30, 31]. Further research into the role of these additional measures is warranted.

Clinical treatment challenges based on the ICF model

The WHO states that any clinician working with patients should be able to optimize a structured and individualized treatment and/or rehabilitation plan for these patients **(Chapter 1)** [3, 4]. The information gained from patients regarding impairments, activity limitations, and participation restrictions should be used to help develop and adapt physical therapy interventions [3, 4]. As previously stated in this thesis, no evidence-based postoperative physical therapy intervention protocols were available for hip arthroscopy patients, and it was unclear which activity limitations and participation restrictions might exist after hip arthroscopic surgery and rehabilitation [30]. Therefore, we developed a postoperative physical therapy intervention based on available literature, as well as our clinical experience (see **Chapter 7**). The short- and mid-term results of hip arthroscopy patients treated with this postoperative physical therapy intervention were investigated in 37 recreational athletes by means of PROs, sports questionnaires, and hip functional performance tests **(Chapter 7)**. These tests included range of motion (ROM), strength, balance, and hop tests. Good recovery of hip function based on these PROs, functional performance tests, and return to sports activities was found at a mean follow-up time of 2.3 years after surgery. To our knowledge, no other studies have reported clinical outcome data (especially functional performance tests) in combination with a full description of the postoperative physical therapy intervention [30].

The few studies that do provide clinical outcome data for hip arthroscopy patients (most without describing the exact physical therapy interventions) are based on PROs only [32]. A systematic review by Hetaimish et al. [32] reported that only 34% of the studies addressing the recovery of hip arthroscopy patients reported ROM and only 14% reported data on return to sports. As noted above, additional measurements (beyond PROs), such as hip functional performance tests, are now needed to determine patient recovery and provide insight into risk factors for possible recurrent or new injuries [31].

Current evidence for postoperative physical therapy interventions

Few postoperative physical therapy interventions have been described for hip arthroscopy patients, and outcome data on recovery of these patients is limited. Thus, information on the effectiveness of these interventions is scarce [11, 33-35]. Most of these

data are reported in case reports or case series [11, 33-35]. Cheatham et al. [34] investigated the available evidence for postoperative hip arthroscopy rehabilitation in a systematic review and found only six studies (all case reports/series) with Level 4 evidence, based on the Levels of Evidence for Primary Research Questions. They concluded that, based on these six studies, a 4- to 5- stage rehabilitation program with an initial period of weight-bearing and mobility precautions seems effective, although more high-quality studies are warranted to further investigate this [34]. Gryzbowski et al. [35] performed a similar review that included 18 studies into postoperative physical therapy interventions for hip arthroscopy patients. A lack of high-quality evidence, heterogeneity in studies, subjects, and surgical demographics as well as poorly described rehabilitation protocols precluded the assimilation of outcomes to generate an evidence-based guideline [35].

Both of these studies indicate that evidence regarding the effectiveness of postoperative physical therapy interventions is scarce [34, 35]. The results described in **Chapter 7** are a first attempt to provide data about the recovery of patients treated with a postoperative physical therapy intervention. However, different postoperative physical therapy interventions should be investigated and compared to decide which intervention provides the best results [33]. Also, as there currently are no studies available comparing postoperative physical therapy interventions to no therapy at all, the contribution of physical therapy to 'normal' biological healing is unclear [36, 37].

Future evidence for postoperative physical therapy interventions

Based on the above considerations, a protocol for a feasibility study into two different postoperative physical therapy interventions for hip arthroscopy patients is described in **Chapter 8**. This feasibility study aims to investigate feasibility and acceptability of physical therapy aimed at self-management versus usual care physical therapy in patients who have undergone hip arthroscopy for FAI. A preliminary estimate of the difference in effect between physical therapy aimed at self-management versus usual care physical therapy will also be determined. The results of this study are expected in mid-2018. These results are necessary to provide information for the development of a Randomized Clinical Trial (RCT) into physical therapy aimed at self-management versus usual care physical therapy in patients who undergo hip arthroscopy for FAI [38]. Recently, Bennel et al.[39] have published a similar study protocol for an RCT into postoperative physical therapy interventions for hip arthroscopy patients diagnosed with FAI. This study will compare formal physiotherapy-prescribed rehabilitation with self-directed rehabilitation using PROs only. Results of this study are expected in mid-2017.

In general, there continues to be a lack of evidence about postoperative physical therapy interventions for hip arthroscopy patients [18, 34, 35]. Future studies should report on the precise content of the intervention, decisions regarding therapy frequency, and intensity and duration of the interventions. Also, the effectiveness of these interventions, as well as 'normal' biological healing of these patients, should be more thoroughly investigated. Prospective cohort studies and RCTs should use PROs as well as functional performance tests to describe clinical outcomes. Use of the Medical Research Council guideline on development and evaluation of complex interventions is strongly advocated for these future intervention studies [40]. Only then can the effectiveness of hip arthroscopic surgery as well as postoperative physical therapy interventions be established.

Directions for future research

An overview of the information added to the clinical diagnosis of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology based on this thesis is presented in Figure 1. The authors feel that it is not yet possible to properly consider an overview of the information added to the treatment of hip arthroscopy patients, for example, based on the MRC guidelines. This is because there is as yet too little evidence to provide definite recommendations. For now, one can state that; 1) the short- and mid-term results of hip arthroscopy patients treated with our postoperative physical therapy intervention are good; 2) that beyond PROs, the use of functional performance tests and return to sport data seem adequate additions in the evaluation of the recovery of hip arthroscopy patients and that; and 3) further research is currently underway.

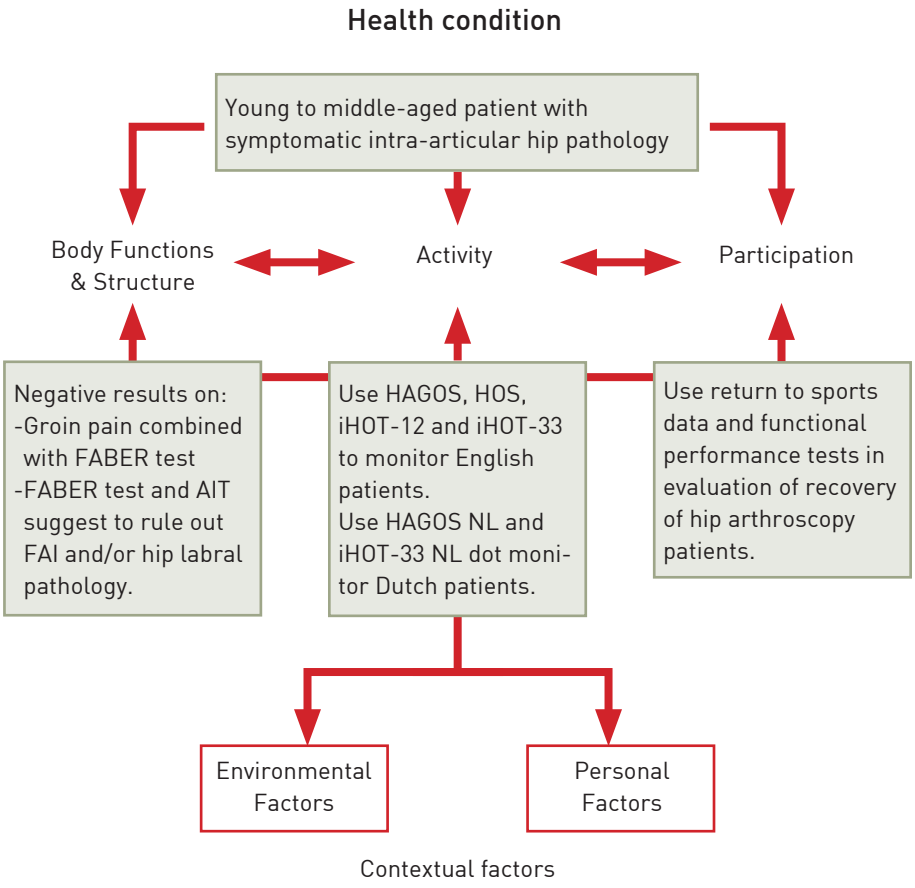


Figure 1 - The International Classification of Functioning, Disability, and Health (ICF) model based on the World Health Organization (WHO) adapted with information from this thesis.

Although the results of the studies in this thesis reveal new information on the diagnosis and treatment of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology, they also generate new questions and hypotheses. Two important new questions to improve diagnoses and treatment of these patients that warrant further research are; 1) What is the exact pathogeneses of FAI and associated conditions such as hip labral pathology; and 2) Is there a role for conservative treatment of these pathologies in young to middle-aged active patients and what should it look like?

Future diagnostic challenges

As stated in **Chapter 1**, the pathogeneses of FAI and associated conditions remains unclear [41-43]. However, knowledge on the exact pathogeneses of FAI and these associated conditions would provide opportunities for better diagnoses and, perhaps, eventually prevention of these injuries. Labral pathology, instability, chondral lesions, and ligamentum teres tears can be theoretically attributed to trauma, as well as FAI or degenerative causes in interaction with high risk sports activities [41-43]. Studies that have used three-dimensional CT and MRI scans have supported these assumptions [9, 10]. However, the pathogeneses of FAI itself is subject to debate [41-43]. One explanation is that FAI is a result of normal generic variability [41-43]. A relation with childhood disorders such as Slipped Capital Femoral Epiphyses (SCFE) has also been described [44]. Another explanation is that FAI might be the result of the mechanical load during growth and development [41, 42, 45]. As Agricola et al. [41, 45] described, evidence exists that FAI is influenced by high impact loading in adolescence as a higher prevalence of cam-type deformities were found in young soccer players than in their nonathletic peers. The last explanation might be found based on a more evolutionary perspective [43, 44]. As Hogervorst et al. [43] describe, the development of pincer-type impingement in females might be explained by the evolutionary conflict between upright gait and the birth of large-brained fetuses, whereas the development of cam type impingement in men might be partly attributed to adaptation to running. The presence of FAI in asymptomatic volunteers may support these findings [43]. Further research in this area is currently underway and necessary to provide definitive answers to the above questions. Findings from such research should allow the development of tests and imaging methods with increased accuracy of diagnoses and possible prevention of these injuries.

Future treatment challenges

The other important question that arises based on the results of this thesis is; is there a role for conservative treatment of intra-articular hip pathology in young to middle-aged active patients and what should it look like?

Currently, treatment of intra-articular hip pathology in young to middle-aged patients means hip surgery [1, 2, 11]. However, as described above, the presence of FAI is also found in asymptomatic volunteers [43]. Also, indications exist that there might be a biological healing response from within the acetabular labrum itself [46]. Furthermore, case studies have described the restoration of pain-free hip function in patients with symptomatic intra-articular hip pathology without surgical intervention [47]. For example, Wall et al.,[47] provided a systematic review of conservative treatment interventions for symptomatic intra-articular hip pathology and found that the current literature seems to promote an initial trial of conservative treatment, especially physical

therapy and activity modifications. Also, several large RCTs comparing conservative treatment with hip arthroscopy are currently being executed worldwide [19, 36, 37, 39].

The results of these studies, combined with more knowledge on the pathogeneses of intra-articular pathology (especially FAI), might completely change the way we look at intra-articular hip pathology and how to diagnose and treat these conditions. Over the next years, the real value of hip arthroscopic surgery, as well as conservative and postoperative physical therapy, for intra-articular hip pathology in young to middle-aged patients will become clear.

Conclusive remarks

This thesis originated in response to the rise of hip arthroscopic surgery and the need to optimize care for patients with symptomatic intra-articular hip pathology undergoing hip arthroscopy. Clinicians need to be able to accurately diagnose and monitor patients. Furthermore, in order to optimize the effectiveness of hip arthroscopic surgery, information on best postoperative physical therapy interventions is necessary. The results of this thesis form a framework for an evidence-based approach to the diagnosis and postoperative physical therapy intervention of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology.

Based on the studies described in this thesis it can be concluded that:

- Many different physical diagnostic tests for symptomatic intra-articular hip pathology exist, but currently no single test can be used to confirm or discard the diagnosis of intra-articular hip pathology in clinical practice (**Chapter 2**).
- Combining patient history parameters and physical diagnostic tests increases diagnostic accuracy. In clinical practice, the absence of groin as main location of pain combined with a negative FABER test or the combination of a negative AIT and a negative FABER test could be used to rule out the diagnosis of symptomatic FAI, hip labral pathology, or both (**Chapter 3**).
- The HAGOS, HOS, iHOT-12, and iHOT-33 PROs can be recommended for assessment of young to middle-aged adults with pain related to the hip joint, undergoing non-surgical treatment or hip arthroscopy (**Chapter 4**).
- The HAGOS NL and iHOT-33 NL are internally consistent, valid and reliable for use in a Dutch population of young physically active individuals with hip, groin, or hip and groin pain (**Chapters 5 & 6**).
- Additional measurements such as functional performance tests, imaging, return to sports/work data and information on injury recurrence are necessary to evaluate an intervention (**Chapter 7**).
- The overall short- and mid-term results of hip arthroscopy patients treated with our postoperative physical therapy intervention show good recovery based on PROs, functional performance, and return to sports activities (**Chapter 7**).
- Prospective cohort studies and RCTs that use hip functional performance tests and clearly defined postoperative physical therapy interventions are currently underway and warranted in order to establish the precise recovery of these hip arthroscopy patients and indicate the possible role of physical therapy in this recovery (**Chapter 8 & 9**).
- Further research into the exact pathogeneses of intra-articular hip pathology in

young to middle-aged patients and the role of possible conservative treatment for these patients is urgently warranted (**Chapter 9**).

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SUMMARY

This thesis contributes to the development of an evidence-based approach to the diagnosis and postoperative physical therapy intervention of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology. **Chapter 1** introduces the rationale for this thesis by explaining that the rise of hip arthroscopies combined with improvements in imaging led to a better understanding of hip joint pathology. Traditional open hip surgery is often performed in older patients, whereas hip arthroscopy is often applied in a young to middle-aged, active and athletic population. This means that clinicians (doctors and physical therapists) encounter a 'new' population of hip patients with different needs and limitations.

The challenges for the clinician are to recognize and accurately diagnose hip joint pathology and to optimize treatment. This thesis addresses these challenges based on the International Classification of Functioning, Disability, and Health (ICF) model. A model developed by the World Health Organization (WHO) in order to classify the consequences of a health condition (disease or disorder) based on several levels; body functions and structures (impairments), activities (activity limitations), and participation (participation restrictions).

Chapters 2 and 3 of this thesis focus on impairments (i.e., body functions and structures) in young to middle-aged patients with symptomatic intra-articular hip pathology, with the aim of establishing fast and accurate diagnosis. **Chapter 2** describes the results of a systematic review of the physical tests used to diagnose intra-articular hip pathology (femoroacetabular impingement (FAI), hip labral pathology, or both). A total of 21 studies were included, in which 18 different physical diagnostic tests were described. The Levels of Evidence for Primary Research Questions was used to establish the level of evidence of each study. The Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool was used to assess the quality of the diagnostic accuracy studies. For those studies that only described physical diagnostic tests (n = 7), the evidence levels were poor (Level IV/V). For the diagnostic accuracy studies (n = 14), the evidence levels were moderate (Level II–IV). Based on the QUADAS tool, only 3 studies were judged to be of good quality. However, because of several methodological problems, none of the tests described in these 3 studies were identified as being appropriate to reliably confirm or discard the diagnosis of FAI and/or hip labral pathology.

To address this, **Chapter 3** investigates the diagnostic accuracy of patient history parameters combined with physical diagnostic tests (as found in **Chapter 2**) in hip arthroscopy patients. Seventy-seven patients were pre-operatively investigated for clinical presentation and physical tests, after which diagnoses and treatment by means of hip arthroscopy were performed. Seventy-six of these patients were arthroscopically diagnosed with FAI, hip labral pathology, or both. *Groin as main location of pain*, the Anterior Impingement test (AIT), Flexion-Abduction-External Rotation (FABER) test and Fitzgerald test had a high sensitivity (range 0.72–0.91) compared to the gold standard, arthroscopic diagnoses. Sensitivity increased when combining these tests, with *groin as main location of pain* combined with a positive FABER test, or a positive AIT and a positive FABER test being the shortest, most sensitive combinations. Therefore, the results of this study show that, in clinical practice, the absence of *groin as main location of pain* combined with a negative FABER test or the combinati-

on of a negative AIT and a negative FABER test can be used to rule out the diagnoses of symptomatic FAI, hip labral pathology, or both.

The monitoring of activity limitations and participation restrictions (based on the ICF model) experienced by hip arthroscopy patients is the focus of **Chapters 4–6**. To date, Patient-Reported Outcomes questionnaires (PROs) have been commonly used to investigate experienced activity limitations and participation restrictions. **Chapter 4** describes a systematic review addressing which PROs would be useful for the monitoring of patients with hip joint-related pain. Twenty studies were included, in which nine different PROs were identified. The methodological quality of these studies was determined using the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) checklist together with a standardized evaluation of measurement properties of each PRO. Based on these quality evaluations, 4 PROs (the Hip And Groin Outcome Score (HAGOS), Hip Outcome Score (HOS), international Hip Outcome Tool-12 (iHOT-12) and IHOT-33) can be recommended for the assessment of young to middle-aged active individuals with hip-related pain. In **Chapters 5 and 6** translation, cross-cultural adaptation and validation of two of these questionnaires (the Dutch HAGOS (HAGOS NL) and iHOT-33 (iHOT-33 NL)) are performed. Translation and cross-cultural adaption into Dutch were performed based on existing guidelines, and the validity and reliability analysis was based on the COSMIN checklist. Two groups of young to middle-aged active patients (n = 194 for HAGOS NL and n = 214 for iHOT-33 NL) with hip and groin-related pain were included in these studies. Test-retest reliability, internal consistency, principal component analysis, measurement error, construct validity, distribution of scores, floor and ceiling effects, and minimal important change were established for both questionnaires. Both the HAGOS NL and iHOT-33 NL proved internally consistent, valid, and reliable for use in young to middle-aged active individuals with hip-related (HAGOS NL and iHOT-33 NL) and groin-related (HAGOS NL) pain. Floor effects (21%) were found only for the Physical Activity subscale of the HAGOS NL.

According to the WHO, the information gained from patients regarding impairments, activity limitations, and participation restrictions as described in the ICF model should be used to help develop and adapt individual physical therapy treatment. Currently, information on postoperative physical therapy interventions for hip arthroscopy patients is scarce: 1) only a few case studies have described clinical outcome data; 2) no evidence-based postoperative physical therapy intervention protocols are available; and 3) it is unknown which activity limitations and participation restrictions may exist after hip arthroscopic surgery. The prospective cohort study described in **Chapter 7** was a first step to contribute evidence by describing the short- and mid-term results of hip arthroscopy patients treated with our own postoperative rehabilitation protocol. A total of 37 recreational athletes who finished postoperative rehabilitation at least 6 months before the start of the study were investigated by means of PROs, sports questionnaires, and hip functional performance tests. These tests included range of motion (ROM), strength, balance, and hop tests. The overall short- and mid-term follow-up results showed good recovery of the hip function based on PROs, functional performance, and return to sports activities.

The dearth of evidence-based postoperative physical therapy intervention protocols,

together with the results from **Chapter 7**, led to the development of a feasibility study for a randomized clinical trial (RCT). This feasibility study compares two different postoperative rehabilitation strategies, physical therapy aimed at self-management versus usual care physical therapy, and is described in **Chapter 8**. Within this study protocol, the feasibility and acceptability of a self-management intervention will be determined. Also, a preliminary estimate of the difference in effect between physical therapy aimed at self-management versus usual care physical therapy in patients who undergo hip arthroscopy for FAI will be determined. Results of this study are expected mid-2018.

Chapter 9 discusses the main findings from the preceding chapters and provides proposals for an evidence-based approach to the diagnosis and postoperative physical therapy intervention of young to middle-aged patients undergoing hip arthroscopy for symptomatic intra-articular hip pathology.
Based on the studies described in this thesis it can be concluded that:

- Many different physical diagnostic tests for symptomatic intra-articular hip pathology exist, but currently no single test can be used to confirm or discard the diagnosis of intra-articular hip pathology in clinical practice (**Chapter 2**).
- Combining patient history parameters and physical diagnostic tests increases diagnostic accuracy. In clinical practice, the absence of groin as main location of pain combined with a negative FABER test or the combination of a negative AIT and a negative FABER test could be used to rule out the diagnosis of symptomatic FAI, hip labral pathology, or both (**Chapter 3**).
- The HAGOS, HOS, iHOT-12, and iHOT-33 PROs can be recommended for assessment of young to middle-aged individuals with pain related to the hip joint, undergoing non-surgical treatment or hip arthroscopy (**Chapter 4**).
- The HAGOS NL and iHOT-33 NL are internally consistent, valid and reliable for use in a Dutch population of young physically active individuals with hip, groin, or hip and groin pain (**Chapters 5 & 6**).
- Additional measurements such as functional performance tests, imaging, return to sports/work data and information on injury recurrence are necessary to evaluate an intervention (**Chapter 7**).
- The overall short- and mid-term results of hip arthroscopy patients treated with our postoperative physical therapy intervention show good recovery based on PROs, functional performance, and return to sports activities (**Chapter 7**).
- Prospective cohort studies and RCTs that use functional performance tests and clearly defined postoperative physical therapy interventions are currently underway and warranted in order to establish the precise recovery of these hip arthroscopy patients and indicate the possible role of physical therapy in this recovery (**Chapter 8 & 9**).
- Further research into the exact pathogeneses of intra-articular hip pathology in young to middle-aged patients and the role of possible conservative treatment for these patients is urgently warranted (**Chapter 9**).

SAMENVATTING

Het doel van dit proefschrift is bijdragen aan de ontwikkeling van een wetenschappelijke bewezen benadering voor de diagnose en postoperatieve fysiotherapeutische behandeling van patiënten van jonge tot middelbare leeftijd die een kijkoperatie van de heup ondergaan voor symptomatisch heupletsel. In **hoofdstuk 1** wordt de rationale van dit proefschrift geïntroduceerd; de stijging in het aantal uitgevoerde kijkoperaties in de heup en verbeteringen in beeldvormende technieken hebben geleid tot een beter begrip van de afwijkingen van het heupgewricht en het weefsel eromheen. Traditioneel gezien wordt open heup chirurgie vaak ingezet bij oudere patiënten, terwijl een kijkoperatie vaker wordt ingezet bij patiënten van jonge, tot middelbare leeftijd met een actieve en sportieve levensstijl. Dit betekent dat artsen en fysiotherapeuten een 'nieuwe' groep patiënten met heuppijn zien die andere behoeften hebben en andere beperkingen ervaren.

De uitdaging in de praktijk is om afwijkingen in de heup in deze groep patiënten op tijd te herkennen en te diagnosticeren en om te zorgen voor een optimale behandeling. Dit proefschrift benadert deze uitdagingen aan de hand van het International Classification of Functioning, Disability, and Health (ICF) model. Dit model is ontwikkeld door de World Health Organization (WHO) om de gevolgen van een gezondheidstoestand (ziekte of aandoening) in te delen in verschillende niveaus: functies en anatomische eigenschappen (beperkingen), activiteiten (beperkingen in activiteiten) en participatie (participatie problemen).

In **hoofdstukken 2 en 3** van dit proefschrift ligt de focus op de beperkingen (functies en anatomische eigenschappen) die patiënten met symptomatisch heupletsel ervaren, met als doel het vaststellen van een snelle en accurate diagnose. **Hoofdstuk 2** beschrijft de resultaten van een systematische review naar de lichamelijke testen die gebruikt worden voor de diagnose van letsel in het heupgewricht (femoroacetabulair impingement (FAI), labrum letsel of beiden). In totaal werden 21 studies bestudeerd, waarin 18 verschillende lichamelijke diagnostische testen werden beschreven. De mate van bewijslast van iedere studie werd vastgesteld door middel van The Levels of Evidence for Primary Research Questions lijst. De kwaliteit van de studies werd beoordeeld met de Quality Assessment of Diagnostic Accuracy Studies (QUADAS) lijst. De studies die alleen lichamelijk testen beschreven (n = 7) lieten een lage bewijslast zien (Level IV/V). De studies naar diagnostische accuraatheid (n = 14) hadden een hogere bewijslast (Level II-IV). Met behulp van de QUADAS lijst werden 3 studies beoordeeld als studies van 'goede kwaliteit'. Echter, vanwege verschillende methodologische problemen werd geconcludeerd dat geen van de testen uit deze 3 studies geschikt is om op betrouwbare wijze de diagnose van FAI en/of labrum letsel van de heup vast te stellen.

In **hoofdstuk 3** wordt daarom onderzocht hoe accuraat de diagnostiek is van patiënt specifieke kenmerken gecombineerd met lichamelijke testen (beschreven in **hoofdstuk 2**) bij patiënten die een kijkoperatie van de heup ondergaan. Zevenenzeventig patiënten werden voor de operatie onderzocht op het klinisch beeld en met lichamelijke testen, waarna de diagnose en behandeling plaats vond via een kijkoperatie. Bij 76 van deze patiënten werd tijdens de operatie FAI, of labrum letsel of beiden vastgesteld. *Liespijn als hoofdlocatie van de klachten*, de Anterior Impingement Test (AIT), de Flexion-Abduction-External Rotation (FABER) test en de Fitzgerald test vertoon-

den een hoge sensitiviteit (range 0.72-0.91) vergeleken met de gouden standaard, de kijkoperatie. De sensitiviteit verbeterde bij een combinatie van deze testen, waarbij de combinatie van *liespijn als hoofdlocatie van de klachten* samen met een positieve FABER test of een positieve AIT en een positieve FABER test, de snelst uit te voeren en meest sensitieve combinaties waren. De resultaten van deze studie laten zien dat, in de klinische praktijk, afwezigheid van *liespijn als hoofdlocatie van de klachten* gecombineerd met een negatieve FABER test of de combinatie van een negatieve AIT en een negatieve FABER test gebruikt kunnen worden om de diagnoses FAI, labrum letsel of combinaties hiervan uit te sluiten.

Het monitoren van de beperkingen in activiteiten en participatie problemen (gebaseerd op het ICF model) zoals ervaren door patiënten die een kijkoperatie van de heup ondergaan is de focus van **hoofdstukken 4 – 6**. Momenteel worden vaak patiënt gerapporteerde uitkomstmaten (PROs) gebruikt om deze beperkingen in activiteiten en participatie problemen te onderzoeken. **Hoofdstuk 4** beschrijft een systematische review waarin onderzocht wordt welke PROs zinvol zouden kunnen zijn voor het monitoren van personen met heup gerelateerde pijnklachten. Twintig studies werden geselecteerd waarin 9 verschillende PROs werden beschreven. De methodologische kwaliteit van deze studies werd bepaald aan de hand van de the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) lijst samen met een gestandaardiseerde evaluatie van de meeteigenschappen van elke vragenlijst. Op basis van deze evaluaties zijn 4 PROs gevonden die geadviseerd worden voor de beoordeling van actieve personen van jonge tot middelbare leeftijd met heup gerelateerde pijnklachten, namelijk: de Hip And Groin Outcome Score (HAGOS), de Hip Outcome Score (HOS), de international Hip Outcome Tool-12 (iHOT-12) and IHOT-33. In **hoofdstukken 5 en 6** is de vertaling, aanpassing aan de Nederlandse cultuur en validatie van 2 van deze vragenlijsten (de Nederlandse HAGOS (HAGOS NL) en de iHOT-33 (iHOT-33 NL)) beschreven. De vertaling en aanpassing aan de Nederlandse cultuur zijn uitgevoerd op basis van bestaande richtlijnen en de validatie en betrouwbaarheidsanalyse werden gebaseerd op de COSMIN lijst. Twee groepen actieve personen van jonge tot middelbare leeftijd (n = 194 voor de HAGOS NL en n = 214 voor de iHOT-33 NL) met heup en lies gerelateerde pijnklachten werden geïncludeerd in deze studies. De test-hertest betrouwbaarheid, interne consistentie, principale-componenten analyse, meetfout, construct validiteit, spreiding van scores, vloer en plafond effecten en minimaal relevant verschil werden bepaald voor beide vragenlijsten. Beide vragenlijsten, de HAGOS NL en iHOT-33 NL, werden intern consistent, valide en betrouwbaar bevonden voor gebruik bij personen met heup gerelateerde (HAGOS NL en iHOT-33 NL) en lies gerelateerde (HAGOS-NL) pijnklachten. Vloer effecten (21%) werden alleen gevonden voor de fysieke activiteiten schaal van de HAGOS NL.

Volgens de WHO zou de informatie verkregen van patiënten over functies en anatomische eigenschappen, beperkingen in activiteiten en participatie problemen zoals beschreven in het ICF model, gebruikt moeten worden om op het individu afgestemde fysiotherapeutische behandelingen te ontwikkelen en aan te passen. Momenteel is er weinig informatie beschikbaar over fysiotherapeutische behandelingen na een kijkoperatie voor heuppatiënten; 1) slechts enkele casestudies hebben klinische uitkomsten beschreven; 2) er zijn geen wetenschappelijk bewezen fysiotherapeutische behandelprotocollen voor na de operatie beschikbaar; 3) het is onbekend welke

beperkingen in activiteiten en participatie problemen kunnen blijven bestaan na een kijkoperatie. De prospectieve cohort studie beschreven in **hoofdstuk 7** draagt bij aan de wetenschappelijke kennis door het beschrijven van de korte en middellange termijn resultaten van patiënten die een kijkoperatie van de heup hebben ondergaan en behandeld zijn met ons eigen fysiotherapeutische behandelprotocol voor na de operatie. Zevenendertig recreatieve sporters die de revalidatie na de operatie minstens 6 maanden voor de start van de studie hadden afgerond, werden geselecteerd en onderzocht door middel van PROs, sport specifieke vragenlijsten en functionele heuptesten. Deze testen bevatten onder andere mobiliteit, kracht-, balans- en sprong testen. De korte en middellange termijn resultaten lieten zien dat er sprake was van een goed herstel van de heupfunctie, gebaseerd op PROs, functionele heuptesten en terugkeer naar sportactiviteiten.

Het gebrek aan wetenschappelijk bewezen postoperatieve fysiotherapeutische behandelprotocollen tezamen met de resultaten van **hoofdstuk 7** hebben geleid tot de ontwikkeling van een haalbaarheidsstudie voor een randomized controlled trial (RCT). Deze haalbaarheidsstudie vergelijkt twee verschillende aanpakken van revalidatie na een kijkoperatie van de heup, namelijk fysiotherapie gericht op zelfmanagement versus de reguliere fysiotherapeutische behandeling en is beschreven in **hoofdstuk 8**. Binnen dit studieprotocol wordt de haalbaarheid en acceptatie van de zelfmanagement interventie onderzocht. Tevens wordt de voorlopige schatting van het verschil in effect tussen fysiotherapie gericht op zelfmanagement versus de reguliere fysiotherapeutische behandeling van patiënten die een kijkoperatie voor FAI krijgen, onderzocht. De resultaten van deze studie worden gedurende 2018 verwacht.

In **hoofdstuk 9** worden de belangrijkste bevindingen van de voorgaande hoofdstukken besproken en worden voorstellen gedaan voor een wetenschappelijk bewezen benadering van de diagnose en postoperatieve fysiotherapeutische behandeling van patiënten die een kijkoperatie ondergaan vanwege symptomatisch heupletsel. Gebaseerd op de studies beschreven in dit proefschrift kan worden geconcludeerd dat:

- Er verschillende lichamelijke diagnostische testen bestaan voor patiënten met symptomen die wijzen op letsel in het heupgewricht, maar dat er momenteel geen enkele individuele test gebruikt kan worden om de diagnose van een letsel in het heupgewricht in de klinische praktijk te bevestigen of uit te sluiten (**hoofdstuk 2**).
- Het combineren van patiënt specifieke kenmerken en lichamelijke diagnostische testen de accuraatheid van de diagnostiek vergroot. In de klinische praktijk kunnen afwezigheid van *liespijn als hoofdlocatie van de klachten* gecombineerd met een negatieve FABER test of de combinatie van een negatieve AIT en negatieve FABER test, worden gebruikt om de diagnoses FAI, labrum letsel of combinaties hiervan uit te sluiten (**hoofdstuk 3**).
- De HAGOS, HOS, iHOT-12 en iHOT-33 kunnen worden geadviseerd voor de evaluatie van personen met heup gerelateerde pijnklachten, die een conservatieve fysiotherapeutische behandeling of een kijkoperatie van de heup ondergaan (**hoofdstuk 4**).
- De HAGOS NL en iHOT-33 NL intern consistent, valide en betrouwbaar zijn voor gebruik in een Nederlandse populatie van jonge, lichamelijk actieve personen met heup, lies of heup en liespijn (**hoofdstukken 5 & 6**).
- Aanvullende testen en gegevens zoals functionele testen, beeldvorming, data over terugkeer naar (sport)activiteiten en nieuwe blessures nodig zijn om een interven-

tie te evalueren (**hoofdstuk 7**).
- De korte en middellange termijn resultaten van patiënten die een kijkoperatie van de heup ondergaan en behandeld zijn met ons eigen fysiotherapeutische behandelprotocol voor na de operatie een goed herstel tonen op basis van PROs, functionele heuptesten en terugkeer naar (sport)activiteiten (**hoofdstuk 7**).
- Prospectieve cohort studies en RCTs die functionele testen gebruiken alsmede duidelijk beschreven postoperatieve fysiotherapeutische behandelingen momenteel uitgevoerd worden en noodzakelijk zijn om het precieze herstel van kijkoperatie patiënten te onderzoeken en de mogelijke rol van fysiotherapie in dit herstel te bevestigen/ontkrachten (**hoofdstukken 8 & 9**).
- Nader onderzoek naar de exacte oorzaak van letsel in het heupgewricht bij patiënten van jonge tot middelbare leeftijd en de mogelijke rol van conservatieve fysiotherapeutische behandelingen voor deze patiënten hard nodig is (**hoofdstuk 9**).

DANKWOORD

'Ja ja, geef maar eerlijk toe: dit is de eerste pagina van het proefschrift die je leest…'.

Betrapt? Leuk! Maar het mag en ik vind het niet erg. Want wat voor velen de eerste pagina's zijn die gelezen worden van een proefschrift, is dit voor mij bijna het einde. Het einde van een traject dat in 2011 heel voorzichtig begon zomaar op een zomerse barbecue met de vraag van Robert van Cingel: *'Zeg, wil jij anders niet promoveren?'* en wat nu heeft geleid tot dit proefschrift.
Een traject wat mijn werk als fysiotherapeute en bewegingswetenschapper bij Sport Medisch Centrum Papendal en menige dag van mijn privé leven heeft gekleurd de laatste jaren.
En ook een traject wat voor mij onlosmakelijk is verbonden met dat andere grote werkdoel; werken als fysiotherapeute voor het (baan)wielrennen op de Olympische en Paralympische Spelen van Rio in 2016. Twee grote doelen die veel tijd kostten en elkaar vaak in de weg zaten. Want daar waar ik druk was met de wielrenners, kreeg de promotie te weinig aandacht en andersom. Daarom heb ik besloten ze in dit stuk van mijn proefschrift voor één keer te verenigen. Bij deze presenteer ik met trots 'mijn' wielerploeg:

Coach, assistent coach en talentscout

Robert, jij bent in dit traject mijn talentscout, maar nog heel veel meer mijn coach geweest. Jij bent degene geweest die al voordat ik het zelf had bedacht, een plan had gemaakt voor mijn promotietraject, die mij al die jaren onvoorwaardelijk geholpen heeft en altijd klaar stond als ik weer eens je kantoor binnen rende met vragen of opmerkingen. Eindeloze kopjes koffie zijn er gedronken aan de vergadertafel en vele documenten doorgenomen (met rode, uhh of gele of nou ja één kleur pen). Het feit dat ik de ruimte heb gekregen mijzelf te ontwikkelen in dit promotietraject vanuit SMCP vind ik super! Nog steeds blijf jij uitdagingen zoeken waar ik mij in vast kan bijten. Dank daarvoor!
Enrico, wanneer ik aan één assistent coach niet voldoende had en meer vragen als antwoorden kon vinden over die lastige heuppatiënten, was jij er op de achtergrond. Bedankt voor de goede samenwerking de afgelopen jaren, voor de vele patiënten die wij samen gezien hebben, voor de broodnodige informatie over hoe het nu 'echt' werkt in zo'n heup en natuurlijk voor de wijntjes bij jouw thuis in Nijmegen!
En uiteindelijk is er dan maar één die echt aan het roer staat en dat was jij in mijn geval, Ria. Voor heel veel vragen, voor nog veel meer mails, voor eindeloze telefoontjes, voor hele vroege of hele late overleggen op de Radboud en voor meters en meters aan feedback. Er waren momenten dat ik de documenten niet meer durfde te openen vanwege de hoeveelheid feedback, maar het was zeker zinvol. Heel erg bedankt voor je steun en hulp de afgelopen jaren.

Teamies

Omdat je zonder goede ploeg nergens bent en omdat je in een ploeg altijd kan samenwerken, heb ik daar ook dankbaar gebruik van gemaakt de afgelopen jaren. Dank je wel alle lieve collega's van Sport Medisch Centrum Papendal voor alle hulp de afgelopen jaren of dat nu was met de printer (Madelin; hoe werkt dat ding?), met het schrijven van artikelen (Bas, Linn, Nicky), het behandelen van patiënten (Rolf, Marieke, Luc, Britt) of gewoon het aanhoren van mijn voortdurende gezeur over wat er allemaal weer niet lukte (iedereen en in het bijzonder Anique). Dank jullie wel en in het bijzonder dank aan mijn huidige en eerdere fysiotherapie collega's…

Peloton

De wedstrijd is geen wedstrijd zonder tegenstand of medewerking. Gelukkig heb ik van velen medewerking gekregen.
Bedankt Marc Wagener voor je hulp bij het vinden van patiënten over de afgelopen jaren en de vakinhoudelijke uitleg. Sebastiaan Jansen voor je hulp bij het uitpluizen van vele vragenlijsten. Alle stagiaires voor de hulp bij het verzamelen van data. Alle medeauteurs voor de aanvullingen en feedback om dit proefschrift te maken wat het nu is en uiteraard alle patiënten van wie ik zoveel heb mogen leren de afgelopen jaren.
In het bijzonder bedankt Igor Tak voor je waardevolle gesprekken alsmede ook de twee artikelen die hier in dit proefschrift zitten als gevolg van onze samenwerking. Hopelijk kunnen we in de toekomst al onze ideeën nog verder ontwikkelen.
Bedankt Mascha Spijkers, voor de lay-out en enorme hulp in het realiseren en drukken van dit proefschrift.
Bedankt geachte promotiecommissie, voor uw bereidheid om dit proefschrift te beoordelen. Ik kijk uit naar de inhoudelijke discussie die hierop gaat volgen.

En ondanks de voortdurende strijd met tijd verdelen tussen de sporters en de promotie, bedankt aan jullie wielrenners; ik heb de afgelopen jaren met heel veel plezier met jullie samen gewerkt en hoop dat de komende jaren nog zeker zo te kunnen blijven doen. Jullie enthousiasme en vastberadenheid is voor mij een extra motivatie geweest om dit proefschrift goed af te ronden en de wedstrijden en vele uren op de baan waren een welkome afleiding van het schrijfwerk.
Uiteraard zijn er dan ook nog de 'echte' coaches en stafleden die ik niet vergeten mag; allemaal enorm bedankt! In het bijzonder bedankt Rene: met je vastbeslotenheid en uitdagingen die mij altijd scherp hebben weten te houden, want goed is niet goed genoeg, tenzij.....; Voor Martin vanwege al je handigheidjes, adviezen, leuke avonden en natuurlijk je hulp bij het maken van dit proefschrift; voor Floor en Geeske, want die eindeloze stroom cocktails en gezellige avondjes hebben mij enorm veel plezier en afleiding bezorgt en; voor Eelke, coach en ondertussen ook goede vriend. Jij weet als geen ander mij uit mijn comfort zone te halen, mij uit te dagen eens op een andere manier naar de zaken te kijken ook al heeft dat stevige disccusies tot gevolg. Daarnaast heb je ergens tussen al die tripjes Nederland - Portugal ook nog met mij de basis voor het lekenpraatje en de stellingen weten te leggen. Dank!

Mechaniekers

En hoe goed je ook je best doet, zonder fiets ben je geen wielrenner en zonder mechanieker heb je geen fiets. Zonder basis had ik dit boek niet schrijven kunnen.
Dus al die vriendinnetjes en vrienden die het met mij uithouden, avondjes wijntjes drinken, stappen, leuke dingen doen en ondertussen heel heel heel veel gezeur te verdragen hebben gehad; dank jullie wel! Ja jullie dus in het bijzonder Karin, Kim, Renee, Linn, Rianne, Britt, Anke, Anke en Nora.
Dank je wel opa, oma's en al die anderen vrienden en familie die er altijd zijn als ik ze nodig heb. Ik hoop dat jullie van de promotie plechtigheid kunnen genieten.

Beate; paranimf en mijn 'interne' mentor. Dat is hoe ik je naar anderen omschrijf en dat ben jij voor mij deze 10 jaar bij SMCP ook altijd geweest. Nog steeds denk ik zo vaak; 'verdorie hoe kan ze dat nu allemaal weten?' Dank je daarvoor; jij houdt mij scherp!

Anke, meis, Anks, dank je wel. Voor alles, voor alle jaren kleuterschool, middelbare school, jeugdjaren, studententijd, vakanties, lief en leed tot aan nu. Jouw enorme doorzettingsvermogen en inzet zijn voor mij altijd een inspiratie. Friendship will last forever I hope en om in je eigen woorden te blijven; 'we gaan eeuwen terug, maar hopelijk ook nog mijlen vooruit'.

Bruders, bedankt voor al jullie jaren van vertellen dat jullie het echt wel beter kunnen dan ik en dat ik me niet overal mee moet bemoeien; maar ook bedankt voor het er altijd voor mij zijn als het nodig is. Bert, ik ben super trots hoe jij al meer dan 10 jaar je eigen zaak runt. Sjef, ik ben bang dat deze aardbol bijna te klein is voor je, maar ik ben super trots op al je buitenland avonturen! Jullie vormen de uitdaging voor mij om het nog beter te willen doen. En Kiran, bedankt voor het op het rechte pad houden van die kleine.
Pap en mam, jullie zijn bij alles de basis van wat ik doe en ik weet dat ik bij jullie altijd terecht kan; een 'thuis-thuis' waar menigeen alleen van kan dromen. Van jullie heb ik geleerd dat ik 'meer als best niet kan doen' en dat van 'hard werken nog nooit iemand is dood gegaan'. Jullie hebben ervoor gezorgd dat ik vandaag ben wie ik ben en ik kan niet omschrijven hoe gelukkig en trots ik ben dat jullie mijn ouders zijn. Des te meer nu ik mezelf ouder mag noemen besef ik hoeveel ik aan jullie te danken heb. Dank....

Fysiotherapeut

En zoals elke ploeg ook zijn fysiotherapeut nodig heeft (ja pretentieus dit), zo heb ik zelf de mijne: Joost – Jos – lieverd, omdat er geen woorden zijn voor wat jij voor mij betekent blijf ik stil....(eindelijk ja).

Op jou, op ons en onze kleine erwt....
Omdat geluk inderdaad niet vanzelfsprekend is.

CURRICULUM VITAE

Marsha Petranel Willemijn Tijssen werd geboren op 11 april 1986 te Boxmeer. Ze rondde haar middelbare school opleiding aan het Elzendaal college in Boxmeer af in 2004 en startte in datzelfde jaar met de opleiding Fysiotherapie aan de Hogeschool Utrecht. Gedurende deze opleiding volgde ze een minor Fysiotherapiewetenschap aan de Universiteit Utrecht. In 2007 rondde zij de opleiding Fysiotherapie cum laude af en startte zij na een periode van reizen als waarnemend fysiotherapeut bij Sport Medisch Centrum Papendal.

Naast haar werkzaamheden als fysiotherapeute, startte zij in 2008 in deeltijd met de opleiding Master Biology of Human Performance and Health aan Maastricht University. Vanaf de afronding van deze opleiding in 2010 is Marsha tevens als bewegingswetenschapper verbonden aan Sport Medisch Centrum Papendal.

Gedurende de 10 jaar waarin zij werkzaam is als fysiotherapeute/bewegingswetenschapper bij Sport Medisch Centrum Papendal heeft Marsha vele cursussen op het gebied van musculoskeletale revalidatie gevolgd. Daarnaast werden vanaf medio 2011 haar werkzaamheden als fysiotherapeute uitgebreid met de begeleiding van topsporters verbonden aan het Centrum voor Topsport en Onderwijs, oa: tafeltennis, paralympisch tafeltennis, paralympisch skiën, wielrennen en mountainbike. Ook startte in 2011 de 'on the road' begeleiding voor onder andere de Koninklijke Nederlandse Algemene Schermbond (KNAS) en de Koninklijke Nederlandse Wieler Unie (KNWU). Als fysiotherapeute voor de KNWU was zij in 2012 gedurende de Paralympische Spelen te Londen en in 2016 gedurende de Olympische en Paralympische Spelen van Rio de Janeiro werkzaam.

Vanaf 2012 verbond Marsha zich als buitenpromovenda aan de Radboud Institute for Health Sciences afdeling Scientific Institute for Quality of Healthcare voor haar PhD 'How to get a grip on the hip?' onder leiding van Prof. dr. M.W.G. Nijhuis-Van der Sanden en copromotoren Dr. R.E.H. van Cingel (Sport Medisch Centrum Papendal) en Dr. E. de Visser (Rijnstate ziekenhuis, Arnhem). Gedurende deze periode heeft zij tevens verschillende cursussen en colleges met betrekking tot heupletsel ontwikkeld voor Hogeschool Utrecht, Hogeschool van Arnhem en Nijmegen en voor de Regionale Genootschappen Fysiotherapie Groot Gelre, Twente en Ijsselzoom en Maasvallei. Ook heeft zij op meerdere internationale congressen gesproken als genodigd spreker.

In de komende jaren hoopt Marsha haar functie als fysiotherapeute en bewegingswetenschapper te kunnen blijven combineren om zo bij te blijven dragen aan optimale patiëntenzorg en wetenschappelijk onderzoek. Vanaf medio 2017 zal zij starten als projectleider van het nieuw te realiseren kenniscentrum van Sport Medisch Centrum Papendal.

LIST OF PUBLICATIONS

Articles
International

Tijssen M, van Cingel R, van Melick N, de Visser E. Patient-Reported Outcome questionnaires for hip arthroscopy: a systematic review of the psychometric evidence. BMC Musculoskelet Disord. 2011 May 27;12:117. doi: 10.1186/1471-2474-12-117.

Tijssen M, van Cingel R, Willemsen L, de Visser E. Diagnostics of femoroacetabular impingement and labral pathology of the hip: a systematic review of the accuracy and validity of physical tests. Arthroscopy, 2012, 28(6), 860 – 871.

Tijssen M, van Cingel R, de Visser E, Nijhuis-van der Sanden M. A clinical observational study on patient-reported outcomes, hip functional performance and return to sports activities in hip arthroscopy patients. Physical Therapy in Sport, 2016, 20, 45 - 55.

Tijssen M, van Cingel RE, Staal JB, Teerenstra S, de Visser E, Nijhuis-van der Sanden MW. Physical therapy aimed at self-management versus usual care physical therapy after hip arthroscopy for femoroacetabular impingement: study protocol for a randomized controlled trial. Trials Journal, 2016, 17, 17 - 91.

Tijssen M, van Cingel RE, de Visser E, Hölmich P, Nijhuis-van der Sanden MW. Hip joint pathology: relationship between patient history, physical tests, and arthroscopy findings in clinical practice. Scandinavian Journal of Medicine & Science in Sports, 2017, 27(3), 342 – 350

Tijssen M, Tak I, Stubbe J, Haverkamp D, Visser de E, Nijhuis-van der Sanden M, Cingel van R.
Translation, cross-cultural adaptation and validation of the Dutch international Hip Outcome Tool-33 (iHOT-33) according to the COSMIN checklist in young physically active individuals with symptomatic hip joint pathology. Submitted for publication vervangen door Accepted for publication by the Journal of Orthopaedic & Sports Physical Therapy, August 2017.

Other

Tijssen M, van der Hoeven H, van Cingel R. Infrapatellar contracture syndrome als complicatie na een patellapeesruptuur. Sport en Geneeskunde, 2010 mei (2), 22 – 26.

Tijssen M, Schamp T, Tak I. Vertaling, cross-culturele adaptatie en validatie van patient reported outcome measures. Sport en Geneeskunde, 2017 maart (2), 42 – 44.

Abstracts

Tijssen M, van Cingel R, de Visser E, R. Nijhuis-van der Sanden. Diagnostics of Intra-articular Hip Pathology: Relation Between Physical Tests, Imaging, and Arthroscopy. International Society for Hip Arthroscopy, congres München Duitsland, 2013.

M. Tijssen. Diagnostics and treatment of patients with impingement of the hip joint. European Society of Sports traumatology, Knee surgery and Arthroscopy, congres Amsterdam Nederland, 2014.

Tijssen M, van Cingel R, de Visser E, R. Nijhuis-van der Sanden. Femoro-acetabulair impingement en labrumletsel van de heup: relatie tussen anamnese, lichamelijke testen, beeldvorming en heuparthroscopie. Nederlandse Orthopaedische Vereniging, congres Maastricht Nederland, 2015.

Tijssen M, van Cingel R, de Visser E, R. Nijhuis-van der Sanden. Revalidatie na heuparthroscopie: een klinisch observationele studie over het middellange termijn herstel van heupfunctie en terugkeer naar sport activiteiten. Nederlandse Orthopaedische Vereniging, congres Maastricht Nederland, 2015.

Tijssen M, van Cingel R, de Visser E, Nijhuis-van der Sanden M. Intra-articulair heupletsel: relatie tussen anamnese, lichamelijk onderzoek en heupartroscopie in de praktijk. Vereniging Sport Geneeskunde, congres Eindhoven Nederland, 2015.

M. Tijssen. Functional tests and outcomes. Austrian Society for Hip Arthroscopy, congres Wenen Oostenrijk 2015.

Tijssen M. Diagnose en conservatieve behandeling van intra-articulaire heuppathologie. Vereniging Sport Geneeskunde, congres Ermelo Nederland, 2016.

Co-authored

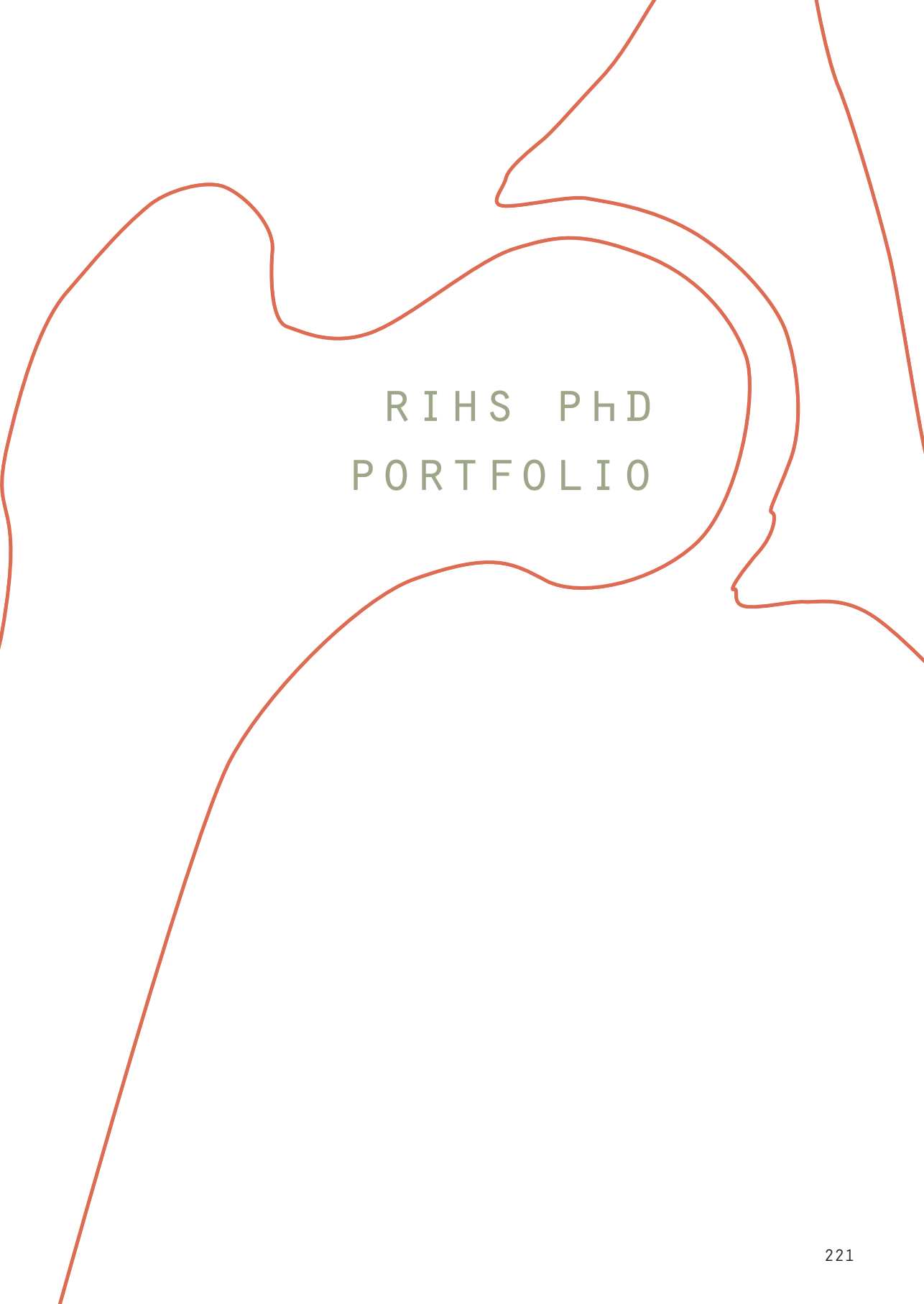
Engelen-van Melick N, van Cingel RE, **Tijssen M**, Nijhuis-van der Sanden MW. Assessment of functional performance after anterior cruciate ligament reconstruction: a systematic review of measurement procedures. Knee Surg Sports Traumatol Arthrosc. 2013 Apr;21(4):869-79. doi: 10.1007/s00167-012-2030-6. Epub 2012 May 12. Review.

de Visser E, **Tijssen M**. Labrumletsels van het heupgewricht. Nederlands Tijdschrift voor Traumatologie, 2013, 21(2), 69-75.

Thorborg K, **Tijssen M**, Habets B, Bartels EM, Roos EM, Kemp J, Crossley KM, Hölmich P. Patient-Reported Outcome (PRO) questionnaires for young to middle-aged adults with hip and groin disability: a systematic review of the clinimetric evidence. British Journal of Sports Medicine, 2015, 49(12), 812.

Habets B, van Cingel R, **Tijssen M**, Staal B. Intramachine reproducibility of the Humac NORM isokinetic dynamometer for strength measures of the knee and shoulder musculature. Submitted for publication.

Tak I, **Tijssen M**, Schamp T, Sierevelt I, Thorborg K, Kerkhoffs G, Stubbe J, Beijsterveld van J, Haverkamp D. Translation, cross-cultural adaptation and validation of the Dutch Hip And Groin Outcome Score according to the COSMIN checklist in young physically active individuals with hip or groin pain. Submitted for publication.



RIHS PhD PORTFOLIO

RIHS PhD Portfolio

Institute for Health Sciences
Radboudumc

Name PhD student:
M.P.W. Tijssen

Department:
Scientific Institute for
Quality of Healthcare

Graduate School:
Radboud Institute for Health Sciences

PhD period: 31-01-2012 - 15-12-2017

Promotor:
Prof. dr. M.W.G. Nijhuis-Van der Sanden

Co-promotors:
Dr. R.E.H. van Cingel
Dr. E. de Visser

	Year(s)	ECTS
TRAINING ACTIVITIES		
a) Courses & Workshops		
- BROK cursus (UMC Radboud)	2012	1.5
- Symposium Statistiek en Meta-analyse (UMC Radboud)		0.1
- NCEBP cursus (UMC Radboud)	2013	1.6
- Presenteren Eigen Onderzoek (UMC Radboud)		1.5
- Seminar Cochrane Collaboration (Universiteit van Amsterdam)		0.1
- Opfriscursus Statistiek met SPSS (UMC Radboud)	2014	2.0
- Liesklachten bij voetballers (NPI)	2015	0.5
- Symposium 'Hamstring and groin injuries' by Gerard Verall		0.2
- BROK herregistratie (UMC Radboud)	2016	0.1
- College 'Motor learning in injury prevention' by Anna Benjaminse		0.2
- Masterclass Topsport fysiotherapeut (NOC-NSF)		0.2
- Cursus Projectmatig werken (Hole18)	2017	1.75

	Year(s)	ECTS
TRAINING ACTIVITIES		
b) Seminars & lectures		
- Regionaal Genootschop Fysiotherapie Groot Gelre, Presentatie college 'Intra-articulair letsel van de heup', Arnhem The Netherlands.	2012	0.25
- Regionaal Genootschop Fysiotherapie Twente en Ijsselzoom, Presentatie college 'Intra-articulair letsel van de heup', Zwolle The Netherlands.		0.25
- Regionaal Genootschop Fysiotherapie Maasvallei, Presentatie college 'Intra-articulair letsel van de heup', Cuijck The Netherlands.		0.25
- Regionaal Genootschop Fysiotherapie Maasvallei, Presentatie college 'Intra-articulair letsel van de heup', Urmond, The Netherlands		0.25
- NVS Sportmasseurs, Presentatie 'Heupletsels bij sporters', Arnhem The Netherlands.	2013	0.25
- National Center of Performing Arts, Presentatie 'Voetballer ontmoet danser, heupletsels', Arnhem The Netherlands.	2016	0.25
c) Symposia & congresses		
Oral presentations		
- Diagnostics of Intra-articular Hip Pathology: Relation Between Physical Tests, Imaging and Arthroscopy, International Society for Hip Arthroscopy,, congress Munich Germany.	2013	0.75
- Functional tests and outcomes, Austrian Society for Hip Arthroscopy, congress Vienna Austria.	2014	0.75
- Diagnostics and treatment of patients with impingement of the hip joint, European Society of Sports traumatology, Knee surgery and Arthroscopy, congress Amsterdam The Netheralnds.		0.75
- Imaging in hip disorders, International Society for Hip Arthroscopy, congress Cambridge, United Kingdom.	2015	0.75
- Intra-articulair heupletsel: relatie tussen anamnese, lichamelijk onderzoek en heupartroscopie in de praktijk, Vereniging Sport Geneeskunde, congress Eindhoven The Netherlands.		0.50
- Diagnose en revalidatie van intra-articulair heupletsel, Nederlandse Vereniging voor Artroscopie, congress Den Bosch, The Netherlands.	2016	0.25
- Hoe herkennen en behandelen we heupletsel, Hogeschool van Arnhem en Nijmegen, Symposium voor het werkveld, Nijmegen, The Netherlands.		0.25
- Diagnose en conservatieve behandeling van intra-articulaire heuppathologie. Vereniging Sport Geneeskunde, congress Ermelo The Netherlands.		0.50

TRAINING ACTIVITIES	Year(s)	ECTS
d) Other		
- Physical therapist for Dutch Cycling Federation during 2012 London Paralympic Games	2012	
- Physical therapist for Dutch Cycling Federation during 2016 Rio de Janeiro Olympich Games	2016	
- Physical therapist for Dutch Cycling Federation during 2016 Rio de Janeiro Paralympic Games		
- Radio interview Omroep Brabant 'Rol van fysiotherapeut in leven topsporter'		
TRAINING ACTIVITIES		
e) Lecturing		
- Hogeschool van Utrecht, Master Sportfysiotherapie guest colleges 'Paralympische sporter' 2x, Utrecht The Netherlands.	2014-2015	0.8
- Hogeschool van Arnhem en Nijmegen, Master Musculoskeletaal gastcolleges 'Heuppathologie' 3x, Nijmegen The Netherlands.	2015-2016	1.2
f) Supervision of internships / other		
- Supervision internship Movement Science, T. Diemel, with focus on ' beeldvorming bij intra-articulair heupletsel', Arnhem The Netherlands..	2013	1
- Hogeschool van Arnhem en Nijmegen, Bachelor Fysiotherapie, external client and supervisor of research projects 5x, Arnhem The Netherlands.	2012-2017	5
ANCILLARY ACTIVITITES		
Review scientific publication		
- BMC Musculoskeletal Disorders	2013	0.1
- BMJ Journal	2017	0.1
- Journal of Orthopaedic & Sports Physical Therapy	2017	0,1
TOTAL		**25.05**

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